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A Micro Level Study: Supply Responsiveness of Banana and Demand Inputs – Profit Function Approach – Vadipatti Block, Madurai District

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The profit function approach is widely used in supply response studies to estimate simultaneously the input supply and factor demand equations. It can be used to explain the production behaivour of farmers, as it incorporates prices as explaining variables and allows for imperfect profit maximisation by farmers at the micro level. It also permits for the payment and receipts of different prices for homogenous variable inputs and outputs respectively and for varying quantity of fixed inputs. Thus it takes care of the inter-farm variation in equating marginal value of product with the prices of variable input.

The profit function approach is necessary to discuss the production and productivity trends in agriculture in order to assess the performance of the Indian agricultural sector. The analysis of agricultural production assumes an important role in the formulation of agricultural policy. One of the main objectives of agricultural policy is to increase output with the existing resources. It warrants a study of price response, economies of scale, efficient allocation of variable factors of production and pricing of the factors of production.

This paper makes an attempt to study the supply response and input demand in response to changing prices with respect to two farm categories, namely, small farms and large farms. According to the conventional method, supply response is studied using time series data, and the quantity supplied is regressed on price, allowing for various lags and shifters in this model. However, input demand and output supply are being inter-linked with each other, the estimation of output supply alone may give inefficient estimates of the underlying supply relationship. The difficulties of estimation involved in this approach were reviewed by Lim (1975). It is desirable therefore, to estimate simultaneously the interlinked output supply and factor demand equations. Profit function analysis, the procedure used in this study, is an approach to derive simultaneously output supply and factor demand equations. The Profit Function Approach formulated by Lau and Yotopoulos (1972) helps to estimate the maximum profit of a firm, in terms of prices of output and variable inputs and quantities of fixed factors of production. The model has also taken into account the fact that prices, technology and resource endowments may vary from farmer to farmer.

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The assumption of profit maximisation can be tested by jointly considering the variable factor demand function and the profit function. The market behaviour can be statistically benefited by examining the equality between the marginal product of its input and price. Own and cross price elasticities of other variable inputs is not derived independently but jointly as a system of output supply and factor and demand equations which incorporate the interdependent nature of output and input decisions by the farmers. The profit function approach is also based on the following assumptions.

The assumptions inherent in a profit function model are:

(a) Firms seek to maximise short-term profits, given the resources and technology with which they operate.
(b) Firms are price takers with respect to prices received for output and prices paid for inputs and
(c) The production function which underlies the profit function exhibits decreasing returns to scale in variable inputs.

OBJECTIVES

On the basis of these assumptions the following objectives are set for the study. (1) To study the fixed resource allocation to the cultivation of banana and (2) To investigate simultaneous input supply and factor demand in small and large farms with regard to their own prices and the prices of variable inputs and units of fixed inputs.

SAMPLE DESIGN

Profit function has been made on micro level data regarding the details of inputs and output of crop productions have been collected through an intensive field survey by collecting a sample of 150 agricultural households, 52 large farmers and 98 small farmers. That cultivation on an area of 2.5 hectares and more were grouped under the large farmers category while those cultivating less than 2.5 hectares of land were classified as small farmers. The district of Madurai consists of six taluks which include 13 blocks. The survey has been designed on the basis of proportionate random sampling technique among the thirteen blocks and Vadipatti taluk has been selected for sample survey, because it was the leading block for banana cultivation among the thirteen blocks in Madurai district during 2006-07. The data collected pertains to the agricultural year 2006-07. From the block we have proceeded to the village level by selecting five villages from the block. The selection has been made at random basis in banana cultivation. From each village the samples are selected according to their holding sizes. For collecting primary data the researcher has visited each of the selected farm holders at least thrice in the agricultural year, viz., once at the beginning of the planting, next at the middle of the stage and finally at the

stage of harvesting. The questionnaire schedules used for collecting detailed information were pre-tested by conducting a pilot survey of 25 farm holders in the selected villages, the results of which gave satisfactory indicators of the adequacy of the questionnaire.

