

## **MODELLING THE COST STRUCTURE OF SMALL SCALE EXPORT ORIENTED VEGETABLE FARMS IN THE NORTH AND SOUTH DAYI DISTRICTS**

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### **ABSTRACT**

Using the seemingly unrelated regression technique, we estimated the cost function, represented by the coefficients of cost share equations for fertilizer, fuel, agrochemicals and labour, for the vegetable export farms in the North and South Dayi Districts of the Volta Region of Ghana from cross-sectional time series data. The elasticities of factor substitution and demand are estimated. There is a high and significant degree of substitution between agrochemicals and fertilizer (2.1576). The estimated cross price demand elasticities show that agrochemical and fertilizer are substitutes. One percent decrease (increase) in the price of fertilizer (agrochemical) will, significantly, lead to 0.3232 (0.4268) percent decrease (increase) in the demand for agrochemical (fertilizer). These results mean that the effect of policy action on the price of one of these two inputs will also effect changes in the demand of the other input. The estimated elasticities of substitution and factor demand show that labour is a complementary, though insignificant, input for fertilizer, fuel and agrochemicals. Implications for managing fertilizer, fuel, and agrochemicals and emerging farm businesses are discussed.

**KEY WORDS:** Cost Function, Elasticities of Substitution, Factor Demand, Cost Share Equations, Seemingly Unrelated Regression

### **INTRODUCTION**

Export is important for all countries particularly developing countries, as it brings the vital foreign exchange needed for development and payment for goods and services.

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One area of the economy that has great potential of being a driving force is the non-traditional agricultural export (NTAE) industry. The non-traditional agricultural export sector comprises of fish and seafood, game and wildlife and horticultural products such as pineapple, pawpaw, fruits and vegetables.

Vegetable growing, technically termed olericulture is gaining ground in the Ghanaian agricultural production sector on commercial basis. Different types of vegetables are grown in Ghana. The types commonly grown in Ghana include: Tomatoes (*Lycopersicon esculentum*), Onion (*Allium cepa*), Shallot (*Allium esculonicum*), Okra (*Hibiscus esculentus*), Egg plant (*Solanum melongena*), Local spinach (*Amaranthus* spp), Indian or Gambian spinach (*Basella alba*), Sweet and chillipepper (*Capsicum annum*), and hot pepper (*C. frutescens*). According to Sinnadurai (1992) vegetables are grown in most gardens in Ghana, but the commercial production sector is restricted, mostly to the southern coastal plains in the wet season and the northern Guinea Savannah under irrigation. Some production but on small scale also occurs in the southern Guinea Savannah and forest zones during the wet and dry season

In general, there are two major systems of growing vegetables, namely extensive and intensive systems (Norman, 1992). The extensive system of production consists of growing vegetables on large scale of land, using labor and sometimes mechanization depending on the size of the land. The intensive system on the other hand involves cropping on the same piece of land over some period of time, usually at least twice in a year and may have irrigation facilities. Agrochemicals and fertilizers are highly employed compared to the extensive system. The production is made purposely for a specific market at a specific period.

In recent times, there has been a tremendous interest and increase in vegetable crop production with a consequent high demand for vegetables in Ghana. This is the result of many favourable factors including the realization of the nutritional importance of vegetables in diet, which is associated with the increase in the standard of living and education. Another factor is the high export potential of some of the vegetable crops (Norman, 1992). To increase the ratio of foreign exchange derived from the exporting sector, the non-traditional agricultural crops have been introduced as part of Ghana's export products (Government of Ghana, 1983). A vegetable, as a non-traditional agricultural product, has a great potential to earn foreign exchange for the Ghanaian economy. The producers must therefore make use of the available resources wisely and minimize production cost in order to increase production and also help them to be competitive on the international market.

A lot of factors affect vegetable production in Ghana. These factors may be classified as on-farm and off-farm factors. Examples of the on-farm factors include the land size, labour, cost of agrochemicals, cost of fertilizers, the cost of preparing and maintenance of the land, pests and diseases, available storage and processing facili-

ties. The off-farm factors may include factors beyond the control of the producers. Some of these are rainfall patterns, market demands, inflation rate, and exchange rate, among others. Some of these factors can be controlled, especially the on-farm factors in order to acquire higher profit from the farming activity. Most of the vegetables grown in Ghana for export are the exotic types. Their production tends to involve higher expenditure, since specialists and special inputs are required. Farmers must therefore adopt strategies to minimize cost of production if they seek to maximize profit. What strategies should farmers adopt?

