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Relative efficiency of women as farm managers: Profit function analysis in Côte d'Ivoire

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Abstract

The efficiency of women farmers in the agricultural sector of developing countries is passionately debated. Very few studies have examined this issue in African agriculture. All previous studies were based on production functions, but have been criticised as suffering from simultaneous equation bias because the input levels are endogenous. The profit function method avoids these problems. No previous study has used the profit function method to test for technical, allocative and economic efficiency differences between women and men farmers. The objective of this paper was to determine whether women rice farmers are less efficient than men rice farmers in Côte d'Ivoire using the restricted normalised profit function method. Our results show that the relative degree of efficiency of women is similar to that of men. The paper provides empirical support for efforts to eliminate bias against women farmers in African agriculture.

1. Introduction

The importance of women farmers in the agriculture of developing countries is widely recognised (Boserup, 1970; Gladwin, 1991; Lele, 1991). Women provide a significant share of the labour (both family and hired) for farm activities (Dixon, 1982), and are important as primary producers of food crops (Dey, 1984; Dozon, 1985; FAO, 1985; Savane, 1985; Weekes-Vagliani, 1985). Studies have shown that women also play major roles in farm-level decision-making, either as farm managers managing their own fields (Moock, 1976) or as 'effective decision-makers' even in households in which the household head is a male, either because of their specific skills or when the husbands are absent for longer periods because they are employed in urban areas (Quisumbing, 1994).

Despite their importance, women farmers face daunting constraints to their productivity, arising from limited access to extension, to capital markets, and to new technologies (Birkhaeuser et al., 1991; Bindlish and Evenson, 1993; Dey, 1984; Quisumbing, 1994; FAO, 1985). An argument often used against female farmers is that they are less efficient than male farmers (FAO, 1985). 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 has to do with the extent to which farmers make efficient decisions by using inputs up to the level at which their marginal contribution to production value is

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equal to the factor cost. Economic efficiency combines technical and allocative efficiency. It is possible for a firm to have either technical or allocative efficiency without having economic efficiency. Technical and allocative efficiency are necessary, and when they occur together, are sufficient conditions for achieving economic efficiency (Yotopoulos and Nuggent, 1976).

Whether men are more efficient than women in farm production is passionately debated. Only few studies have examined this issue in Africa (Moock, 1976, Kenya; Saito et al., 1992, Kenya and Nigeria; Bindlish and Evenson, 1993, Kenya; Bindlish et al., 1993, Burkina Faso; Udry et al., 1995, Burkina Faso), often with variable results. Using Cobb–Douglas production functions with dummy variables to represent the gender of either the field owner (Moock, 1976; Saito et al., 1992) or the head of the household (Saito et al., 1992; Bindlish and Evenson, 1993; Bindlish et al., 1993), these studies found that the coefficient of the gender dummy variable was insignificant in Kenya (Moock, 1976; Saito et al., 1992; Bindlish and Evenson, 1993) and Burkina Faso (Bindlish et al., 1993). Results for Nigeria were mixed, with the gender variable not significant when data for total farm output at the household level were used but were significantly higher for men when the total value of production at the plot level was used (Saito et al., 1992). Udry et al. (1995) examined gender-based productivity differences in Burkina Faso and found that output per hectare was lower on plots controlled by women. However, such differences in productivity cannot be taken as indicative of production inefficiency. When corrections were made for the differences in input type and quality, the authors noted that "The gender yield differential, apparently, is caused by the difference in the intensity with which measured inputs of labour, manure and fertiliser are applied on plots controlled by men and women rather than by differences in the efficiency with which these inputs are used" (p. 416). In production function estimates for all crops, sorghum and vegetables (a crop in which women specialised), Udry et al. (1995) found that except in the case of sorghum, the coefficient on the gender variable was not significant.

Criticisms of these studies have pointed out that the reliance on production function methods to test for allocative and economic efficiency suffers from problems of simultaneity bias because input levels are endogenously determined (Quisumbing, 1994). In a comprehensive review of state-of-the-art studies on gender and farm efficiency, Quisumbing (1994) noted that such "problems of endogeneity can be avoided by estimating profit or cost functions instead of production functions" (p. 8). Although applications of profit function analysis are extensive in the efficiency literature (Yotopoulos and Lau, 1973; Lau, 1976; Khan and Maki, 1979; Saleem, 1988; Duraisamy, 1990), studies have not used this approach to examine efficiency differences between men and women farmers (Quisumbing, 1994). This partly reflects the lack of appropriate gender-disaggregated field data. Given that rice in West Africa is often referred to as a 'woman's crop'—because of the importance of women as primary producers and decision-makers on the rice fields (Dey, 1984; Carney, 1988)—it offers itself as an interesting crop with which to examine this question. The objective of the paper was to determine, using the restricted normalised profit function method (Yotopoulos and Lau, 1973; Lau, 1976), whether female rice farmers are less efficient than male rice farmers in Côte d'Ivoire.

