



AgEcon SEARCH
RESEARCH IN AGRICULTURAL & APPLIED ECONOMICS

The World's Largest Open Access Agricultural & Applied Economics Digital Library

This document is discoverable and free to researchers across the globe due to the work of AgEcon Search.

Help ensure our sustainability.

Give to AgEcon Search

AgEcon Search
<http://ageconsearch.umn.edu>
aesearch@umn.edu

*Papers downloaded from **AgEcon Search** may be used for non-commercial purposes and personal study only. No other use, including posting to another Internet site, is permitted without permission from the copyright owner (not AgEcon Search), or as allowed under the provisions of Fair Use, U.S. Copyright Act, Title 17 U.S.C.*

AN ESTIMATION OF THE EFFICIENT SIZE OF SUGARCANE ENTERPRISES FOR FARMERS IN TRINIDAD

Donald W. Palmer¹ and Carlisle A. Pemberton²

¹ *Lecturer, Browns Town Community College, St. Ann, Jamaica*

² *Senior Lecturer, University of the West Indies, St. Augustine, Trinidad*

Copyright 2008 by the Caribbean Agro-Economic Society.

All rights reserved. Readers may make verbatim copies of this document for non-commercial purposes by any means, provided that this copyright notice appears on all such copies.

AN ESTIMATION OF THE EFFICIENT SIZE OF SUGARCANE ENTERPRISES FOR FARMERS IN TRINIDAD

Donald W. Palmer²

Carlisle A. Pemberton³

ABSTRACT

This research paper provides an estimation of the efficient size of operation for sugarcane farmers in Trinidad. The estimates were based on a sample of two hundred and twenty-seven farmers selected from a cost of sugarcane production survey. To identify the efficient size of operation the ordinary least square estimation technique was used. The identification of the efficient size of operation allowed a test of the hypothesis that the minimum point on the long run average cost curve was significantly greater than the average enterprise size of six acres.

The long run total cost curve was estimated and the cubic functional form provided the best fit based on both the adjusted R^2 and the result from the Wald test. The results of the estimation process indicated that the optimal size was 32 acres of sugarcane and that 98% of the farmers operated at less than this size.

Keywords : cost function, cost elasticity, efficient size, sugarcane, Trinidad

² *Lecturer, Browns Town Community College, St. Ann, Jamaica*

³ *Senior Lecturer, University of the West Indies, St. Augustine, Trinidad*

1.0 THE SUGARCANE INDUSTRY OF TRINIDAD AND TOBAGO

1.1 Introduction

The growing of sugarcane and the production of sugar has a long and rich history in Trinidad. Trinidad with a population of approximately 1.3 million people employed approximately 12,200 persons in the sugar industry in 2002, also the Trinidad Sugar industry has been absorbing over 25% of the total labor of the country since 1994.

1.2 Recent Performance of the Sugarcane Industry

There have been many changes in the Trinidad and Tobago sugarcane industry, chief among these are the proposed change in the way the price of sugarcane is to be determined and the closing down of the Brechin Castle Factory. A new payment by quality scheme is to be adopted to determine the price of sugarcane. Also the Usine Ste. Madeline factory will process all the sugarcane that the country will produce. Sugarcane is an important agricultural crop produced in Trinidad and its derivative sugar accounted for approximately 40 to 50 percent of total agricultural GDP from 1994 to 2002.

Caroni (1975) Ltd., the largest single sugarcane producer has undergone many changes in its operations. The company has been

restructured and now a new company, the Sugar Manufacturing Company has been formed. The new Sugar Manufacturing Company will no longer be engaged in cane cultivation and will purchase all of its supplies from private farmers. An Estate Development and Management Company has also been established to develop and manage Caroni's 32,000 hectares of land. The vision for the new Caroni is that in the year 2004, farmers will cultivate, harvest and sell all the sugarcane that Caroni will need for the manufacturing and refining of sugar.

The land formerly owned by Caroni (1975) Limited, and now by the Estate Management Company (EMC), will be given out (leased etc.) for housing estates, industrial estates and for agriculture.

