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## **FARMERS' TECHNOLOGY, ECONOMIC PERFORMANCE AND RELATIVE ECONOMIC EFFICIENCY OF COUNTRY BEAN GROWERS**

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### **ABSTRACT**

This paper examined farmers' country bean production technology and proposed an econometric model for estimating the normalized profit distribution function using a Three Staged Generalized Method of Moment procedure. The advantage of the model is that it used Cobb-Douglas form of profit function which is linear in logarithm. The second moment function of profit can be used for measuring risk involved in input use under uncertainty. Furthermore, the results could be used for testing relative economic efficiency of growers'. The empirical data on country bean production validated the model. The result showed that fertilizers and pesticides were risk increasing inputs in country bean production. The small farmers were found to be more efficient. The study concludes that under uncertain environmental condition, relative economic efficiency can be assessed through estimation of normalized profit distribution function.

### **I. INTRODUCTION**

Country bean (*Dalichos lablab*) is an indigenous vegetable of Indo-Bangladesh region. The plant is long trailing and branched. It is treated as a perennial crop at some places. It is a very important vegetable of Bangladesh and India. In terms of dry matter, calorie, protein, fat, vitamin A and B, the pods are superior to most other vegetables of creeping nature. Nutritionally, the seed is also nearly at the top of the pulse's list. Country bean is very rich in carbohydrate, protein, fat, vitamins and minerals. In the past years, it was a homestead vegetable in Bangladesh but recently it is cultivated commercially as field crop in flood free high land.

The growing seasons of country bean in Bangladesh can be categorized into summer and winter season. Most of the vegetables in our country are grown in winter (Rabi Season). The average annual production of vegetables is found only 2.5 million tons excluding potato and sweet potato (Anonymous, 1993). The optimum requirement of vegetables for an adult person is 285 gm (Hossain *et. al.* 1990). While the per capita daily

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consumption is only 25 gm in our country (Ramphall and Gill, 1990). In reality the per capita consumption of vegetables in Bangladesh is much lower as compared to Western and South Asian countries. Average production of vegetables in gm/day/person in Japan, Russia, USA, Malaysia, Thailand, Philippines and Nepal are 348, 324, 314, 79, 161, 155 and 168 respectively. (Ahmed and Shajahan, 1991). As a result, chronic malnutrition is commonly evident in Bangladesh. It was observed that winter vegetables production in Bangladesh increased by 2.27 percent annually during the period 1985-90. (GOB, 1991). However, the versatile adoptable characteristics of this vegetable in terms of production season, cultivable land, calorie contents, nutrition values, requirements of low cost, less diseases infestation, and profitable, return on investment have opened a new arena to the farmers to choose country bean for commercial cultivation among other winter vegetables in Bangladesh.

In 1991, country bean was cultivated in Bangladesh covering 7% and 5% of total area and production of winter vegetables respectively (BBS, 1992). Though country bean can be produced all over Bangladesh, the districts Chittagong, Comilla, Noakhali and Dhaka were the intensive bean producing areas. The Pabna district ranked the highest in respect of production per unit area. More specifically, Atghoria and Isurdhi thana of Pabna district ranked top for country bean production and the trend in hectarage and production were found positive during the period 1989-1993 (BBS, 1994).

The rate of adoption and sustainability of commercial production of a crop depends upon its economic performance, specifically on its profitability. Economic viability is one of the important criteria for assessing the suitability of a new crop technology (Gonzales *et. al.* 1986). Profitability will give direction of adjustments required in the long run to improve the level of economic efficiency by resource allocation. However, no study so far had been done to estimate the economic performance and to examine the profitability of country bean production in farmers' field. Keeping this in view, the objective of the present paper is to examine and analyze technology used, economic performance and profitability of country bean production in the selected study area of Bangladesh.

## II. METHODOLOGY

### Sources of Data

The survey was conducted at seven consecutive villages, namely, Collage Para, Bottola, Kushtipara, Uttarchak, Nagadaho, Sajoypur and Atghoria of Atghoria thana under Pabna district. The farmers produced country bean commercially were the respondent for the present study. Simple random sampling technique was followed in selecting the sample farmers. A total of 60 farmers out of 100 was selected for interview. Data were collected from the sample farmers during the period of November 1995 to March 1996 through field survey using predesigned interview schedules.

