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An Econometric analysis of production functions of Tea, Tamulbari Tea Estate, Lahowal, Dibrugarh, Assam

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ABSTRACT
In this paper an attempt has been made to model production function for Tea production of Tamaulbari Tea Estate. For this data on the variables-production of Tea, capital and labour invested are collected for sixteen years. Cobb-Douglas production function and linear production functions are modelled and constant returns to scale are tested. Also, for the goodness of fit, R^2 the coefficient of determination is computed for both the models and a comparison have been made using Gujrati's method (1970). It is found that both the models are found to be satisfactory as evidenced by the coefficient of determination and significant regression coefficients. Log linear model has found to be better models compared to linear model as evidenced by the transformed coefficient of determination.

1. Introduction

Tea is the premier agro based industry in India. Now India is the second largest producer of tea, the largest consumer and the fourth largest exporter (after Srilanka, Kenya and China) in the world. Commercial tea production began only in the 1830's. The first shipment of Assam tea was shipped to England in 1838. The state of Assam is the world's largest tea growing region by production, lying on either side of the Brahmaputra River, and bordering Bhutan, Bangladesh, Myanmar and very close to China. The tea production spread to other parts of India by 1860's.India's current tea production 1244 million kgs. It has increased approximately five fold from a level of 255 m kg in 1947.Its position in the national economy is vital as a major foreign exchange earner. In addition, sizeable amount of money goes to the Government exchanger from tea industry in the form of taxes and duties. As tea plays an important role in the economy of the country, it is considered necessary to investigate its long term performances in a systematic and scientific manner. Therefore the study is being proposed to investigate the production function that describes the output of tea.

Assam Tea is grown on area of over 307000 hectares. Assam produces 675 m kilos of Tea in 2017. Assam is one of the major tea growing areas of India. So we have chosen Tamulbari Tea Estate of Asam for our investigations. Tamulbari tea estate is famous for good quality of tea in upper Assam. The product of this tea estate is well accepted among the people of this region and it has a good reputation on other parts of India also. Therefore, we felt, it is justified to undertake an investigation regarding the modelling of the Tea production.

In this paper we make an attempt to model production function of Tea production of Tamulbari tea Estate. For this data on the variables-production of Tea, capital and labour invested are collected for sixteen years. Cobb-Douglas production function and linear production functions are modelled and constant returns to scale are tested. Also for the goodness of fit, R^2 -the coefficient of determination is computed for both the models and a comparison have been made for the same.

2. Data for the Study:

We have collected "production of tea" of Tamulbari Tea estate for last sixteen years from2001 to 2016 along with labour and capital invested. All the inputs (labour and capital) in terms of money and outputs (tea production) are given in terms of kilogram.

3. Methodology and Review of Literature:

The production function is a technical or engineering relation between input and output. As long as the natural laws of technology remains unchanged, the production remains unchanged. In traditional economic theory we usually think of land, labour and capital as typical inputs and finished product as the output.

3.1 Cobb-Douglus Production Fuction (1928): The statistical investigation in to laws of production by C.W. Cobb and P.H. Douglas are among the most celebrated in the History of Econometrics. They have proposed the general production function,

$$x = An^{\alpha}K^{\beta}u \qquad (1)$$

Where x =output, n =labour input, k= Capital input, u= Random disturbance, A=efficiency of parameters, as a fairly universal law of production. The function is linear function; it can be transformed in to a linear function to converting all variables in to logarithms. In logarithms, the associated linear function is

$$\log x = \log A + \alpha \log n + \beta \log k + \log u \qquad (2)$$

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Or $x' = A' + \alpha n' + \beta k' + u'$ (2.1)

The parameters of Cobb-Douglas function, in addition to being elasticity's, possess other attributes important in economic analysis. The sum of exponents shows the degree of return to scale in production. Where

$\alpha + \beta = 1$ Constant return to scale, $\alpha + \beta < 1$ decreasing return to scale and $\alpha + \beta > 1$ increasing return to scale.

3.2 Method of Least Squares: Carl Friedrich Gauss (1795) was first defined the method of least squares has some very attractive statistical properties that have made it one of the most powerful and popular method of regression analysis.

