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ESTIMATION OF RETURNS TO SCALE AND TECHNICAL CHANGE : A CASE STUDY IN BOKAJAN CEMENT INDUSTRY, ASSAM

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Abstract

This paper attempts to study the performance of Bokajan Cement Industry in Assam in terms of Returns to Scale that are operating therein. It also aims at measuring the technical change in the industry by using the Production Function approach.

Key words: Cobb-Douglas production function, Returns to scale, Technical change.

1. Introduction

Assam continues to make efforts for gearing up industrial activities not only by harnessing the untapped resources available in the state through various growth inducing factors but also taking steps for removal of existing infrastructure inadequacies. Assam is widely known for its abundant mineral resources. The exploitation of minerals in the state comprises of mainly Petroleum (crude), Natural Gases (Utilised), Coal, Limestone etc. Since, industry is the backbone of our economy. So, it has a large potential for developing mineral based industries, viz., Oil Industry, Natural Gas Industry, Coal Industry, Cement Industry etc.

Limestone is the basic raw material required for production of cement. It is available at Dillai Parbat in Karbi Anglong district in the state of Assam. So, with this available raw material, Bokajan Cement Factory occupies a place of prestige in the state of Assam. The foundation stone of Bokajan Cement Factory was laid on 17th January, 1971 by the then honourable President of India Sri Fakharuddin Ali Ahmed. Since its inception, Bokajan Cement Industry has a long association with Assam and it has been playing a significant role in transforming the economy of the region. And so far as our knowledge goes, no econometric study has been conducted on the production process of such a major industry in this region. So, an attempt has been made in this paper to study the production behaviour of the Bokajan Cement Industry with the aid of advance econometric tools that would be helpful to point out the necessary recommendations and suggestions for further study to improve the production of Bokajan Cement industry.

In this context, it is proposed to investigate the nature of returns to scale that are operating in the industry and it is also proposed to measure the technical change in industry by the production function approach.

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The growth of output of an individual unit takes place apart from that occurring due to input factors. These types of changes in output take place due to technological change. Originally, M. Abramoviz (1956) explained growth of output in US economy with the help of this kind of study.

Murray Brown (1966) classified technical changes into neutral and non-neutral. A neutral change does not affect factors of production, i.e., it has no effect on the marginal rate of substitution of capital for labour and hence for a given ratio of factor prices does not influence the proportions in which capital and labour inputs are combined. Thus, such technical progress does not affect the capital or labour intensity of the productive process. On the other hand, a non-neutral change alters the production relation. It can be either labour saving or capital saving.

Solow (1957) provided a relatively extreme study of how technical progress might be handled and shifts in the aggregate production function separated from movements. He devised to measure technical change by specifying a simultaneous equation system. He used production function approach by considering some assumptions-

(i) The production function is of Coob-Douglas type.

(ii) The factors are paid according to their marginal products.

(iii) There is a constant returns to scale.

(iv) The technical progress is neutral type.

2. Models and Methodology Adopted

The most widely used production function for measuring returns to scale is Cobb Douglas (CD) Production Function. The general form of Cobb-Douglas Production Function is given by

$$Q = AL^{\alpha}K^{\beta}U \qquad (2.1)$$

Where, Q = output, L = labour input, K = capital input, A = constant, U = disturbance term, α and β are positive parameters.

Writing in log form, the equation becomes

$$\log Q = \log A + \alpha \log L + \beta \log K + \log U \qquad (2.2)$$

Under constant returns to scale, the economic theory would suggest that

$$\alpha + \beta = 1 \qquad (2.3)$$

Equation (2.3) is known as linear equality restriction.

If we use (2.3), we can write the CD Production function as

$$\log(Q/L) = \log A + \beta \log(K/L) + \log U \qquad (2.4)$$

Now, following the Restricted Least Squares (RLS) technique, F-test can be applied to test the relation (2.3), where the F- statistic is defined as

$$F = [(RSS_R - RSS_{UR}) / m] / [RSS_{UR} / (n-k)] \sim F(m, n-k) \qquad (2.5)$$

Where,

RSS_R = Residual Sum of Squares of the restricted regression

RSS_{UR} = Residual Sum of Squares of the unrestricted regression

m = no. of linear restrictions

k = no. of parameters in the unrestricted regression

n = no. of observations

Now to measure the technical change, following Solow (1957), the production function can be written as

$$Q = A(t)\,F(K,L) \qquad (2.6)$$

Where, K and L represents capital and labour respectively and the multiplicative factor A(t) measured the cumulated effects of shifts in the function.