2. Data

The gender-disaggregated data used for the analysis were collected in 1993–1994 from a random sample of 347 men and 63 women rice farmers in three districts of northern Côte d'Ivoire. The data covered fertiliser applications, labour use (family and hired), access to extension and credit, farm size, paddy prices, wages, fertiliser prices, capital assets and the farmers' education level (Table 1). We found no significant difference in the access of women to extension services; 98% of the men have access to extension compared with 91% of the women farmers. Significant differences were found in access to education and credit, however. Only 2% of the female farmers are educated (i.e. have ever attended school) compared with 21% of the male farmers. Women are also at a disadvantage in their access to credit services. Eighty-six percent of men farmers have access to credit compared with only 59% of the women. Women also appear to receive less for their

Table 1
Average characteristics of female and male rice farmers in the sample, collected from three districts of northern Cote d'Ivoire in 1993

	Men ($N = 347$)	Women ($N = 63$)
Age (years)	41	45
Years of experience in rice farming	15	11
Contact with extension (% of farmers)	98	91
Access to credit (% of farmers)	86	59
Access to education (% of farmers)	21	2
Cultivated rice area (ha)	2.3	1.1
No. of person-days worked on owner's field	94	109
Wage rate (CFA day^{-1})	540	555
NPK use per farm (kg)	334	159
NPK (kg ha^{-1})	148	126
Urea use per farm (kg)	117	67
Urea (kg ha^{-1})	70	73
Price of NPK (CFA kg^{-1})	111	100
Price of urea (CFA kg^{-1})	108	104
Value of of paddy (CFA kg^{-1})	71	62

output than men: the average price received for paddy by men was 71 CFA kg^{-1}, compared with a mean farm-gate price of 62 CFA kg^{-1} for women. We did not observe any differences in quality or grade of output between men and women farmers. The higher prices obtained by men may reflect the fact that men are better organised into farmer cooperatives than women, differences in the timing of sales or the type of market outlets used.

No significant differences were seen in the use of chemical fertiliser. Men applied 148 kg NPK ha^{-1} compared with 126 kg ha^{-1} for women, whereas the application of urea was 70 kg ha^{-1} for the men and 73 kg ha^{-1} for women. Average expenditure on the use of other inputs (i.e. insecticides and herbicides) was similar for both men and women farmers; women spent an average of 15600 CFA ha^{-1} on these inputs compared with 11200 CFA ha^{-1} for men. Women in the sample also have access to the use of mechanised equipments (i.e. oxen or tractors) mainly through an equipment rental market that is active in the region of study. Average yields obtained by female farmers was 1.5 kg ha^{-1} compared with 2.0 kg ha^{-1} for the male farmers. However, mean values, by masking the substantial inter-farm variability in yields, resource endowments, and factor-use proportions across fields of female and male farmers, are not appropriate measures of relative farm efficiency. The profit function provides a better measure of relative efficiency differences.

3. Empirical model and hypotheses

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

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

where q_j represents the normalised 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 normalised restricted profit function, direct application of Hottelings–Shephard's Lemmas to the function yields the corresponding factor demand and output supply equations

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

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

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

Eqs. (1) and (3) form the theoretical basis for the specifications of the empirical models. Following previous studies (Lau and Yotopoulos, 1971; Khan and Maki, 1979; Saleem, 1988; Duraisamy, 1990), the specification of the systems of equations of the normalised restricted profit function and the factor share equations is given as

$$\ln\pi_i^* = \ln A^* + \delta_{\mathrm{m}r}^* D_{\mathrm{m}} + \sum_{i=1}^{2}\theta_l^* \ln w_i + \sum_{i=1}^{2}\beta_i^* \ln Z_i + \sum_{i=2}^{3} d_i^* R_i + \Psi_i \qquad (4)$$

$$\frac{-w_i X_i}{\pi_i^*} = \alpha_i^{*\,\mathrm{m}} D_{\mathrm{m}} + \alpha_i^{*\,\mathrm{f}} D_{\mathrm{f}} + \zeta_i \quad i = 1,2 \qquad (5)$$

where π^* is the normalised profit in FCFA (FCFA 520 = US\$1), defined as revenue less variable costs