We explore this question. Specifically, we investigated the following research questions to get an understanding of the cost structure of small-scale export oriented vegetable farms: What are the major cost components in vegetable production? What is the cost function for the vegetable farm? The paper looks at the case of such farms located in the North and South Dayi Districts in the Volta region of Ghana: (i) to describe the major cost components (shares) of the vegetable production farms in the study area and (ii) to estimate the cost function, factor elasticities of substitution and demand for export-oriented vegetable farms.

The modeling of the cost structure of a farm is very useful for making managerial decisions on the farm. Also a cost function analysis is important in providing quantitative insight into the response of producers to changes in input prices, substitution possibilities between inputs and scale elasticities. Also the estimated values of the cost function may help in the planning of future activities of vegetable and related farms. This is because they provide an indication of the changes in inputs levels and therefore output that could be expected as a result of the changes in prices and other factors. In addition to this, the study generally adds to information on the limitations to vegetable production in the country and North and South Dayi Districts in particular.

The North and South Dayi Districts are located in the Volta Region of Ghana and lie within latitudes  $6^{\circ} 20'N$  and  $7^{\circ} 05'N$  and on longitude  $0^{\circ} 17'E$ . The economies of the Districts are similar, basically dominated by agricultural activities that forms about 62 percent of the active labour force. The climatic conditions of the Districts are also similar and favourably support variety of crops and livestock production, including a high potential for vegetable production. The climate of the Districts is tropical, greatly influenced by the southwest monsoons from south Atlantic and dry harmattan winds from the Sahara. There are two rainy seasons, the major one from mid-April to early July and the minor one from September to November. The average annual rainfall varies from 900 mm to 1300 mm. The vegetation of the Districts is a mix of Guinea woodland and deciduous forest. The rest of the paper is structured as follows: in the next section a brief review on the cost function representation is presented; the theoretical model, methods for addressing the specific objectives and data description are presented in the third, fourth and fifth sections, respectively; the results and discussion of the main findings are presented in the sixth section while the last section presents the conclusions of the paper.

## **A BRIEF REVIEW OF THE COST FUNCTION REPRESENTATION**

The previous works on the productions and cost functions have gone through several directions. It has been realized that the use of cost functions rather than a production function has several advantages. The cost function approach has some advantages over the production function approach (Binswanger, 1974; Sankhayan, 1988). It is indicated that it is not necessary to impose homogeneity of degree one on the production process to arrive at the estimation equation. Cost functions are homogenous in prices regardless of the homogeneity properties of the production process. In view of this, doubling of all prices will double the cost but will not affect the factor ratios. If production function procedure is used to estimate the elasticities of substitution or factor demand in the many factor case, the matrix of estimates of the production function coefficients has to be inverted. This will inevitably exaggerate estimation errors, but with the cost function approach such problems are not encountered. Another advantage is the lack of multicollinearity among factor prices but vice versa in the case of production approach.

Traditionally, the Cobb-Douglas model is used to analyze studies related to production and cost functions. According to Greene (2000) a classic paper presented by Arrow, Chenery, Minhas, and Solow (1961) called into question the inherent restrictions of the Cobb-Douglas model that all elasticities of factor substitution are equal to one. This alarm raised by Arrow et al (1961) gingered a lot of economists to look for alternative analytical procedures. Among these was the dual formulation procedure which has the following advantages: There is the possibility of representing the cost function in two ways (Samuelson, 1983). Demand and supply functions can be generated as explicit functions of relative prices without imposing the arbitrary constraints on the production patterns required in the Cobb-Douglas model. In addition the implications of production theories can be incorporated more easily into the model (Binswanger, 1974).