### Analytical Technique

#### Estimation of Gross Margin

The gross margin or the income above variable costs for each enterprise is needed to be considered for selection of a crop. The higher the gross margin of the crop enterprise, the more it will be preferred. A gross margin estimated for a single crop enterprise is the difference between total income and total variable costs. Another way of viewing gross margin is to consider it the enterprise's contribution to fixed costs and profit after the variable costs have been paid. Therefore, calculating gross margin of an enterprise requires the yields or production level of that enterprise and price for the output. The total income per unit of enterprise is equal to output price times yield or production. The calculation of total variable cost requires a list of each variable input needed, the amount required and price of each input.

#### Estimation of the Profit Function

The profit function provides an alternative approach to the analysis of production process. There exists a one-to-one correspondence between the set of production functions satisfying certain regularity conditions and the set of profit functions derived from the former. For any production function satisfying the desirable properties, a dual profit function exists which satisfies certain desirable characteristics. Thus, in general, one can consider profit functions instead of production functions for empirical analysis (Lau and Yotopoulos, 1972).

Suppose a farmer has the following production functions :

$$(1) Y = f(X_i, Z_k),$$

with the conventional neoclassical properties where  $Y$  is the output,  $X_i$  represents the variable inputs, and  $Z_k$  stands for the fixed factors in production. The variable profit function (i.e. current revenue less current total variable costs) would be written as:

$$(2) \pi' = P \cdot f(X_1, \dots, X_i, Z_1, \dots, Z_k) - \sum_{i=1}^n W_i X_i$$

where  $\pi'$  is the variable profit in normal terms,  $P$  is the output price, and  $W_i$  is the price of variable factor  $i$ . Without loss of generality, (2) can be expressed in terms of the normalized profit function by deflating all nominal values by output price,  $P$  such that (2) becomes:

$$(3) \pi = f(X; Z) - \sum w_i X_i$$

where the  $X$  and  $Z$  are in vector form, with  $\pi = \pi'/P$  and  $w_i = W_i/P$ , the normalized prices respectively.

Assuming the farmer chooses  $Y$  and  $X$ 's to maximize profits, the following marginal productivity conditions must be fulfilled, which are:

$$(4) df/dX_i = w_i, i = 1, \dots, n$$

The solution of equation (4) would yield the profit maximizing quantities of variable inputs, denoted by  $X_i^*$ 's, as functions of the  $w_i$ 's and quantities of the fixed inputs, as given below:

$$(5) X_i^* = X_i^*(w, Z)$$

where the  $W$ 's and  $Z$ 's are in vector form.

Substituting (5) into (3) yields the normalized profit function

$$(6) \pi^* = \pi^*(w_1, \dots, w_n; Z_1, \dots, Z_k)$$

where  $\pi^*$  is the maximized value of the profit for each set of values  $(P, W, Z)$ , or in normalized terms, for each set  $(w, Z)$ .

A profit function is capable of showing the influence of input prices, output price and fixed factor on profit in country bean production process. In the study area, the inputs employed for producing country bean were mainly human labour, chemical fertilizer (i.e. Urea, TSP and MP), manure, and insecticides. These inputs prices, output price and cultivated land per farm were considered as, a prior explanatory variables responsible for the profit of country bean production. Therefore, these inputs prices, output price and cultivated land are hypothesized to explain the variation in profit of country bean. Accordingly, a Cobb-Douglas profit function is specified to determine the possible relationship between the profit of country bean and explanatory variables as specified.

The Cobb-Douglas profit function was used in the form of:

$$(7) \ln \pi = \ln A + b_1 \ln w_1 + b_2 \ln w_2 + b_3 \ln w_3 + b_4 \ln w_4 + b_5 \ln Z + u$$

Where

- $\ln$  = natural log
- $\pi$  = Profit (Tk/ha)
- $w_1$  = Wage rate (Tk/manday)
- $w_2$  = Price of manure (Tk/kg)
- $w_3$  = Price of fertilizer (Tk/kg)
- $w_4$  = Price of insecticides (Tk/ml)
- $Z$  = Cultivable land per farm (ha)
- $u$  = random disturbance term

