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FACTORS AFFECTING PROFITABILITY OF SMALL SCALE FARMING IN SOUTHERN TRINIDAD & TOBAGO

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Abstract

This study examined several possible factors determining the profitability of small scale crop farmers in Trinidad and Tobago in the Caribbean. Industrial/urban influence on profit efficiency was tested by the creation of a special variable (IFOUR). This variable along with farming and socio-economic variables were incorporated into a translog augmented stochastic profit frontier. The significance of coefficients was tested as well as the calculation of the elasticity of profit with respect to the wage rate. The study found a significant negative impact of wage rates on profitability. Also the age of the farmer negatively affected profitability, while the number of years farming had a positive effect. This latter variable also significantly influenced both the one-sided error and idiosyncratic error terms. However IFOUR measuring industrial/urban influence did not significantly affect the profitability. The farmers had a mean profit efficiency of 48.4%, which was low in international comparisons.

Key Word: *Caribbean Farming, Stochastic Profit Frontier*

1. Introduction

Low farm profitability is a major concern of developing countries because of concerns for its effects on food security, by limiting the supply of food and the access to food by rural households because of low farm incomes (Aung, 2011; Liverpool-Tasie, Kuku & Ajibola, 2011 pp. 6-24). Food security concerns have developed because of recent food shortages and high food prices. Several factors have been offered for these recent developments, including increased demand for food grains and oil seeds for fuel production, increasing prices for these commodities, the weak US dollar, the increase in farm production costs due to higher energy prices and droughts (Mitchell, 2008). However this article focuses on low farm profitability in an industrializing, developing country and in small scale crop farming and its possible causes such as high input prices, especially for labour and other socio-economic factors.

Industrialization, the development of manufacturing industry and mineral resource extraction, has long been favoured as the vehicle for economic growth of tropical countries, since it tends to create economic activity of higher productivity (UNIDO, 2008). Industrialization generally concentrates in specific geographical areas, because of the tendency of firms to cluster, either because of the location of the extractable mineral resource, or because of agglomeration economies in manufacturing. These economies are associated with access to a pool of specialised workers and quick access to supplies of inputs and knowledge relevant to the manufacturing firms (UNIDO, 2008).

Because of the concentration of activity geographically, industrialisation leads to issues associated with urbanisation - the growth in size, social and economic influence of towns and cities, especially into surrounding rural areas. These issues include the formation of slums, the spread of disease, gang violence, pollution etc. Industrialization can also have a major impact on employment creation, both formal and informal, as well as on the increase in labour wage rates. It can also cause an increase in the rental value of land within its specific geographical area of influence, as well as provide an expanding market for food produced in proximal areas.

Several studies have examined the industrialization of agriculture and the food sector. For example, Sexton (2000) examined the implications for competition and welfare of the industrialization and consolidation in the U.S. food sector. Sonka (2003) examined the implications for the grain industry in the US, while Molnar, Hoban, Parrish, and Futreal (1997) examined the trends and spatial patterns of agricultural industrialization and the implications for field-level work by the Natural Resources Conservation Service of the USDA. However fewer studies have examined the possible impact of industrialization in the economy as a whole, on the agricultural sector. Hyami (1969) argued for example that, based on international comparisons and the analysis of the Japanese experience, industrialization may promote agricultural development, by improving the conditions of supply of modern inputs to agriculture. He used this argument to explain the observation that the agricultural productivity of less developed countries, whose comparative advantage seems to lie in agriculture grew slowly, relative to agriculture in developed countries. On the other hand, Henneberry, Khan, and Piewthongngam (2000) based on an analysis of Pakistan's industrial and agricultural sectors, concluded that while the sectors are complementary, “industry tends to benefit more from agricultural growth than vice versa”.

What this study proposes is that the “industrial/urban influence” (consisting of the proximity to an industrial centre and the population density of the area in which the farm is located) can affect farm profitability directly as well as through labour wage rates and family labour utilization. This article examined the effects of these factors, as well as other farm and farmer related characteristics on the profitability of small scale farming in an expanding industrial area in southern Trinidad and Tobago, a small island nation in the Caribbean.