Table 2
Estimated simultaneous regressions (SUR) of systems of normalised restricted profit function and factor share equations for male and female rice farmers, Cote d'Ivoire, 1993

	Model I unrestricted	Model II 2 restrictions	Model III 4 restrictions
Normalised profit function			
Wage rate (θ_1^*)	−0.455	−0.454	−1.386
	(−1.65) *	(1.65) *	(−7.83) **
Fertiliser price (θ_2^*)	−2.016	−2.019	−0.880
	(−3.92) **	(−3.93) **	(−8.67) **
Capital (β_1^*)	0.123	0.123	0.136
	(2.31) **	(2.31) **	(2.67) **
Land (β_2^*)	0.682	0.682	0.655
	(8.52) **	(8.52) **	(8.30) **
Sex of farmer (δ_m^*) (1 = male, 0 = female)	0.173	0.142	0.159
	(1.32)	(1.46)	(1.54)
Constant	7.263	7.292	8.739
	(8.96) **	(9.02) **	(11.19) **
Factor share equations			
Labour			
Factor share parameter for men (α_L^{*m})	−2.593	−2.504	−1.386
	(−7.14) **	(−7.49) **	(−7.83) **
Factor share parameter for women (α_L^{*f})	−2.017	−2.504	−1.386
	(−2.36) **	(−7.49) **	(−7.83) **
Fertiliser			
Factor share parameter for men (α_F^{*m})	−1.220	−1.262	−0.880
	(7.67) **	(−8.63) **	(−8.67) **
Factor share parameter for women (α_F^{*f})	−1.496	−1.262	−0.880
	(−4.01) **	(−8.63) **	(−8.67) **

Values in parentheses are the respective *t*-values of the associated parameters.
* Significant at 5–10%; ** significant at 1%.

normalised by the price of paddy (p); A^* is the intercept; X_1 is the number of person-days of labour used including family and hired labour; w_1 is the wage rate normalised by the price of paddy; w_2 is the price of fertiliser normalised by the price of paddy; X_2 is the quantity of fertiliser 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 area to rice in hectares; D_m is a dummy variable taking on the value of unity for male farmers; D_f is a dummy variable, taking on the value of unity for female farmers. R_i are dummy variables corresponding to the survey districts. [1] 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 nonzero, while the co-variance of error terms of any of the equations for different farms are assumed to be zero. Following previous studies, Zellners' seemingly unrelated regression method (SUR) was used to estimate the system of equations in order to obtain asymptotically efficient parameter estimates.

The results of the estimated equations are presented in Table 2. The coefficients all have the expected theoretical signs and nine of the ten variables are significant at between the 5% and 1% levels. As is theoretically consistent, the coefficients of the prices for fertiliser and labour are negatively signed as expected. Capital and land are highly significant in the profit function.

The hypotheses tested and their results are shown in Table 3. All tests are evaluated at the 5% level of

[1] 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).

Table 3
Statistical tests of hypotheses on relative efficiency differences between women and men rice farmers, Cote d'Ivoire, 1993

Hypotheses: Maintained	Hypotheses: Tested	Computed χ^2	Critical χ^2	P-value
Hypothesis 1				
	$\delta_m^* = 0$	1.76	3.84	0.18
Hypothesis 2				
	$\alpha_L^{*m} = \alpha_L^{*f}$ $\alpha_F^{*m} = \alpha_F^{*f}$	4.03	5.99	0.13
Hypothesis 3				
	$\delta_m^* = 0$ $\alpha_L^{*m} = \theta_1^*$ $\alpha_F^{*m} = \theta_2^*$	6.17	7.81	0.10
Hypothesis 4				
	$\alpha_L^{*m} = \theta_1^*$ $\alpha_F^{*m} = \theta_2^*$	23	5.99	0.001E-02
Hypothesis 5				
	$\alpha_L^{*f} = \theta_1^*$ $\alpha_F^{*f} = \theta_2^*$	4.9	5.99	0.0845
Hypothesis 6 $\alpha_L^{*m} = \alpha_L^{*f}$ $\alpha_F^{*m} = \alpha_F^{*f}$ $\alpha_L^{*m} = \theta_1^*$ $\alpha_F^{*m} = \theta_2^*$	$\beta_1^* + \beta_2^* = 1$	9.1	3.84	0.0023

