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Full Length Research Paper

Price and non-price determinants of farm household demand for purchased inputs: Evidence from northern Ghana

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The study examined the factors that influence the use of purchased inputs (fertilizer, hired labour, seed and ploughing services) by smallholders in Northern Ghana. The seemingly unrelated regression technique was used to estimate a system of cost share equations of the factor inputs. The elasticities of substitution and factor demand have been estimated. The estimated results suggested that higher amount of remittance received and the attainment of basic education significantly led to higher fertilizer expenditure, suggesting that credit and basic education programmes were important for increasing expenditure on production enhancing inputs like fertilizer. The own-price elasticities of demand for the inputs were significant and had the expected negative signs. The demand for seed and ploughing services were quite price inelastic, while the demand for fertilizer and hired labour were price elastic. The estimated own-price elasticities of demand for fertilizer and hired labour indicated substantial high degrees of price responsiveness of farmers for them. The estimated cross-price elasticities suggested that smallholders would substitute relatively more hired labour for fertilizer, if the relative price of fertilizer to hired labour is increased.

Key words: Purchased inputs, cost shares, elasticities, smallholders, Northern Ghana.

INTRODUCTION

Agriculture in Ghana is generally traditional in nature. Most farms are less than 5 hectares and the farmers use simple implements with little or no application of fertilizer. The agriculture in Ghana is generally rain fed and output is invariably related to the amount and pattern of rainfall. In particular less than 8,000 hectares of land is irrigated. Ghana's agricultural output grew at average rates of about 1.1 percent during 1990 - 1994, 4.4% during 1995 - 1999 and 4.2% during 2000 - 2003 (ISSER, 2004), and these may be considered low for a developing economy. The achievement of high annual growth rate in agricultural output becomes feasible when adequate physical, institutional, and human resources are developed and new technologies are adopted. Among such measures, improved seeds, mechanisation, irrigation and fertilizer application are expected to play a leading role. Jha and Hojjati (1993) in a study in Zambia found out that fertilizer use can trigger the process of transforming subsistence agriculture to commercial farming.

The empirical record suggests that in many semiarid areas cash crops like cotton, sunflower and groundnut provide higher returns to land and labour than food crops and these present different opportunities to promote smallholder income growth, food security and national foreign exchange generation programmes (Jayne, 1994). In recent period a number of programmes have been initiated under the Government of Ghana Presidential Special Initiatives (PSI) to support the production sector. The initiatives currently cover four products, namely cassava (*Manihot esculenta*), garments and textiles, oil palm (*Elaeis guineensis*) and salt which are located in the southern part of the country. These initiatives are expected to contribute significantly to foreign exchange earnings, unemployment and poverty reduction, particularly in the rural areas of Ghana.

In Northern Ghana, similar initiatives are envisaged to begin soon to support cotton (*Gossupium hirsutum*) and sorghum (Sorghum *bicolor*) production. In Ghana, cotton and sorghum are grown largely in northern Ghana. Sorghum production, for instance, is expected to be expanded in order to provide a local raw material source for the brewing industry in Ghana. To make the contribution of the initiatives meaningful, the productivity of the smallholders must be increased and the complements of improved seed, mechanization, fertilizer, insecticides, and herbicides are essential. Knowledge of the factors that influence farmers' use of purchased inputs is important. The research question posed by the present study is: what are the factors that affect farmers' use of purchased inputs in Northern Ghana? The present study, using an existing data, examines the factors that influence smallholder farmers' demand for purchased inputs (fertilizer, hired labour, seed and ploughing services) in Northern Ghana. The paper uses estimated cost share equations to analyse the effects of micro (farm)-level variables on the use of these factor inputs by farmers. The effects of non-price variables and price variables are discussed. Most of the farmers' households (51 percent) have, generally, illiterate adult members, while about 31.5 percent have primary level education. Averages household size and landholding of the households are 14 persons and 4.08 ha, respectively, which include averages of 15 persons and 6.86ha for cotton farmers and 14 persons and 3.46 ha for non-cotton farmers.

The cost of ploughing land for production constitutes the major component of farm cost for both cotton and non-cotton farmers, accounting for 39.3 percent and 33.4 percent to their respective farm cost. Though, a larger proportion of cotton farmers (75.0 %) purchased fertilizer compared to non-cotton farmers (50.4 %), the quantity of fertilizer they purchased per cultivated land size was quite smaller, 0.68 bag/ha (34 kg/ha), than that of non-cotton farmers, 0.84 bag/ha (42 kg/ha). The average quantity of fertilizer purchased per cultivated land size is 0.81 bag/ha (40.5 kg/ha). It has been noted that most of the farmers growing cotton acquired the fertilizer for use as part of a package for their cotton fields, but some are diverted to other crop fields (Mensah-Bonsu, 2003; Al-Hassan and Egyir, 2001). Panin (1988) described the comparative advantage of bullock traction to hoe tillage in farm production in Northern Ghana, while Hesse (1997) investigated the sustainability of bullock traction by comparing the state of bullock traction in 1994 to the situation in 1982. The results of their studies suggested that though bullock ownership decreased between 1982 and 1994, the area ploughed with bullock traction increased because of an increase in bullock traction renting services in the study areas (Hesse, 1997). The present study looks at factors that affect farmers' use of purchased inputs like ploughing services.

The rest of the paper is organized as follows: Section 2 presents the materials and methods which included the theoretical and empirical models, and the data used. The estimation and results are presented in Section 3, while the discussion of the results is presented in Section 4. Lastly the conclusion of the study is presented in Section 5.

MATERIALS AND METHODS

Specification of theoretical model

The study assumes that a farm household to a large extent faces imperfect labour and land markets, but there are more effective markets (though not perfectly competitive) for other farm inputs like fertilizer and farm products like cotton which are tradable. Differences in transaction costs, for different rural locations, affect the return to individual farm households from the purchase of fertilizer from urban markets and the value of product which is normally sold at the farm level.