A major location of industrialisation in Trinidad and Tobago is the southern area of Point Fortin on the island of Trinidad. Point Fortin was the first centre of oilfield operations in Trinidad and has been described as “the town that oil built” growing up in the space of 50 years from 1907, “from a forest clearing to a modern town of 30,000 people” (Brereton 1982). Since 1999, there has been another surge in industrialisation in Point Fortin as the Liquefied Natural Gas (LNG) industrial plants are located there. Atlantic LNG Company, produces LNG from natural gas delivered from fields in and around Trinidad and Tobago, and is the seventh largest LNG producer in the world, and the largest such producer in the Western Hemisphere. The company occupies a significant position in the local energy industry, as it is the largest single contributor to Trinidad and Tobago’s exports and a significant contributor to the country’s gross domestic product (GDP). Its annual production represents more than half of the economic contribution of the entire refining sector. The area around Point Fortin formed the location of this study.

The next section presents the conceptual framework of the study which is followed by the empirical procedures used.

2. Conceptual Framework

Models of urban influence provide a useful point of departure for developing a theoretical framework for this study, (for example, Levanis, 2005), and this approach is therefore adopted. We assume,

- An industrial centre which provides a market for small farmers located at increasing distances, δ, from the centre
- Each small farmer rents an acreage of land A, which is devoted to production of one crop
- Farmers utilize hired labour, x, obtained at a price w. Part of the labour input, family labour, may be fixed in the short run. Family labour may include those "disguisedly employed" with marginal productivity close to zero or even negative (Lewis, 1954).
- Each small farmer produces one crop which is chosen according to the demands of the market at the industrial centre, as well as the edaphic and topographical conditions of the farm.
- The small farmer maximizes profits, π, subject to the constraint of an implicit production function, F (y*, x, A) = 0, where y* is the fixed level of the crop produced
- The farmer's use of technology is affected by a number of socioeconomic factors including the farmer's age, gender, and educational attainment.
- The average cost of transporting the crop produced to the industrial centre is τ, with τ being a positive function of distance – the further away from the industrial centre the greater the transportation cost.
- The small farmer sells the constrained crop output y* at the industrial centre at a price p, but the farmer receives a net price [$p-\tau(\delta)$] because of the transportation costs $\tau(\delta)$ to the market and $\tau'(\delta)>0$
- Land at the industrial centre has an annual rental value per acre of V_I and this annual rental declines exponentially with distance from the centre at rate -ϕ.

Profit maximization at the farm level can thus be represented by the Lagrangian function:

$$\max L=[p-\tau(\delta)]y^{*}-wx-Ae^{-\phi\delta}V_I-\lambda F(y^{*},x,A) \qquad (1)$$

Where w, p, δ are quasi-fixed variables –fixed for the individual farmer but variable cross sectionally and V_I is quasi-fixed at any point in time but variable over time and the profit equation is constrained by the fixed production function $F(y^{*},x,A)$.

The first order condition of the maximization yields:

$$L_x=-w-\lambda F_x=0 \qquad (2)$$

$$L_A=-e^{-\Phi\delta}V_I-\lambda F_A=0 \qquad (3)$$

$$L_\lambda=F\left(y^{*},x,A\right)=0 \qquad (4)$$

These equations will yield optimal levels of labour x' and land A' and optimal profit levels of y'. The second order maximization condition:

$$\lambda\left(F_x^2F_{AA}+F_A^2F_{xx}\right)>0 \qquad (5)$$

imposes no constraint on the sign of F_A or F_x. We therefore assume $F_x > 0$ and $F_A > 0$.

To determine how the optimal profit π' varies for changes in the quasi fixed variables of distance δ, V_1, p and w, the envelope theorem can be utilized with the profit equation and optimal values of x, x' and A, A'.

$$\pi' = y^* p - \tau(\delta) y^* - wx' - A' e^{-\phi\delta} V_1 \tag{6}$$

Then $$\left(\partial\pi'/\partial p\right) = y^* > 0 \tag{7}$$

$$\left(\partial\pi'/\partial\delta\right) = -y^* \tau'(\delta) + Ae^{-\phi\delta} V_1 \phi \tag{8}$$

$$\left(\partial\pi'/\partial V_1\right) = -Ae^{-\phi\delta} < 0 \tag{9}$$

$$\left(\partial\pi'/\partial w\right) = -x' < 0 \tag{10}$$

Equation 7 suggests that increasing the output price increases the optimal profit of the farmer, while equation (9) suggests that increasing the annual rental value of land reduces the optimal profit. Equation (8) suggests that increasing the distance from the industrial centre can have a positive or negative effect on the optimal profit depending on which effect is greater – the positive effect of the farm being further from the industrial centre (with lower land annual rental values) or the negative effect of increasing cost of transportation of the crop produced to the industrial centre (Proposition 1). Equation (10) suggests that increasing wages will lower the optimal profit (Proposition 2).