The normalised profit function corresponding to Cobb-Douglas production function was jointly estimated along with the four variable input demand functions with random disturbances for two reasons. Moreover, the assumption of profit maximisation is unlikely to prevail in a maximise utility. Despite these limitations, the advantages of using profit function model based on competitive principles as noted by Lau and Yotopoulos (1972) and Kalirajan and Shand (1981) are as follows:

The estimation of parameters is straightforward as is their interpretation in the dual profit function, which is also Cobb-Douglas and using this model, it facilitates ready comparison of the results with those of the others. It was of the form:

$$\text{Log } л^* = \alpha_0\beta_1^* \log W + \beta_2^* \log F + \beta_3^* \log M + \beta_4^* \log I + \alpha_1^* \log A + \alpha_2^* \log C + U$$

$$-\frac{WX_1}{\pi^*}\beta_1^* + U_2 \qquad \beta_1 = \frac{\partial \ln \pi}{\partial \ln m}$$

$$-\frac{FX_2}{\pi^*}\beta_2^* + U_2 \qquad \beta_2 = \frac{\partial \ln \pi}{\partial \ln f}$$

$$-\frac{MX_3}{\pi^*}\beta_3^* + U_3 \qquad \beta_3 = \frac{\partial \ln \pi}{\partial \ln m}$$

$$-\frac{1X_4}{\pi^*}\beta_4^* + U_4 \qquad \beta_4 = \frac{\partial \ln \pi}{\partial \ln m}$$

л* = restricted profit (current revenue less current variable costs) per farm, normalised by the price of banana.
W = real wages/day for crop maintenance
F = real fertiliser price/kg.
M = mechanical labour.
I = irrigation.
A = total area cultivated.
C = capital flow (calculated as the sum of depreciation, maintenance and opportunity cost of capital stock).
X_1 = total labour man-days utilised.
X_2 = total quantity of fertilisers utilised.
X_3 = total irrigation utilised.
X_4 = total mechanical labour utilised, α and β are parameters to be estimated.

RESULTS AND DISCUSSION

The above equations have been estimated jointly by using Zellner's seemingly unrelated regression which provides asymptotically more efficient estimates than the production function estimated by ordinary least squares (Zellner, 1962). The results of the estimated regression equations are presented in Table 1.

TABLE 1. JOINT ESTIMATION ON NORMALISED PROFIT FUNCTION AND LABOUR DEMAND AND FUNCTION; SMALL AND LARGE FARMS (BANANA) (2006-2007)

		Estimated Coefficient Zellner's Method with Restrictions	
Variables	Parameters	Small Farms	Large Farms
(1)	(2)	(3)	(4)
Constant	α_0	5.4533*(12.433)	5.896*(14.083)
Log W	β_1*	-0.3595*(-8.881)	-0.3861*(-11.890)
Log F	β_2*	-0.1199*(-5.358)	-0.1443*(-8.127)
Log M	β_3*	-0.0443*(-6.438)	-0.0516*(-9.395)
Log I	β_4*	-0.0690*(-6.234)	-0.0769*(-7.383)
Log A	α_1*	0.6764*(15.065)	0.5814*(12.654)
Log C	α_2*	0.3427*(7.966)	0.3195*(7.467)
Labour Demand	β_1*	-0.3595*(-8.881)	-0.3861*(-11.890)
Fertiliser Demand	β_2*	-0.1199*(-5.358)	-0.1443*(-8.127)
Mechanical Labour Demand	β_3*	-0.0443*(-6.438)	-0.0516*(-9.395)
Irrigation Demand	β_4*	-0.0690*(-6.234)	-0.0768*(-7.383)

Note: Figures in parentheses represent 't' values.
*Indicate that the coefficients are significant at 1 per cent level.

The estimated coefficients of the normalised variable input prices are negative as expected from the theory of profit function and also statistically significant at 1 per cent level. This implies that an increase in the normalised price of any variable input reduces the normalised profit. The parameter estimates of the quantities of fixed inputs – area and capital – are positive. This indicates that an increase in the quantities of fixed inputs leads to increase the normalised profit.

Labour Demand and Output Response

In an underdeveloped economy, among the various sectors, agriculture occupies a predominant place. The growth of the primary sector becomes the chief concern of the planners and policy makers. However, the growth of the agriculture sector depends upon the introduction of new technology and availability of inputs. Along with the growth of the agriculture sector, the introduction of new agricultural technology leads to increased employment opportunities and avoid seasonal unemployment in the sector. Basically, the demand for labour is determined by the various types of technology used, distribution of land ownership, and social, economic, political and institutional factors. With the existence of seasonal unemployment and disguised unemployment in this sector, the conventional method

encourages the adoption of labour-intensive technology rather than the capital-intensive technology. This approach was supported by Khusro (1964) , Mehra (1976), Rudra and Mukhopadyay (1976).