For most farm households who operate in the imperfect market environments their utility and profit maximizing decisions are jointly determined, where the optimal production and consumption levels are determined within an integrated framework (Lopez, 1986). Few others, who participate in the near perfect markets for some farm inputs and products, on the other hand, may maximize profit separately from utility maximizing decision-making process. But given the desired level of output that gives the maximum utility and/or profit level, each of these two types of farmers (producers) would want to minimize their respective cost of production, notably costs of purchased inputs. Hence, both types of producers will minimize their production cost, given their respective level of output.

Let the production function of a farm be given as:

$$q = q(X, Z, H) \quad (1)$$

Where; *q*, *X*, *Z* and *H* present vectors of farm household's farm output, purchased input quantity, household fixed factor and household characteristics, respectively. The production function (equation 1) is assumed to be well-behaved (That is, a concave function): it is twice differentiable where $\partial q(*)/\partial X > 0$ and $\partial^2 q(*)/\partial X^2 < 0$. The cost of purchased input is given by:

$$C = Xp \quad (2)$$

Where, **p** is vector of input prices (which reflect also the differences in transaction costs for input at various locations). The two types of farmers are assumed to minimize their cost of production subject to their respective given level of output.

$$\underset{X^*}{Min} C = Xp \quad (3)$$

Subject to; $q = q(X, Z, H)$

Lagrangean function is

$$L = Xp + \lambda(q - q(X, Z, H)) \quad (4)$$

The first order conditions, from equation 4, are given as:

$$\frac{\partial L}{\partial X} = p - \lambda \frac{\partial q}{\partial X} = 0$$

$$\frac{\partial L}{\partial \lambda} = q - q(X, Z, H) = 0$$

Taking total differentials of the first order conditions give

$$dp - (\lambda \frac{\partial^2 q}{\partial X^2} dX + \frac{\partial q}{\partial X} d\lambda) = 0 \quad (5)$$

$$dq - \frac{\partial q}{\partial X} dX = 0 \quad (6)$$

Rearranging equations 5 and 6 implies

$$\begin{bmatrix} 0 & \partial q/\partial X \\ \partial q/\partial X & \partial^2 q/\partial X^2 \end{bmatrix} \begin{bmatrix} d\lambda/\lambda \\ dX \end{bmatrix} = \frac{1}{\lambda} \begin{bmatrix} \lambda dq \\ dp \end{bmatrix} \quad (7)$$

And the Bordered Hessian (*BH*), from equation 7, is given by

$$BH = \begin{bmatrix} 0 & \partial q/\partial X \\ \partial q/\partial X & \partial^2 q/\partial X^2 \end{bmatrix}$$

The Bordered Hessian where computed are all expected to be positive (That is, $BH_2 > 0$, $BH_3 > 0$, etc). Solving the first order conditions and adding vectors of household fixed factors and other characteristics of the farm household give a vector (system) of purchased factor input function of the form:

$$X^* = x(p, q, Z, H) \quad (8)$$

Substituting equation 8 into equation 2, the corresponding minimum cost function is derived as:

$$C^* = c(p, q, Z, H) \quad (9)$$

Applying Shephard's duality theorem, which hold for the cost function, the cost-minimizing factor demand is given by:

$$\frac{\partial C^*}{\partial p} = X^* \quad (10)$$

That is, the input functions are the derivatives of the cost function with respect to the input prices.

Specification of empirical model

Factor cost share equations derived from the translog cost function are estimated in the present paper. Due to its flexibility and limited priori restrictions on scale economics and substitution of factors, the translog cost function is the most particularly useful function for estimating the factor demand functions (Binswanger, 1974; Greene, 2000). Rewriting equation 9 in natural logarithm, the cost function C* takes the form,

$$\ln C^{\bullet} = c(\ln p, \ln q, \ln Z, \ln H) \quad (11)$$

Where; *p*, *q*, *Z* and *H* are defined above. There are two possible approaches for estimating the cost function using the translog functional form. One approach involves estimating all the coefficients including the intercept term of the translog cost function. This approach has been used by Dalton et al. (1997) and Obare et al. (2003). With the other approach, if one imposes the symmetry and constant returns to scale conditions, then some of the coefficients (coefficients of interest) of the total cost function are estimated. With the constant returns to scale condition imposed, the output term (*lnq*) is omitted from equation 11 and the cost function is specified as an average cost function (*C***). With this approach n - 1 cost share equations are derived and estimated, directly using the seemingly unrelated regression technique.

The last cost share equation is derived from the coefficients of the estimated cost shares equations using the symmetry and homogeneity conditions. In this case not all the coefficients of the total cost function are estimated. This approach has been followed by Fulginiti and Perrin (1990) in their profit function, Binswanger (1974), Berndt and Wood (1975) and described by Greene (2000). Imposing the constant returns to scale condition, the translog cost function is expressed, from equation 11, as a logarithmic Taylor series expansion to the second term of a twice differentiable analytic cost function about the point $\ln p = 0$, $\ln Z = 0$ and $\ln H = 0$ as:

$$\begin{aligned} \ln C^{\bullet\bullet} &= a_0 + \beta_i \ln p_i + \beta_m \ln Z_m + \beta_k \ln H_k \\ &+ 0.5\sum_i\sum_j \alpha_{ij} \ln p_i \ln p_j + 0.5\sum_m\sum_n \alpha_{mn} \ln Z_m \ln Z_n + 0.5\sum_k\sum_l \alpha_{kl} \ln H_k \ln H_l \\ &+ \sum_i\sum_m \alpha_{im} \ln p_i \ln Z_m + \sum_i\sum_k \pi_{ik} \ln p_i \ln H_k + \sum_m\sum_k \pi_{mk} \ln Z_m \ln H_k \end{aligned} \quad (12)$$