Proposition 3 of this study is that the socioeconomic factors affecting the level of technology in use by farmers also affect the profitability of the farmer with respect to the stochastic profit frontier. Where socioeconomic factors cause a greater reduction in the technical efficiency of the farmer's crop production, such a farmer will be farther below the stochastic profit frontier.

Proposition 2 was tested using significance tests on the coefficients of the wage variables as well as the calculation of the elasticity of profit with respect to the wage rate, in the profit function and the stochastic profit frontier estimated in the study.

Proposition 1 was tested by the creation of a special variable to incorporate the industrial/urban influence in the estimation of the augmented stochastic profit frontier.

Proposition 3 was tested by also incorporating the socioeconomic factors in the estimation of the augmented stochastic profit frontier.

2.1. Profit Function

The profit function used in this study is derived from equation (1) by substituting the optimal values of the inputs into the profit equation to yield a function

$\pi' = \pi'(p, w, V_1, \delta, z)$ where π' is the optimal profit and z is a vector of fixed inputs.

2.2. Stochastic Profit Frontier

The single output stochastic profit frontier was utilised to test Propositions 1 and 3 and 4 of this study (Coelli et al., p. 33). The derivation of this profit frontier is based on Kumbhakar and Lovell (2000, p. 187). The measure of profit efficiency is a function eff defined as follows:

$$eff_g = \frac{(\pi')_g}{(\pi')} \tag{11}$$

where (π') indicates the maximum profit possible, as opposed to (π'_g) the actual profit of farmer g; and $eff_g \leq 1$ being equal to one on the profit frontier, if farmer g actually adopts a profit maximizing combination of inputs and output and z is a vector of fixed inputs.

In this study, allocative and technical inefficiency were assumed to be combined to form an overall profit inefficiency, ($ineff$) and no attempt was made to decompose them. Thus profit inefficiency is due to any inefficiency factor that causes the profit of an individual farmer, g, to be below the profit frontier and is defined as

$$\ln eff = \ln(\pi')_g - \ln(\pi') = -ineff_g \tag{12}$$

Where $ineff_g \geq 0$ and $ineff_g = 0$ if farmer g is on the profit frontier.

The stochastic profit frontier for the study (Model 2) was therefore:

$$\ln \pi'_g = \ln \pi'\left(p, w, V_1\delta, z\right) + \left(v - ineff\right) \tag{13}$$

Thus profit inefficiency appears in (13) as an additive error component and standard practice is followed by adding a normally distributed random error term v. The specification of the distribution of v used in the study is $v_i \; i = 1, \ldots, t \sim \textit{independently and normally distributed where } N(0, \sigma_V)$.

The specification of the distribution of the one sided inefficiency term, $ineff$, used was:

$$\text{Half normal } N^+(0, \sigma_u^2) \tag{14}$$

To explain any observed heterogeneity in the profit efficiency as estimated by the stochastic profit frontier three approaches have been utilized in the literature (Greene, 33-38). One approach has been to introduce the possible factors directly into the profit frontier to form an augmented stochastic profit frontier. An alternative is to specify a conditional mean model, in which the mean of the truncated normal distribution is modelled as a linear function of the sets of the possible factors (covariates) (STATA, p. 563) and a third approach is to test for heteroscedasticity in the error terms. Greene argues that no approach is considered superior. The augmented stochastic profit frontier and the heteroscedasticity of the error term approach were adopted in this study. Model 3 was the augmented profit frontier which utilized the same error structure as Model 2 but included a vector of possible factors directly in the model as additional explanatory variables. Model 4 provided another means of explaining this heterogeneity through a specification of the inefficiency term, to test for heteroscedasticity in the variance of *ineff*. Selected factors were assumed to affect the variance of the inefficiency term ($\sigma^2{}_{ineff}$). Thus the variance ($\sigma^2{}_{ineff}$) is assumed to be dependent on a linear combination of variables given by the vector *k*, hence:

$ineff_i\ i = 1,\ldots,t \sim independently\ distributed\ N^{+}(\mu, \rho' k)$ with truncation point at zero and $\sigma^2_{ineff} = \rho' k$ (Model 4) (15)

Finally another possible explanation of heterogeneity was tested through a further assumption of heteroscedasticity in the idiosyncratic variance v_t. Here again this variance σ_v^2 is assumed to be dependent on a linear combination of variables given by the vector *k*. Hence for this model (Model 5):

$v_i, i = 1,\ldots,t \sim independently\ distributed\ N^{+}(\mu, \alpha' k)$ with truncation point at zero. (16)

3. Empirical Specification

Four models were estimated in the study using the computer programme STATA 12.