Under constant returns to scale (2.6) may be written as

$$Q/L = A(t)\,F(K/L,\,1)$$

$$\text{or} \quad q = A(t)\,f(k) \qquad (2.7)$$

Where, q and k are output per unit of labour and capital per unit of labour respectively. Changes in output per unit of labour over time are therefore the result of either neutral technical change or of increase in capital per unit of labour.

Taking the total differential of (2.8) w.r.t. time, by letting,

$$q' = dq/dt \qquad k' = dk/dt \qquad A' = dA(t)/dt$$

$$q' = A' f(k) + \frac{\delta q}{\delta k} \cdot k' \qquad (2.8)$$

dividing (2.8) by q leads to an expression for the proportionate rate of change in output per unit of labour

$$\frac{q'}{q} = \frac{A'}{A(t)} + \frac{\delta q}{\delta k} \cdot k' \qquad (2.9)$$

Solow assumes that factors are paid their marginal products, so that

$$\frac{\delta q}{\delta k} = \frac{\delta Q}{\delta K} = \frac{m}{p} \qquad (2.10)$$

Equation (2.9) can be written as

$$\frac{q'}{q} = \frac{A'}{A(t)} + \left(\frac{mk}{pQ}\right) \cdot \frac{k'}{k} \qquad (2.11)$$

$$\text{or} \quad \frac{\Delta q}{q} = \frac{\Delta A(t)}{A(t)} + \beta \frac{\Delta k}{k} \qquad (2.12)$$

Where, $\beta = \frac{mk}{pQ}$ and Δ's are the discrete approximation to time derivatives. Using this relationship, the quantity $\frac{\Delta A}{A(t)}$ can be estimated for each year. This is an index of technical change, measuring the proportionate change in output per unit of labour.

Solow assumed that there is a fixed share of capital (β) in the output per head. Hence, β coefficient has been calculated by fitting the function

$$\frac{Q}{L} = A\left(\frac{K}{L}\right)^{\beta} \qquad (2.13)$$

i.e., taking labour productivity is a function of net capital per unit of labour, β indicates that if we increase capital per unit of labour (K/L) or capital intensity by one percent, the labour productivity would rise by β percent.

Applying the above methodology, we have calculated A(t) series for the cement industry by taking A(1988=1) and by using the fact that

$$A(t+1) = A(\tau)\left[1 + \frac{\Delta A(t)}{A(t)}\right] \qquad (2.14)$$

The data used for this study have been collected from the official records of the concerned industry for the period 1988-2008.

3. Results and Discussion

Estimation of Cobb-Douglas Production Function

The fitted CD production function is

$$\log Q = .484 + .485^{*} \log L + .625^{*} \log K \qquad (3.1)$$

$$(1.639) \quad (.137) \quad (.287)$$

$R^2 = .786$ $\quad \bar{R}^2 = .761$ $\quad F = 31.306$

$RSS_{UR} = .569$ $\quad d = 1.362$

*indicates significant at 5% probability level.

Figures in the bracket indicate standard error of respective coefficient.

It is seen that the value of R^2 is high indicating the fit of the model is quite well. Again, the output - labour elasticity is about .485 and the output - capital elasticity is about .625 which are significant at 5% probability level. If we add these coefficients, we obtain 1.11, suggesting that the Bokajan Cement Industry during the study period was experiencing increasing returns to scale. Also, the Durbin-Watson d-statistic indicates that there is no 1st order positive autocorrelation in the regression.

To see if that is the case, let us impose the restriction of constant returns to scale, and

Table 1 : Values of A(t) series over the period.

