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Econometric Analysis of Production Behavior in the Chemical Industry of Bangladesh: A Panel Data Framework

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Abstract:

In this study we have attempted to consider the relationship between the gross output and few explanatory variables in the form of Cobb-Douglas production function model of different firms of Chemical industry of Bangladesh using panel data framework. For analysis purpose we have used data for 4 sub-sectors of chemical industry namely, PVC pipe, Paper, Sanitary ware and Insulator for the period 1999 to 2009.However, for our study purpose we have considered only fixed effect model version of panel data. In this study we consider only four possible cases of fixed effect model which are (1) all coefficients constant across time and individuals, (2) slope coefficients constant over individuals and time but intercept varies across individuals, (3) slope coefficients constant over individuals and time but intercept varies over individuals and time, (4) all coefficients varies across individuals. To stay in the competitive market we have to invest as much possible. Total cost has positive effect on the production. We have considered economies of scale. Results indicate the necessity for appropriate policies at the national level for raising production to increase contribution of chemical industry to GDP.

Key words: Production, Industry, Chemical, Analysis, Model

Introduction:

Bangladesh is mainly known as an agricultural country. But at present, it is obvious that a great part of the economy of this country is influenced by the industrial sector. According to “The Report of Economic Review-2008”, total industry sector accounts around 29.73% of GDP at constant price for Fiscal Year

2008-'09. Among all manufacturing sector Chemical sector contributes 6.00% to total value added to GDP. However, unexplored potentials of Chemical sectors may provide more contribution of this sector. Thus, it calls for studying the determinants of Chemical manufacturing sector. Identification and analysis of various dimensions of Chemical manufacturing needs some sound methodological techniques. One such technique is Panel Data Regression Analysis Model. Panel data regression model allows to identify attributes which prompts one to Chemical production and also to determine relative importance of attributes. So far my knowledge goes not much work on chemical production and processing and its impacts on social economic and natural environment have been done. It is imperative to identify factors which can boost up chemical manufacturing sector so that more benefits out of this sector can be served to greater national interests. In the competitive world the more industrialized a country is more developed. To see how industrial sector contributes to the economic development of the country, we have to know its contribution to production. GDP(Gross Domestic Product) of a country measures the growth of the country.

Objectives of the study:

The main objective of this study is to examine the influence of several inputs on the outputs of some selected firms of chemical industries by fitting suitable panel data regression models. The specific objectives of this study are outlined below:

- To fit the panel data regression model that fit the yearly data for some selected firms of chemical industries in Bangladesh.
- To investigate what particular type of inputs are influencing the industrial production most in the selected firms.
- Formulate policies implications.

Methodology and sources of data:

In this study to reach our goal we have used panel data, obviously secondary data because of lack of time and resources. In this study data was collected on yearly basis. For such purpose, we have use four set of chemical consumption data. These data were collected from BCIC (Bangladesh Chemical Industries Corporation) publications of MIS (Management Information System) report. Data are taken for the ten time periods 1999-2000, 2000-2001, 2001-2002, 2002-2003, 2003-2004, 2004-2005, 2005-2006, 20006-2007, 2007-2008, and 2008-2009. In the data set we select one dependent variable and three independent variables. The dependent variable is the Production of chemical industries(Y) and the independent variables are Manpower(X_1), Assets (X_2), and Total Costs(X_3), of chemical industries. Although the original study covered several companies, for illustrative purpose we have obtain data on four sectors, Fertilizer Sector (FS), Paper Sector (PS), Cement Sector (CS) and Insulator and Sanitary ware Sector (ISS).

Conceptual Framework of Cobb-Douglas production function and Panel Data:

Mathematically, the production function can be written as: $Y=f(X_1, X_2, X_3\ldots X_K)$

Where, Y stands for the quantity of output i.e. production; f is a function containing one or several parameters and $X_1, X_2, X_3, \ldots X_K$ are k factors of production. The Cobb-Douglas production function has a number of well-known properties that justify its wide application in economic literature. Mathematically, this production function is generally given by:

$$Y_i = k\prod_{j=1} X_{ji}^{\beta_j} e^{u_i}$$

Transforming to log-linear form, the function becomes $\log_e Y_i = \log_e k + \sum_{j=1} \beta_j \log_e x_{ji} + u_i$

Where, Y=Output, K=Constant, X_{ji}=Input j in the sector i; β_j =Elasticity of output with respect to input j; U= Residual. The sum of the elasticities i.e. $\sum \beta_j$ gives information about the returns to scale, that is, the response of output to a proportionate change in the inputs.

- $\sum \beta_j > 1$, indicates increasing returns to scale i.e. a doubling of all inputs may lead to more than a doubling of output.
- $\sum \beta_j < 1$ indicates decreasing returns to scale i.e. a doubling of all inputs may lead to less than a doubling of output.
- $\sum \beta_j = 1$ indicates constant returns to scale i.e. a doubling of all inputs may lead to a doubling of output.

Panel data: A data set containing observations on multiple phenomena observed over multiple time periods is called panel data. Data sets with more than two dimensions are typically called multi-dimensional panel data. Types of panel data: There are three types of panel data which are (i) Catch up panel data, (ii) Follow back panel data and (iii) Retrospective panel data.

Analysis of panel data: Panel data analysis is statistical method, widely used in econometrics, epidemiology, social science and business, which deals with two-dimensional panel data. A general panel data regression model is written as $y_{it} = \alpha + \beta X_{it} + U_t$. $i = 1, 2 \ldots N; t = 1, 2 \ldots T$

Where i is the individual dimension and t is the time dimension.

Panel data analysis has three more-or-less independent approaches: (1) Independently pooled panels (2) Random Effects Models and (3) Fixed Effects Models.