A few studies have been made by Johl (1974), Subramaniyan (1987), Bisaliah (1978) and Sharma (1974) in India regarding the labour saving effects of mechanisation through the adoption of high-yielding varieties (HYVs), multiple cropping system and intensive use of input factors. Nevertheless, the influence of the existing agrarian structure, labour market and the socio-economic aspects should not be overlooked. Among the prevailing controversial views, an examination of the labour-absorptive capacity of the small and large farmers of high-yielding variety of banana in Vadipatti block plays an important role in the formulation of agricultural policy. Moreover, the success or failure of Government policy and high-yielding variety programme in improving agricultural production and welfare of the agricultural sectors and primary sectors depends on the responses of farm holders to input and output factor price changes. The examination of the efficiency of the market instruments (prices) involves the estimation of demand and supply functions from which one can study the response of farmers to changes in market prices. Originally the Government used a combination of short-run price policies and long-run intensive technological instruments such as, investment in modern technology and infrastructure to achieve their objectives, so as to increase output and farm incomes. As per the reasons stated above, with the rising input costs against the output prices, a study on the banana supply responses and input demand to changing output among the farmers becomes important. The elasticities obtained from such an analysis would contribute reliable information towards the formulation of agricultural policy. This section reveals the supply responsiveness of banana and demand for inputs with regard to their own prices and the prices of other inputs.

Given the profit function approach, own and cross price elasticities of demand for factor inputs and supply elasticities of banana in Vadipatti block were calculated using the formula given in Table 2.

Table 2 reveals the own and cross price elasticities of demand for labour and output supply of banana for small and large farmers in the study block.

TABLE 2. OWN AND CROSS PRICE ELASTICITIES OF DEMAND FOR LABOUR AND OUTPUT SUPPLY: SMALL AND LARGE FARMS (BANANA) 2006-2007

	Endogenous Variable			
	Output supply		Labour Demand	
Exogenous variables	Small farms	Large farms	Small farms	Large farms
(1)	(2)	(3)	(4)	(5)
Banana price	0.0481	0.5438	1.4812	1.5438
Real wage	-0.3595	-0.3861	-1.3595	-1.3861
Real fertiliser price	-0.1199	-0.1443	-1.1199	-1.1443
Real mechanical labour price	-0.0443	-0.0516	-1.0443	-1.0516
Real irrigation price	-0.0690	-0.0768	-1.0690	-1.0768
Land	0.6764	0.5814	1.6764	1.5814
Capital	0.3427	0.3195	1.3427	1.3195

The output supply elasticities for small and large farmers with respect to own prices were 0.0481 and 0.5438 respectively. That is, according to 'ceteris paribus' assumption, a 1 per cent increase in banana price would respectively increase their output supply by 0.04 per cent and 0.05 per cent. This indicated that the sample farmers were highly responsive to changes in banana price. Banana price is considered as an effective tool to increase output supply in the study block. Their highly responsive nature to changes in banana price indicates that the banana crop can be substituted by sugarcane and paddy.

The changes in banana price appeared to have an insignificant effect on the demand for labour in banana cultivation. A one per cent increase in banana price was found to ensure a less than one per cent rise in the demand for labour (0.54 per cent for small farmers and 0.54 per cent for large farmers).

An increase in the real price of the variable inputs negatively affected banana supply and demand for labour in both cases (small and large farms). The impact of elasticities and the influence of these variables were quite low in the determination of output supply and labour demand in banana farming. However, increase in farm wage had a relatively serious negative effect on the supply of banana and demand for labour than other input factors. These elasticities imply that a 1 per cent increase in real wage would induce the small farmers to reduce labour employment by 3.35 per cent in the case of small farmers and 1.38 per cent in the case of large farmers. This implied that wage rate is also one of the most important factors that significantly affect farm employment opportunities.

The elasticities of banana output with respect to land were 0.06 and 0.05 for small farms and large farms respectively. This indicated that an increase in area under banana had a favourable impact on banana supply. In the case of capital, the respective elasticities were quite low, as compared to land, namely, 0.03 and 0.03. This may be due to the problems of constructing capital flows from capital stocks and also of measuring this variable for a particular crop.

With respect to labour demand, the study reveals that the demand for labour in banana crop enterprise is highly elastic to wage changes and that a rightward shift in the supply functions of labour may easily be absorbed by reducing the wage rate. In other words, a slight decrease in wage rate leads to induce a greater demand for labour. However, in practice, this is undesirable as the wage rate considered in the model is the real wage rate because of the fact that the active labour unions may resist undue wage cuts. Further, the result indicates that an increase in banana price is found to have a substantial effect on labour absorption. However, it is to be noted that the output price policy should not be considered as the only solution to increase labour absorption in agriculture. For example, the adoption of appropriate technology such as supply of high-yielding varieties of banana having better yield potential than the present level may be considered as a better alternative of increasing labour demand. The optimal package of strategies for improving the non-economic factors such as social reforms, the inheritance system and the efficient labour organisation

can also have a favourable effect on labour absorption. However, the suitability of any policy instrument should be judged only by its overall social and economic consequences.