#### Relative Economic Efficiency

The profit function model described earlier can be used to measure relative economic efficiency of the growers. There may have differences in technical efficiency and differences in price efficiency that might exist between farms. The purpose of this section is to introduce such differences and to combine them into the concept of relative economic efficiency. Given comparable endowments, identical technology and normalized input prices, the normalized profit function of the two farms should be identical if they have both maximized profits. To the extent that the one farm is more

price efficient, or more technically efficient, than the other, the normalized profit will differ even for the same normalized input prices and endowments of fixed inputs. Following Lau and Yotopoulos (1971) we can test the null hypothesis of equal relative economic efficiency of two groups of farms by comparing the actual normalized profit functions of the two farms. An overall indication of the relative efficiency between two farms may be obtained by comparing the actual value of the normalized profit functions.

If  $\pi_a^1 > \pi_a^2$  for all normalized price within a specified range, then clearly, the first farm is relatively more efficient within the price range, here  $\pi_a^1$  and  $\pi_a^2$  are the normalized profit function of group 1 and group 2 farms respectively. Alternatively, let us specify normalized profit function of two groups of farms as :

$$(8) \ln \pi_a^1 = \ln A^1 + \sum_{j=1}^n \alpha_j \ln W_j^1 + \sum_{j=1}^n \beta_j \ln Z_j^1$$

$$(9) \ln \pi_a^2 = \ln A^2 + \sum_{j=1}^n \alpha_j \ln W_j^2 + \sum_{j=1}^n \beta_j \ln Z_j^2$$

If  $A^1 = A^2$ , then the two functions  $\pi_a^1$  and  $\pi_a^2$  should be identical. Therefore, we can test equal relative efficiency hypothesis by utilizing a farm size dummy variable in the logarithmic normalized profit function and examining its value is equal to zero. Hence the estimating equation is :

$$(10) \ln \pi = \alpha_0 + S + \sum_{j=1}^n \alpha_j \ln W_j + \sum_{j=1}^n \beta_j \ln Z_j$$

Where  $\pi$ ,  $W$  and  $Z$  are as defined earlier and  $S$  is farm size dummy.

### Estimation Procedure

#### The Flexible Moment-Based Approach

There is a growing body of literatures on the use of Method of Moment (MM) procedure to account stochastic technologies in agricultural production through estimation of moments of output or profit as a function of decision variables (Day, 1965; Anderson, 1981; Roumasset, 1976; De Janvry, 1972, Moscardi and De Janvry, 1972; Heart, Hardekar and Anderson, 1982; Antle, 1983, Antle and Goodger, 1984). The MM procedure for estimating output or profit function has some advantages over Ordinary Least Square (OLS) method. First, the moment functions can be used to quantify the effect of decision variables on the first moment (mean) and second moment (variance) as well as on higher moments of output or profit. The second moment function of output or profit can be used for measuring risk involved in input use under uncertainty. There may result poor parameter estimates of output or profit function from OLS method because of existence of heteroscedasticity problem. Since MM procedure uses Generalised Least

**Square** (GLS) technique incorporating weighted regression, the heteroscedasticity problem is solved automatically. Therefore, the profit distribution function was estimated following Generalized Method of Moment as outlined by Antle and Goodger (1984). This section outlines the flexible moment based approach to estimating and testing the moment based profit distribution functions defined in equation(6). The linear moment presented here is based on the hypothesis that a linear-in-parameters relationship exists between moments of the profit distribution and the farm managers decision variables (the model can be generalized to nonlinear functions; and any other random variable, such as output, can be modeled in place of profit. The approach has the advantage of being flexible in the sense that distinct parameters can be estimated for each moment and selected independent variables relationship. In addition, this approach can be used with a single cross section (or time series) of data, as well as pooled data and the parameter estimates have known asymptotic distributions which can be used to construct tests of hypotheses about the structure of the technology.