If the parameters α and π were zero, then the translog function would be reduced to a Cobb-Douglas function. The derivative of translog cost function with respect to a factor price, which gives the cost share of the purchased factor input in total cost, is:

$$s_i = \frac{\partial \ln C^{\bullet\bullet}}{\partial \ln p_i} = \beta_i + \sum_j \alpha_{ij} \ln p_j + \sum_m \pi_{im} \ln Z_m + \sum_k \pi_{ik} \ln H_k \quad (13)$$

Where; s_i is the cost share of the "i^{th}" factor in total farm cost. The cost shares for the purchased inputs are calculated (from the field data) as:

$$s_i = \frac{p_i x_i}{\sum p_i x_i}. \quad (14)$$

The cost shares equations are estimated for hired labour (S_H), fertilizer (S_F), Seed (S_S) and ploughing (S_P). They are expressed from equation 13 and after adding some dummy variables they can be represented as:

$$\begin{aligned} S_H &= \beta_H + \alpha_{HH} \ln P_H + \alpha_{HF} \ln P_F + \alpha_{HS} \ln P_S + \alpha_{HP} \ln P_P + \pi_{HL} \ln Z_L \\ &+ \pi_{HA} \ln H_A + \pi_{HC} \ln H_C + \pi_{HR} \ln H_R + \pi_{HV} D_V \end{aligned} \quad (15)$$

$$\begin{aligned} S_F &= \beta_F + \alpha_{FH} \ln P_H + \alpha_{FF} \ln P_F + \alpha_{FS} \ln P_S + \alpha_{FP} \ln P_P + \pi_{FL} \ln Z_L \\ &+ \pi_{FA} \ln H_A + \pi_{FC} \ln H_C + \pi_{FR} \ln H_R + \pi_{FV} D_V \end{aligned} \quad (16)$$

$$S_S = \beta_S + \alpha_{SH}\ln P_H + \alpha_{SF}\ln P_F + \alpha_{SS}\ln P_S + \alpha_{SP}\ln P_P + \pi_{SL}\ln Z_L + \pi_{SA}\ln H_A + \pi_{SC}\ln H_C + \pi_{SR}\ln H_R + \pi_{SV}D_V \quad (17)$$

$$S_P = \beta_P + \alpha_{PH}\ln P_H + \alpha_{PF}\ln P_F + \alpha_{PS}\ln P_S + \alpha_{PP}\ln P_P + \pi_{PL}\ln Z_L + \pi_{PA}\ln H_A + \pi_{PC}\ln H_C + \pi_{PR}\ln H_R + \pi_{PV}D_V \quad (18)$$

Where; β_i, α_{ij} and π_{im} are coefficients, P_H, P_F, P_S and P_P are prices of hired labour, fertilizer, seed and ploughing services and Z_L, H_A, H_C and H_R are household's landholding (fixed factor), adult size, size of cattle held and remittances received in the rainy season respectively. D_V are the dummies for the household's average education level, location and growing of cotton.

The elasticities of substitution and factor demand are estimated from the coefficients of the cost shares equations. The Allen elasticities of substitution (AES) and Morishima elasticities of substitution (MES) have been used to examine smallholder agricultural production structures (Obare et al., 2003; Dalton et al., 1997). Blackorby and Rusell (1989) provide a complete discussion on the shortcomings and merits of the Allen and Morishima elasticities measures. AES do not indicate the curvature or ease of substitution. They are single input - price elasticities and do not relate the optimal input ratios to those of input prices. Thus, they cannot provide information on the relative input responsiveness to changes in input prices. In contrast, the MES preserve the salient features of the Hicksian concept in the multifactor context and measure the ease of substitution. The MES are, therefore, sufficient statistics for assessing the effects of changes in the price on relative factor shares. The elasticities are estimated at the sample means of the factor(s) concerned. The Allen elasticities of substitution (η_{ij}) and the corresponding standard errors are given as:

$$\eta_{ii} = \frac{\alpha_{ii} + s_i(s_i - 1)}{s_i^2}; \quad \eta_{ij} = \frac{\alpha_{ij} + s_i s_j}{s_i s_j},$$

where; $\eta_{ij} = \eta_{ji}$; $\quad s.e(\eta_{ij}) = s.e(\alpha_{ij}) / s_i s_j$

The elasticities of factor demand and the corresponding standard errors are given as:

$$\psi_{ii} = \frac{\alpha_{ii} + s_i(s_i - 1)}{s_i} = \eta_{ii} s_i; \quad \psi_{ij} = \frac{\alpha_{ij} + s_i s_j}{s_i} = \eta_{ij} s_j,$$

Where; $\psi_{ij} \neq \psi_{ji}$; $\quad s.e(\psi_{ij}) = s.e(\alpha_{ij}) / s_i$

While, the MES are estimated from the factor demand elasticities as $\psi_{ij} - \psi_{ii}$ Imposing restrictions on the parameters to ensure homogeneity with respect to input prices, household fixed factors and other household factors require (from equation 13) that:

Costs for the different respondents from 30 villages in three different population density areas.