The selection between these methods depends upon the objective of our analysis. For our research we consider fixed effect model (as we want to draw inferences only about the examined entities, firms, individuals) which is delineated below. Estimation of panel data regression models depends on the assumptions we make about the intercept, the slope coefficients, and the error term u_{ij}. There can be many possibilities but here we highlight only four of them:

1. All Coefficients Constant across Time and Individuals

Under this assumption the regression model is $Y_{it} = \beta_0 + \beta_1 X_{1it} + \beta_2 X_{2it} + \beta_3 X_{3it} + \ldots\ldots + u_{it}$ … (1)
Where i stand for the i^{th} cross-section unit and t for the t^{th} time period u involves differences over time and individuals. Here we consider 4 individuals and 3 regressors and time from 1999 through 2008.
All together we shall have 4×10=40 observations and 4 parameters. This assumes that the slope coefficients of the independent variables are all identical for all the firms. Obviously these are highly restricted assumptions. Therefore, despite its simplicity, the pool regression may misrepresent the true picture of the relationship between dependent and independent variables across the firms.

2. Slope coefficients constant over individual and time but the intercept Varies across individuals

One way to take into account the “individuality” of each company or each cross-sectional unit is to let the intercept vary for each firm but still assume that the slope coefficient are constant across individuals and time. To see this we write the model as $Y_{it} = \beta_{0i} + \beta_1 X_{1it} + \beta_2 X_{2it} + \beta_3 X_{3it} + \ldots\ldots + u_{it}$ ……… (2)
We put the subscript i on the intercept term to suggest that the intercepts of all firms may different; the differences may be due to special features of each firm, such as managerial style or managerial philosophy. This model is known as fixed effects model (FEM). The term “fixed effects” is due to the fact, although the intercept may differ across individuals, each individuals intercept does not vary over time; that is, it is time invariant. When we actually allow for the (fixed effect) intercept to vary between companies, we can easily do that by the dummy variable technique, the differential intercept dummies. Therefore, we write the model (2) as

$$Y_{it} = \alpha_0 + \alpha_1 D_{1i} + \alpha_2 D_{2i} + \ldots + \alpha_{m-1} D_{(m-1)i} + \beta_1 X_{1it} + \beta_2 X_{2it} + \beta_3 X_{3it} \ldots\ldots + u_{it} \quad \ldots\ldots (2.1)$$

Where D_{1i}=1, if the observation belongs to first firm, D_{1i}= 0 otherwise; D_{2i}=1 if the observation belongs to second firm, D_{2i}= 0 otherwise and so on. If we have m firms, we can introduce (m-1) dummies, to avoid the situation of perfect collinearity. The firm for which we do not use dummy becomes comparison firm. Of courses, we are free to choose any firm as the comparison firm. Here we consider 4 individuals and 3 regressors and time from 1999 through 2008.All together we shall have 4×10=40 observations and 7 parameters.

3. Slope coefficients constant over individual and time but the intercept Varies over individuals and Time

Under this assumption we allow time effects on the model because various factors such as technological changes, changes in government regulatory and /or tax policies, and external effects such as wars or other conflicts shift over time. Such time effect can be easily accounted for if we introduce time dummies, one for each year. If we have data for n years, we can introduce (n-1) dummies. Under this assumption we can the model as

$$Y_{it} = \alpha_0 + \alpha_1 D_{1i} + \alpha_2 D_{2i} + ... + \alpha_{m-1} D_{(m-1)i} + \lambda_1 D_{time1} + \lambda_2 D_{time2} + ... + \lambda_{(n-1)} D_{time(n-1)}$$
$$+ \beta_1 X_{1it} + \beta_2 X_{2it} + \beta_3 X_{3it} ..... + u_{it} ....(3)$$

Where D_{time1}=1 if the observation belongs to first year, D_{time1}= 0 otherwise, etc. The year for which we do not use dummy is treat as base year whose intercept value is given by λ_0.

Here we consider 4 individuals and 3 regressors and time from 1999 through 2008. All together we shall have 4×10=40 observations and 43 parameters.

4. All Coefficients Vary across Individuals

Here we assume that the intercepts and the slope coefficients are different for all individuals, or cross-section units but time invariant for an individual. Then the model is

$$Y_{it} = \alpha_0 + \alpha_1 D_{1i} + \alpha_2 D_{2i} + ... + \alpha_{m-1} D_{(m-1)i} + \beta_1 X_{1it} + \beta_2 X_{2it} + \beta_3 X_{3it} + \gamma_1 (D_{1i} X_{1it}). + \gamma_2 (D_{1i} X_{2it}) +$$
$$\lambda_3 (D_{1i} X_{3it}). + ... + \lambda_m (D_{(m-1)i} X_{3it}).. + u_{it} ....(4)$$

Here we consider 4 individuals and 3 regressors and time from 1999 through 2008. All together we shall have 4×10=40 observations and 16 parameters. In this research work, we consider four firms as PVC pipe; Cement, Paper and Sanitary ware firms and take three regressors as Manpower, Asset and Total Cost. For the above four cases our model is given below:

For the first case, $Y_{it} = \beta_0 + \beta_1 X_{1it} + \beta_2 X_{2it} + \beta_3 X_{3it} + u_{it}$

For the Second case, $Y_{it} = \alpha_0 + \alpha_1 D_{1i} + \alpha_2 D_{2i} + \alpha_{3i} D_{3i} + \beta_1 X_{1it} + \beta_2 X_{2it} + \beta_3 X_{3it} + u_{it}$

Here, D1i=1 when observation comes from firm of paper, otherwise D_{1i} = 0.