With the restructuring of Caroni, the divesting of the agricultural land and the cane farmers producing all the cane required, it has become necessary to estimate the efficient size of operation for the cane farmers. The industry foresees farmers growing all the cane. The company might give lands to former workers, to allow all the canes to be grown by farmers. The company may be faced with the situation of determining what size should they give to ensure the lowest cost of production by farmers. The efficient size of operation will give an indication of the output level that will minimize the long-run average cost of producing

sugarcane. It would be interesting to know the efficient size of sugarcane enterprise since this information can be used for the urgent land distribution policy sought by the Sugar Manufacturing Company.

1.3 Hypothesis

The output by cane farmers that would make sugarcane production efficient is unknown. Given the current enterprise mean of six acres; it is hypothesized that the optimal size of enterprise is greater than the current size of six acres.

1.4 Objectives and Scope of the Research Project.

The main objective of the research project was to estimate the efficient size of operation for sugarcane farmers in Trinidad. The specific objective of the research project was to estimate a total cost function. This function gives an indication of the minimum cost require to produce a given level of output. This will be determined from the cost function perspective, although the profit function approach could also be used to identify the optimal size of operation.

2.0 LITERATURE REVIEW

Four recent papers on the analysis of return to size were done by Salassi and Champagne (1997), Elhendy and Alzoom (2001), Alvarez and Arias

(2003) and Stefanou and Madden (1990).

Salassi and Champagne (1997) studied the cost structure and economies of size in the Louisiana Sugarcane Processing Industry. Their analytical framework provided a good theoretical basis to evaluate economies of size. Within their analytical framework was a treatment of the theoretical relationship between the firm cost and output (economies of size). Their analytical framework provided a convenient measure of economies of size by using the concept of the elasticity of the cost curves.

Elhendy and Alzoom (2001) analyzed the economics of fish farming in Sudia Arabia. Their study used cross-sectional data from 23 intensive fish farms. They estimated a cost function by using ordinary least squares and found that the minimum average cost of production occurred at 201 tonnes of talapia per year per farm.

Alvarez and Arias (2003) studied diseconomies of size with fixed managerial ability. They concluded that managerial ability is an important issue when analyzing (dis) economies of size. Economies of size can be defined as the reduction in average cost as a result of increase in firm's size. They stated that it is possible to distinguish between diseconomies of size related to an increase in size (technological diseconomies) and diseconomies of size related to low level of managerial ability

(managerial diseconomies). Technological (dis) economies is taken to mean those economies of scale that technology permits to achieve conditional on the level of managerial ability, while managerial (dis) economies are those that managerial ability permits to achieve conditional on the level of output. They concluded that increasing farm size while holding managerial ability constant could be an important source of diseconomies of size.

Stefanou and Madden (1990) provided arguments to justify the use of the cost function as opposed to the use of the profit function approach to the measuring of size economies. They argued that the cost function approach is preferred since the entire range of the average cost curve is theoretically admissible.

3.0 ANALYTICAL FRAMEWORK

3.1 Time Horizon For Decision Making In Economic Theory

Economic theory has divided the decision-making periods of firms into four main categories. These are the very short run, short run, long-run and the very long run. Resources or factors of production are divided according to the decision periods. A resource is said to be fixed if its quantity does not vary during the production period. A resource is said to be variable if its quantity is to

be varied either at the start or during the production period. All resources used are either fixed or variable. The group of all fixed resources at a particular time is often referred to as a plant (Doll and Orazem 1978).

3.2 Long Run Costs And The Shape Of The Long Run Average Cost Curve

In the long run a firm can choose the level of output of its “fixed” factors - there may be quasi-fixed factors in the long run. It may be a feature of the technology that some costs have to be paid to produce no positive level of output. But in the long run there are no fixed costs, in the sense that it is always possible to produce zero units of output at zero cost (Varian 1996).