The moment functions of the probability of distribution of profit are related to the farmers' decisions. To see this, define the probability density of profit as  $f(\pi | x)$ , where  $\pi$  is profit and  $x$  is vector of decision variables. The density function is defined for a given set of decision variables as:

$$(11) \quad \begin{aligned} \mu_1(x) &= \int \pi f(\pi | x) d\pi \\ \mu_i(x) &= \int (\pi - \mu_1)^i f(\pi | x) d\pi, \quad i \geq 2 \end{aligned}$$

For the  $j$ th observation define  $\pi_j$  as profit and  $x_j = (x_{1j}, \dots, x_{nj})$  as the explanatory variable vector. The moment functions given in equation (11) are written in linear form as

$$\begin{aligned} \mu_{1j}(x_j) &= x_j \tau_1 \\ \mu_{ij}(x_j) &= x_j \tau_i, \quad i \geq 2 \end{aligned}$$

In general, the moment functions can be specified as any linear-in parameters functional form (Fuss, McFadden, and Munlak 1978). Profit is random and  $E(\pi) = \mu_{1j}$ , so the first moment function can be written as the regression equation

$$(12) \quad \pi_j = x_j \tau_1 + u_j, \quad E(u_j) = 0,$$

where  $u_j$  is assumed to be independently distributed. Similarly, noting that

$$E[(\pi_j - \mu_{1j})^i] = E(u_j^i) \equiv \mu_{ij}, \quad i \geq 2,$$

the  $i$ th moment function is written as the regression equation

$$(13) \quad u_j^i = x_j \tau_i + v_{ij}, \quad E(v_{ij}) = 0, \quad i \geq 2.$$

The goal is to estimate the  $\tau_i$  parameters which relate inputs to moments. The least squares estimate  $\tau_1^{\wedge}$  of  $\tau_1$  is consistent. In addition, using the residuals  $u_j^{\wedge} = \pi_j - x_j \tau_1^{\wedge}$ , the least squares regression of  $u_j^{\wedge i}$  on  $x_j$  can be shown to produce a consistent estimate  $\tau_i^{\wedge}$  of  $\tau_i$ ,  $i \geq 2$ . However, the least squares formulas for the standard errors of the  $\tau_i^{\wedge}$  are not

valid because (11) and (12) are heteroscedastic. To see this, observe that the variance of  $\pi_j$  is assumed to be  $\mu_{2j} = x_j \tau_2$ , and the variance of  $u_j$  is  $E(v_{ij})^2 = \mu_{2i,j} - \mu_{ij}^2$ ,  $i \geq 2$ .

Since  $\tau_i^{\wedge}$  is a consistent estimator of  $\tau_i$ , it follows that the weight  $w_{ij}^2 = x_j \tau_2^{\wedge}$  is a consistent estimator of  $\mu_{2j}$  and in general

$$w_{ij}^2 = x_j \tau_{2i}^{\wedge} - (x_j \tau_i^{\wedge})^2, i \geq 2,$$

is a consistent estimator of  $E(v_{ij})^2$ . Therefore, a feasible GLS estimator for  $\tau_1$  can be obtained by the weighted regression

$$\pi_j / w_{ij} = x_j \tau_1 / w_{ij} + u_j / w_{ij},$$

and a feasible GLS estimator for any  $\tau_i$ ,  $i \geq 2$  can be obtained by the weighted regression

$$u_j^i / w_{ij} = X_j \tau_i / w_{ij} + v_{ij} / w_{ij}$$

These estimators are asymptotically normally distributed. Therefore, standard large-sample test statistics can be used.

In applications of the above estimation procedure, another problem must be taken into account. When estimates of the regression variances  $w_{ij}^2$  are computed, some can be negative because of either sampling error or sample bias in the parameter estimates which has to be dropped. Fortunately, this problem can be solved using existing computer software. To obtain the results reported below, the SAS computer program, developed by School of Advanced Statistics was used.

### III. RESULTS AND DISCUSSION

#### Nature and Extent of Technology Used

Farmers mostly used the home supplied seed. Before dribbling the seed, digging of pit was done by following 3x2.5m spacing. The spacing of pit and seed per pit varied from farmer to farmer. The average number of pit and country bean plant per hectare were found to be 1112 and 1203 respectively. After completion of the pit digging, most of the farmers (90%) applied both chemical fertilizers, and manure as basal dose. Out of them, 66% and 24% farmers applied only the chemical fertilizer, and chemical fertilizer plus manure respectively. Only a few farmers (10%) did not use any of the fertilizer as basal dose. However, the rate of application of fertilizers were 0.083, 0.051, 0.023, and 0.389 kg per pit of nitrogen, phosphate, potash, and manure respectively. Accordingly, the farmers applied 91.79, 57.25, 25.59, and 4310 kg per hectare of nitrogen, phosphate, potash, and manure respectively.