Model 1 - normalized translog profit function

The normalized translog profit function for a single output was used to estimate the stochastic profit function where normalization embeds the restrictions on the parameters of the function required to achieve linear homogeneity (Khumbhakar and Lovell, 2000).

This function is:

$$\ln\frac{\pi}{p} = \beta_0 + \beta_1 \ln\frac{w}{p} + \frac{1}{2}\beta_2[\ln\frac{w}{p}]^2 + \sum_{q=1}^{2}\gamma_q \ln z_q + \frac{1}{2}\sum_{q=1}^{2}\sum_{r=1}^{2}\gamma_{qr}\ln z_q \ln z_r + \sum_{q=1}^{2}\alpha_q \ln\frac{w}{p}\ln z_p + v \quad (17)$$

Where:

π/p = normalized profit

w/p = normalized wage rate

z_1 = acreage of crop (assumed fixed)

z_2 = family labour (mandays)

From this model, the elasticities of profit with respect to crop acreage, family labour and wage rate were calculated.

Model 2 – Stochastic Profit Frontier specified as:

$$\ln\frac{\pi}{p} = \beta_0 + \beta_1 \ln\frac{w}{p} + \frac{1}{2}\beta_2[\ln\frac{w}{p}]^2 + \sum_{q=1}^{2}\gamma_q \ln z_q + \frac{1}{2}\sum_{q=1}^{2}\sum_{r=1}^{2}\gamma_{qr}\ln z_q \ln z_r + \sum_{q=1}^{2}\alpha_q \ln\frac{w}{p}\ln z_p - ineff + v \quad (18)$$

This model adds to the profit function, the one sided inefficiency term *ineff*.

Model 3 – The Augmented Stochastic Profit Frontier specified as:

$$\ln\frac{\pi}{p} = \beta_0 + \beta_1 \ln\frac{w}{p} + \frac{1}{2}\beta_2[\ln\frac{w}{p}]^2 + \sum_{q=1}^{2}\gamma_q \ln z_q + \frac{1}{2}\sum_{q=1}^{2}\sum_{r=1}^{2}\gamma_{qr}\ln z_q \ln z_r +$$

$$\sum_{q=1}^{2}\alpha_q \ln\frac{w}{p}\ln z_p + c_1 IFOUR + c_2 gender + c_3 parcels + c_4 age + c_5 yrscrop - ineff + v \quad (19)$$

where in addition to the variables described in (18), the following additional variables were included. These variables are defined as:

IFOUR = industrial / urban influence (to cater for the variables V_1 and δ)

gender = gender of farmer

parcels = number of parcels of land

yrscrop = years growing the crop

Model 4 was estimated to explain possible heteroscedasticity associated with the one-sided inefficiency error term (*ineff*). The model had the same structure as (19) except for the distribution of the error term, *ineff*, as noted earlier.

Model 5 was estimated to explain possible heteroscedasticity in the idiosyncratic error term v. The model had the same structure as (19) except for the distribution of the idiosyncratic error term *v* as noted earlier.

4. Descriptive Statistics

Descriptive statistics on the variables included in the model are given in Table 2. The dependent variable was the normalized profit of the crop, where profit was calculated as gross revenue minus the variable cost of production. Family labour was included as a fixed input and if the farmer used only used family labour, a fixed rate of $10 per man-day was used for *w*. Where labour was hired the actual hired labour wage rate was used for *w*. The variables utilized in the vector *k* are also given in Table 1. The inclusion of these variables was supported by previous research especially Bravo-Ureta and Pinhiero (1997) and Solis, Bravo-Ureta and Quiroga (2009) in the case of “education”, Bravo-Ureta and Pinhiero (1997) Hossain (1989) in the case of “age” and Adewumi and Adebayo (2008) in the case of “years growing crop” and Kalirajan and Shand (1985) in the case of “gender”.