D_{2i} = 1 when observation comes from firm of cement, otherwise D_{2i} = 0.

D_{3i} = 1 when observation comes from firm of sanitary ware, otherwise D_{3i} = 0.

We do not take dummy variable for firm of PVC pipe to avoid perfect multicollinearity and this firm is taken as comparison firm. For the third case,

$$Y_{it} = \alpha_0 + \alpha_1 D_{1i} + \alpha_2 D_{2i} + \alpha_3 D_{3i} + \lambda_1 D_{time1} + \lambda_2 D_{time2} + ... + \lambda_9 D_{time9} + \beta_1 X_{1it} + \beta_2 X_{2it} + \beta_3 X_{3it} + u_{it}$$

Here, D_{1i}=1 when observation comes from firm of paper, otherwise D_{1i} = 0.

D_{2i} = 1 when observation comes from firm of cement, otherwise D_{2i} = 0.

D_{3i} = 1 when observation comes from firm of sanitary ware, otherwise D_{3i} = 0.

D_{time1}=1 when observation comes from the year 1999, otherwise D_{time1}= 0.

D_{time2}=1 when observation comes from the year 2000, otherwise D_{time2}= 0.

....

D_{time9}=1 when observation comes from the year 2008, otherwise D_{time9}= 0.

For the forth case, $Y_{it} = \alpha_0 + \alpha_1 D_{1i} + \alpha_2 D_{2i} + \alpha_3 D_{3i} + \beta_1 X_{1it} + \beta_2 X_{2it} + \beta_3 X_{3it} + \gamma_1 (D_{1i} X_{1it}).$

$$+ \gamma_2 (D_{1i} X_{2it}) + \gamma_3 (D_{1i} X_{3it}). + ... + \gamma_9 (D_{3i} X_{3it}).. + u_{it}$$

Here, D1i=1 when observation comes from firm of paper, otherwise D_{1i} = 0.

D_{2i} = 1 when observation comes from firm of cement, otherwise D_{2i} = 0.

D_{3i} = 1 when observation comes from firm of sanitary ware, otherwise D_{3i} = 0.

Estimation and Testing Procedure: In this study, OLS method has been applied to estimate all the parameters of the model under consideration.

The Panel Data Regression Model: The present study considers the panel data regression model and it is generally expressed as follows: $Y_{it} = \alpha_i + \beta_i X_{it} + U_{it}$, $i =$ 1, 2, 3, 4… N and $t =$ 1, 2, … T (years). There are N firms and each having T observations on X & Y.

Let $\bar{X}_i$ and $\bar{Y}_i$ be the means of X &Y for i[th] firm.

Let, $W_{XXi} = \sum_t (X_{it} - \bar{X}_i)^2$, $W_{XYi} = \sum_t (X_{it} - \bar{X}_i)(Y_{it} - \bar{Y}_i)$ and $W_{YYi} = \sum_t (Y_{it} - \bar{Y}_i)^2$

$\therefore \hat{\beta}_i = \dfrac{W_{XYi}}{W_{XXi}}$, and $\hat{\alpha}_i = \bar{Y}_i - \hat{\beta}_i \bar{X}_i$

The residual SS, $RSS_i = W_{YYi} - \dfrac{W_{XYi}}{W_{XXi}}$ having $T_i - 2$ df. ; [Here T_i =10]

To test the hypothesis, $H_0 : \alpha_1 = \alpha_2 = ... = \alpha_N$ and $\beta_1 = \beta_2 = ... = \beta_N$

We estimate a common regression, $Y_{it} = \alpha_i + \beta_i X_{it} + U_{it}$

Let, $T_{xx} = \sum_i \sum_t (x_{it} - \bar{x})^2$, $T_{xy} = \sum_i \sum_t (x_{it} - \bar{x})(y_{it} - \bar{y})$ and $T_{yy} = \sum_i \sum_t (y_{it} - \bar{y})^2$

Residual SS, $\mathrm{RSS} = \mathrm{T}_{yy} - \dfrac{T_{xy}^2}{T_{XX}}$ with df= $\left(\sum_i T_i\right) - 2$. Thus, $\hat{\beta} = \dfrac{T_{XY}}{T_{XX}}$ & $\hat{\alpha} = \bar{y} - \beta\bar{x}$

To test homogeneity of regression, we use an F test. We basically estimate the panel data regression.

$Y_{it} = \alpha_i + \beta_i X_{it} + U_{it}$ Subject to (2N-2) linear restrictions implied by hypothesis H_1 which is

$H_1 : \alpha_1 = \alpha_N, \alpha_2 = \alpha_N, ..., \alpha_{N-1} = \alpha_N$

$\beta_1 = \beta_N, \beta_2 = \beta_N, ..., \beta_{N-1} = \beta_N$

The unrestricted residual SS,S_1 is, $S_1 = \sum_i RSS_i$ with $\mathrm{df} = \sum_i (\mathrm{T_i} - 2) = \sum_i T_i - 2N$

The restricted residual SS,S_2 is, $S_2 = RSS(\text{given above})$ with df= $\sum_i \mathrm{T_i} - 2$

Test statistic is: $F = \dfrac{(S_2 - S_1)/(2N-2)}{S_1/(\sum_i T_i - 2N)}$, which follows F-dist[n] with df (2N-2), $(\sum T_i - 2N)$.

Significant F $\longrightarrow$ Significant differences in coefficients and so do not pool the data.

Insignificant F $\longrightarrow$ Pool the data and estimate common single equation.

Suppose we are interested in testing the hypothesis $H_2 : \beta_1 = \beta_2 = ... = \beta_N$

Thus we have to estimate, $y_{it} = \alpha_i + \beta x_{it} + u_{it}$ having equal β but different α's for all firms.