Consider two- variable Population Regression function (PRF) as

$Y_i = \beta_1 + \beta x_i + u_i$ (3)

The PRF is not directly observable; we estimate it from the sample regression function (SRF) as

$Y_i = \hat{\beta}_1 + \hat{\beta}_2 x_i + \hat{U}_i$ (3.1)

$=> \hat{U}_i = Y_i - \hat{\beta}_1 + \hat{\beta}_2 x_i$ (4)

$$=> \sum \hat{U}_i^2 = \sum (Y_i - \hat{Y}_i)^2$$

$$= \sum (Y_i - \hat{\beta}_1 - \hat{\beta}_2 X_i)^2 \quad (3.2)$$

3.3 Testing the Linear equality in Cobb-Douglas production Function:

From equation (2)

$\log x = \alpha_0 + \alpha \log n + \beta \log k + U$

where $\alpha_0 = \log A \& U = \log U$ If there are constant return to scale economic theory suggest that,

$\alpha + \beta = 1$ (4)

This is an example of linear equality restrictions. If there are constant return to scale,i.e. (4) is valid and there are two approaches viz. T- test approach, and F-test approach

3.4 t-test approach:

Having estimated α and β , a test of hypothesis conducted by the t- test namely

$$t = \frac{(\hat{\alpha} + \hat{\beta}) - (\alpha + \beta)}{S.E.(\hat{\alpha} + \hat{\beta})}$$

$$= \frac{(\hat{\alpha} + \hat{\beta}) - 1}{\sqrt{\text{var}(\hat{\alpha}) + \text{var}(\hat{\beta}) + 2\,\text{cov}(\hat{\alpha}, \hat{\beta})}} \quad (5)$$

3.5 R^2 -Coefficient of determination:

Coefficient of determination R^2 is given by, $R^2 = \frac{ESS}{TSS}$, where ESS= Explained Sums of Squares and TSS= Total Sums of Square

3.6 Linear model and log linear model:

Here we have fitted both the models linear and log linear model in cooperating tea production as explained variable and labour and capital invested as explanatory variables. The log linear model,

$\log p = \log A + \alpha_1 \log L + \alpha_2 \log K + U$

Or $Y = \alpha_0 + \alpha_1 X_1 + \alpha_2 X_2 + U$ (6)

Where p stands for output and, $L \& K$ stands for labour and capital input respectively.

The linear model is

$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + U$ (7)

Where Y stand for output and, $X_1 \& X_2$, stands for labour and capital input respectively.

In log linear model,

$\hat{\alpha}_1 = \frac{L}{P}\frac{\partial P}{\partial L} = \frac{\partial \log P}{\partial \log L}$ and $\hat{\alpha}_2 = \frac{K}{P}\frac{\partial P}{\partial K} = \frac{\partial \log P}{\partial \log K}$ represents elasticity due to labour and capital input while in linear model, $\hat{\beta}_1 = \frac{\bar{X}_1}{\bar{Y}}\frac{\partial Y}{\partial X_1}$ and $\hat{\beta}_1 = \frac{\bar{X}_2}{\bar{Y}}\frac{\partial Y}{\partial X_2}$, represents elasticity due to labour and capital input respectively.

4. Analysis and Discussion:

4.1 log linear model:

The models have been fitted as follows:

From the collected data following results have been obtained as,

$$\bar{Y} = 5.882, \bar{X}_1 = 6.7251, \bar{X}_2 = 7.1877, \sum X_1^2 = S_{11} = .7622$$

$$\sum X_{22} = S_{22} = .3240, \sum Y^2 = S_{yy} = .0718, \sum x_1 x_2 = .4282,$$

$$\sum x_1 y = S_1 y = -.1096, \sum x_2 y = S_2 y = -.0047,$$

where $y = Y - \bar{Y}, x_1 = X_1 - \bar{X}_1, x_2 = X_2 - \bar{X}_2$ and we get the following results

$$\hat{\alpha}_1 = -0.5267, \hat{\alpha}_2 = 0.6609, \hat{\alpha}_0 = 4.6692, R^2_{y.x_1x_2} = .7607, \hat{\sigma} = .0361$$

$$S.E.(\hat{\alpha}_1) = 0.0812, S.E.(\hat{\alpha}_2) = 0.1249, S.E.(\hat{\alpha}_0) = 0.2538, Cov(\hat{\alpha}_1, \hat{\alpha}_2) = -.0085,$$

$$t_{\hat{\alpha}_0} = 9.2692, t_{\hat{\alpha}_1} = -6.4865, t_{\hat{\alpha}_2} = 5.2994,$$

Therefore the fitted log linear model as

$$Y = 4.6698 - 0.567 X_1 + 0.6619 X_2 \qquad (7.1)$$

For 95% confidence interval

$(\hat{\alpha}_0 \pm 2.16 S.E.(\hat{\alpha}_0) = (5.7580, 3.5816); (\hat{\alpha}_1 \pm 2.16 S.E.(\hat{\alpha}_1) = (-0.3502, -.07032)$ and

$(\hat{\alpha}_2 \pm 2.16 S.E.(\hat{\alpha}_2) = (0.9317, .3921)$.