The long-run average cost (LRAC) curve shows the minimum average cost of producing a given level of output. When all factors of production are varied, there exists a least-cost method of producing each possible level of output. Thus, with the given factor prices, there is a minimum achievable cost for each level of output; if this cost is expressed in terms of dollars per unit of output, the long-run average cost of producing each level of output is obtained. When this cost of producing each level of output is plotted on a graph, the result is called a long run average cost curve (Lipsey, Courant and Ragan 1999).

3.3 Economies of Size

Economies of size may be defined as equivalent to a falling long-run average cost curve function. Classic economies of size relate to the effect on average cost of production of different rates of output, per unit of time, of a given commodity, when all possible adaptations have been carried out to make the production as efficient as possible (Lipsey, Courant and Ragan 1999). It is assumed that, at every point on the LRAC resources are used efficiently – not only has the least-cost combination of factors been chosen but also there is no slack, or X-inefficiency (Salassi and Champagne 1997).

The shape of the long-run average cost curve can determine economies or diseconomies of size existing in a particular industry. As the size of the plant increases, economies of size will cause the long-run average cost curve to decline. Diseconomies of size, existing over a certain range of plant size, will cause the long-run average cost curve to rise (Salassi and Champagne 1997). The minimum point on the LRAC defines the optimal plant size (Doll and Orazem 1978, Lipsey, Courant and Ragan 1999).

It can also be shown that the optimal plant size, the minimum point on the LRAC, occurs where the long-run average cost curve is equal to the marginal cost (MC) curve

i.e. $LRAC (AC) = MC$

$$\text{and } AC = \frac{TC}{Q}$$

Finding the minimum of the long run average cost curve is achieved by applying the first order (necessary) optimization condition.

$$\frac{d(AC)}{dQ} = \frac{d}{dQ} \frac{TC}{Q}$$

using the quotient rule

$$\begin{aligned} \frac{d(AC)}{dQ} &= \frac{Q \cdot \frac{dTC}{dQ}}{Q^2} - TC \cdot \frac{\frac{dQ}{dQ}}{Q^2} = 0 \\ &= Q \cdot MC - TC = 0 \end{aligned}$$

$$\text{therefore } MC = \frac{TC}{Q} \text{ or } MC = AC.$$

We can determine the second – order (sufficient) condition so that the optimal point is indeed a minimum point on the long run average cost curve.

$$\text{Recall that } \frac{d(AC)}{d(Q)} = QMC - TC = 0$$

Then

$$\frac{d^2(AC)}{dQ^2} = Q \frac{d(MC)}{dQ} + MC \cdot \frac{dQ}{dQ} - \frac{d(TC)}{dQ} > 0$$

$$\text{Recall that } \frac{dTC}{dQ} = MC$$

$$\text{Therefore } Q \frac{d(MC)}{dQ} + MC - MC > 0$$

Which implies that

$$\frac{d^2(AC)}{dQ^2} = Q \frac{d(MC)}{dQ} > 0$$

Since quantity Q is positive this means that

$$\frac{d(MC)}{dQ}$$

must be positive or in other words the slope of the marginal cost curve needs to be positive where it cuts the average cost curve.

3.4 Estimation of the Model

Empirical studies of industry cost curves estimate a long-run cost curve using cross-sectional data from the industry, assuming that the same technology applies to all firms and that firms are seeking to minimize costs at each planned level of output. A cost curve estimated through regression analysis for a cross-sectional sample of firm cost-output points represents an estimate of the long-run cost curve for the industry. Most studies estimate the average cost curve by regressing average cost per unit of output over firm size, since this reduces the problem of heteroscedasticity (Salassi and Champagne 1997).

Estimation Technique

Single equation linear regression was used to estimate the cost functions using ordinary least squares.

Functional Forms for the Cost Function

Several functional forms of cost functions have been estimated in empirical studies. The more common ones, which relate cost to output, are the linear, quadratic and cubic cost functions (Intriligator, Bokin and Hsiao 1978).

The study estimated the following functional forms of the cost function.