Table 3 shows the demand for variable inputs with respect to their own prices for small farms and large farms.

TABLE 3. DEMAND FOR VARIABLE INPUTS WITH RESPECT TO ITS OWN PRICE FOR SMALL FARMS AND LARGE FARMS (BANANA) (2006-2007)

Particulars (1)	Small farms (2)	Large farms (3)
Demand for labour with respect to real wage	-1.3595	-1.3861
Demand for fertiliser with respect to real fertiliser price	-1.1199	-1.1443
Demand for mechanical labour with respect to real irrigation price	-1.0443	-1.0516
Demand for irrigation with respect to real irrigation price	-1.0690	-1.0768

Source: Estimated values from primary data.

The study shows that a 1 per cent increase in the prices of variable inputs, such as labour, fertiliser, mechanical labour and irrigation was accompanied by 1.35 per cent, 1.11 per cent, 1.04 per cent, 1.06 per cent decrease in their respective demand in small farms. In the case of large farms, it was followed by a decline of 1.38 per cent, 1.14 per cent, 1.05 per cent, 1.07 per cent in the demand for the respective variable inputs. The analysis reveals that the demand for variable inputs with respect to their own prices was highly elastic. The elasticities indicated that a 1 per cent increase in the prices of the variable inputs was followed by more than 1 per cent fall in their demand. The studies by Subramaniyan (1986) and Nirmala (1992) almost reported similar findings.

Among the prices of variable inputs, real wage was indicated as the most important factor of production affecting the agricultural employment to a greater extent.

Own and cross price elasticities of demand for variable inputs with respect to small and large farms of banana are presented in Table 4.

TABLE 4. OWN AND CROSS PRICE ELASTICITIES OF DEMAND FOR VARIABLE INPUTS WITH RESPECT TO SMALL AND LARGE FARMS (BANANA) (2006-2007)

Particulars (1)	Prices of labour (2)	Price of fertilisers (3)	Price of mechanical labour (4)	Price of Irrigation (5)
		Small farms		
1. Demand for labour	-1.3595	-0.1199	-0.0443	-0.0690
2. Demand for fertiliser	-0. 3595	-0.1199	-0.0443	-0.0690
3. Demand for labour	-0. 3595	-0.1199	-1.0443	-0.0690
4. Demand for irrigation	-0. 3595	-0.1199	-0.0443	-1.0690
		Large farms		
1. Demand for labour	-1.3861	-0.1443	-0.0516	-0.0768
2. Demand for fertiliser	-0. 3861	-0.1443	-0.0516	-0.0768
3. Demand for labour	-0. 3861	-0.1443	-0.0516	-0.0768
4. Demand for irrigation	-0. 3861	-0.1443	-0.0516	-1.0768

Source: Estimated values from primary data.

Table 4 reveals that the cross price elasticities of the variable inputs for small and large farms were negative and low. The negative sign of the variable inputs implied that they were complements rather than substitutes. The factor input cannot be substituted by any other inputs. However, they can be ignored because of the fact that the magnitude of their cross elasticities was quite low. Moreover, it should be noted that a given change in any of the exogenous variables in input demand is symmetric in this approach, which is due to the inherent assumption of unit elasticity of substitution among factor input pair in the Cobb-Douglas production function.

It should be noted that the estimates of short-run banana supply elasticity with respect to its price is not comparable with the short-run and long-run elasticities obtained from aggregate time series data using Nerlovian supply response model. However, the estimates are in conformity with supply response elasticity for wheat by Sidhu and Carles (1979) for India. Hence the elasticity of banana with respect to variable and fixed inputs is less than one (inelastic).

The variable input demand elasticities indicate that the demand for variable inputs labour, fertiliser, mechanical labour and irrigation are elastic with respect to changes in their own price and banana price. These supply elasticity estimates may be used to evaluate the impact of various kinds of micro policy implications. The impact of an exogenous change in any one of the variables such as price of banana, wage are, fertiliser price, mechanical labour and irrigation, cost on banana supply and the required variable inputs can be assessed using these elasticities.