A lot of other functional forms have been developed by researchers over the decades. Some of these are the Generalised Leontief, Generalised Cobb- Douglas, Generalised Square Root Quadratic introduced by Diewert (1971, 1973 and 1974). The translog frontier was proposed by Christensen, Jorgensen & Lau (1971, 1975) and the Generalised Box-Cox introduced by Berndt and Khaled (1972). Among the various functional forms the translog functional form provides accurate global approximation (Christensen, Jorgenson, and Lau, 1973). The translog function exhibits non-constant marginal productivity that is increasing, decreasing and negative marginal product singularly, in pairs or all three simultaneously. With these characteristics the translog function is useful in describing inputs – output data encompassing all the three traditional stages of production which are increasing positive, declining positive and negative marginal products. It also permits invariable elasticity of substitution over the range of inputs.

The translog cost function is written as a logarithmic Taylor series expansion to the second order of twice differential analytic cost function around variable of one. The translog function is a functional form in its own right if we assume that all derivatives and cross derivatives are constant (Binswanger, 1974). Usually this constraint is imposed if the parameters are estimated regression equations. Mostly no constraint is imposed on the elasticities of substitution or of factor demand, which makes the function more general than other functional forms. Using the translog functional form, the cost function can be estimated directly or in its first derivatives which by Shephard Lemma are factor shares equations (Greene, 2000). The set of factor shares estimation equations are linear in logarithms and have proper exogenous variables on the right hand side if the analysis pertains to a firm or an industry. The present paper follows the factor shares equations estimation technique to obtain the coefficients for the cost function and the factor elasticities of substitution and demand.

### THE THEORETICAL MODEL

The farm is assumed to minimize cost of production given the desired output level. Assuming, the factor inputs used in the production are made up of only labour and capital, the total cost function and equation are given respectively as

$$C = c(L, K) \tag{1}$$

and

$$C = r_1L + r_2K \tag{2}$$

The production function is given as

$$q = q^0(L, K) \tag{3}$$

Where,  $r_1$  and  $r_2$  are the unit cost of labour and capital respectively, L and K are the quantities of labour and capital used, respectively, q is a given total output level while C is total cost of production. The characteristics of the production function are

$$\begin{aligned} &\frac{\partial q}{\partial L} > 0 \quad \text{and} \quad \frac{\partial^2 q}{\partial L^2} < 0; \quad \frac{\partial q}{\partial K} > 0 \quad \text{and} \quad \frac{\partial^2 q}{\partial K^2} < 0, \quad \text{while} \\ &\text{that of the cost function are} \quad \frac{\partial C}{\partial L} > 0 \quad \text{and} \quad \frac{\partial^2 C}{\partial L^2} > 0; \quad \frac{\partial C}{\partial K} > 0 \\ &\text{and} \quad \frac{\partial^2 C}{\partial K^2} > 0 \end{aligned}$$

With a fixed level of output, the farm must minimize cost subject to the given level of output. The Lagrangian composite function is then formed out of equations (2) and (3) as

$$\Phi = r_1L + r_2K + \lambda[q - q^0(L, K)] \tag{4}$$

Taking partial derivatives of the composite functions gives

$$\frac{\partial \Phi}{\partial L} = r_1 - \lambda \frac{\partial q^0}{\partial L} \quad (5)$$

$$\frac{\partial \Phi}{\partial K} = r_2 - \lambda \frac{\partial q^0}{\partial K} \quad (6)$$

$$\frac{\partial \Phi}{\partial \lambda} = q - q^0(L, K) \quad (7)$$

Solving the partial derivatives simultaneously gives the equilibrium levels of L, K and  $\lambda$  as  $L^*$ ,  $K^*$  and  $\lambda^*$  each being a function of the factor prices ( $r_1, r_2$ ) and output

level ( $q$ ).  $\lambda$  represents the shadow marginal cost of production (i.e.  $\frac{\partial \Phi}{\partial q}$ ). The equilibrium levels of L, K and  $\lambda$  required to obtain the minimum cost of production is given by  $K^* = k(r_1, r_2, q^0)$ ,  $L^* = L(r_1, r_2, q^0)$ ,  $\lambda^* = \lambda(r_1, r_2, q^0)$  as:

$$C^* = r_1 L^* + r_2 K^* \quad (8)$$

Hence augments of the factor inputs L and K are also the augments of the cost function which can be expressed as:

$$C^* = C(r_1, r_2, q) \quad (9)$$

Applying Shephard's duality theorem, which hold for the cost function, the cost-minimizing factor demand, from equation 8, is given by

$$\frac{\partial C^*}{\partial r_1} = L^* \quad ; \quad \frac{\partial C^*}{\partial r_2} = K^* \quad (10)$$

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

## METHODS OF ANALYSIS

### Descriptive Analysis

The specific descriptive statistic used to address the objective one is the pie chart. The pie chart shows the specific percentage by cost which each variable input is associated with. The largest portion by percentage represents the major cost component associated with vegetable production while the smallest portion represents the least cost component in the study area.