For test on return to scale $|t| = 12.7552$ which is statistically significant at 5% probability level of significance. Observing the fitted production function in equation (6.1), it is seen that all regression coefficients are statistically significant and the function is well fitted as evidenced by the coefficient of determination $R^2_{y.x_1x_2} = .7607$. In other words 76.07% of variation in Y is explained by the variables X_1 and X_2. Elasticity coefficient labour and capital are -0.5267 & 0.669 respectively which are less than one. So the production is under elastic. So far as test on return to scale is concerned, the t-value is found to be statistically significant. Which indicates that null hypothesis of constant return to scale is rejected i.e. the production system provides return to scale. Here $\hat{\alpha}_1 + \hat{\alpha}_2 = 0.1352 < 1$, so decreasing return to scale is evidenced in the production system.

4.2 Linear model:

Linear model is fitted as follows,

$$\bar{X}_1 = 59.7273, \bar{X}_2 = 161.4109, S_{yy} = 24.8325 \sum X_1^2 = S_{11} = 1220.0964$$

$$\sum x_1 x_2 = S_{12} = 16482.3672, \sum x_1 y = S_{21} = -304.35 \sum x_2 y = -25.6789$$

$$\sum x_1 y = S_{21} = -304.35 , \sum x_2 y = -25.6789$$

where $y = Y - \bar{Y}, x_1 = X_1 - \bar{X}_1, x_2 = X_2 - \bar{X}_2$ and we get the following results

$$\hat{\beta}_1 = -0.0439, \hat{\beta}_2 = 0.0129, \hat{\beta}_0 = 8.3103, R^2_{y.x_1x_2} = .0.5217, \hat{\sigma} = .9853$$

$$S.E.(\hat{\beta}_1) = 0.0170, S.E.(\hat{\beta}_2) = .0108, S.E.(\hat{\beta}_0) = 1.3385, Cov(\hat{\alpha}_1, \hat{\alpha}_2) = -0.001$$

$$t_{\hat{\beta}_0} = 6.2087, t_{\hat{\beta}_1} = --2.5824, t_{\hat{\beta}_2} = 1.1944,$$

Therefore the fitted linear model is

$$Y = 8.3103 - 0.0439 X_1 + 0.0129 X_2 \qquad (7.1)$$

For 95% confidence interval

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$(\hat{\beta}_0 \pm 2.16 S.E.(\hat{\beta}_0) = (11.2015, 5.4191); (\hat{\beta}_1 \pm 2.16 S.E.(\hat{\beta}_1) = (-0.0072 - .0806)$ and

$(\hat{\beta}_2 \pm 2.16 S.E.(\hat{\beta}_2) = (0.0362, -0.0104)$.

For test on return to scale we get the value of $|t| = 73.6429$, which is statistically significant at 5% probability level of significance. From the fitted linear model (7.1) we have seen that all regression coefficients are statistically significant and the model is moderately fitted as evidenced by the coefficient of determination $R^2_{y.x_1x_2} = 0.5247$. In other words 52.4% of variation in Y is explained by the variables X_1 and X_2. Elasticity coefficient labour and capital are -0.334 & 0.2680 respectively and both are less than one. So the production is under elastic. So far as test on return to scale is concerned, the t-value is found to be statistically significant. Which indicates that null hypothesis of constant return to scale is rejected i.e. the production system provides return to scale. Here, $\hat{\beta}_1 + \hat{\beta}_2 = -0.0694 < 1$ so decreasing return to scale is evidenced in the production system.

5. Comparison:

For comparisons of two models a criteria developed by Gujrati, D.N. (1970) is used wherein transformed R^2 is used. From the calculation we have found that $r^2 = 0.5417$ and $R^2 = 0.7607$, so log linear model gives better fit to the production data compared to that given by linear model

6. Conclusion:

In this paper we have fitted tea production function for Tamulbari Tea Estate using log linear model and linear model. Both the models have been fitted using output as explained and labour & capital as explanatory variables. Both the models found to be satisfactory as evidenced by coefficients of determination and significant regression coefficients. Log linear model has been found to be better model compared to linear model as evidenced by the transformed coefficients of determination. transformed coefficients of determination has been used because explained variable in the two models are in different scales viz., in log linear explained variable in log scale while in linear model explained variable is free of log scale. Also recalling the standard error of regression, we have seen that S.E. of regression in log linear model is 0.0361 while in linear model S.E. is 0.9853, therefore it is clear that log linear model yields precise estimates compared to linear model. So we may whip away to conclude that log linear model is better fitting model for tea production of Tamulbari Tea estate.

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