Linear form (LRTC) = β_1 total yield(1)

Quadratic form (LRTC) = β_1 total yield + β_2 total yield²(2)

Cubic form (LRTC) = β_1 total yield + β_2 total yield² + β_3 total yield³(3)

Where LRTC is the long run total cost.

4.0 METHODOLOGY

4.1 Description of the Data

The data was obtained from a 1987 cost of sugarcane production survey conducted by the, then Department of Agricultural Economics and Farm Management, now the Department of Agricultural Economics and Extension, Faculty of Agriculture and Natural Sciences, The University of The West Indies, St. Augustine, Trinidad. The instrument used to collect the data was a questionnaire.

This data was used as this was the only available data set. A check with the Department and the various cane unions revealed that there was no other existing cost of sugarcane production survey with sufficient data points, suited for the analysis.

4.2 Analysis Of The Data.

4.2.1 Coding of the Data

The data for all the questionnaires was coded into the statistical software -- Statistical Package for Students of Social Sciences (SPSS). A sample of two hundred and twenty-seven (227) questionnaires was selected for the analysis.

4.2.2 Choice of Variables

The second step was to choose the variables which were to be included in the model, for the analysis to be carried out. The variables total cash cost and total yield were chosen from the questionnaire.

Total cash cost was obtained by adding the total of operational cost and the total of other cost. Total operational cost is the total of all the operational or variable costs including the cost for hired labour, material, chemicals, fertilizers, own vehicle and draught animal. Total other cost is the total of the fixed or overhead cost, example land and building taxes, tools, rents etc. Total yield was the tonnage of cane obtained for the 1987 sugarcane crop.

4.3 Estimation Procedure

4.3.1 Computation of the Various Descriptive Statistics

The third step was to compute various descriptive statistics for the variables, total acreage and total yield. The following measures of central tendencies and measures of variation were computed for the farmers: the mean, mode, median, range, standard deviation and sample variance (Table 1).

4.3.2 Specification and Estimation of the Econometric Model

The fourth step, in the methodology, was to specify the models. The models were specified as

$$C_i(y) = S\beta_n \text{ total yield}^n + e_i$$

Where $C(y)$ is the total cash cost

$n = 1, 2 \text{ or } 3$

$i = 1, 2, 3, 4, \dots, 227$

e_i is the i^{th} error term associated with the i^{th} the observation.

After the model was specified, the fifth step was to estimate the parameters of the model. In the estimation of the long run total cost function, total cash cost was assumed to be the dependent variable while total yield (tons) was assumed to be the explanatory variable. Various functional forms of the cost function were estimated. These included the linear, quadratic and cubic functional form. These functional forms were obtained by regressing total yield (the explanatory variable) against total cash cost (the dependent variable).

The sixth step was to test the model for the presence of homoscedasticity using the White test, test for the presence of autocorrelation using the Durbin-Watson test statistic and test for the presence of multicollinearity using the Eigenvalue - Conditional index approach.

The final step was to conduct hypothesis tests on the model. The first hypothesis was to use the t -test to test the significance between optimal or efficient enterprise size of 32 acres and the mean enterprise size of 6 acres in the survey. The second hypothesis was to test the hypothesis that b_3 in the cubic functional form was equal to zero using a Wald test.

5.0 RESULTS

5.1 Results for the Estimation Process

5.1.1 Result for the Various Functional Form for the Long Run Total Cost Curve.

Linear Form

$$\text{LRTC} = 92.36 \text{ total yield} \dots\dots\dots(1)$$

$$\text{s.e.} = (2.68)$$

$$\text{t-value} = (25.187)$$

$$\text{p-value} = (0.000)$$

$$R^2 = 0.733$$

$$\text{Adjusted } R^2 = 0.733$$

$$\text{Akaike information criterion} = 20.80759$$

$$\text{Schwarz Criterion} = 20.82268$$

$$\text{Durbin-Watson Statistics} = 2.047380$$

Quadratic Form

$$\text{LRTC} = 99.52 \text{ total yield} - 0.015 \text{ total yield}^2 \dots\dots\dots(2)$$

