A CASE STUDY OF
PRODUCTION BEHAVIOUR OF PETROLEUM INDUSTRY
OF ASSAM

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Introduction

Assam has a unique historical distinction with regard to the process of industrial development like some other States of the country like Maharastra and West Bengal. In fact, the base for industrial development of the State was started with the establishment of tea plantation and oil industry in the upper Assam area as were the cases of Maharsatra and West Bengal in regard to cotton textile and jute textile industries respectively. Although the rate of process of industrial development in Assam is slow compared to many emerging States like Gujarat, Haryana, etc. in spite of that the petroleum industry has made significant contribution to the process of industrial development in the State.

The petroleum crude oil in the country was first discovered in 1866 in and around Digboi and Naharkatia in upper Assam and consequent upon it, a refinery was established in Digboi under Assam Oil Company in 1901, a then British Company responsible for exploration and production of petroleum product in Assam.

The percentage contribution of Petroleum Industry towards Gross State Domestic Product ranges between 8 to 10 percent. (Report, Indian Bureau of Mines, Nagpur, 2005)

Petroleum Sector in Assam provides direct and indirect employment to about 10,000 people. It may be noted that the direct employment of BRPL was 1723 in 2005-06. But indirect employment generation in the State as well as in the rest of the country in several times more than the direct employment due to linkage effects. Moreover, backward and forward linkages of the petroleum refining sector as a whole on the aggregate economy of Assam is quite significant. (Govt of Assam, Report, 1990)

At present, there are four Refineries in the State – Digboi Refinery, Guwahati Refinery, Bongaigaon Refinery and Numaligarh Refinery.

The first commercial activity of the refinery started with the despatch of the first batch of Kerosene to the market in January 1902.

Digboi Refinery was entirely rebuilt in 1923. Simultaneously, the oil field production and refinery capacity increased. Ultimately Digboi emerged into a cost efficient commercially viable unit.

Establishment of another new refinery became necessary after discovery of new crude oil fields in the District of Sibsagar in upper Assam. The second refinery was commissioned at Noonmati area of Guwahati in 1961 and managed by Indian Oil Corporation (IOC) with the refining capacity of 1 MMTPA (million metric tonnes per annum).

Bongaigaon Refinery & Petrochemicals Limited (BRPL), the third refinery in Assam was set up as Public Sector Limited Company in January 1972 and was commissioned in 1974 with headquarter at Dhaligaon in the old Bongaigaon District of Assam, with the refining capacity of 2.35 MMTPA.

Again the Government of India set up the 4th Refinery in Assam at Numaligarh under Golaghat district of Assam. This new company, Numaligarh Refinery Limited (NRL) was set up in 1993 with the refining capacity of 3 MMTPA.

Statement of the Problem :

Bongaigaon Refinery and Petrochemicals Limited (BRPL) has unique distinction compared to other three oil refineries in Assam as well as rest of the country. All the other three refineries, namely, Digboi, Guwahati and Numaligarh have only refining facilities of crude oil. But besides refining crude oil, BRPL has large petrochemical units. BRPL provides raw materials for growth of a large number of downstream industries based on its petrochemical units. This unique distinction of BRPL as refinery cum petrochemical complex among the Indian refineries has drawn our attention to make an in depth study of the production behaviour of the Refinery.

Thus, BRPL has the unique distinction of being the first refinery in the country integrated with a petrochemical complex. Besides it is the only Public Sector Company which provides Polyster Staple Fibre starting from refinery crude oil down to paraxylene, Dimethyl Terephthalate (DMT) and Polyster Staple Fibre (PSF) Production in a single chain. Besides, BRPL did select the most modern technology from the world reputed process licensers for its petrochemicals as well as Polyster Staple Fibre (PSF) Plant.

Another factor which tempted to choose BRPL among the refineries of Assam for our study is that it is one of the high profit making refinery.

In 2005-06, profits before tax and profits after tax of BRPL are Rs. 267.27 crores and Rs. 174.26 crores respectively.

The refinery consists of Crude Distillation Unit (CDU), Kerosene Treating Unit (KTU), Delayed Coker Unit (DCU), Coke Calcination Unit (CCU).