### The Empirical Model

Assuming the vegetable farm is faced with a two-stage differentiation production function given as:

$$Q = q(L, F, FU, AC) \tag{11}$$

where, Q is output of vegetables, L is labour input employed in vegetable production, F is fertilizer used in vegetable production, FU is the fuel input used in vegetable production and AC is the agrochemicals (excluding fertilizer) used in the farming. Assuming prices are exogenous and the farm is to minimize costs, the duality principles of economic theory can be applied to derive the cost function as

$$C = C(r_1, r_2, r_3, r_4, Q) \tag{12}$$

where, C is the total cost of production,  $r_1$  is the unit cost of labour,  $r_2$  is the unit cost of fertilizer,  $r_3$  is unit cost of fuel and  $r_4$  is the unit cost of agrochemicals. Rewriting the equation (11) in natural logarithms

$$\ln C = (\ln r_1, \ln r_2, \ln r_3, \ln r_4, \ln Q) \tag{13}$$

Expanding  $\ln C$  in a second order Taylor series about the point  $\ln C(\cdot) = 0$ , the following translog function is obtained, assuming a constant return to scale for output:

$$\begin{aligned} \ln C = & a_0 + \ln Q + a_1 \ln r_1 + a_2 \ln r_2 + a_3 \ln r_3 + a_4 \ln r_4 + 0.5d_{11} \ln^2 r_1 + 0.5d_{22} \ln^2 r_2 \\ & + 0.5d_{33} \ln^2 r_3 + 0.5d_{44} \ln^2 r_4 + d_{12} \ln r_1 \ln r_2 + d_{13} \ln r_1 \ln r_3 + d_{14} \ln r_1 \ln r_4 \\ & + d_{23} \ln r_2 \ln r_3 + d_{24} \ln r_2 \ln r_4 + d_{34} \ln r_3 \ln r_4 \end{aligned} \tag{14}$$

where  $a_1, a_2, a_3, a_4, d_{11}, d_{22}, d_{33}, d_{44}, d_{12}, d_{13}, d_{14}, d_{23}, d_{24}, d_{34}$  are coefficients which are estimated in the paper and  $a_0$  is a constant term. The share of the various inputs in the total cost function is derived from the translog function as:

$$S_1 = \partial \ln C / \ln r_1 = a_1 + d_{11} \ln r_1 + d_{12} \ln r_2 + d_{13} \ln r_3 + d_{14} \ln r_4 \tag{15}$$

$$S_2 = \partial \ln C / \ln r_2 = a_2 + d_{12} \ln r_1 + d_{22} \ln r_2 + d_{23} \ln r_3 + d_{24} \ln r_4 \tag{16}$$

$$S_3 = \partial \ln C / \ln r_3 = a_3 + d_{13} \ln r_1 + d_{23} \ln r_2 + d_{33} \ln r_3 + d_{34} \ln r_4 \tag{17}$$

$$S_4 = \partial \ln C / \ln r_4 = a_4 + d_{14} \ln r_1 + d_{24} \ln r_2 + d_{34} \ln r_3 + d_{44} \ln r_4 \tag{18}$$

where  $S_1, S_2, S_3, S_4$  are the shares of labour, fertilizer, fuel and agrochemicals in the total cost of the farm which are estimated in the paper. The share of each input in the total cost is obtained by dividing the cost of the input by the total cost of the inputs

$$S_i = p_i x_i / \sum_{i=1}^4 p_i x_i$$

used for vegetable production (i.e. ), where  $p_i$  is the unit cost of the input 'i' and  $x_i$  is the quantity of the input. For the cost share equations functions to conform to a well-behaved cost function, certain restrictions are implied for the parameters in the cost share equations. The restrictions are:

*Symmetry Condition*

$$d_{ij} = d_{ji}$$

*Homogeneity Conditions (in prices)*

$$\sum_{i=1}^4 a_i = 1 \quad ; \quad \sum_{j=1}^4 d_{ij} = 0 \quad ; \quad \sum_{i=1}^4 d_{ij} = 0$$