Minθ = $(y_{it} - \hat{\alpha}_i + \hat{\beta} x_{it} + u_{it})^2$ w.r.to α_i & β, leads to

$$\frac{\partial\theta}{\partial\alpha_i} = \hat{\alpha}_i = \bar{y}_i - \hat{\beta}\bar{x}_i \quad \left[\because \sum_t \left(y_{it} - \hat{\alpha}_i - \hat{\beta} x_{it}\right) = 0\right] \quad \text{and} \quad \frac{\partial\theta}{\partial\beta} = \sum_{it} x_{it}\left(y_{it} - \hat{\alpha}_i - \hat{\beta} x_{it}\right) = 0$$

Substitute the value of $\hat{\alpha}_i$, $\sum_{it} x_{it}\left(y_{it} - \bar{y}_i - \hat{\beta}(x_{it} - \bar{x}_i)\right) = 0$ Or $\hat{\beta} = \dfrac{W_{XY}}{W_{XX}}$

$$W_{XY} = \sum_{it} X_{it}(Y_{it} - \bar{Y}_i) = \sum_i W_{XYi}, W_{XX} = \sum_{it} X_{it}(X_{it} - \bar{X}_i) = \sum_i W_{XXi}$$

The restricted residual SS, S_3 is, $S_3 = W_{YY} - \frac{W_{XY}^2}{W_{XX}}$ With df = $\sum_i T_i - (N+1)$

Test statistic is: $F = \frac{(S_3 - S_1)/(N-1)}{S_1/(\sum_i T_i - 2N)}$, which follows F-dist^n with df = (N-1), $(\sum T_i - 2N)$

Common intercept and different slopes, $H_3 : \alpha_1 = \alpha_2 = ... = \alpha_N$

We need to minimize θ = $\sum_{it} (y_{it} - \alpha - \beta_i x_{it})^2$

$$\begin{pmatrix} y_1 \\ y_2 \\ . \\ y_n \end{pmatrix} = \alpha \begin{pmatrix} 1 \\ 1 \\ . \\ 1 \end{pmatrix} + \beta_1 \begin{pmatrix} x_1 \\ 0 \\ . \\ 0 \end{pmatrix} + \beta_2 \begin{pmatrix} 0 \\ x_2 \\ . \\ 0 \end{pmatrix} + ... + \beta_N \begin{pmatrix} 0 \\ 0 \\ . \\ x_N \end{pmatrix} + \begin{pmatrix} u_1 \\ u_2 \\ . \\ u_N \end{pmatrix}$$

We poll all the data & regress the entire set of y observation on N dummies with a constant term. Thus dummies are

$D_{1t} = \begin{cases} x_{1t}, \text{for observation of first firm} \\ 0, \text{otherwise} \end{cases}$, $D_{2t} = \begin{cases} x_{2t}, \text{for observation of second firm} \\ 0, \text{otherwise} \end{cases}$

and $D_{3t} = \begin{cases} x_{3t}, \text{for observation of third firm} \\ 0, \text{otherwise} \end{cases}$; etc.

It is noted here that firm of insulator, i.e. consisting of the remaining firms has been taken as the base category in the specification of dummies for firms. The coefficients of dummies are the estimate of β's and $\hat{\alpha}$ is the intercept.

If S_4 is the residual SS from this equation, the test statistic for the hypothesis H_3 is,

Test statistic is, $F = \frac{(S_4 - S_1)/(N-1)}{S_1/(\sum_i 2T_i - 2N)}$,which follows F-dist^n with df = (N-1), $(\sum 2T_i - 2N)$

If one wishes to test conditional hypothesis, $H_4 : \alpha_1 = \alpha_2 = ... = \alpha_N$ given $\beta_1 = \beta_2 = ... = \beta_N$

Unrestricted residual SS is S_3 with df= $\sum_i T_i - (N+1)$ & restricted residual SS is S_2 with df= $\sum_i T_i - 2$.

Test statistic, $F = \frac{(S_2 - S_3)/(N-1)}{S_4/(\sum_i T_i - (N+1))}$, which follows F-dist^n with df =(N-1),[$\sum T_i - (N+1)$]

If we want to test, H_0: $\beta_1 = \beta_2 = ... = \beta_N$ given $\alpha_1 = \alpha_2 = ... = \alpha_N$

Unrestricted residual SS is S_4 with df = $\sum_i T_i - (N+1)$ & restricted residual SS is S_2 with df = $\sum_i T_i - 2$.

Test statistic, $F = \frac{(S_2 - S_4)/(N-1)}{S_4/[\sum_i T_i - (N+1)]}$, which follows F-dist^n with df = (N-1),[$\sum T_i - (N+1)$]

The common strategy is to estimate equation with a common intercept & slope and different intercepts & common slope. We need, $\bar{x}_{i,} \bar{y}_{i,} W_{XXi}, W_{XYi}, W_{YYi}$ and $\bar{x}, \bar{y}, T_{xy,} T_{xx,} T_{yy}$

If we estimate separate regression $\hat{\beta}_i = \dfrac{W_{xyi}}{W_{xxii}}$ and $\hat{\alpha}_i = \bar{y}_i - \hat{\beta}_i \bar{x}_i$

If we estimate a regression with a common slope & intercept $\beta = \dfrac{T_{xy}}{T_{xx}}, \quad \alpha = \bar{y} - \hat{\beta}\bar{x}$

Regression with common slope & different intercepts $\beta = \dfrac{W_{xy}}{W_{xx}}, \quad \alpha_i = \bar{y}_i - \hat{\beta}\bar{x}_i$

This is a dummy variable regression. In production studies with y as output & x is input, α_i is assumed to be managerial input for i^{th} firm.