$$\text{s.e} = (5.61) \quad (0.01)$$

$$\text{t-value} = (17.78) \quad (-1.45)$$

$$\text{p-value} = (0.000) \quad (0.149)$$

$$R^2 = 0.736$$

Adjusted $R^2 = 0.735$

Akaike information criterion = 20.80711

Schwarz Criterion = 20.83728

Durbin- Watson Statistics = 2.030701

Cubic Form

$LRTC = 119.85 \text{ total yield} - 0.11 \text{ total yield}^2 + 0.000081 \text{ total yield}^3 \dots\dots(3)$

s.e = (9.725) (0.038) (0.000)

t-value = (12.325) (-2.844) (2.546)

p. value = (0.000) (0.005) (0.012)

$R^2 = 0.744$

Adjusted $R^2 = 0.741$

Akaike information criterion = 20.78739

Schwarz Criterion = 20.83265

Durbin- Watson Statistics = 2.047380

The estimated cubic functional form provided the best fit to the data, in that all of its parameters were significant at the 2% level of significance and also it had the highest adjusted R^2 value. The cubic functional form had the following formulation

$LRTC = 119.85 \text{ total yield} - 0.11 \text{ total yield}^2 + 0.000081 \text{ total yield}^3 \dots\dots(3')$

The following implications can be drawn from the empirical result

a) Average long-run average cost (LRAC) and long-run marginal cost (LRMC) curves.

$LRAC = \frac{LRTC}{\text{total yield}} = 119.85 - 0.11$

$\text{total yield} + 0.000081 \text{ total yield}^2 \dots(4)$

$$LRMC = \frac{dLRTC}{d\text{total yield}} = 119.85 - 0.22 \text{ total yield} + 0.000243 \text{ total yield}^2 \dots(5)$$

From Table 1, the mean of the total acreage was 6 acres and the mean of total yield was 127.67. These two figures gave a yield per acreage ratio of 21.26 tons of sugarcane per acreage. Enterprise size of 2 acreages and output of 50 tons occurred most frequently.

5.2 Economies of Size Analysis

This section presents the economies of size analysis for the data.

The level of output that will minimize marginal cost is based on the rule; the second derivative of long-run average cost with respect to total yield is equal to zero.

$$\frac{dLRTC}{d\text{yield}} = 2 \text{ } _2 + 6 \text{ } _3 = 0 \dots\dots\dots(6)$$

and this occur where

$$\text{total yield}^* = \frac{-2 \text{ } _2}{6(0.000081)} = \frac{-2(-0.11)}{6(0.000081)} = \frac{0.22}{0.000486} = 453 \text{ tons } _6 \text{ } _3$$

The level of output that would minimize per unit cost of production (and which correspond to the efficient scale) is that for which

$E_C = 1$ or which $LRMC = LRAC$
(7)

This occurs where

$$2 \text{ } _2 \text{ total yield} + 3 \text{ } _3 \text{ total yield}^2 = \text{ } _2 \text{ total yield} + \text{ } _3 \text{ total yield}^2 \text{ and gives}$$

$$\text{yield}^* = \text{ } _2 = \frac{-(-0.11)}{2(0.000081)} = \frac{0.11}{.000162}$$

$$= 679 \text{ tons(7')}$$

$$\text{ } _2 \text{ } _3$$

Graph of the Output Level That Minimizes the Long Run Average Cost Curve

The minimum of the LRAC occurs at an output level of 679 tons.i.e. the optimal enterprise size was approximately 32 acres.

5.3 Results for the Econometric Analysis of the Data

The data was tested for the presence of multi-collinearity, autocorrelation and heteroscedasticity. The result of the various tests will be presented in the following tables.

The condition index of 25.17 indicated that there was moderate to strong collinearity between total yield, its square and cube.

Result of the Test for Autocorrelation

The software computed the Durbin – Watson test statistic and found it to be 2.04738. This indicates the absence of first order autocorrelation in the data.