The Petro Chemicals units are –

(i) Xylene Plant

(ii) Dimethyl Terephthalate (DMT)

(iii) Polyster Staple Fibre (PSF)

Objective :

The object of the study is to analyse the production behaviour of BRPL in terms of productivity, rate of return, economic efficiency etc. using three standard production functions like Cobb – Douglas (C-D) production function and Constant Elasticity of Substitution (CES) production function.

Hypothesis :

The hypothesis of the study is that the refinery is running under increasing returns to scale with high economic efficiency.

Methodology :

The production behaviour of BRPL is investigated with the help of production function. In this study production functions, namely, Cobb-Douglas (C-D) production function and Constant Elasticity of Substitution (CES) production function are applied in our empirical investigation.

The usual Cobb-Douglas production function in the form

$$Q = AK^{\alpha}L^{\beta}e^{u}$$

where, Q, K and L denote output, capital and labour and A, α and β are the parameters and u is random variable, is used in the estimation of the production behaviour of BRPL. Parameters are estimated using the Least Square Method after logarithmic transformation of the variables. (Cobb C.W. & Douglas P.H., 1928)

The generalized form of Constant Elasticity of Substitution production function developed by Arrow, Chenery, Minhas and Solow,

$$Q = A[\delta K^{-\rho} + (1-\delta)L^{-\rho}]^{-\theta/\rho} e^{u}$$

where Q, K and L have the same meaning as in the case of C-D production function, has been used in our empirical investigation. The CES production function has been estimated adopting Kmenta's method. (Kmenta, 1986)

The status of production of BRPL in recent years has been furnished in the Table (1)

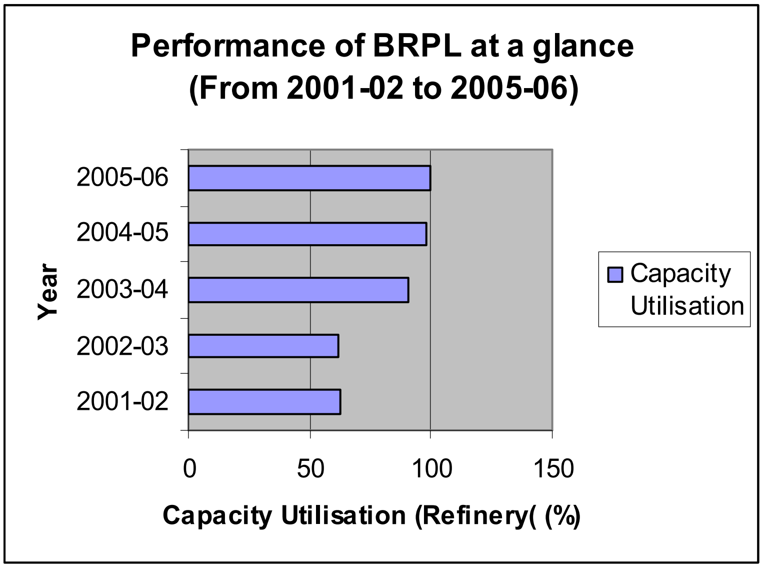
Table 1

Performance of BRPL at a glance (From 2001-02 to 2005-06)

Year ended 31 March	**2001-02 Rs. Lakh**	**2002-03 Rs. Lakh**	**2003-04 Rs. Lakh**	**2004-05 Rs. Lakh**	**2005-06 Rs. Lakh**
Crude throughput (Refinery) (MMT)	1.475	1.463	2.127	2.311	2.356
Capacity Utilisation (Refinery) (%)	63	62	91	98	100
Distillate yields (Refinery) (%)	81.2	82.8	85.8	84.1	89.5
Fuel Loss (Refinery) (%)	6.5	6.5	5.6	5.5	5.4

Source : 32nd Annual Report 2005-06, BRPL

The following bar diagram depicts the increasing capacity utilization of BRPL.



Highlights of Physical Performance :

- The percentage of capacity utilization in BRPL is satisfactory in recent years. In 2005-06, 100% capacity utilization creates a record in the history of BRPL.
- The refinery processed 2.35million tonnes of crude oil in 2005-06 which is also remarkable.
- In 2005-06, there is lowest fuel & loss of 5.4% on crude throughput. Previous year fuel & loss was 5.5%.