Econometric Validation of the Analysis: An important stage in any econometric research is assessing the model and the method of model estimation by econometric criteria**.** The acceptability of any set of parameter estimates depend on whether they process all econometric criteria. Most of the econometric variables face the problem of econometric analysis. These are: (i) Heteroscedasticity (ii) Autocorrelation and (iii) Multicollinearity. For testing Heteroscedasticity we have adopted Spearman's rank correlation test, Park test, Goldfeld-Quandt test, Breusch-Pagan-Goldfrey test and White test. For first case among four possible cases mentioned earlier Goldfeld-Quandt test result is 0.203 which is less than the tabulated value at 5% level of significance with 10 df and it indicates no heteroscedasticity in the data. For the second case Breusch-Pagan-Goldfrey test result is 13.88 which is less than the tabulated value at 5% level of significance with 6 df and it indicates no heteroscedasticity in the data. For third case White test result is 34.84 which is less than the tabulated value at 5% level of significance with 27df and it indicates no heteroscedasticity in the data. For the fourth case Breusch-Pagan-Goldfrey test result is 11.47 which is less than the tabulated value at 5% level of significance with 15 df and it also indicates no heteroscedasticity in the data. Similarly for testing autocorrelation, we have adopted Graphical method, Durbin-Watson test, and Breusch-Godfrey test. For the first case Durbin-Watson d value is 0.446 which is less than d_L at 5% level of significance and it indicates that autocorrelation is present in the data. For the second case, Durbin-Watson d value is 1.704 which is lie between d_L and d_U at 5% level of significance and it indicates that autocorrelation is not present in the data. For the third case, Breusch-Godfrey test result is 12.96 which is less than the tabulated value 5% level of significance with 8 df and indicates no autocorrelation in the data. For the fourth case Breusch-Godfrey test result is 16.62 which is less than the tabulated value 5% level of significance with 9 df and also indicates no autocorrelation in the data. Finally we conclude that our different test results suggest that autocorrelation is not a problem for the data. For testing multicollinearity, we use Variance Inflation Factor (VIF) Test which indicates that multicollinearity is not severely present in the data for all cases.

Result Discussion: The most crucial part of any research work is the methodology of analyzing the collected data. It is because of the fact that the data itself are unable to provide any meaningful 'information'. To get something useful from the collected data, one has to analyze it expediently. The analyzed data has to be interpreted by the researcher from every perspective possible, to gain insight about the phenomenon under consideration. Here, firstly I have discussed whether our panel data have structural change or not. For test of presence or absence of structural change in our panel data we construct a Cobb-Douglas production function model for each Panel data regression model (All Coefficients Constant across Time and Individuals, Slope coefficients constant over individual and time but the intercept Varies across individuals, Slope coefficients constant over individual and time but the intercept Varies across individuals and All Coefficients Vary across Individuals). Finally, I have discussed the parameter estimate for all models.

Model for All Coefficients Constant across Time and Individuals

We consider the following Panel data regression model: $Y_{it} = \beta_0 + \beta_1 X_{1it} + \beta_2 X_{2it} + \beta_3 X_{3it} + u_{it}$

After incorporating Cobb-Douglas production function model in the panel data regression model we have,
$\ln Y_{it} = \beta_0 + \beta_1 \ln X_{1it} + \beta_2 \ln X_{2it} + \beta_3 \ln X_{3it} + u_{it}$ ………….. (1.1) where, $t = 1,2,.............,10$

Table 1: OLS estimates of parameters

Variable	Parameter	Estimates of coefficients	t-value	p-value	R^2	$\bar{R}^2$
Constant	β_0	-1.547	-1.458	0.154	0.879	0.869
MP	β_1	-0.549	-4.901	0.000*		
ASS	β_2	0.336	2.219	0.033*		
TC	β_3	1.175	6.413	0.000*		

Source: Prepared by Author. * indicate significant

Here, MP= Number of employee, TC= Total Cost, ASS=ASSET

The estimated model is: *ln* Production = -1.547-0.459*ln*MP+0.336*ln*ASS+1.175*ln*TC………..(1.2)

We examine the results of the pooled regression and applying conventional criteria, we see all the coefficients are individually statistically significant, the slope coefficients have the expected positive signs and the R^2 value is reasonably high. As expected, Y (Production) is positively related to X_2 (Asset) and X_3 (Total cost) and negatively related to X_1 (Manpower).The estimated model assumes that the intercept values of all firms are the same. It is also assumes that the slope coefficients of the three variables are all identical for all the four firms. From the value of adjusted R^2, ($\bar{R}^2$) it can be concluded that 86.9% of the variations in the production of Chemical manufacturing industry is explained by the Manpower, Asset and Total Cost. The R^2=.879 and adjusted R^2, $\bar{R}^2$=.869 are very high which indicates that estimated model fits the data well. The parameter estimate for the number of employee (MP) has significant effect. From the table we observe that the coefficient of variable MP is -.549. It is found that labor effect is negative, implying that the number of workers is much more than that of actual production workers needed. If the employees of an industry are industrious and trained, the production will be increased. The coefficient of the variable Asset is 0.336. This parameter estimate is significant. That is, we can say that one percent increase in Asset, led on the average to about a 0.336 percent increase in production. This result is satisfactory, because if we increase our total Asset then our production will be increased. The coefficient of the variable Total Cost is 1.175. This parameter estimate has significant effect. That is, we can say that one percent increase in total cost, led on the average to about a 1.175 percent increase in production. This result is satisfactory, because if we increase industrial cost i.e. cost of material supplies that have been physically incorporated increase the product and by products, cost of fuel and electricity used for manufacturing purpose, as well as payment for work done by others, the production will obviously increase. After adding the estimates of the coefficients, we get the value for the returns to scale parameter, which is .962. This indicates decreasing returns to scale. That means, if the input is doubled, output will be decreased by less than doubled. To find some way to take into account the specific nature of the four firms, we have to go to the next assumption.