5.3.1 Tests of Hypothesis Within the Model

After estimating the model and conducting the various econometric tests, two tests of hypotheses were conducted. The first test of hypothesis dealt with the statistical significance of the theoretical value of 32 acres against the observed value of 6 acres. The second hypothesis dealt with the validity of restricting the b_3 co-efficient in the cubic functional form.

Hypothesis One

Null hypothesis: The minimum point of 32 acres on the LRAC is not significantly greater than the present enterprise size of 6 acres.

Alternative hypothesis: The minimum point of 32 acres on the LRAC is significantly greater than the present enterprise size of 6 acres.

The software computed the test statistics as a left tail test but taking the symmetrical distribution of the t – distribution the result is still valid. Also taking into consideration that the t –test approximates to the normal distribution, for large sample size then the T -

distribution can be used instead of the normal distribution.

Since the absolute value of 58.7 is greater than all of the table values, we will reject the null hypothesis and accept the alternative hypothesis. We will then conclude that the minimum value of 32 acres is significantly greater than the observed value of 6 acres.

Hypothesis Two

The Wald test will be used to test the significance of the b_3 co-efficient in the cubic functional form.

Null Hypothesis The co-efficient on the cubic term in the polynomial model is equal to zero

Alternative Hypothesis The co-efficient on the cubic term in the polynomial model is not equal to zero

Since the p-value of 0.01 is less than 0.05 we will reject the null hypothesis that b_3 is equal to zero. We can then conclude that the cubic functional form provides the best fit for the data when compared to the quadratic functional form. In other words the co-efficient of 0.000081 adds to the explanatory power of the model.

6.0 DISCUSSION

Discussion on the Estimation Results

The results discussed will utilize farm sizes ranging from a minimum of 0.25 acres to a maximum of 35 acres. It was

observed from the data that 1,362.83 acreages of land produced 28,981.5 tons of sugarcane. These figures gave a yield of 21.26 tons of sugarcane per acreage (Table 1). Using 679 tons as the minimum efficient size of operation and a yield to acreage ratio of 21.26, then it would require an enterprise size of approximately 32 acres to reach the maximum efficient size

Examination of the Long Run Marginal Curve revealed that a total yield of 453 tons would minimize the curve. Also it was discovered that the level of output that minimizes the average cost per unit of output was 679 tons of sugarcane (Figure 1). There were only three farms that had an average output greater than 679 tons. This implies that only three farms were experiencing diseconomies of size. From the above discussion it can be concluded that 98% of the farmers were experiencing increasing returns to size.

As can be seen from equation 3, the estimated cubic function provided the best fit for the data, in that all the parameters were significant at the 2% level of significance. The R square (R^2) value of 0.744 indicated that 74.4% of the variation of total cash cost was explained by total yield, its square and its cube. The adjusted R square value of 0.741 indicated that even after the degrees of freedom have been accounted for, 74.1% of the total variation in total cash cost was still explained by the explanatory variables.

It can also be concluded that the cubic functional form provides an adequate fit for the data, since from graph, the LRAC had a L-shape which is consistent with the theory of estimating LRAC from observations. A Wald test was conducted to verify if the b_3 co-efficient was statistically different from zero (Table 5). The result obtained indicated that it was statistically different from zero. A *t*-test was conducted to test whether or not the minimum point of 32 acres was significantly greater than the observed value of 6 acres. The conclusion was that there was a significant difference between the two enterprise sizes (Table 4).

6.2 Discussion on the Econometric Tests

Some standard econometrics tests were conducted on the data. The data was tested for the presence of multi-collinearity, autocorrelation and heterosedasticity.

The data was tested for the presence of multi-collinearity using the Eigenvalue - Conditional index approach (Table 2). The condition index was found to be 25.17. This indicated that there was moderate to strong collinearity between total yield, its square and cube values. This result was expected as the variables were all powers of the original variable total yield.