(Row sum is zero); and (Column sum is zero)

The study estimated the system of cost share equations for fertilizer, hired labor (permanent and casual), fuel and agrochemical using their prices and proportion of farmland cultivated (which was fixed for each of the farms). 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 labour is dropped and the prices of fertilizer, fuel and agrochemical relative to the price for labour are used in the three equations estimated. The symmetry and homogeneity restrictions allow the coefficients of the equation which is dropped to be estimated. Obare, Omamo, and Williams (2003), Dalton, Masters and Foster (1997) and Fulginiti and Perrin (1990) have followed similar approach to describe the production structure of agriculture in Kenya, Zimbabwe and Argentina, respectively. Fulginiti and Perrin (1990) added land and precipitation as fixed input in their study.

**Estimation of Cost Share Equations**

The coefficients and the constant term of the cost shares equation for fertilizer, fuel and agrochemicals are estimated using the seemingly unrelated regression technique while that of labour ( $S_1$ ) is derived from the estimated equations using the symmetric and homogeneity conditions imposed on the share equations. Each of the firms included in the study cultivated a fixed proportion of the amount of land held and this is added to the equations estimated to act as a fixed factor. The equations estimated are:

$$S_2 = a_2 + d_{22} \ln(r_2 / r_1) + d_{23} \ln(r_3 / r_1) + d_{24} \ln(r_4 / r_1) + \pi_2 \ln A \tag{19}$$

$$S_3 = a_3 + d_{33} \ln(r_3 / r_1) + d_{23} \ln(r_2 / r_1) + d_{34} \ln(r_4 / r_1) + \pi_3 \ln A \tag{20}$$



$$S_4 = a_4 + d_{44} \ln(r_4 / r_1) + d_{24} \ln(r_2 / r_1) + d_{34} \ln(r_3 / r_1) + \pi_4 \ln A \quad (21)$$

where, A is the proportion of land size cultivated (fixed). The proportion of land factor also obeys the homogeneity conditions, where the column sum is equal to zero

$$\sum_{i=1}^4 \pi_i = 0$$

(i.e. ).

For the translog cost function the elasticities of substitution and factor demand are estimated from the coefficient estimates of the cost shares equations. The elasticities are estimated for the sample means of the factor shares for the export oriented farms.

The elasticities of factor substitution ( $\sigma_{ij}$ ) and the corresponding standard errors ( $s.e(\sigma_{ij})$ ) are given, respectively, as:

$$\sigma_{ij} = \frac{d_{ij} + S_i S_j}{S_i S_j} \quad \sigma_{ii} = \frac{d_{ii} + S_i(S_i - 1)}{S_i^2} \quad , \text{ where } \sigma_{ij} = \sigma_{ji} ;$$

$$s.e(\sigma_{ij}) = \frac{s.e(d_{ij})}{S_i S_j} \quad s.e(\sigma_{ii}) = \frac{s.e(d_{ii})}{S_i^2}$$

and

The price elasticities of input demand ( $\eta_{ij}$ ) and the corresponding standard errors ( $s.e(\eta_{ij})$ ) are given, respectively, as:

$$\eta_{ij} = \frac{d_{ij} + S_i S_j}{S_i} = \sigma_{ij} S_j \quad \eta_{ii} = \frac{d_{ii} + S_i(S_i - 1)}{S_i} = \sigma_{ii} S_i \quad , \text{ where } \eta_{ij} \neq \eta_{ji} ;$$

$$s.e(\eta_{ij}) = \frac{s.e(d_{ij})}{S_i} \quad s.e(\eta_{ii}) = \frac{s.e(d_{ii})}{S_i}$$

and

### THE DATA

The data required for the estimation of the factor demand equations need to contain sufficient variability in all the exogenous variables (both fixed household factors and prices). The variability in fixed 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). 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 has been described above. 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 paper uses cross-sectional and time series data for four export farms level data for the cost structure analysis.