(a) Symmetry: $\alpha_{ij} = \alpha_{ji}$; i, j = 1, 2, 3, 4

(b) Homogeneity in prices:

$\sum \beta_i = 1$; (Row sum is zero);

$$\sum_j \alpha_{ij} = 0$$

$$\sum_i \alpha_{ij} = 0$$

(Column sum is zero)

(c) Homogeneity in farm household factors:

(i) Fixed Factor (Land):

(Column sum is zero): $\sum_i \pi_{im} = 0$;

(ii)Other Factors

(Column sum is zero): $\sum_i \pi_{ik} = 0$

Since the sum of the cost shares of the factors is equal to 1, one of the cost share equations is dropped during the estimation to ensure linear independent of the system. The equation for ploughing is dropped and the prices of hired labour, fertilizer and seed relative to the price for ploughing are used in the three equations estimated. The symmetry and homogeneity restrictions allow the coefficients of the equation which is dropped to be calculated. The present study estimates the system of cost share equations for fertilizer, hired labour, seed and ploughing services using their prices and farm household characteristics. Obare et al. (2003), Dalton et al. (1997) and Fulginiti and Perrin (1990) have followed similar approach to describe the production structure of agriculture in Kenya, Zimbabwe and Argentina, respectively. Beside the factor prices, the farm household characteristics such as total landholding (as a fixed factor), family size, number of cattle owned and remittance received during the rainy season were expected to influence the farm household purchase of input. Fulginiti and Perrin (1990) added land and precipitation as fixed input in their study.

Data description

The data for the estimation of factor demand equations need sufficient variability in all the exogenous variables (both fixed household factors and prices). The variability in the household factors is usually greater in cross-sectional farm level data than in time series data, while price variability is usually fairly small across households but greater in time series data (Sadoulet and de Janvry, 1995). However, a proper account of the transactions costs incurred by different households, particularly in regions such as the present study areas, would usually reveal greater variability in the prices paid by the different households. A combined cross-sectional and time series data set as used by Bapna, Binswanger and Quizon (1984) for India and Esfahani (1987) for Egypt is the most ideal for the estimation of system of equations similar to what is described in Section 3. However, estimations have been done using farm level data involving different regions in the case of Sidhu and Baanante (1981) for India and using time series data in the case of Fulginiti and Perrin (1990) for Argentina. The present study uses cross-sectional farm level data and assumes greater variability in household factor characteristics as well as reasonable variability in prices for purchased inputs, like fertilizer, due to transactions

The study uses available farm household data collected in April - May 2000 from 30 villages located in three different populated areas, namely Langbensi (located in sparsely populated district of East Mamprusi), Nangodi (located in the very densely populated district of Bolgatanga) and Bawku-Garu (located in densely populated district of Bawku-East) areas in Northern Ghana. The survey included 175 households selected from the 30 villages. The numbering of structures by the Ghana Statistical Services during the 2000 Ghana Population and Housing Census was used to select 5 compound households for each village at interval of 3. At the villages named Nakpanduri and Sakogu 34 households in-cluded in a research undertaken by Panin in 1982 and repeated by Hesse in 1994 were interviewed. After data cleaning, the sample size was reduced to 166 compound households, but due to some missing data points, 149 households (including 28 cotton farmers and 121 non-cotton farmers) were used during the regression estimation. The definition, measurement units and mean values for the regression variables are summarized in Table 1 for cotton and non-cotton farmers in Northern Ghana. The data construction is presented in an appendix.

ESTIMATION AND RESULTS

The parameters of the system of cost share equations for hired labour, fertilizer, seed and ploughing services were estimated using seemingly unrelated regression technique of Zellner (1962). The parameters could be estimated using the ordinary least squares (OLS). However, OLS estimation will yield inefficient results because of the restrictions imposed and the correlation of the error terms across the systems of equations (Zellner, 1962). As the sum of the shares is equal to one and therefore the system is not linearly independent, one of the cost share equations was dropped. The ploughing services share equation was dropped from the model and the prices of hired labour, fertilizer and seed relative to the price for ploughing are used in the three equations estimated in order to make the remaining equations linearly independent. The coefficients of the ploughing services share equation were calcu-lated from the other estimated coefficients using the symmetry and homo-geneity conditions. The seemingly unrelated regression was iterated and this allowed the estimated parameters to converge to maximum likelihood results, and in effect made the parameter estimates significantly invariant irrespective of the cost share equation that was dropped. The variance – covariance matrix of the coefficients were estimated and the approximate – variance theorem was applied to derive the variances and consequently the standard errors of the calculated coefficients for the cost share equation for ploughing services. The estimated results are presented in Tables 2 and 3. The interpre-tation of the results was done with care because the variations in the hired labour wage and fertilizer price were fairly small across households (Table 1).

The Breusch-Pagan test result suggested that the residuals of the estimated cost share equations were correlated, thus using the seemingly unrelated regression technique was appropriate. The chi-square test results also confirmed the symmetry and homogeneity conditions (Table 2). Thus, the coefficients for the price variables in the cost share equations are represented by the diagonal coefficients in Table 3.

The non-price variables that have significant and positive effects on the cost share of fertilizer included the adult size (significant at 1 percent level), amount of remittance received (significant at 10% level), attainment of basic level (Middle or Junior Secondary School) of education (significant at 1 percent level) and location in sparsely populated area (significant at 1 percent level). The results suggested that higher amount of remittance received and the attainment of basic education led significantly to higher expenditure on fertilizer for farm production. The size of cattle held and location of sparsely populated area, respectively, had positive and negative significant effects on the cost share of hired labour. The size of cattle held also had a negative and significant effect on the cost share of ploughing. The effects due to the size of cattle on the costs share of ploughing and hired labour suggested that farmers who have (more) cattle spent less on ploughing, but more on hired labour for farm production. The household's landholding as an important economic variable had significant and positive effect on the cost share of seed, and negative effects on cost shares of hired labour and fertilizer. The estimated results showed that four out of nine coefficients (α_{ij}) for prices, which have their standard errors estimated, were statistically significant. The coef-ficients for the price variables (α_{ij}) themselves have little economic meanings. Their economic meanings were better evaluated by the estimated elasticities of factor substitution and factor demand and these estimated elasticities are presented in Tables 4 and 5, respectively.