Year	Output (Q)	Labour (L)	Output per unit of labour (Q/L)=q	Δq	$\frac{\Delta q}{q}$	Capital (K)	Capital per unit of labour (K/L)=k	Δk	$\frac{\Delta k}{k}$	$\beta\left(\frac{\Delta k}{k}\right)$	$\frac{\Delta A(t)}{A(t)}$	A (t)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
1988-1989	1243.89	191.29	6.5026	-	-	1242.03	6.4929	-	-	-	-	1.0000
1989-1990	2373.68	212.37	11.1771	4.6745	0.4182	1340.05	6.3100	-0.1829	-0.0290	-0.0142	0.4324	1.4324
1990-1991	2027.66	240.58	8.4282	-2.7489	-0.3262	1237.02	5.1418	-1.1682	-0.2272	-0.1111	-0.2151	1.2173
1991-1992	2180.09	283.31	7.6951	-0.7331	-0.0953	1428.23	5.0412	-0.1006	-0.0200	-0.0098	-0.0855	1.1318
1992-1993	2299.98	308.34	7.4592	-0.2358	-0.0316	1798.48	5.8328	0.7916	0.1357	0.0664	-0.0980	1.0338
1993-1994	3185.59	328.05	9.7107	2.2515	0.2319	1903.58	5.8027	-0.0301	-0.0052	-0.0025	0.2344	1.2682
1994-1995	3595.35	394.65	9.1102	-0.6005	-0.0659	1942.29	4.9216	-0.8812	-0.1790	-0.0876	0.0216	1.2899
1995-1996	4510.47	414.11	10.8920	1.7817	0.1636	1938.36	4.6808	-0.2408	-0.0514	-0.0252	0.1887	1.4786
1996-1997	4731.28	463.82	10.2007	-0.6913	-0.0678	1951.36	4.2071	-0.4736	-0.1126	-0.0551	-0.0127	1.4659
1997-1998	4340.75	534.4	8.1227	-2.0780	-0.2558	1737.83	3.2519	-0.9552	-0.2937	-0.1436	-0.1122	1.3537
1998-1999	3637.97	558.43	6.5146	-1.6080	-0.2468	1722.25	3.0841	-0.1678	-0.0544	-0.0266	-0.2202	1.1335
1999-2000	4312.59	682.35	6.3202	-0.1944	-0.0308	1653.24	2.4229	-0.6612	-0.2729	-0.1335	0.1027	1.2362
2000-2001	5115.62	702.65	7.2805	0.9603	0.1319	1886.86	2.6853	0.2625	0.0977	0.0478	0.0841	1.3203
2001-2002	3683.42	731.31	5.0367	-2.2437	-0.4455	1745.42	2.3867	-0.2986	-0.1251	-0.0612	-0.3843	0.9360
2002-2003	4229.57	568.23	7.4434	2.4067	0.3233	2116.91	3.7254	1.3387	0.3594	0.1757	0.1476	1.0836
2003-2004	3671.01	532.03	6.9000	-0.5434	-0.0788	1851.83	3.4807	-0.2448	-0.0703	-0.0344	-0.0444	1.0392
2004-2005	3990.14	535.18	7.4557	0.5557	0.0745	1991.44	3.7211	0.2404	0.0646	0.0316	0.0429	1.0822
2005-2006	4186.98	969.8	4.3174	-3.1383	-0.7269	2202.74	2.2713	-1.4497	-0.6383	-0.3121	-0.4148	0.6674
2006-2007	4722.98	696.76	6.7785	2.4611	0.3631	2712.88	3.8936	1.6222	0.4166	0.2037	0.1593	0.8267
2007-2008	5162.61	670.18	7.7033	0.9248	0.1201	2781.66	4.1506	0.2571	0.0619	0.0303	0.0898	0.9165

Rs. in lakhs

Column (11) has been found by multiplying ($\Delta k/k$) by the calculated value of $\beta = 0.489$.
Column (12) = Column (6) - Column (11)

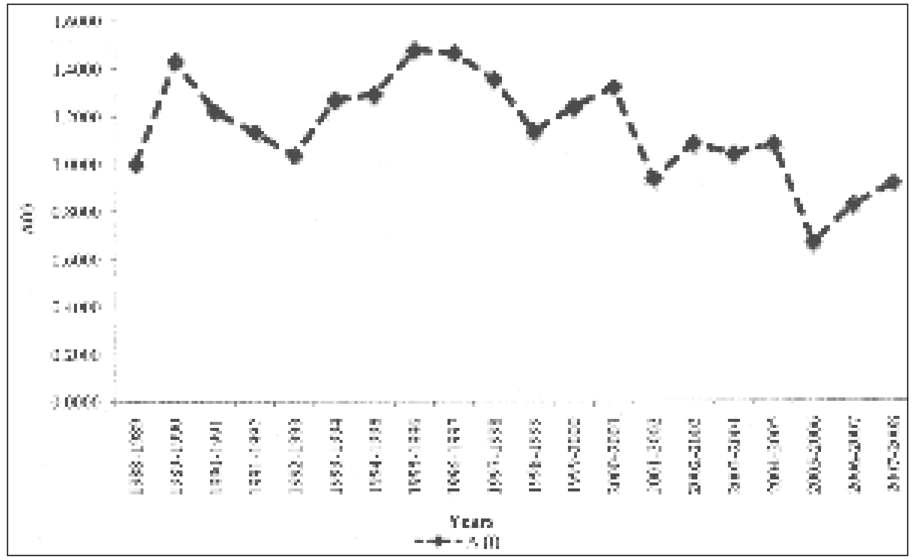

Fig. 1 : Contribution of technical change in the growth of cement industry.