Direct and Indirect Production Elasticities

The advantage of the Profit Function Approach is that from the estimated elasticities of real profit function, indirect estimates of production elasticities may be calculated. It should be noted that the indirect estimates of production elasticities are statistically consistent and symptomatically efficient. On the other hand, the direct estimate of production elasticities are statistically inconsistent and are not free from simultaneous bias, because of the direct estimates of production function. These are obtained by estimating single equation ordinary least squares method. Further, the specification of different variables in the production and profit functions are different.

By using the following formula, the indirect estimates of production elasticities were derived from the 'real' profit function.

$a_j = a_j^* (1-u)^{-1}$, j = 1, 2, ……m

$B_j = B_j^*(1-u^*)^{-1}$, j = 1, 2, …….n

$$U^* = \sum_{j=1}^{n} B_j^*$$

TABLE 5. FORMULAE TO ESTIMATE OUTPUT SUPPLY AND INPUT DEMAND FROM COBB-DOUGLAS PROFIT FUNCTION -2006-2007

Description (1)	Parameters of profit function (2)
(a) Supply elasticities	
(i) with respect to real price of i-th variable input, Xi	β_1*
(ii) with respect to fixed input, Zi,	α_j*
(iii) with respect to input price, Py	$-\Sigma\beta_j$*
(b) Input demand elasticities	
(i) Own price elasticity of Xi	β_j*-1
(ii) Cross price elasticity for Xi with respect to real price Pi	β_j*
(iii) Variable input Xi with respect to fixed factor Zj	α_j*
(iv) Demand elasticity of Xi with respect to output price	$-\Sigma\beta_j$* + 1

Source: Lau and Yotopoulos, *op.cit.*, p.17.

The indirect production elaticities of two farms are given in Table 6.

From the indirect estimates, in this table, it seems that there is evidence of constant returns to scale with regard to both small farms (0.98) and large farms (0.93) of banana cultivators in the study.

TABLE 6. INDICRECT ESTIMATES OF PRODUCTION ELASTICITIES - 2006-2007

Variables (1)	Small farms (2)	Large farms (3)
Labour	0.22	0.23
Fertiliser	0.07	0.09
Mechanical labour	0.02	0.03
Irrigation	0.04	0.04
Area	0.42	0.35
Capital	0.21	0.19
Sum of statistics	0.98	0.93

Source: Estimated as described by Lau and Yotopoulos *op.cit.*, p.21.

The production elasticities of labour were found to be equal for small farms (0.23) as well as large farms (0.22). This implies that the share of labour factor input in the total output of the two farms is more than 20 per cent. This study reveals that, with respect to labour demand, it is highly elastic to wage changes and that a rightward shift in the supply function of labour may easily be absorbed by reducing wage rate.

Likewise, the production elasticity of land was very high in small farms (0.42) compared to large farms (0.35) in banana cultivation. It was followed by capital flow. The share of the capital flow was (0.21) for small farms and (0.19) for capital farms. These three input demand factors are considered as the most important factors of production with shares of 85 and 77 per cent respectively in the total output share of the small farms and large farms in the study block. The remaining input factors share did not reveal predominance in these two farms. This may be due to the fact that the high yielding variety of banana is not mere response of fertiliser, mechanical labour and irrigation. The indirect estimates for the two farms indicated the presence

of constant returns to scale. This finding rules out the policy of consolidation of holding in the study block to improve the supply of banana.

POLICY IMPLICATION

All this led to the conclusion of almost elastic nature of a higher order of the banana supply changes in price. This seems to be applicable not only to short run elasticity but also to long run elasticity. Further heavy winds reduced banana supply drastically in Tamil Nadu as well as in Madurai district. Therefore, it is suggested that causarina may be planted around the banana cultivated area as a wind break to save banana plants. The government should also try to introduce crop insurance scheme to avoid unforeseen loss due to wind and other natural calamities.

Apart from the conclusions, the study also exhibited that non-price factors would also be of great help to the farmers cultivating banana crop as a predominantly commercial crop in Tamil Nadu. The government should make other technical inputs, such as fertiliser, modern irrigation and high-yielding varieties of seeds suitable to the soil available to the farmers. This factor promotes the farmer towards increasing income. Improvement in the quality of human labour due to the increased investment in education and training regarding better techniques can help banana cultivation in a bigger way. The price factors especially the relative price of banana and the ratio between banana price index and the overall price index have not been favourable to the banana farmers. Therefore, a boost of price incentive also calls for improving banana supply in future in the state and be included more positively to changes in price of banana.

These three input demand factors were considered to be the important factors of production. The remaining input factors share did not reveal predominance among the two groups of farmers. This may be due to the fact that the high yielding variety of banana was not merely fertiliser, irrigation and mechanical labour responsive.

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