The Durbin – Watson procedure was used to test for the presence of first order autocorrelation in the data. The Durbin – Watson test statistics of 2.045 indicated that there was no autocorrelation between the observations. This result was expected, as the data used was a cross-sectional survey of sugarcane farmers and all the observations were independent of each other.

The White test was used to test for the presence of homoscedasticity (Table 3). The obs* R squared value of 78.6 and its associated p-value of 0.00 allowed us to reject the null hypothesis of homoscedasticity. Rejecting the null hypothesis of homoscedasticity allows us to accept the alternative hypothesis of a heteroscedastic variance. The presence of heteroscedasticity will yield biased estimators of the variance, however this is not a matter for major concern since we are only interested in the value of the co-efficients. The adjusted R squared value of 0.3315 indicated a poor fit for the model since after the number of explanatory variables were taken into account only 33.15% of the variation in the square of the residuals were explained by the original variables and the square of these original variables.

6.3 Concluding Statements

The study results shows that only three (3) of the farms have an output level greater than 679 tons. This implies that

only three farms sampled in 1987 may have been experiencing diseconomies of size. This further implies that the other two hundred and twenty – four (224) farmers were experiencing economies of size.

In this article, we are suggesting that 98.7% of the farmers surveyed were experiencing economies of size, i.e. 224 farmers. Our theoretical model studies the implication of increasing yield, showing that there is an optimal enterprise size that will produce the level of output which minimizes the long run average cost curve. Therefore, since the output level is below the optimal level of 679 tons, then increasing output will further reduce cost until yield reaches 679 tons.

The empirical part of the project explored the estimation of the long run total cost function and by further extension the long run average and marginal cost curves. Our model allows us to empirically identify the optimal enterprise size, which was found to be 32 acres.

The objective of this research project was to estimate the maximum efficient size of operation and this was found to occur at a yield of 679 tons per acre. This optimal level of yield translated into a sugarcane acreage of 32 acres.

BIBLIOGRAPHY

- Elhendy, M.A., E. and A. Alzoom. 2001. Economics of Fish Farming in Saudi Arabia: Analysis of Cost of Tilapia Production. Agricultural Economics Department. King Saud University. Saudi Arabia.
<http://www.uq.edu.au/aem/abstract515.pdf>
- Alvarez, A. and C. Arias. 2003. Diseconomies of Size With Fixed Managerial Ability. American Journal of Agricultural Economics 85(1): 134 – 142.
- Doll, J.P. and F. Orazem. 1978. Production Economics. Theory with Application. United States.
- Intriligator, M. 1978. Econometrics Models, Techniques and Applications, Prentice Hall Inc.
- Lipsey, G.R., P.N. Courant and C.T.S. Ragan. 1999. Economics 12th edition. Massachusetts: Addison – Wesley.
- Salassi M. and L Champagne. 1997. Cost Structure and Economies of Size in Louisiana Sugarcane Processing Industry. Research Report no. 709. Department of Agricultural Economics and Agribusiness. Louisiana State University.
- Stefanou, S.E., and J.P. Madden. 1990. Economies of Size Revisted. Journal of Agricultural Economics 39 (1): 125 – 132.
- Varian, H. 1996. Intermediate Microeconomics. Fourth edition. California. W.W. Norton and Company.

Table 1: Descriptive Statistics For the Data Set

	Total Acreage	Total YIELD (tons)
Mean	6.00	127.67
Standard Error	0.44	10.00
Median	3.00	65
Mode	2.00	50
Standard Deviation	6.67	150.65
Sample Variance	44.44	22694.68
Kurtosis	4.84	7.40
Skewness	2.16	2.41
Range	34.75	1023.00
Minimum	0.25	7.00
Maximum	35.00	1030.00
Sum	1362.83	28981.50
Count	227	227

Table 2: Result of the Test for Multi-collinearity Using the Eigenvalue – Condition Index Approach.**Collinearity Diagnostics^a**