Table 1. Descriptive Statistics of Variables (n = 106)

Variable	Mean	Standard Deviation
A. Dependent variable		
Normalized profit (π / p)	3375.37	7967.81
B. Input variables		
Crop Acreage (acres) (z_1)	4.12	3.63
Family Labour (man-days) (z_2)	241.08	230.51
Wage rate (dollars per day) (w) (nominal $10 /day family labour)	19.32	15.72
C. Farm and Farmer Characteristics*		
IFOUR	5.89	5.35
No. of parcels of land	1.30	0.59
Age of farmer	53.36	12.86
Years growing crop	18.98	13.31
Gender (male=0 female =1)	15 females (14%)	91 males (86%)

Source: Computed from Field Survey Data, 2008

Note: All dollar values are quoted in $TT, * Elements of the vector *k*. Thus the selected farmers had a single enterprise so that all inputs, costs and revenue can be attributed to that enterprise. The sample size was 106 farmers.

5. The Survey

This section will give a description of the field survey carried out in this research. First the study area is outlined, followed by a description of the sampling procedure and method of data collection. Further information on the survey can be found in Patterson-Andrews and Pemberton (2009).

5.1. The Study Area

The study was carried out in the south-western area of Trinidad, in the area surrounding the industrial centre of Point Fortin. The area is 495 square kilometers or approximately 10% of the area of Trinidad and Tobago. The study area consisted of 215 enumeration districts (EDs) with 44 EDs in the Borough of Point Fortin and 171 in the Siparia Regional Corporation where an enumeration district (ED) as defined by the CSO (2011) is "a defined geographical area comprising approximately 150-200 households". The smallest geographical area at which data can be readily access would thus be the ED.

There are 1417 agricultural holdings in the study area, with 57% of farmers involved in crop production and 23% involved in mixed farming. Small farming predominates in the area, with approximately 92% of farmers having holdings of less than 5 hectares. Of these 25% have holdings less than 0.5 hectares. 83% of farmers have had either primary or secondary education and 23% have had some level of agricultural training. The main crops grown in the study area were cassava, corn, pigeon peas and hot peppers (CSO, 2005).

5.2. Sampling Procedure and Sample Size

The survey was designed to capture *inter alia* the effects of an industrial/urban influence on the profitability of crop production. For measuring the effects of this influence, an index was developed whereby the distance from the industrialized centre as well as the population of the area in which the farmer is located were used to develop a special Index of Inverse Industrial/Urban Influence (IFOUR) for each ED, where this index is inversely related to the proximity of the ED to the industrial centre and also inversely related to the population of the area. IFOUR was constructed based on distance from the industrial center and the population density of the ED. $IFOUR_s$ for an ED_s within the study area is defined as

$$IFOUR_s = \ln [0.5(1/\theta_s) + 0.5\delta_s] \qquad (20)$$

where θ_s is the population density of the ED, measured as:

θ_s = Total population of ED_s /area of ED_s in sq. kilometers,

and δ_s is the distance of the ED_s from the industrial centre. Thus the smaller the population density of the ED and the further it was from the industrial center, the greater the value of IFOUR and the smaller the industrial/urban influence and the more "rural" the ED was.

The population examined in this study consisted of non-tree crop farmers in the Siparia Regional Corporation and the Borough of Point Fortin. A list of all non-tree crop farmers in the study area served as the sample frame. A two stage sampling procedure was used. A frequency distribution of EDs based on the IFOUR was developed. The value of IFOUR was determined for each ED. A proportional random sample of 129 EDs was drawn with the proportions based on the frequency distribution of the EDs by IFOUR.

In Stage 2 all farmers in the selected EDs growing only cassava, green corn, hot peppers or pigeon peas as their only crop were interviewed and included in the study.

5.3. Method of Data Collection

Data was collected using a structured questionnaire in face to face interviews by trained enumerators during the period July to September 2008 for the June 2007 to June 2008 cropping period. Data was collected on the socio-economic and demographic characteristics of respondents, prices of inputs and output of the crop as well as the quantity of inputs and the output and sales of the crop.

6. Results and Discussion

This section provides the descriptive statistics for the farmers and selected variables included in the empirical specification of the stochastic profit frontier. In addition, it presents the results of the estimation of the Stochastic Profit Frontier.

In Table 1, the mean farm size was found to be 4.12 acres with an average use of 241.08 man days of family labour and an average wage rate of $19.32 per day. Farms were in EDs with an average IFOUR value 5.89. The mean number of years of formal schooling of farmers was 8.81 years and they grew their crop on an average of 1.30 parcels of land. The mean age of farmers was 53.36 years and they had been growing their crop for an average of 18.98 years. There were 15 females and 91 males in the sample. As seen in Table 2, the mean acreage of the crop was 1.23 acres; with the average price of the crops as $4.60/lb with pigeon peas being the crop fetching the highest price. The average profit per crop (farmer) was $13841.09.