The farmers applied 27.5 and 45.2 kg/ha of nitrogen and phosphate and full amount of potash and manure as basal dose. After 2 to 3 days of basal fertilizer application, the farmer dribbled the country bean seed in the pit. The number of seed per pit ranged from 2 to 3. The farmers dribbled the seed during the period of mid August to end of September

'95. Support was prepared for climbing of plant after 30 days of sowing by using bamboo, GI wire and thread.

Topdressing of fertilizer was started after establishment of the country bean plant. The number of topdressing varied from farmer to farmer which ranged from 2 to 3 split of application. The farmers topdressed only nitrogen, and phosphate. Most of the farmers (75%) topdressed only nitrogen. The quantity of nitrogen and phosphate applied as topdressing were 64.28 and 12.05 kg/ha respectively. Only 20% farmers topdressed their fertilizer around the pit. Near about 80% of the farmers topdressed the fertilizer by following the method of broadcasting.

The cent percent farmers applied insecticides. The name of insecticides were Novazon, Diazinon, Dimacron, Marshal, Simbus and Sumi Alfa etc. The number of spraying varied from farmer to farmer ranged from 3 to 5 split. On an average, the farmers sprayed 3117.71 ml/ha of insecticide. Usually 2 to 3 weedings were done properly. Harvesting of green vegetables was started after 75 to 90 days of dribbling the seed and continued up to Spring months. The number of harvesting varied from farmer to farmer and ranged it from 21 to 30.

### **Costs and Return of Country Bean Production**

For producing a crop, costs and return are important factors which dominates the decision making process of the farmers. The farmers producing country bean had to incur cost of different inputs. Some inputs were purchased while some were home supplied. In this paper, the costs for all inputs either it was home supplied or purchased, have been calculated as cash costs or direct expenses. To determine the costs for home supplied inputs, opportunity cost concept was applied. On the other hand, Gross return from country bean production was defined as the country bean yield multiplied by its price.

It was found that on an average, per hectare gross cost for producing country bean was Tk 21127.05 (Table 1). Share of human labour, and material inputs to the total cost of production were 38%, and 62% respectively. Material inputs costs ranked the highest (62%) and human labour cost (38%) was the second highest in the total cost of production. Among the material inputs costs, cost of bamboo and seed ranked the highest and second highest respectively.

It revealed that the average yield of country bean was 10611.83 kg per hectare. Gross return for producing country bean was Tk 44712.97 per hectare with a gross margin of Tk 23585.74 per hectare (Table 1). On an average, cost per kg and gross margin per kg for producing country bean were Tk. 1.99 and 2.22 respectively. Benefit cost ratio was 2.12 which implies that one taka investment in country bean production brought Tk 2.12 in return.

**Estimates of Profit Distribution Function**

Estimated values of the co-efficients and related statistics of the Cobb-Douglas profit distribution function for the sample country bean producing farms are presented in Table 2.

**Table 1. Per hectare cost and return of country bean production, Atghoria, Pabna, 1995.**

Items	Quantity per hectare	Cost and Return (Tk/ha)	Percentage of total Cost
A. Total cost		21127.05	100
**Human labour (manday)	217.96	8001.44	37.87
Material Inputs (kg/ha)		13125.61	62.13
Seed	13.80	1794	8.49
Manure	4310	1768	8.37
Nitrogen	91.79	1135.48	5.37
Phosphate	57.25	1307.75	6.18
Potash	25.59	337.39	1.60
Insecticide (ml/ha)	3117.71	1776.99	8.41
*Bamboo	263	3506	16.59
*GI Wire	100	500	2.36
*Thread	19	1000	4.73
B. Yield (kg/ha)	10611.83		
C. Gross return (Tk/ha)	-	44712.79	-
D. Gross margin (Tk/ha)	-	23585.74	-
e. Cost/kg (Tk)	-	1.99	-
F. Gross margin/kg (Tk)	-	2.22	-
G. Benefit cost ratio	-	2.12	-

\*Cost of bamboo, GI wire and thread were estimated on the basis of production period of country bean (Tk 40/bamboo, Tk 40/kg for GI wire, Tk 200/kg for thread)

\*\* Human labour included labour used for land preparation, fertilizing, pit digging, support preparation and weeding.