An estimated elasticity of factor substitution was expected to be positive for substitutes and negative for complements. The calculated MES (Table 4) showed high degree of substitutability between fertilizer and hired labour for the farmers (both cotton and non-cotton farmers). The substitutions of fertilizer for hired labour for the different types of farmers (3.5870 for cotton farmers and 2.6570 for non-cotton farmers) were higher than the substitution of hired labour for fertilizer (1.8036 for cotton farmers and 2.1005 for non-cotton farmers), suggesting more intensive use of fertilizer than hired labour. The estimated elasticities also suggested that ploughing and fertilizer use were substitutes, but the degree of their substitutability was low. The MES of ploughing for fertilizer (0.8314 for cotton farmers and 0.7521 for non-cotton farmers) were quite higher than the MES of fertilizer for ploughing (0.2304 for cotton farmers and 0.1603 for non-cotton farmers). The substitutions of ploughing for hired labour for the different types of farmers were higher than the substitutions of hired labour for ploughing. There were low degrees of substitution of fertilizer for seed (0.7666 for the farmers combined) and ploughing for seed (0.6062 for the farmers combined), while the degrees of substitution of seed for fertilizer (1.9982 for the farmers combined) and seed for ploughing (0.7073 for the farmers combined) were relatively higher. For the cotton farmers, the results suggested, clearly, that seed and

Table 1. Descriptive statistics of farm household (1999 farming season) used in the analysis.

Variable definition	Measurement unit	Mean values (Std dev.)		
		Cotton farmers	Non-cotton farmers	All
Observation		**28**	**121**	**149**
Share in farm cost:				
Plough (S_P)		0.393 (0.199)	0.334 (0.230)	0.345 (0.225)
Fertilizer (S_F)	proportion	0.215 (0.182)	0.189 (0.226)	0.194 (0.218)
Hired lab. (S_H)		0.080 (0.091)	0.124 (0.164)	0.116 (0.154)
Seed (S_S)		0.312 (0.195)	0.352 (0.293)	0.345 (0.277)
Plough cost/acre (P_P)	`000Cedis	22.6 (16.7)	26.8 (22.7)	26.0 (21.7)
Fertilizer price (P_F)	`000Cedis	35.2 (7.6)	34.1 (4.7)	34.3 (5.3)
Hired lab. wage (P_H)	`000Cedis	2.2 (0.4)	2.3 (0.7)	2.3 (0.6)
Seed cost/acre (P_S)	`000Cedis	12.9 (13.1)	15.9 (15.1)	15.3 (14.7)
Farm cost	`000Cedis[a]	560.2 (282.6)	375.5 (354.6)	410.2 (349.0)
Ploughed	`000Cedis	213.1 (145.7)	121.7 (141.0)	138.9 (145.8)
Hired lab	`000Cedis	40.2 (50.6)	48.2 (105.2)	46.7 (97.2)
Fertilizer	`000Cedis	110.2 (100.3)	88.8 (130.2)	92.9 (125.1)
Seed	`000Cedis	165.2 (150.6)	94.0 (106.9)	107.4 (119.1)
Other input	`000Cedis	31.3 (47.2)	22.7 (56.7)	24.3 (55.0)
Adult size (H_A)	number of adults	8.2 (3.1)	7.28 (3.77)	7.4 (3.7)
Total landholding (Z_L)	acres	17.16 (13.03)	8.64 (9.41)	10.2 (10.7)
Cattle size (H_C)	number held	4.32 (4.47)	4.07 (5.41)	4.12 (5.22)
Remittance (H_R)	(`000Cedis)	84.9 (185.0)	47.4 (118.1)	54.4 (133.3)
Cotton dummy (D_C)	1 = cotton farmer 0 = non-cotton	1 (0)	0 (0)	0.188 (0.392)
Ave. school level (D_{SL})				
No schooling	1 for ave. school level attained; 0 = otherwise	0.607 (0.497)	0.488 (0.502)	0.510 (0.502)
Primary		0.321 (0.476)	0.314 (0.466)	0.315 (0.466)
Middle/JSS (Basic)		0.071 (0.262)	0.190 (0.394)	0.168 (0.375)
Senior secondary		0.0 (0.0)	0.008 (0.091)	0.007 (0.082)
Location dummy (D_L)				
Sparsely populated dist.	1 if household is located in the stated area; 0 = otherwise	0.428 (0.504)	0.388 (0.489)	0.396 (0.491)
Densely populated dist.		0.464 (0.508)	0.231 (0.423)	0.275 (0.448)
V. densely pop. dist.		0.107 (0.314)	0.380 (0.487)	0.329 (0.471)

Source: Compiled from the 2000 field survey data file of Mensah-Bonsu (2003). [a] Cedi is the unit of currency used in Ghana (The average interbank quarterly exchange rate for the period April 1999 - March 2000 was about US$ 1 = 3,200 Cedis (calculated from ISSER, 2002)).

seed and hired labour were complements. These estimated results, generally, suggested high intensity of seed use, followed by ploughing of farmlands, fertilizer application and hired labour use by farmers in the study areas.

The derived own price and cross-price elasticities of factor demand are presented in Table 5. The cross-price effects between seed and hired labour and between fertilizer and ploughing services were negative, suggesting that these pairs of purchased inputs were complements. Only the complement between seed and hired labour under the cotton farmers' category was significant (10% level). The rest of the derived cross-price elasticities of factor demand were positive. The cross-price effects between ploughing and seed, and between fertilizer and seed were inelastic and significant (at the 10 and 1% levels respectively) for the different farmers' categories. For the different types of farmers, the cross-price effects of fertilizer on demand for hired labour were elastic and significant (estimated elasticities are 1.3435, 1.9933 and 1.4290 for the non-cotton, cotton and the combined farmers, respectively), while, the cross-price

Table 2. Statistical test results for model restrictions.