Model for Slope coefficients constant but the intercept Varies across individuals

Here we consider the following Panel data regression model:

$$Y_{it} = \alpha_0 + \alpha_1 Dp + \alpha_2 Dc + \alpha_3 Ds + \beta_1 X_{1it} + \beta_2 X_{2it} + \beta_3 X_{3it} + u_{it} \text{ .... (2.1)}$$

After incorporating Cobb-Douglas production function model in the panel data regression model we have,

$$\ln Y_{it} = \alpha_0 + \alpha_1 Dp + \alpha_2 Dc + \alpha_3 Ds + \beta_1 \ln X_{1it} + \beta_2 \ln X_{2it} + \beta_3 \ln X_{3it} + u_{it} \text{ ...... (2.1.1)}$$

where, $t = 1,2,.............,10$.

Table2: OLS estimates parameters

Variable	Parameter	Estimates of coefficients	t-value	p-value	R^2	$\bar{R}^2$
Constant	α_0	1.128	0.535	0.596	0.971	0.966
D_P	α_1	0.579	2.049	0.030*		
D_C	α_2	0.736	2.317	0.027*		
D_S	α_3	1.168	2.516	0.046*		

MP	β_1	-0.496	2.387	0.036*		
ASS	β_2	0.298	3.672	0.001*		
TC	β_3	0.820	4.918	0.000*		

Source: Prepared by Author. * indicate significant

Here, D_P= Dummy variable for Paper, D_C= Dummy variable for Cement, D_S= Dummy variable for Sanitary ware and Insulator, MP= Number of employee, TC= Total Cost, ASS=ASSET

The estimated model can be written as:

$$\ln production = 1.128 + 0.579 D_P + 0.736 D_C + 1.168 D_S - 0.496 \ln MP + 0.298 \ln ASS + 0.820 \ln TC$$

The intercept values of the four firms are statistically different; being 1.128 for PVC pipe, 1.707= (1.128+.579) for Paper, 1.864= (1.128+.736) for Cement and 2.296= (1.128+1.168) for Sanitary wear & insulator. These differences in the intercepts may be due to unique features of each firm, such as differences in management style or managerial talent. From the value of adjusted R^2, ($\bar{R}^2$) is 0.966, it can be concluded that 96.6% of the variations in the production of Chemical manufacturing industries is explained by the Manpower, Asset and Total Cost. We have seen that the individual firm's effects were statistically significant. The R^2=.971 and adjusted R^2, $\bar{R}^2$=.966 are very high which indicates that estimated model fits the data well. The parameter estimate for the number of employee (MP) has significant effect. From the table we observe that the coefficient of variable MP is -0.496. That is, we can say that one percent increase in MP, led on the average to about a 0.496 percent decrease in production. It is found that labor effect is negative, the number of production workers is much more than that of actual production workers needed. The coefficient of the variable Asset is 0.298. This parameter estimate is significant. That is, we can say that one percent increase in Asset, led on the average to about a 0.298 percent increase in production. This result is satisfactory, because if we increase our total asset then our production will be increased. The coefficient of the variable total cost is .820. This parameter estimate has significant effect. This result suggests that one increase in total cost led on the average to about a 0.820 percent increase in production. This result is satisfactory, because if we increase total cost i.e. cost of materials supplies that have been physically incorporated, increase the product and by products, cost of fuel and electricity used for manufacturing purpose, as well as payment for work done by others, the production will obviously increase. After adding the estimates of the coefficients, we get the value for the returns to scale parameter, which is 3.105. This indicates increasing returns to scale. That means, if the input is doubled, output will be increased by more than doubled.

Model for Slope coefficients constant but the intercept varies over individuals and Time.

Here we consider the following model:

$$Y_{it} = \alpha_0 + \alpha_1 Dp + \alpha_2 Dc + \alpha_3 Ds + \gamma_1 D_1 + \gamma_2 D_2 + ... + \gamma_9 D_9 + \beta_1 X_{1it} + \beta_2 X_{2it} + \beta_3 X_{3it} + u_{it} \quad ......(3.1)$$

After incorporating Cobb-Douglas production function model in the panel data regression model:

$$\ln Y_{it} = \alpha_0 + \alpha_1 Dp + \alpha_2 Dc + \alpha_3 Ds + \gamma_1 D_1 + \gamma_2 D_2 + .. + \gamma_9 D_9 + \beta_1 \ln X_{1it} + \beta_2 \ln X_{2it} + \beta_3 \ln X_{3it} + u_{it}$$

Where, i = 1,2,3,4 and $t = 1,2,..............,10$

Table3: OLS estimates parameter

Variable	Parameter	Estimates of coefficients	t-value	p-value	R^2	$\bar{R}^2$
Constant	α_0	2.669	2.926	0.364	0.986	0.978
D_P	α_1	0.433	2.781	0.043*		
D_C	α_2	1.477	2.583	0.016*		
D_S	α_3	1.564	5.211	0.000*		
D_1	λ_1	-0.436	-1.587	0.126		
D_2	λ_2	-0.110	-0.462	0.648		
D_3	λ_3	-0.041	-0.183	0.857		