The vegetables normally cultivated in the study area are garden eggs, chilly pepper, okra, cabbage, lettuce and carrot, among others and those normally exported by the firms are chilly pepper, garden egg, okra and cabbage. The pooled data collected covered the period 1997 – 2004 for four vegetable exporting farms located in the North and South Dayi Districts. The data were obtained from primary and secondary sources using a check list of the required data. The minimum daily wage in Ghana, fuel price per litre and fertilizer (NPK 15 – 15- 15) price per kilogram, unit price per litre of agrochemical were used as the unit prices for labour, fuel, fertilizer and agrochemicals, respectively. The minimum wage data was obtained from Trade Union Congress offices in Accra, fuel price per litre was obtained from a fuel filling station in Accra while the fertilizer price was derived from various versions of the “State of the Ghanaian Economy” published by ISSER, Legon (various issues). The data on the unit price of agrochemicals purchased, and the costs of labour, fertilizer, fuel and agrochemical used in a given year were obtained from the exporting farms. The size of landholdings and amount of land cultivated in each year were also obtained from the farms. The summary statistics for the variables used for the descriptive and regression analysis are presented in Table 1.

**Table 1: Summary Statistics of Variables**

<b>Variable</b>	<b>Obs</b>	<b>Mean</b>	<b>Std. Dev.</b>	<b>Min</b>	<b>Max</b>
<b>Cost (£):</b>					
Labour	26	1.20e+07	1.17e+07	1002000	4.09e+07
Agrochemicals		6820442	9613635	439700	3.00e+07
Fertilizer		4809351	6713709	460000	2.50e+07
Fuel		3702900	4184870	411200	1.60e+07
Total cost		2.73e+07	3.17e+07	2953202	1.12e+08
<b>Unit Price of Input:</b>					
Labour (£/day)	26	6296.154	3117.176	2000	11200
Agrochemicals (£/l)		42460	11104.78	20000	65000
Fertilizer (£/kg)		2822.488	3944.737	680	21467.98
Fuel (£/l)		2277.346	1353.324	737.935	4166.5
<b>Cost shares (proportion):</b>					
Labour	26	0.5011563	0.1048289	0.3249618	0.6621645
Fertilizer		0.1498041	0.0345872	0.0907654	0.2234537
Agrochemicals		0.1977916	0.0776957	0.0951876	0.3465702
Fuel		0.1512479	0.07885	0.048562	0.3560549
<b>Land Size (Ha):</b>					
Total held	26	31.61538	19.03277	10	60
Cultivated		6.576923	3.908177	2.5	12.5

Source: Field Survey

## **RESULTS AND DISCUSSION**

### **Cost Share of Variable Inputs in Vegetable Production**

The most important variable cost inputs identified are labour cost, agrochemical cost, fuel cost and the cost of fertilizer. About 50.1 percent of the total cost of the variable inputs taken into consideration is due to labour employment, making labour the highest factor cost in vegetable production. The agrochemical, fuel and fertilizer shares of cost are about 19.8 percent, 15.1 percent and 15.0 percent, respectively (Table 1). The labour cost assumes a high share due to several reasons. Among these include the fact that, most of the workers on the farms, which are limited liability entities, are full time workers while others are casual labourers. Some of the labourers are also retained after the production seasons to do some minor works on the farm. These people receive various sums of payments, which contribute to cost of the farm even if they do not work enough to merit such payments. This is unlike the situation in farm families where families employ their family members including children to work on their farm without paying them.

Vegetables basically are delicate products. Insects and other microbial organisms attack them easily at all stages of growth because of their succulent nature. For them to be neat and attractive in the natural forms for the export market, there is the need to maintain the quality of the products by spraying off the insects and micro – organisms. Also, because of the delicate nature of vegetables, selective weedicides are used to control weeds in order to prevent excessive damage that may be done to the various plants when machines, cutlasses and hoe are used to control weeds.

The cost of fuel basically comprises of fuel for powering the heavy-duty tractors for preparation of farmlands, cold rooms in the absence of electricity and transport the produce from the hinterlands to the cities for export and sometimes for vehicular movement on the farm. The recent escalation in the prices of fuel in the country affects its cost share. From 2000 to the 2004, there has been series of increment in fuel prices ranging from 40 percent to 100 percent. Fertilizer, from Table 1, has the lowest cost share and this may be due to the nature of the farming practices followed by the firms. The various farms from which the data were collected have large farmland (Table 1) and cultivated about 20.8% of the farmland. The farms therefore practice shifting cultivation and land rotation in which inorganic fertilizers are scarcely used.