Test	Calculated χ^2	Implication of results for the derived coefficients
Breush-Pagan test of independence	33.972***	
Symmetry:		
$\alpha_{FH} = \alpha_{HF}$	0.35	
$\alpha_{HS} = \alpha_{SH}$	2.94*	
$\alpha_{FS} = \alpha_{SF}$	1.35	
Homogeneity conditions:		
(a) Prices:		
$\beta_H + \beta_F + \beta_S = 1$		
$\alpha_{HH} + \alpha_{FH} + \alpha_{SH} = 0$	3.28*	$\beta_P \neq 0$ at the 10 % level
$\alpha_{HF} + \alpha_{FF} + \alpha_{SF} = 0$	1.01	$\alpha_{PH} = 0$
$\alpha_{HS} + \alpha_{FS} + \alpha_{SS} = 0$	1.47	$\alpha_{PF} = 0$
(b) Fixed Factor (Land)	17.24***	$\alpha_{PS} \neq 0$
$\pi_{HL} + \pi_{FL} + \pi_{SL} = 0$		
(c) Other Factors	1.27	$\pi_{PL} = 0$
$\alpha_{HA} + \alpha_{FA} + \alpha_{SA} = 0$		
$\alpha_{HC} + \alpha_{FC} + \alpha_{SC} = 0$	0.00	$\pi_{PA} = 0$
$\alpha_{HR} + \alpha_{FR} + \alpha_{SR} = 0$	3.12*	$\pi_{PC} \neq 0$ at the 10 % level
$\alpha_{HV} + \alpha_{FV} + \alpha_{SV} = 0$	0.00	$\pi_{PR} = 0$
	χ^2 Calculated for each of the dummies was insignificant	$\pi_{PV} = 0$ for each dummy

*** denotes 1 % significance; ** denotes 5 % significance; * denotes 10 % significance.

effects of hired labour on demand for fertilizer were inelastic and significant (estimated elasticities are 0.8793, 0.7464 and 0.8525 for the non-cotton, cotton and the combined farmers, respectively).

The own-price elasticities of factors' demand were significant and had the right (negative) signs. The demand for ploughing services and seed were quite price inelastic, while the demand for fertilizer and hired labour were price elastic for the different categories of farmers. The estimated own-price elasticities of demand for fertilizer and hired labour were 1.221 and 1.314 respectively for the non-cotton farmers and 1.147 and 1.594 respectively for the cotton farmers.

DISCUSSION

The study found out that, given unchanged factor prices, higher amount of remittance received and the attainment of basic education were important for higher expenditure on fertilizer for farm production. Jha and Hojjati (1993) using probit and ordinary least squares techniques find out that a higher level of education and access to oxen led to higher (significant) fertilization rates and concluded that education is important when the intensity of fertilizer application is considered, though not in the decision of whether to use fertilizer. The results of the present study implied that if the rural folks are adequately provided with resources such as funds (remittances) and knowledge (education), then they may follow improved production methods including fertilizer application. It has been suggested that credit with education programme is important for good recovery of loans given to farmers.

The fact that labour may be unavailable and very expensive to hire in sparsely populated areas might account for the negative and significant effect of the sparsely populated location dummy variable on the cost share of hired labour. This negative effect on hired labour might have been compensated for (in consistent with the estimated high substitutability between fertilizer and hired labour (Table 4)) by the positive and significant effect of the sparsely populated location dummy on the expenditure share of fertilizer. Thus, in sparely populated agricultural region, farmers would substitute fertilizer use for hired labour. The negative and significant effect of the size of cattle on the cost share of ploughing suggested that farmers who have (more) cattle spent less on ploughing. It is important to mention that a bullock-ploughing service (animal traction) is more common especially for smaller farm size and less expensive than tractor ploughing service. It may be deduced that integrating smallholder cattle rearing would help farmers to reduce their expenditure on ploughing. The estimated positive and negative effects of household's land size on

Table 3. Parameter estimates: Seemingly unrelated regression results.

Regressors	Purchased inputs			
	Share of hired labour	Share of fertilizer	Share of seed	Share of ploughing services
	Coefficient (SE)	Coefficient (SE)	Coefficient (SE)	Coefficient (SE)
Intercept (β_i)	0.0868 (0.1855)	0.4421 (0.2110)**	-0.0221 (0.2633)	0. 4932 (0.2726)*
Price (α_{ij}):				
H. labour (P_H): α_{HH} ;α_{FH} ;α_{SH} ;α_{PH}	-0.0542 (0.0626)	0.1430 (0.0712)**	-0.1814 (0.0889)**	0.0926 (0.0920)
Fertilizer (P_F): α_{FF} ; α_{SF} ;α_{PF}		-0.0777 (0.0654)	0.0868 (0.0816)	-0.1521 (0.0862)*
Seed (P_S): α_{SS} ; α_{PS}			0.1153 (0.0176)***	-0.0207 (0.0319)
Plough (P_P): α_{PP}				0.0802
Household Characteristics (π_{ik})				
Total land (Z_L)	-0.0417 (0.0193)**	-0.0402 (0.0220)*	0.0499 (0.0274)*	0.0320 (0.0284)
Adult resident size (H_A)	-0.0370 (0.0265)	0.0936 (0.0302)***	-0.0564 (0.0376)	-0.0002 (0.0389)
Cattle size (H_C)	0.0368 (0.0127)***	-0.0028 (0.0144)	-0.0011 (0.0180)	-0.0329 (0.0186)*
Remittances (H_R)	-0.0010 (0.0024)	0.0046 (0.0028)*	-0.0036 (0.0034)	-0.0000 (0.0036)
Grown cotton (D_C)	-0.0123 (0.0325)	-0.0170 (0.0370)	-0.0208 (0.0462)	0.0501 (0.0478)
School level[a] (D_{SL})				
Primary	-0.0072 (0.0263)	0.0057 (0.0299)	0.0068 (0.0373)	-0.0053 (0.0386)
Middle/JSS	0.0483 (0.0343)	0.1010 (0.0390)***	-0.0876 (0.0487)*	-0.0617 (0.0504)
Senior Sec.	0.1733 (0.1388)	-0.0081 (0.1579)	-0.1042 (0.1970)	-0.0610 (0.2040)
Location dummy[b] (D_L)				
Sparsely populated dist.	-0.1010 (0.0324)***	0.1186 (0.0369)***	-0.0460 (0.0461)	0.0284 (0.0477)
Very densely pop. dist.	-0.0392 (0.0349)	-0.2141 (0.0397)***	0.2230 (0.0495)***	0.0303 (0.0512)
Observation	149	149	149	
Root MSE	0.1353	0.1540	0.1921	
R-squared	0.2170	0.4971	0.5153	
Chi-square	41.2828	147.2709	158.3913	