D_4	λ_4	-0.050	-0.237	0.814		
D_5	λ_5	-0.289	-1.447	0.161		
D_6	λ_6	-0.293	-1.563	0.131		
D_7	λ_7	-0.067	-0.417	0.680		
D_8	λ_8	0.052	0.367	0.717		
D_9	λ_9	0.208	1.651	0.112		
MP	β_1	-0.065	2.78	0.043*		
ASS	β_2	0.079	2.26	0.037*		
TC	β_3	0.594	2.582	0.016*		

Source: Prepared by Author. * indicate significant

Here, D_P= Dummy variable for Paper sector, D_C= Dummy variable for Cement sector,

D_S= Dummy variable for Sanitary ware and Insulator sector, D_1 = Dummy variable for the year1999, …. D_9 = Dummy variable for the year 2008, MP= Number of employee, TC= Total Cost, ASS=Asset

The estimated model can be written as:

$$\ln production = 2.669 + 0.433Dp + 1.477Dc + 1.564Ds - 0.436D_1 - 0.110D_2 - 0.041D_3 - 0.050D_4$$
$$-0.289D_5 - 0.293D_6 - 0.067D_7 + 0.052D_8 + 0.208D_9 - 0.065\ln MP + 0.079\ln ASS + 0.594\ln TC....(3.2)$$

From the value of adjusted R^2 , ($\overline{R}^2$) is 0.978, it can be concluded that 97.8% of the variations in the production of Chemical industry is explained by Manpower, Asset and Total Cost. The R^2=.986 and adjusted R^2, $\overline{R}^2$=.978 are very high which indicates that estimated model fits the data well. From the table we observe that the coefficient of variable MP is -0.065. It shows that labor effect is negative, implying that the number of workers is much more than that of actual production workers needed. The coefficient of the variable Asset is 0.079. This parameter estimate is significant. That is, we can say that one percent increase in Asset, led on the average to about a 0.079 percent increase in production. This result is rational because increase of production obviously depends on asset. The coefficient of the variable Total Cost (TC) is 0.594. This parameter estimate has significant effect. That is, we can say that one percent increase total cost, led on the average to about a 0.594 percent increase in production. This result is satisfactory, because if we increase total cost i.e. cost of material supplies that have been physically incorporated increase the product and by products, cost of fuel and electricity used for manufacturing purpose, as well as payment for work done by others, the output will obviously increase. We have already seen that the individual enterprise effects were statistically significant, but individual year effects were not because adjusted R^2, ($\overline{R}^2$) for second model is 0.966 and adjusted R^2, $\overline{R}^2$ for third model is 0.978. The overall conclusion that emerges is that perhaps there are pronounced individual firms effects but no time effect. In other words, the production function for the four firms is the same except for their intercepts. In all cases we have considered, the X variables had a strong impact on Y. After adding the estimates of the coefficients, we get the value for the returns to scale parameter, which is 3054. This indicates increasing returns to scale. That means, if the input is doubled, output will be increased by more than doubled.

Model for all Coefficients Vary across Individuals: Here we consider the following model:

$$Y_{it} = \alpha_0 + \alpha_1 Dp + \alpha_2 Dc + \alpha_3 Ds + \beta_1 X_{1it} + \beta_2 X_{2it} + \beta_3 X_{3it} + \gamma_1(DpX_{1it}) + ... + \gamma_3(DpX_{3it}) + \gamma_4(DsX_{1it}) + ...$$
$$+\lambda_8(DsX_{1it}) + \lambda_9(DsX_{3it}).. + u_{it}..(4.1)$$

After incorporating Cobb-Douglas production function model in the panel data regression model:

$$\ln Y_{it} = \alpha_0 + \alpha_1 Dp + \alpha_2 Dc + \alpha_3 Ds + \beta_1 \ln X_{1it} + \beta_2 \ln X_{2it} + \beta_3 \ln X_{3it} + \gamma_1(Dp\ln X_{1it}) + ... + \gamma_3(Dp\ln X_{3it})$$
$$+\gamma_4(Ds\ln X_{1it}) + ... + \lambda_8(Ds\ln X_{1it}) + \lambda_9(Ds\ln X_{3it}).. + u_{it}$$

where, $t = 1,2,.............,10$

Table 4: OLS estimates parameter

Variable	Parameter	Estimates of coefficients	t-value	p-value	R^2	$\overline{R}^2$

Constant	α_0	-1.612	-0.342	0.735		
D_p	α_1	7.957	0.883	0.386		
D_C	α_2	-3.808	-0.943	0.354		
D_S	α_3	3.363	0.483	0.633		
D_PMP	λ_1	0.131	0.209	0.836	0.977	0.966
D_PASS	λ_2	0.528	1.461	0.156		
D_PTC	λ_3	-0.637	-1.304	0.204		
D_CMP	λ_4	-1.138	-0.339	0.738		
D_CASS	λ_5	0.422	1.271	0.215		
D_CTC	λ_6	0.069	0.143	0.888		
D_SMP	λ_7	1.071	1.327	0.196		
D_SASS	λ_8	0.489	1.331	0.195		
D_STC	λ_9	-0.113	-0.161	0.874		
MP	β_1	0.245	3.232	0.002*		
ASS	β_2	-0.123	2.613	0.048*		
TC	β_3	1.105	3.265	0.003*		

Source: Prepared by Author. * indicate significant

Here, MP= Number of employee, TC= Total Cost, ASS=ASSET

The estimated model can be written as:

in Production= $-1.612+7.957D_p-3.808D_c+3.363D_s+0.245\ln MP- 0.123\ln ASS+1.105\ln TC+$

$0.131(D_p \mathit{ln}MP)+ 0.528(D_p \mathit{ln}ASS) -0.637(D_p \mathit{ln}TC) -1.138(D_C \mathit{ln}MP)+ 0.422(D_C \mathit{ln}ASS)+ 0.069 (D_C \mathit{ln}TC)$