In 2001-02 distillate yields of the refinery was 81.2%, which again shows satisfactory yield i.e. 89.5% in 2005-06.

From above analysis it is found that the physical performance of refinery is most satisfactory in the year 2005-06.

Review of Literature on Empirical Production Function:

A good deal of analytical literature exists at broad levels like comprehensive analysis of various industries. But few empirical studies have been carried out relating to the production behaviour of specific industries. Some studies relating to the production behaviour of industries are :-

Recently a number of authors like Buck and Atkins (1976), Dixon and Thirlwall (1975), Tooze (1976) have fitted Constant Elasticity of Substitution (CES) production function to regionally differentiated census of production data for U.K. manufacturing industries. The estimated values of parameters of these production functions especially the value of the elasticity of substitution (σ) have been used both in the analysis of regional problems and as a basis for regional policy recommendations. These authors have used a well known relation of the CES production function to estimate σ. The relation is –

$$\text{Log}\left(\frac{Q}{L}\right) = a + \sigma\ \text{Log}\ \frac{\delta Q}{\delta L} \quad \text{-----} (1)$$

where Q represents net output and L represents labour inputs. On the assumption that output prices do not vary between regions and that firms pay labour its marginal physical product, equation (1) can be transformed into the estimation equation –

$$\text{Log } q = b + \sigma \text{ Log } w \qquad \text{--------} \quad (2)$$

where q represents the value of net output per employee and w represents earnings per employee.

Pokorney (1993) used Cobb-Douglas (C-D) production function for the estimation of behaviour of U.K. coal- mining industry. He used a time series data over the period 1964 to 1980.

There have been many applications of C-D production function to individual industries. An interesting contribution based almost completely upon engineering data in the metal machine industry is a study by Kurz (1963).

A study on cross-section production functions and the elasticity of substitution in American manufacturing industry was done by C.E. Ferguson (1963). The author used international data from 19 countries and 24 industries to fit this regression. The author used Arrow, Chenery, Minhas, Solow (ACMS) model. He found that the elasticity of substitution between capital and labour in manufacturing industry was less than unity.

A study on production functions for Australian manufacturing industries was done by W.T. Burley (1973). This paper takes as its point of departure the Arrow, Chenery, Minhas, Solow (ACMS) (1958) time series estimation of the side relationship of the CES production function and proposes an energy measures of capital namely, horsepower.

Another well known cross section study is by Hilderbrand and liu (1965). Though they took a C-D production function but allowed an important modification. The parameters α and β are taken to vary over the cross section and depends on the quality of capital and labour. Their model is –

$$Q = AK^{\alpha\ (InRi)}\ L^{\beta(InSi)}\ \varepsilon_i$$

where Ri and Si are the measures of quality of capital and labour respectively.

Nerlove (1963) also used cross section data to study the behaviour of US electric supply industry. He studied the returns to scale of the industry.

Dhrymes (1965) did some extensions and facts for the CES class of production functions.

An alternative estimates of the elasticity of substitution – an inter-metropolitan CES production function analysis of U.S. manufacturing industries, 1958-1972 was prepared by Christos C. Paraskevopoulos (1979).

Clague (1967) did an international comparison of industrial efficiency between Peru and U.S. by fitting CES production function. The study is important in the sense that the careful studies on inter-country differences in productivity are few in number. The study measured the efficiency parameters of eleven manufacturing industries in Peru and the U.S.

Another related work on the efficiency of cotton textile industry in various countries was carried out by the Economic Commission for Latin America (1950).

Similarly, attempt was made by Health (1957) to measure the efficiency of a group of industries taken together in Canada and Britain, by fitting C.D. production function.

Ashraf (1986) in one of his studies fitted CD production function for different Indian industries. The importance of the study is that the selections of variables were done on the ground that the model should not emphasize only on the demand side or supply side factors, e.g. in one of the models, output is taken to depend not only on industrial power but also on the per-capita income.

Mohanty (1986) exploited C-D type production function to see the behaviour of the small scale industries of Orissa. Mohanty took time series data for five years only from 1976-77 to 1980-81 to estimate the C-D production function, but the study has a limitation of very smaller degrees of freedom.