Table 2. Further Descriptive Statistics (n=106)

	Mean	Std. Deviation
Price per lb Crop ($TT)	4.60	2.9
Profit Crop ($TT)	13841.09	30259.2
Acreage of Crop	1.23	1.23
Distance from Industrial Centre (km)	1.81	1.137

Source: Computed from Field Survey Data, 2008

6.1. Translog Profit Function

Table 3 presents the results for the estimated profit function. Here it is seen that the translog model provides a good fit to the data as the F-test suggested the overall significance of the regression line. The wage coefficient was negative and significant in accordance with the properties of the profit function.

Table 3. Model 1 - Normalized Translog Profit Function

Number of obs	=	106.000		
F(9, 96)	=	9.770		
Prob > F	=	0.000		
R-squared	=	0.478		
Adj R-squared	=	0.429		
$\ln \pi/p$	Coef.	Std. Err.	t	P>t
$\ln w/p$	-1.435	0.602	-2.38	0.019
$h(\ln w/p)^2$	0.070	0.214	0.33	0.745
$\ln z_1$	0.346	0.517	0.67	0.505
$\ln z_2$	-1.240	0.413	-3	0.003
$h(\ln z_1)^2$	0.314	0.164	1.91	0.059
$h(\ln z_2)^2$	0.241	0.072	3.34	0.001
$h (\ln z_1) (\ln z_2)$	-0.003	0.151	-0.02	0.986
$(\ln w/p) (\ln z_{1)}$	0.320	0.158	2.03	0.046
$(\ln w/p) (\ln z_{2)}$	0.256	0.092	2.78	0.007
_cons	10.909	1.275	8.55	0

Source: Computed from Field Survey Data, 2008

6.2. Translog Profit Frontier Results

Estimates of the coefficients of the Stochastic Profit Frontier (Model 2) are given in Table 4. The coefficients for the constant, farm acreage squared and family labour squared were positive and significant, while the coefficients for the normalized wage rate and family labour were negative and significant. The significance and the values of the coefficients were more or less in line with those for the profit function in Model 1. Thus in Table 5, the estimates of the elasticities of profit are of similar magnitude and sign as those estimated for the profit function. The value of λ (σ_u / σ_v) implies that the standard error associated with the inefficiency error term is twice the standard error of the idiosyncratic error term and the 95% confidence interval suggests that this value is significantly different from zero justifying the use of the stochastic profit frontier model.

Table 4. Model 2 - Stochastic Profit Frontier

ln π/p	**Coef.**	**Std. Err.**	**z**	**P>z**
ln w/p	-1.142	0.558	-2.05	0.041
h(ln w/p)^2	0.093	0.192	0.48	0.629
ln z_1	0.461	0.471	0.98	0.328
ln z_2	-0.958	0.389	-2.46	0.014
h(ln z_1)^2	0.326	0.147	2.21	0.027
h(ln z_2)^2	0.194	0.066	2.93	0.003
h (ln z_1) (ln z_2)	0.038	0.136	0.28	0.783
(ln w/p) (ln $z_{1)}$	0.235	0.145	1.62	0.106
(ln w/p) (ln $z_{2)}$	0.193	0.089	2.18	0.029
_cons	10.952	1.195	9.17	0
/lnsig2v	-1.336	0.434	-3.08	0.002
/lnsig2u	0.094	0.371	0.25	0.8
sigma_v	0.513	0.111	0.335	0.784
sigma_u	1.048	0.195	0.728	1.508
sigma2	1.361	0.331	0.713	2.009
lambda	2.044	0.288	1.480	2.608

Source: Computed from Field Survey Data, 2008

6.3. Elasticities

In Table 5 it is also seen that the elasticity of profit with respect to wage rate was negative which again is in accordance with the properties of the profit function. The coefficients for family labour for the profit function and the stochastic profit frontier were significantly negative, though the coefficients for family labour squared were significantly negative. Overall the elasticity of profit with respect to the family labour input was positive which again conforms to expectations. The coefficient of crop acreage squared was significantly positive as was the coefficient of the interactive term with the wage rate. Thus overall the elasticity of profit with respect to the crop acreage was positive in keeping with expectations.