Source: Estimated from the 2000 field survey data file of Mensah-Bonsu (2003). In parentheses are standard errors (SE); ***, ** and * denote 1%, 5% and 10% significant levels, respectively. t-value = coefficient/SE. [a] No schooling is the excluded category. [b] Densely populated district is the excluded category.

cost shares of seed and fertilizer, respectively, were consistent with processes for agricultural intensification (transformation) as a result of land becoming scarce. The negative effect of landholding on the cost share of hired labour was, however, unexpected.

The results, in general, confirmed that the different type of farmers had considerable substitution possibilities at their disposal. The highest degrees of substitutability were estimated between fertilizer and hired labour for the farmers and these results are similar to findings of other studies like Dalton et al. (1997) who find the greatest degree of substitutability between labour and biochemical input (attributed much of the cost share to fertilizer) and Obare et al. (2003) who report the highest degree of substitutability between fertilizer and labour. The estimated MES suggested that higher fertilizer price relative to hired labour wage is associated with lower fertilizer to hired labour use intensity and vice versa. Thus, to promote fertilizer use by farmers in order to enhance agricultural production, the relative price level of fertilizer to the wage rate for labour, for example, should be of considerable interest to policy makers. These results were substantiated by the estimated cross-price elasticities of factor demand, which suggested that the different types of farmers would response greatly and substitute relatively more hired labour for fertilizer if the relative price of fertilizer to hired labour is high. The estimated price effects (elasticities) of fertilizer on demand for hired labour were 1.3435, 1.9933 and 1.4290 (That is, elastic and significant) for the non-cotton, cotton and the combined farmers, respectively. On the other intensive use of fertilizer than hired labour. The estimated MES values, comparatively, suggested high intensity of seed use, followed by ploughing of farmlands, fertilizer application and hired labour use in the study areas. But Obare et al (2003) obtain a finding that confirms the labour intensive

Table 4. Allen and Morishima elasticities of factor substitution.

Price	Fertilizer		Hired labour		Seed		Ploughing services	
	AES	MES	AES	MES	AES	MES	AES	MES
Combined farmers								
Fertilizer	-6.2144(1.7359)***	0		2.0587		1.9982		0.7680
Hired labour	7.3621(3.1677)**	2.7812	-11.6774(4.6683)**	0		0.1305		2.4973
Seed	2.2970(1.2193)*	0.7666	-3.5432(2.2265)	-0.0895	-0.9304(0.1480)***	0		0.6062
Ploughing services	-1.2687(1.2658)	0.1761	3.3152(2.3002)	0.8063	0.8262(0.2679)***	0.7073	-1.2229	0
Cotton farmers								
Fertilizer	-5.3433(1.4188)***	0		1.8936		1.8637		0.8314
Hired labour	9.2841(4.1247)**	3.5870	-19.8225(9.6842)**	0		-0.3503		3.1380
Seed	2.2950(1.2174)*	0.8112	-6.2268(3.5417)*	-0.1821	-1.0201(0.1806)***	0		0.6448
Ploughing Services	-0.8045(1.0226)	0.2304	3.9336(2.9146)	0.7194	0.8311(0.2603)***	0.6626	-1.0268	0
Non-cotton farmers								
Fertilizer	-6.4509(1.8251)***	0		2.1005		2.0320		0.7521
Hired labour	7.0970(3.0357)**	2.6570	-10.6017(4.0779)***	0		0.2017		2.3953
Seed	2.3015(1.2236)*	0.7561	-3.1558(2.0367)	-0.0706	-0.9095(0.1418)***	0		0.5960
Ploughing services	-1.4028(1.3617)	0.1603	3.2350(2.2205)	0.8266	0.8243(0.2708)***	0.7162	-1.2732	0

The AES are symmetric because of the restriction $\alpha_{ij} = \alpha_{ji}$; MES are asymmetric. In parenthesis are standard errors (SE); ***, ** and * denote 1%, 5% and 10% significant levels, respectively. t-value = coefficient/SE.

Table 5. Derived elasticities of factor demand.