Edward J. Mitchell (1968) presented a production model with two labour inputs explaning the international pattern of labour productivity and wages.

Thus, keeping in view different production functions used to study the production behaviour of industries, we have adopted the appropriate production functions to suit our data for empirical study of BRPL.

Regression Analysis:

The Cobb- Douglas production function of the following form has been estimated

$$Q = AK^{\alpha} L^{\beta} e^{u}$$

Q = Output produced by the industry BRPL, K = Capital, L = Labour,

α, β and A are parameters and u is disturbance term.

Data of 0utput., Labour and Capital have been collected for 16 years. i.e. from 1990-91 to 2005-06.

Table 2

Estimated Results of Cobb-Douglas (C-D) Production Function of BRPL

Regressor	Co-efficient	t- ratio
Constant	93.901	-
Capital	1.009	2.806*
Labour	2.384	3.042*

$R^2 = .71$ $\bar{R}^2 = .66$

Degrees of freedom = 13

* significant at 5% level

F = 15.535, significant at 5% level

The estimated results for BRPL shown in the table 2. Elasticity of output with respect to capital (α) and elasticity of output with respect to labour (β) are 1.009 and 2.384 respectively. Since $\alpha + \beta > 1$, the industry is operating under increasing returns to scale. It implies that proportionate rise in output is larger than proportionate rise in capital and labour inputs. The hypothesis of increasing returns to scale is accepted.

The efficiency parameter A is equal to 93.901 implying high economic efficiency of the industry. One of the hypotheses is of our study is that the industry is operating under high level of economic efficiency.

Hence, the hypothesis is accepted. From the statistical point of view the estimated regression line fit the data well because R^2 and $\bar{R}^2$ value found to be .71 and .66 respectively. That is 71% variation of output is explained by the regressors.

It is found that Variance of Inflation Factor (VIF) is 2. Since VIF is less than 10, there is no severe multicollinearity problem.

The Durbin – watson d statistic is found to be 1.78 implying no autocorrelation.

<u>Estimated Constant Elasticity of Substitution (CES) Production Function</u>

The CES production function of the following form has been estimated for the BRPL –

$$Q = A\,[\delta K^{-\rho} + (1-\delta)\, L^{-\rho}]^{-\theta/\rho}\, e^{u}$$

Where Q is the output produced by BRPL, K is capital, L is total labour employed, δ, θ, ρ and A are parameters and u is the disturbance term. To estimate the above regression equation for BRPL time-series data (period) has been taken into consideration.

The estimated CES production function for BRPL is –

$$\text{In } Q = (11.711) \text{ In } K + 8.085 \text{ In } L + 2.027 (\text{In } K - \text{In } L)^2$$

$R^2 = .84$ $\bar{R}^2 = .81$

F = 21.688, significant at 5% level

Table 3

Estimated Results of CES Production Function of BRPL

A	55.334
δ	3.23
ρ	.155
θ	3.626

For BRPL, the distribution parameter δ is estimated 3.23 and substitution parameter ρ = .155. Hence substitution between capital and labour is 1/(1 +ρ) = .865, which is smaller than unity implying relatively inelastic. Again,θ indicating returns to scale is estimated at 3.626 implies that BRPL is operating under increasing return to scale. The proportionate rise in output is larger than the proportionate rise in capital and labour inputs. Hence the hypothesis of increasing returns to scale is accepted. R^2 and $\bar{R}^2$ are found to be .84 and .81 implying good fit. F statistic is also found to be significant. For BRPL, the efficiency parameter (55.33) is found to be very high implying high level of economic efficiency i.e. the industry is operating with good management and satisfactory technical efficiency. Thus the hypothesis of high economic efficiency is accepted.

The hypothesis of the study is tested by using two production functions i.e. Cobb-Douglas (C-D) production function and Constant

Elasticity of Substitution (CES) production function. In the estimation of these two production functions, we get that the Industry is running under increasing returns to scale with high economic efficiency. The high economic efficiency is seen implying efficient management as well as high technical efficiency. That is, hypothesis is found to be true.

In view of the shortfall in crude oil production in the North East Region vis-à-vis the available refining capacity, the allocation of Ravva crude oil to BRPL is vital for the economic operations of the oil refineries in the North East. This is helping the north east refineries including BRPL to achieve better capacity utilization.