### **Cost Function – Coefficient Estimates for the Vegetable Export Farms**

Table 2 shows the various coefficients estimated from the regression model and their standard errors in the brackets. The coefficients for the price of labour have been derived from the estimation equations using the symmetric and homogeneity conditions. The standard errors for the derived coefficients have been estimated using the variance-covariance matrix and cross-estimated equations covariance matrix (the

variance-covariance matrix of the estimators). The coefficients give an idea about the effects of the prices of the variable inputs on the share of each variable input. Also all the coefficients estimates including the intercept terms give the coefficients of the cost function. Only the constant term of the cost function remains not estimated. The variable inputs used are labour, fuel, agrochemicals and fertilizer. Included in the data analysis is a fixed input, which is the proportion of the farmland cultivated over the years. Each of the export oriented farms cultivated a fixed amount of farmland held during the period considered. The values in Table 2 have little economic meaning, but they are best evaluated by the values they imply in the elasticities of substitution and elasticities of factor demand presented in Tables 3 and 4, respectively.

**Table 2: Estimates of the coefficient of the cost share equations**

Variables	Share of fertilizer	Share of fuel	Share of Agrochemicals	Share of Labour <sup>1</sup>
Intercept (ai)	0.3749 (0.1220)	-0.5825 (0.2551)	0.1705 (0.2533)	1.0371 (0.3495)
Price effect (dij)	0.0239 (0.0116)			
Fertilizer	0.0438 (0.0430)	0.0950 (0.0899)		
Fuel	0.0343 (0.0179)	-0.0262 (0.0375)	0.1338 (0.0373)	
Agrochemical	-0.1020 (0.0742)	-0.1126 (0.1069)	-0.1419 (0.0514)	0.3565a
Labour <sup>1</sup>				
Fixed Factor (pi): Land Proportion Cultivated	0.1436 (0.0760)	0.5703 (0.1590)	0.1063 (0.1579)	-0.8202 (0.2179)

Source: Estimation based on data obtained from four Export oriented Vegetable, Farms: Cross-sectional Time Series Data (2005).

Note: In parenthesis are standard errors.

<sup>1</sup>Derived coefficients using the symmetry and homogeneity conditions

<sup>a</sup>The standard error could not be estimated because the covariance matrix for the derived coefficients of price of labour is not available

*Estimated Partial Elasticities of Substitution*

Table 3 presents the partial elasticities of substitution between the variable factor inputs: fertilizer, fuel, agrochemicals and labour. The estimated values show the degree to which one variable input is substituted by the other variable inputs, in case there is a relative change in the prices of the variable inputs. The signs associated with each value indicate whether they are substitutes (positive sign) or complements (negative sign).

Table 3: Estimates of the Partial Elasticities of Substitution

Price	Fertilizer	Fuel	Agrochemicals	Labour
Fertilizer	-4.6105 (0.5169)			
Fuel	2.9338 (1.8985)	-1.4583 (3.9324)		
Agrochemicals	2.1576 (0.6041)	0.1240 (1.2539)	-0.6358 (0.9534)	
Labour	-0.3586 (0.9883)	-0.4859 (1.4106)	-0.4313 (0.5185)	0.4240

Source: Estimated from Table 2. In brackets are standard errors.

The own price elasticity of factor substitution among fuel, agrochemicals and fertilizer have the correct negative sign as expected. This shows that, as the own price of any of these factor inputs increased, the quantity of that factor input used is reduced. The elasticities of substitution between labour and the other inputs, fertilizer, fuel and agrochemical are negative, 0.3586, 0.4859 and 0.4313, suggesting that labour is a complementary input for the other variable inputs considered. The complementarities between labour and the other inputs are, however, not significant. It can also be observed from Table 3 that, there is a high degree of substitution between fuel and fertilizer (2.9338) and more importantly between agrochemicals and fertilizer (2.1576). The degree of substitution between agrochemical and fertilizer is highly significant while that of fuel and fertilizer is not significant. There is little substitution between agrochemical and fuel, with a low and insignificant elasticity of substitution.

#### *Estimated Elasticities of Factor Demand*

Table 4 presents the elasticities of factor input demand. It shows the percentage change in factor input as a result of one percent change in the own price of the input or the price of the other factor input (cross-price effect).