Table 5. Estimated Profit Elasticities for Sample Farmers

Input	Estimated Elasticity from Stochastic Profit Frontier	Estimated Elasticity from Profit Function
Crop Acreage	0.828	0.697
Family Labour	0.113	0.102
Wage Rate	-0.124	-0.129

Source: Computed from Field Survey Data, 2008
Note: *Geometric mean of data was used.

6.4. Profit Efficiency

The stochastic profit frontier was used to calculate the distribution of the profit efficiency of the sample of farmers which is presented in Table 6. The profit efficiency for farmers from the stochastic profit frontier in the study ranged between 0.136622 and 0.825919. Approximately 45% of the farmers had less than 50% profit efficiency and less than 10% of the farmers had profit efficiency greater than 75%. 10.38% of the farmers have an efficiency level of less than 25%. The mean profit efficiency of the farmers was 48.4%.

Table 6. Relative Frequencies of Profit Efficiency

Profit Efficiency (eff)	No of Farmers	Percentage of Farmers
< 0.25	11	10.38
0.25 – < 0.50	37	34.91
0.050 – <0.75	48	45.28
0.75 – 1.00	10	9.43
Total	106	(100%)
Mean Efficiency (standard deviation)	0.4841 (0.1580)	
Maximum Efficiency	0.8259	
Minimum Efficiency	0.1366	

Source: Computed from Field Survey Data, 2008

6.5. Augmented Translog Profit Frontier Results

Table 7 gives the results of the Augmented Stochastic Profit Frontier (Model 3). These results show that the age of the farmer is the only significant additional factor explaining the heterogeneity of the profit of the farmer. The results suggest that the older the farmer the lower the level of profit or the further away the farmer was from the profit frontier.

Table 7. Model 3 – Augmented Stochastic Profit Frontier

ln π/p	Coef.	Std. Err.	z	P>z
ln w/p	-1.136	0.549	-2.07	0.038
$h(\ln w/p)^2$	0.047	0.188	0.25	0.803
$\ln z_1$	0.394	0.469	0.84	0.401
$\ln z_2$	-0.952	0.387	-2.46	0.014
$h(\ln z_1)^2$	0.300	0.148	2.02	0.043
$h(\ln z_2)^2$	0.185	0.065	2.84	0.005
$h (\ln z_1) (\ln z_2)$	0.013	0.140	0.09	0.925
$(\ln w/p) (\ln z_{1)}$	0.276	0.143	1.93	0.053
$(\ln w/p) (\ln z_{2)}$	0.204	0.089	2.3	0.022
_cons	-0.006	0.015	-0.39	0.694
gender	-0.188	0.237	-0.79	0.428
parcels	0.094	0.137	0.69	0.493
age	-0.017	0.007	-2.35	0.019
yrscrop	0.008	0.007	1.16	0.246
_cons	11.692	1.311	8.92	0
/lnsig2v	-1.402	0.419	-3.35	0.001
/lnsig2u	0.038	0.358	0.11	0.915
sigma_v	0.496	0.104		
sigma_u	1.019	0.182		
sigma2	1.285	0.304		
lambda	2.055	0.268		

Source: Computed from Field Survey Data, 2008

The significance of four of the five interaction variables as well as the significance of the age variable suggests the appropriateness of the translog function as well as the augmented stochastic production frontier approach.

6.6. Heteroscedasticity in the Inefficiency Error Term (ineff) Translog Profit Frontier Results

The results for Model 4 are presented in Table 8 and show that with respect to the variables in the *k* vector only the number of years growing the crop weakly affected the variance of the one sided efficiency error term. In this model as the number of years growing the crop increased, the variance of the inefficiency error term and also the profitability of crop farming increased.

Table 8. Model 4 – Heteroskedasticity Associated with the Inefficiency Error Term

ln π/p	Coef.	Std. Err.	z	P>z
ln w/p	-1.042	0.510	-2.04	0.041
h(ln w/p)^2	0.187	0.186	1	0.315
ln z_1	0.400	0.458	0.87	0.382
ln z_2	-0.770	0.363	-2.12	0.034
h(ln z_1)^2	0.298	0.143	2.09	0.036
h(ln z_2)^2	0.164	0.063	2.59	0.009
h (ln z_1) (ln z_2)	-0.017	0.134	-0.13	0.897
(ln w/p) (ln $z_{1)}$	0.250	0.144	1.74	0.081
(ln w/p) (ln $z_{2)}$	0.154	0.080	1.92	0.055
_cons	-0.016	0.017	-0.95	0.342
gender	-0.188	0.323	-0.58	0.56
parcels	-0.026	0.154	-0.17	0.864
age	-0.017	0.010	-1.74	0.082
yrscrop	0.024	0.011	2.24	0.025
_cons	10.613	1.190	8.92	0
lnsig2v				
_cons	-0.890	0.265	-3.360	0.001
lnsig2u				
ifour	-0.121	0.120	-1.010	0.314
gender	-0.830	1.143	-0.730	0.467
parcels	-1.348	1.611	-0.840	0.403
age	-0.020	0.035	-0.580	0.563
yrscrop	0.101	0.056	1.800	0.072
sigma_v	0.641	0.085		