Implementation of improved quality specification Bharat Stage-II for HSD (High Speed Diesel) and MS (Motor Spirit) has commenced from 1st January 2005. Bharat Stage-III (Euro III equivalent) specifications for HSD and MS have come into force from April 2010.

Besides, BRPL has established a Diesel Hydro treatment facility to meet Euro – III/IV quality specification. Motor Spirit (MS) produced at BRPL's refinery conforms to Bharat Stage-II specifications. However for meeting BS-III specification of MS, which is effective from April, 2010 and to lower the production of demand limited Naptha, BRPL has initiated action to implement MS Maximisation & Quality Upgradation Project.

The company is engaging a consultant to study its petrochemicals business to determine the future course of action.

Conclusion : The Board of Directors of BRPL in their meeting held on 7th July, 2005 had approved in principle the merger of the company with holding company Indian Oil Corporation Limited. Further steps are being taken in this direction. It is expected that merger will lead to synergic benefits resulting in improvement in group's profitability.

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Reference:

01. Alam K. (1987) — *The Development Experience in Assam*, **Dutta Barua & Co., Guwahati**

02. Allen R.G.D. (1959) — *Mathematical Economics,* **Macmillan, London**

03. Arora R.C. (1978) — *Industry and Rural Development*, **S. Chand & Company Ltd., New Delhi**

04. Barthwal R. R. (1998) — *Industrial Economics*, **New Age Industrial (P) Ltd., New Delhi.**

05. Baruah S. &. Dowerah R. (1978) *A Comparative Study of Production Function of a Few Manufacturing Industries of Assam and India as a whole.* **North Eastern Economic Review, Vol-II.**

06. Bhasin V. K. & Seth V.K.(1980) *Estimation of Production Functions for Indian Manufacturing Industries,* **Indian Journal of Industrial Relations, Vol-15.**

07. Bhatia R. J. (1954) *The Production Function for Indian Manufacture,* **1948. Journal of Bombay University, Voll-22**

08 Christensen L.R., Jorgenson D.W & Lau.L.J.(1973) *Transcendental Logarithmic Production Frontiers*, **Review of Economics and Statistics, 55**

09 Cobb C.W. & Douglas P.H. (1928) *A Theory of Production*, American **Economic Review, Suppl., Vol. XVIII**

10 Desai Meghnad (1955) *Applied Econometrics,* **Mc Graw Hill Inc. New York**

11 Dhrymes P.J. (1965) *Some Extensions and Tests for the CES Class of Production Functions,* **The Review of Economics and Statistics, November**

12 Douglas P.H. (1948) *Are there Laws of Production?* **American Economic Review, Vol XXXVIII**

13 Frish Ragnar (1965) *Theory of Production,* **D. Reidel Publishing Co. Holland**

14	Green (2003)	*Econometric Analysis,* **Pearson Education, Singapore**
15	Griliches Zvi & Mairesse Jacques (1998)	*Production Functions: The Search for Identification, in. Griliches Z. (ed.), Practicing Econometrics*, **Edward Elgar, U.K.**
16	Griliches Zvi (1998)[a]	*More on CES Production Functions, Practicing Econometrics, in Griliches Z. (ed),* **Edward Elgar, U.K.**
17	Gujrati D. N. (1995)	*Basic Econometrics,* **Mc Graw Hill Inc. Sigapore.**
18	Johnston J. (1984)	*Econometric Methods,* **McGraw Hill Book Company, New York.**
19	Klein Lawrence R. (1974)	*An Introduction to Econometrics,* **Prentice Hall of India Pte, Ltd., New Delhi.**
20.	Kmenta Jan (1986)	*Elements of Econometrics,* **Macmillan, New York.**
21	Leontief W. W. (1968)	*Input-Output Analysis,* **New Ed, Vol.7, Macmillan**
22	Maddala G.S. and Miller Ellen (2004)	*Microeconomics Theory and Applications,* **Mc Graw Hill Book Company, New York**
23	Revankar N. S. (1971)	*A Class of Variable Elasticity of Substitution Production Functions,* **Econometrics, 39**

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