Table 4: Estimated Elasticities of Factor Demand

Price	Elasticity of factor demand			
	Fertilizer	Fuel	Agrochemicals	Labour
Fertilizer	-0.6907 (0.0774)	0.4395 (0.2844)	0.3232 (0.0905)	-0.0537 (0.1480)
Fuel	0.4436 (0.2870)	-0.2205 (0.5946)	0.0187 (0.1896)	-0.0735 (0.2133)
Agrochemicals	0.4268 (0.1195)	0.0245 (0.2480)	-0.1258 (0.1886)	-0.0853 (0.1026)
Labour	-0.1797 (0.4953)	-0.2435 (0.7070)	-0.2162 (0.2599)	0.2125

Source: Estimated from Table 3 or Table 2. In brackets are standard errors

From Table 4, the own price demand elasticities of fertilizer, fuel and agrochemicals are 0.6907, 0.2205 and 0.1258 respectively and they bear the negative signs, as expected. The signs show that the quantities of the different variable inputs demanded go up, when there is a unit decrease in their respective own prices. But the own price elasticities of input demand are inelastic. The estimated own price effect of fertilizer is very significant. However, the estimated own price effect due to labour is, unexpectedly, positive. This positive effect may be due to the use of the minimum wage level as a measure of the price for labour. If the minimum wage is perceived to be low and stay within a wage trap despite increases in the wage level, then firms would hire more. The estimated cross price demand elasticities show that agrochemical and fertilizer, fuel and fertilizer, and agrochemical and fuel are substitutes. These results show that an increase in the price of one factor in a pair will lead to an increase in demand for the other factor in the pair. The results suggest that one percent decrease (increase) in the price of fertilizer will lead to 0.3232 percent decrease (increase) in the demand for agrochemical and this is significant at the one percent level. Similarly, the cross price effect of agrochemical on the demand for fertilizer is very significant (at the one percent significant level) and one percent decrease (increase) in the price of agrochemicals will lead to 0.4268 percent decrease (increase) in the demand for fertilizer. Again, input use complementarities exist between labour and fertilizer, labour and fuel as well as labour and agrochemicals, even though the effects are not significant. This shows that an increase in the price of one of the factor inputs in the pair will lead to decrease in demand for the other factor input in the pair for production. These results suggest that though price effects that increase the use of productive inputs like fertilizer and agrochemicals by emerging farm businesses would not displace hired labour (causal and permanent labour) and are important for job creation in our rural communities, they cannot be relied upon for job creation.

## CONCLUSION

The paper attempted the estimation of the cost function for the vegetable export farms in the North and South Dayi Districts in the Volta Region of Ghana using cross-sectional time series data. The coefficients of the cost function are estimated using the seemingly unrelated regression technique. The estimated coefficients are used to derive the elasticities of factor substitution and the elasticities of factor demand.

The degree of substitution between agrochemicals and fertilizer is high (2.1576) and highly significant. The estimated own price effect of fertilizer is very significant, inelastic (0.6907) and bears the expected negative signs. The estimated cross price demand elasticities show that agrochemical and fertilizer, fuel and fertilizer, and agrochemical and fuel are substitutes. The substitution between fertilizer and agrochemical is significant at the one percent level and the implication is that these two inputs could be used by the export farms in such way as to minimize cost, while maintaining desired output level. The results suggest that one percent decrease (increase)

in the price of fertilizer (agrochemical) will lead to 0.3232 (0.4268) percent decrease (increase) in the demand for agrochemical (fertilizer). Thus, policy action on the price of one of these two inputs, for example fertilizer, could also be used to effect changes in the demand of the other input (in this case agrochemicals).

The estimated elasticities of substitution and factor demand suggest that labour is a complementary input for fertilizer, fuel and agrochemical, even though the effect are not significant. Thus, if fertilizer and agrochemicals issues are well managed in the economy and by the export farms, employment opportunities (both permanent and casual employment) could be enhanced, but one must be cautious of the reliability of the export farms for job creation. The estimated own price effect due to labour is, unexpectedly, positive, which may be due to the use of the minimum wage level as a measure of the price for labour in the paper. But the implication of this result is that if the minimum wage is perceived to be low and stay within a wage trap despite increases in the wage level, then the farms would hire more labour for production.

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