significance. Hypothesis one (H1) states that the economic efficiency (technical and price or allocative efficiency) of men and women farmers are equal. This hypothesis cannot be rejected. The second hypothesis (H2) states that the relative price or allocative efficiency of men and women farmers is equal, i.e. they equate the value of marginal product of labour to wage rate and the value of marginal product of fertiliser to fertiliser price to the same degree. Although the hypothesis being tested is the equality of the elasticities of the variable inputs of men and women in the factor share equations, the test is better conceptualised as $(\alpha_i^{*m} - \theta_i^*) = (\alpha_i^{*f} - \theta_i^*)$, for $i = 1,2$. This hypothesis cannot be rejected. Hypothesis three (H3) states that there is equal relative technical and price efficiency jointly between men and women farmers. This hypothesis cannot be rejected. This is not surprising given the test results of H1 and H2. Hypothesis four (H4) states that men farmers have absolute allocative or price efficiency, i.e. they maximise profits by equating the value of each factor's marginal product to the respective factor price. This hypothesis is rejected. Hypothesis five (H5) states that women farmers have absolute allocative efficiency. This hypothesis cannot be rejected for the female sample. Hypothesis six (H6) states that there are constant returns to scale under the maintained hypothesis of absolute price efficiency for men and women farmers (and thus of equal relative price efficiency). This hypothesis is rejected. There is evidence of decreasing returns to scale for the underlying technology on the farms of both men and women farmers.

To determine the effects of individual production factors on paddy output for the sample farmers, we used identities that link the self-dual profit function with the primal production function (Sidhu, 1974; Yotopoulos et al., 1976; Duraisamy, 1990). It has been shown (Yotopoulos and Lau, 1973) that the indirect production elasticities for the variable inputs can be derived from the self-dual profit function used above, as $\alpha_j = -\alpha_j^*(1-\mu^*)^{-1}$, where α_j^* corresponds to the estimated parameters of the factor prices of these variables in the dual profit function, and $\mu^* = \Sigma\ \alpha_j^*$. The elasticities of the fixed factors are computed as $\beta_j = -\beta_j^*(1-\mu^*)^{-1}$, where β_j is the indirect elasticity of production with respect to the fixed factor. These indirect production elasticity estimates have been shown to have statistical consistency (Sidhu, 1974). Using the pooled sample of farmers (male and female) we estimated these indirect production elasticities. Our estimates (Table 4) show that the elasticity of paddy output is highest with respect to labour (0.42), followed by fertilisers (0.27), land (0.20), and capital (0.04). An increase of labour use by 10% will increase paddy output by 4.2%. Similarly, a 10% increase in fertiliser, land, and capital is expected to lead to 2.7%, 2.0% and

Table 4
Relative productivity effects of production factors used by rice farmers (men and women) in Cote d'Ivoire, 1993. Indirect production elasticity estimates derived from the dual profit function

Production factor	Indirect elasticity estimate
Labour	0.42
Fertiliser	0.27
Land	0.20
Capital	0.04

0.4% increases in paddy output. The highly inelastic response to land and capital may reflect the presence of other technological and infrastructural constraints that limit rice productivity. These results also show that labour is the most limiting factor in rice production, suggesting that the technologies that enhance the productivity of labour are likely to achieve significant positive effects on rice production.

4. Conclusions

This paper presents the results of an empirical application of the profit function method to test for efficiency differences between men and women farmers in African agriculture. Such an application was called for in a recent comprehensive review of the literature on gender and farm efficiency (Quisumbing, 1994). In particular, the results suggest that generalisations on efficiency or otherwise of men and women farmers should be avoided as this would be erroneous at best: efficiency is often dependent on the location and context of the agricultural systems. We found that the relative degree of economic efficiency of women rice farmers is similar to that of men rice farmers in Côte d'Ivoire. Results show that women farmers have absolute allocative efficiency in the use of the inputs at their disposal, although this did not translate into having higher economic efficiency due possibly to lack of better technical options. Also, evidence from the field survey show that men farmers are able to get higher prices for their rice than women, a situation that may reflect the better organisation of men farmers into cooperatives.

One major reason for the neglect of women in rice development projects in West Africa is the erroneous, yet pervasive, assumption that female farmers are less efficient than male farmers. Thus, even in regions of West Africa where women are the traditional rice growers, and rice is considered as a woman's crop, rice development projects choose to focus on men and not women (Dey, 1981, 1984). Results from this paper suggest that there is no economic rationale for biasing rice development strategies towards male farmers in Côte d'Ivoire, as female farmers, when they have access to similar inputs, have equal levels of economic efficiency.

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