$+1.071(D_s \mathit{ln}MP) +0.489(D_s \mathit{ln}ASS) -0.113 (D_s \mathit{ln}TC)$………………………...(4.2)

From the value of adjusted R^2,($\overline{R}^2$) is 0.966, it can be concluded that 96.6% of the variations in the production of Chemical industry is explained by the regression equation. The R^2=.977 and adjusted R^2, $\overline{R}^2$=.966 are very high which indicates that estimated model fits the data well. From the table we observe that the coefficient of variable for MP is 0.245.Which indicates that holding all others factors constant one percent increase in MP, led on the average to about a 0.245 percent increase in production. In other word, over the study period, holding all other factors constant, a one percent increase in the total number of employee led on the average to about a 0.245 percent increase in the production. The coefficient of the variable Asset is -0.123. This parameter estimate is significant. This result indicates that if the asset is decreased one percent then on the average 0.123 percent decrease in production. This result is rational because decrease of production obviously depends on unavailability of the Asset. The coefficient of the variable Total Cost (TC) is 1.705. This parameter estimate has significant effect. This result indicates that if the total cost is increased one percent then on the average 1.705 percent increase in production. This result is satisfactory, because if we increase total cost i.e. cost of material supplies that have been physically incorporated increase the product and by products, cost of fuel and electricity used for manufacturing purpose, as well as payment for work done by others, the production will obviously increase. After adding the estimates of the coefficients, we get the value for the returns to scale parameter, which is 12.556. This indicates increasing returns to scale. That means, if the input is doubled, output will be increased by more than doubled. First of all it can be said that the Cobb-Douglas production function fits well to the yearly data since in all model it has been seen that R^2 and adjusted R^2 are very high. The major findings of this study are the explanatory variables are found to be significant.

Conclusion:

It is well understood that the development of a country is indicated by the number of industry. In this study an attempt has been made to relate production behavior with some economic indicator through building an econometric model. Our study on production behavior is mostly devoted to find the determinants using Cobb-Douglas production function in the context of panel data regression model. In this research work, the main objective is to determine the production of industries (Chemical manufacturing industry) of Bangladesh and also to investigate how different factors influence production of industry. Panel data for the period from 1999 to 2008 collected from the MIS Report (publications of BCIC) have been used for empirical verification of the models. The gross output of chemical manufacturing industry as our dependent variable and we consider manpower, asset and total cost as our independent variable. By multicollinearity detection test (VIF test, tolerance limit) we observed that there is no severe multicollinearity in the data. For detecting autocorrelation we use graphical method, Durbin-Watson d-test, Breusch Godfrey test, we observed that autocorrelation is not present in the data. Now I would like to discuss the results of this study in brief. For detecting heteroscedasticity we use Spearman's rank correlation test, Goldfeld Quandt test, Park test, Breusch Pagan Godfrey test and White test, we observe that the heteroscedasticity is not present in the data.

For the model of all coefficients constant over time and firm: We observe that adjusted R^2 is 0.869. From the value of adjusted R^2, it can be concluded that 86.9% of the variations in the production of chemical manufacturing industry is explained by Manpower, Asset and Total Cost. The R^2 = 0.879 and adjusted R^2 =0.869 are very high which indicates that estimated model fits the data well.

Model for slope coefficients constant but the intercept varies across individuals: From the value of adjusted R^2 = 0.966, it can be concluded that 96.6% of the variations in the production of chemical manufacturing industry is explained by Manpower, Asset and Total Cost. We have seen that the individual firm's effects were statistically significant. The R^2 = 0.971 and adjusted R^2 =0.966 are very high which indicates that estimated model fits the data very well.

Model for slope coefficients constant but the intercept varies over individuals as well as time: From the value of adjusted R^2 = 0.978, it can be concluded that 97.8% of the variations in the production of chemical manufacturing industry is explained by Manpower, Asset and Total Cost. The R^2 = 0.986 and adjusted R^2 =0.978 are very high which indicates that estimated model fits the data very well.

Model for all coefficients vary across individuals: From the value of adjusted R^2 = 0.966, it can be concluded that 96.6% of the variations in the production of chemical manufacturing industry is explained by regression equation. The R^2 = 0.977 and adjusted R^2 =0.966 are very high which indicates that estimated model fits the data very well. For the gross output of chemical manufacturing industry, we observe that the adjusted R^2 is 0.867. That is 86.9% of total variation of output of chemical manufacturing industry is explained by the model of all coefficients constant.

Policy implications:

From our study, we observed that the employee of an industry is a very important factor in production. This factor has a negative effect on the production, implying that the marginal production of labor for the period may be negative i.e the number of production worker is much more than that actual production worker needed. If the workers of an industry are industrious and trained, the production will be increased. So the government or the authority must be concerned about the employees of the industry to produce more production i.e to obtain satisfactory result we have to select industrious workers and they have to be trained. Another important factor in industrial production is Asset. This parameter estimate has a significant effect on production. From the results of our study we can conclude that with the increase of Asset, production will be increased. In our study, we consider an important factor which is the total cost. The total cost has a significant effect on the production. We observed that if we increase the total cost (investment) the production also increases. Now to stay in the competitive market we have to invest as much as possible, we have to consider economic returns to scale. Another important factor in industrial production is the number of firms. From the results of our study we can conclude that with the increase of firms, production will increase. So to obtain satisfactory production we have to establish more firms at the suitable places.

Results indicate the necessity for appropriate policies at the national level for raising production to increase the contribution of chemical industry sector to GDP.

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