Model	Dimension	Eigenvalue	Condition Index	Variance Proportions			
				(Constant)	Total Yield	Square of Total Yield	Cube of Total Yield
1	1	2.942	1.000	.01	.00	.00	.00
	2	.899	1.809	.18	.00	.00	.00
	3	.154	4.376	.27	.07	.00	.05
	4	4.644E-03	25.171	.55	.93	1.00	.95

a. Dependent Variable: Total Cash Cost

Table 3: Result of the Test for Heteroskedasticity Using the White Test

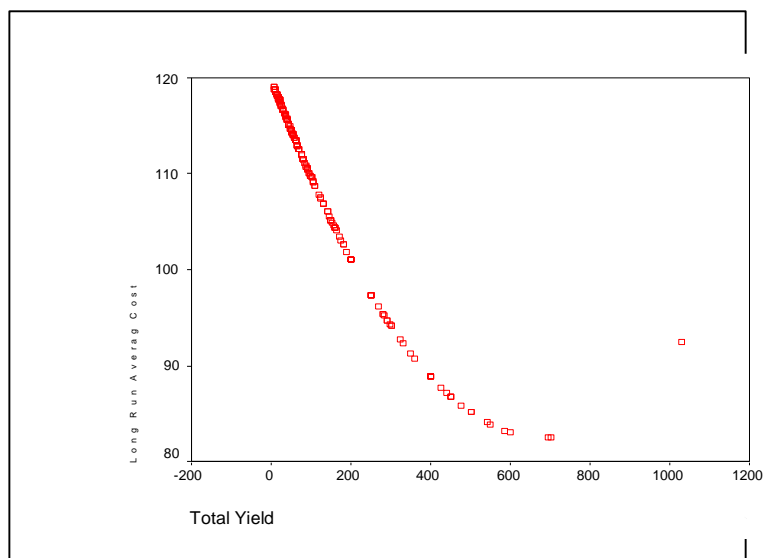
White Heteroskedasticity Test:				
F-statistic	23.41089	Probability	0.000000	
Obs*R-squared	78.60083	Probability	0.000000	
Test Equation:				
Dependent Variable: RESID^2				
Method: Least Squares				
Date: 05/20/04 Time: 22:07				
Sample: 1800 2026				
Included observations: 227				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-39408071	32126867	-1.226639	0.2213
YIELD	1834731.	980759.2	1.870725	0.0627
YIELD^2	-15679.41	7856.730	-1.995666	0.0472
YIELDSQUARE^2	-0.074029	0.022774	-3.250619	0.0013
YIELDCUBE	61.53580	22.73646	2.706481	0.0073
YIELDCUBE^2	2.58E-08	6.87E-09	3.760998	0.0002
R-squared	0.346259	Mean dependent var	60798697	
Adjusted R-squared	0.331469	S.D. dependent var	1.74E+08	
S.E. of regression	1.42E+08	Akaike info criterion	40.40979	
Sum squared resid	4.47E+18	Schwarz criterion	40.50032	
Log likelihood	-4580.512	F-statistic	23.41089	
Durbin-Watson stat	2.113418	Prob(F-statistic)	0.000000	

Table 4: Test for the Statistical Significance Between The Average Enterprise Sizes

T-Test for the Statistical Difference Between Average Farm Sizes		
Null Hypothesis	? =	32
Level of Significance		0.05
Sample Size		227
Sample Mean		6
Sample Standard Deviation		6.67
Standard Error of the Mean		0.442703449
Degrees of Freedom		226
t Test Statistic		-58.73005975
Two-Tailed Test		
Lower Critical Value		-1.970515768
Upper Critical Value		1.970515768
p-Value		7.5041E-139
Reject the null hypothesis		

Table 5: The Result for the Wald Test.

Wald Test:			
Equation: CUBIC			
Null Hypothesis: $C(3) = 0$			
F-statistic	6.482628	Probability	0.011565
Chi-square	6.482628	Probability	0.010893

**Figure 1: Graph of the Output Level That Minimizes the Long Run Average Cost Curve**