These estimates were obtained by using three staged Generalized Method of Moment procedure. All three functions are statistically significant, as judged by F-statistics. The F-value indicates that all coefficients other than zeroes should be rejected for all three moments at all conventional significance levels. The coefficients of wage rate, prices of

manure, chemical fertilizer, and insecticides are negative while the coefficient of land is positive in the first moment function, in accord with a priori economic theory: the function is decreasing in wage rate, and prices of manure, chemical fertilizer and insecticides and increasing in cultivated land. All these coefficients contributed significantly to mean profit. The estimates of second moment function show that prices of chemical fertilizer, and insecticides are risk increasing factor as indicated by positive sign and increase variability of profit while manure and cultivated land are risk reducing factors since they have negative coefficient and reduce variability of profit. The estimates of the third moment function show that wage rate, prices of manure and chemical fertilizer, cultivated land and farm size increase skewness of profit distribution function while price of insecticide reduces skewness of profit distribution.

**Table. 2** Estimated moments of Cobb-Douglas profit function.

Explanatory variables	1st moment	2nd moment	3rd moment
Constant	0.325150	-0.06506	0.000001
Wage rate ( $w_1$ )	-.03063 (0.026250)	0.090654 (0.041663)	0.082960 (0.051336)
Price of manure ( $w_2$ )	-0.202393* (0.065737)	-1.72829* (0.0699725)	0.297382 (0.791236)
Price of fertilizer ( $w_3$ )	-.354960* (0.12415)	0.254799* (0.102619)	0.279631* (0.107691)
Price of insecticide ( $w_4$ )	-1.945062* (0.808111)	.78516* (0.132415)	-0.01375 (0.054861)
Cultivated land (Z)	.984321* (.240432)	-2.55185 (1.472085)	2.11436 (3.091866)
Farm size dummy(S)	-0.872* (0.241143)	.643251* (.241512)	.325123* (.103213)
F-value	65**	512**	45**

Figures within parentheses are standard errors of estimates. \*Significant at 5% level, \*\* Significant at 1% level

#### Relative Economic Efficiency

The hypothesis of relative economic efficiency of growers can be tested in terms of the coefficient of a dummy variable that differentiate the profit functions of two groups of

farms and the test becomes that the coefficient of the dummy variable is not significantly different from zero. Our results showed that the coefficient of farm size is significantly different from zero, therefore, reject the hypothesis of equal efficiency between the small and large farms. Furthermore, the sign of the dummy variable indicates that small farms are more profitable, therefore, more efficient, at all observed prices of the variable input, given the distribution of the fixed factors of production.

#### IV. CONCLUDING COMMENTS

The purpose of this paper is to present an econometric model for estimating the normalized profit distribution function using a Three Staged Generalized Method of Moment procedure in a population of producers who utilize similar production technology. The proposed econometric procedure can be utilized either with a cross section of farm level data on production, prices of inputs and outputs, or with time series data or with pooled data. We used McFadden's profit function, which expresses a farm's maximized profit as a function of the prices of variable inputs of production and quantities of fixed factors. The advantage of the procedure is that it used Cobb-Douglas form of profit function which can be linearized using logarithm. The results of the model can be used for testing relative economic efficiency. The empirical data on country bean production in Bangladesh validated the model. The result showed that fertilizers and pesticides were risk increasing inputs in country bean production. The small farmers were found to be more efficient. The study concludes that under uncertain environmental condition, relative economic efficiency can be assessed through estimation of normalized profit distribution function. We intended our empirical application as an illustration of a method of measuring relative economic efficiency. This method is operational and parsimonious from the point of view of data requirements. The usefulness of the method is not restricted to just comparing small and large farms. Actually much more important insights into the form of economic organizations might be forthcoming if one compares different grouping, such as owners versus share tenants, adopters of new varieties versus nonadopters.

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