Source: Computed from Field Survey Data, 2008

6.7. Heteroskedasticity in the Idiosyncratic Error Term (v) Translog Profit Frontier Results

With respect to coefficients of the *k* vector the results for Model 5 in Table 9 showed that the years growing the crop significantly affected the variance of the idiosyncratic error term. The longer the farmer was growing the crop the greater was the variance.

Table 9. Model 5 – Heteroskedasticity Associated with the Idiosyncratic Error Term

ln π/p	Coef.	Std. Err.	z	P>z
ln w/p				
h(ln w/p)^2	-1.003	0.536	-1.87	0.061
ln z_1	0.195	0.199	0.98	0.327
ln z_2	0.380	0.472	0.81	0.42
h(ln z_1)^2	-0.761	0.365	-2.08	0.037
h(ln z_2)^2	0.349	0.145	2.41	0.016
h (ln z_1) (ln z_2)	0.172	0.064	2.69	0.007
(ln w/p) (ln $z_{1)}$	-0.028	0.132	-0.21	0.834
(ln w/p) (ln $z_{2)}$	0.268	0.152	1.76	0.078
_cons	0.142	0.084	1.69	0.09
ifour	-0.009	0.013	-0.69	0.492
gender	-0.065	0.198	-0.33	0.744
parcels	0.110	0.114	0.97	0.332
age	-0.015	0.007	-2.07	0.038
yrscrop	0.001	0.008	0.14	0.888
_cons	10.531	1.315	8.01	0
lnsig2v				
ifour	0.006	0.039	0.17	0.867
gender	-1.095	0.696	-1.57	0.116
parcels	-0.437	0.410	-1.06	0.287
age	-0.016	0.012	-1.35	0.177
yrscrop	0.041	0.018	2.33	0.02
lnsig2u				
_cons	-1.381	1.649	-0.84	0.402
sigma_u	0.501	0.413		

Source: Computed from Field Survey Data, 2008

7. Conclusion

A translog profit frontier function was used in this study to examine profit efficiency of small scale crop farmers. The estimates of the function showed that the farmers had a mean level of profit efficiency of 48.41% with a range of 13.66% to 82.59%. This suggests that on average 51.59% of potential profit is lost by these farmers through inefficiency.

Rahman (2003) reported a mean profit efficiency of 0.77 (range 5.9% - 83.2%) for Bangladeshi rice farmers while Tijani et al (2006) reported a mean profit efficiency of 84.34% (range 29.11% - 99.27%) for poultry egg farmers in Nigeria. Nganga *et al* (2010) found the mean profit efficiency of milk producing farmers in Central Kenya was 60%. Thus based on previous research, the profit efficiency of the farmers in this study was very low by international comparison.

The variable formulated to measure the industrial/urban influence, IFOUR, did not significantly affect the profitability. These results may imply that the positive effects of industrial/urban influence were counteracted by the additional marketing cost to sell products at the industrial/urban centre.

Proposition 2 was supported in the study by both the coefficient of the wage rate as well as the elasticity of profit with respect to the wage rate being negative. This indicates the importance of wage rates to the profitability of small scale crop production in the study.

With respect to Proposition 3, two socio-economic variables were significant in affecting the profitability of crop farming.

The age of the farmer significantly affected profitability with increasing age reducing profitability. Since the average age of farmers in the study was 53.36 years, policy measures should be implemented geared at increasing the level of youths entering the agricultural field and specifically crop production in Trinidad and Tobago.

The years growing the crop positively influenced the variance of both the one-sided error term (*ineff*) as well as the idiosyncratic error term (v) and also the profitability of crop farming.

The results of this study suggests that education and skill acquisition programmes in agriculture should be organized in the study area, especially for young people to become involved in agriculture, to enable them to maximize the use modern technology to increase profit levels in crop farming in the study area.

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