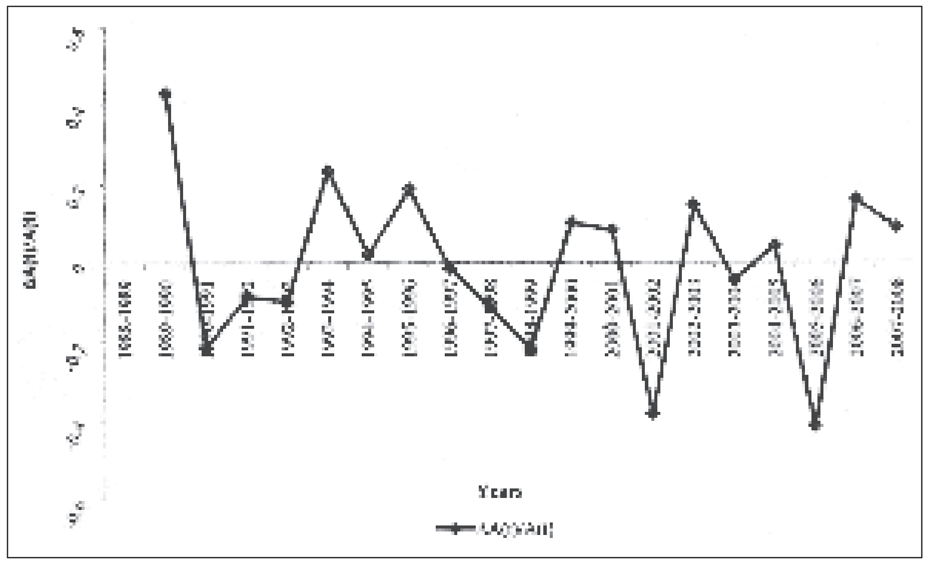

Fig. 2 : Change in residual productivity [ΔA(t)/A(t)] in cement industry.

the estimated regression equation (2.4) is

$$\log (Q/L) = 1.349 + .489^{*} \log (K/L) \qquad (3.2)$$
$$(.177) \quad (.125)$$

$R2 = .458$ $\qquad \overline{R}^2 = .428$ $\qquad F = 15.233$

$RSS_{UR} = .578$ $\qquad d = 1.421$

Here, it is seen that estimated R^2 as well as $\overline{R}^2$ value is low as compared to the earlier regression. However, the coefficient of (log of) capital - labour ratio is significant at 5%

probability level. The Durbin-Watson d- statistic indicates that there is no 1st order autocorrelation in the regression.

The estimated value of F-statistic using (2.5) is 0.2119, which is not significant at 5% probability level. So, we can infer that the Bokajan Cement Industry is characterized by *constant returns to scale* over the period. Thus, it is clear that the assumption of constant returns to scale for measuring technical change in the concerned industry is justified.

Now, we have calculated A(t) series for the industry by using (2.14) which is shown in Table 1. The Table 1 shows that the trend line of technical change over the period is *downward* with a significant trend rate of technical change (.019).

We are considering A(t) series as an *indicator and profile of technical change* and it has revealed fluctuating tendency as shown in Fig. 1. Table 1 reveals that there is a sharp and sudden rise of A(t) in 1989-1990 and it started to decline with small dips till 1992-1993. During 1993-1994 there is a sudden rise and then it has tended continuous decline with some minor dips till the end of the study period. Overall there is a *declining trend* in the technical change in the Bokajan Cement Industry. The annual trend rate of declining the technical change is (.019) which is significant at 5% probability level.

From Table 1, it is observed that $\frac{\Delta A(t)}{A(t)}$ exhibits a constant trend fluctuating about the fixed mean. The series shows a wrong sign during 1990-1993, 1996-1999, 2001-2002, 2003-2004, 2005-2006, which suggests that the rate of technical progress was very *low*. A plot of $\frac{\Delta A(t)}{A(t)}$ over time is shown in the Fig. 2.

Though the value of A(t) indicates a maximum (47%) shift in the production function during 1995-1996, but over the whole period there was a *declining trend* and the average compound rate of decline of A(t) is .019 which is found to be significant at 5% probability level.

Thus, the production process of Bokajan Cement Industry is operating at a *constant returns to scale*, the trend line of technical change of the Industry over the period 1988-2008 is *downward* and the *annual trend rate of declining the technical change is .019*

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