Price	Fertilizer	Hired labour	Seed	Ploughing services
Combined farmers				
Fertilizer	-1.2062 (0.3369)***	0.8525 (0.3668)**	0.7920(0.4204)*	-0.4382 (0.4441)
Hired labour	1.4290 (0.6149)**	-1.3522 (0.5406)**	-1.2217 (0.7677)	1.1451 (0.7945)
Seed	0.4458 (0.2367)*	-0.4103 (0.2578)	-0.3208(0.0510)***	0.2854 (0.0925)***
Ploughing services	-0.2463 (0.2496)	0.3839 (0.2664)	0.2849(0.0924)***	-0.4224
Cotton farmers				
Fertilizer	-1.1472 (0.3046)***	0.7464 (0.3316)**	0.7165 (0.3801)*	-0.3158 (0.4015)
Hired Labour	1.9933 (0.8856)**	-1.5937 (0.7786)**	-1.9440 (1.1057)*	1.5443 (1.1443)
Seed	0.4927 (0.2614)*	-0.5006 (0.2848)*	-0.3185(0.0564)***	0.3263 (0.1022)***
Ploughing Services	-0.1727 (0.2196)	0.3163 (0.2343)	0.2595(0.0813)***	-0.4031
Non-Cotton farmers				
Fertilizer	-1.2212 (0.3455)***	0.8793 (0.3761)**	0.8108 (0.4311)*	-0.4691 (0.4554)
Hired labour	1.3435 (0.5747)**	-1.3135 (0.5052)***	-1.1118 (0.7175)	1.0818 (0.7425)
Seed	0.4357 (0.2316)*	-0.3910 (0.2523)	-0.3204 (0.0500)***	0.2756 (0.0905)***
Ploughing services	-0.2655 (0.2578)	0.4008 (0.2751)	0.2904 (0.0954)***	-0.4258

In parenthesis are standard errors (SE); ***, ** and * denote 1%, 5% and 10% significant levels, respectively. t-value = coefficient/SE.

nature of smallholder agriculture. The own-price elasticities of factors' demand were significant and had the expected negative signs. The demand for ploughing services and seed were quite inelastic, while the demand for fertilizer and hired labour were elastic for different categories of farmers. The estimated own-price elasticities of demand for fertilizer and hired labour (1.221 and 1.314 respectively for the non-cotton farmers and 1.147 and 1.594 respectively for the cotton farmers) were elastic and high and these implied that the farmers would respond substantially to changes in the prices of these two inputs.

Conclusion

Knowledge of the factors that influence smallholders' use of purchased inputs is important and the study attempted to examine the influence of these factors in Northern Ghana. The study concluded cautiously that the provision of adequate funds (credit or remittances) and knowledge (basic education) are important for increased expenditure on productive enhancing factors like fertilizer. Also, it is important that stakeholders promote crop and livestock (cattle) integration (mixed farming) in order to help smallholder farmers to reduce their expenditure on ploughing in Northern Ghana or similar production environment. The own-price elasticities of factors' demand, including fertilizer, hired labour and seed, were significant and had the expected negative signs. The demand for seed and ploughing services were quite price inelastic, while the demand for fertilizer and hired labour were price elastic for both cotton and non-cotton farmers. The estimated own-price elasticities of demand for fertilizer and hired labour indicated substantial high degrees of price responsiveness by smallholder farmers to these two inputs. The derived MES and cross-price effects between fertilizer and hired labour suggested that smallholders would substitute relatively more hired labour for fertilizer, if the relative price of fertilizer to hired labour is high. Thus, to promote fertilizer use by farmers in order to enhance agricultural production, the relative price level of fertilizer to the wage rate for labour, for example, should be of considerable interest to policy makers.

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Appendix: Data construction

The data used for the present analysis have been constructed from a household survey conducted in April - May 2000 in the study area. The hired labour wage used in the analysis is the average wage in each village and is given by the mean of the average wage paid per manday by households for labour hired for planting, weeding, harvesting and other related activities in a given village. For a village with missing hired labour wage the mean wage for the district in which the village falls is used. The price of fertilizer used is the village average price of the weighted average price per bag for the two different types of fertilizer (NPK and sulphate) purchased by the household. In one of the three districts studied, only a respondent reported purchase of fertilizer and therefore the average price paid by the respondent is used as the price for the villages in the district.

The price of seed is approximated by the cost of seed per land size cultivated by a household. The price of ploughing is estimated as the mean of the ploughing cost per size of plot (acre) ploughed by a household. Some households which have missing value for price of ploughing were assigned the average price for their village. The plough service providers usually charge per acre of land ploughed and this is thus a good measure for the price of ploughing. The farm cost used in the analysis included the ploughed, hired labour, seed and fertilizer costs. The hired labour cost is made up of cost of any labour hired for planting, weeding, harvesting and other activities and fertilizer cost are given by the products of their respective quantities and actual prices by paid by a household for the different types of fertilizer, while the plough costs is the costs incurred by a household for the plots ploughed. The seed cost is given by the sum of the different seeds (maize, sorghum, millet, groundnut, soybean, cowpea, cotton, etc) cultivated.

The shares of plough, hired labour, seed and fertilizer in a household's farm cost, used as the dependent variables, are estimated as their respective cost divided by the farm cost. The other costs included other input (chemicals, livestock feed, irrigating plots, other implement hired, other farm cash expenses) cost. The prices and costs are measured in Cedis, the currency of Ghana.

The adult size is the number of persons counted as part of the resident household and are aged 15 years and above. Total landholding is the size of land held (cultivated plus uncultivated land) by a household and is measured in acres. The total land held is assumed fixed. The size of cattle is the number of cows and bulls owned by a household at the beginning of the farming season in (April) 1999. Remittance measured in Cedis, is the amount of cash and value of in-kind received from migrated members during the rainy season. Cotton dummy is the dummy variable for the growing of cotton and it is equal to 1 if a household grown cotton and 0 otherwise. Average school level is a dummy for the average school level attained by the household members aged 15 years and above. The average school level dummy has been categorized in the dataset as: 0 for no schooling; 1 for primary; 2 for middle and junior secondary school; 3 for senior secondary school and other higher levels.

The Stata regression estimation command ran is able to generate its own dummies for the school levels with a value of 1 for a given average school level attained and 0 otherwise. Location dummy is a dummy for the population density of the district where a household is located. Three different population densities, namely sparsely populated district, densely populated district and very densely populated district based on 2000 Ghana population census, are defined with a value of 1 if a household is located in a given district and 0 otherwise.

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