AN ANALYSIS OF ENERGY INTENSITY AND CAPACITY UTILISATION OF TWO MAJOR ENERGY INTENSIVE MANUFACTURING INDUSTRIES IN INDIA: 1980-81 TO 2011-12

Pinki Bera[1]

PhD. Scholar, Department of Economics,

Vidyasagar University, Midnapore-721102, W.B, India

E-Mail: pinkibera123@gmail.com ; Mobile No. : 8389089146/ 9800882898

Prof. (Dr.) Mihir Kumar Pal[2]
Professor, Department of Economics, Vidyasagar University,
E-Mail: mihirpal@yahoo.com

Abstract

In this paper, we tried to estimate the Energy Intensity (EI) and Capacity Utilisation (CU) of two major energy intensive industries, Chemical and Chemical Products Industry and Basic Metal industry over the period 1980-81 to 2011-12 and also a comparative analysis for pre and post -liberalisation period. We find that the rate of capacity utilization is less than unity for all observation in Chemical and Chemical Product Industry as well as Basic Metal industry. The energy intensity is increasing in the post-reform period than the pre-reform period.

1. INTRODUCTION

The economic development of an economy depends to a large extent on the performance of the manufacturing industry. Industrial output depends on a large number of inputs. Energy is one of input that is used in the production process. The manufacturing industries are the major consumers of conventional energy.

The conventional sources of energy are generally non-renewable sources of energy, which are being used since a long time. These sources of energy are being used extensively in such a way that their known reserves have been depleted to a great extent.

Energy has been universally recognised as one of the most important inputs for economic growth and human development. Earlier studies have found a strong two way relationship between economic development and energy consumption (Dhungel, 2008). One of the most significant energy related changes in last 20 years has been significant reduction in energy intensity in the world's developed countries. Number of factors influence energy requirement of an economy, where economic growth is one of the most important factors. Economic growth is often accompanied by industrialisation electrification and rapid growth of infrastructure. Economic growth tends to be directly correlated with increased energy consumption, at least to a certain point. Beyond a certain point however, further economic development actually can lead to structural shifts in the economy that reduce the prominence of energy consumption of an economy as higher income levels can lead to the development and diffusion of more technologically sophisticated and less energy intensive machines.

On the other hand, Manufacturing Capacity Utilisation is such a key indicator of economic performance which explains changes in investment, inflation, long-run output growth etc. In view of severe scarcity of capital resources in any developing country like India, capacity utilisation is a crucial factor that not only affects growth but also indicates the level of resource utilisation in an economy. Therefore, the estimation of capacity output and its utilisation will be very useful to evaluate the variations in the performance of an industry over a period of time.

In this paper we examine the Energy Intensity and Capacity Utilisation of two major manufacturing industries such as Chemical and Chemical Product and Basic Metal over the period 1980-81 to 2011-12, that covers both pre-reform and post-reforms period.

This paper is organised as follows: Chapter 2 deals with the brief survey on literature. Chapter 3 presents the database and methodology of our study. Chapter 4 analyses the results and discussion part on the energy intensity and Capacity Utilisation of the industries. Chapter 5 outlines the summary and conclusion part of our study.

CHAPTER 2

LITERATURE REVIEW

2.1 Review of literature on energy intensity in India:

The energy intensity of some manufacturing industries in India is the highest among the world. The manufacturing sector is the largest consumer of commercial energy in India; this sector consumes about half of the commercial energy available in the country. Energy consumption per unit of production in the manufacturing of steel, aluminium, cement, paper, textile etc is much higher in India, even in comparison with some developing countries.

Ang (1995): in his paper he has examine sectoral disaggregation, structural effect an industrial energy use and their interrelationships in manufacturing industries in Singapore from 1974-1989. He has decomposed the changes in total energy consumption and the changes in aggregate energy intensity in industries. He has used the variables like energy consumption, total output and energy intensity. His findings suggest that the impact of structural change can be large in energy demand projection in industrial sectors.

Bhattacharya and Paul (2001): have attempted to find the relative contribution of activity effect, intensity effect and structural effect to the changes in sectoral energy consumption and the changes in energy intensity in the different sectors of the Indian economy during 1980-1996. They have divided their study period into three sub-periods such as 1980-85, 1985-90 and 1990-96. They have observed that total energy intensity has increased due to the structural effect in industrial sector in India during 1980-85. Negative intensity effect has caused a decline in total energy intensity in industry sector in India during 1980-90. The structural effect (positive) has dominated the changes (positive) in total energy intensity of Indian industries during 1990-96.

Goldar (2010): in his paper he has examined the factors that influence energy intensity in Indian industries. He has taken up ten, four digit industries from 2003-04, the energy intensity is more than 10%, it is found that these industries have accounted for 57% of total energy consumption in organised manufacturing and about 25% in value added and 22% in value of output during 2003-04.

Sahu and Narayanan (2009): the demand for commercial energy has been growing rapidly, with the growth of the economy. The Indian manufacturing sector is the largest consumer of commercial energy compared to other industries in India. In their study they found that energy consumption of the aggregate Indian manufacturing industry was rising in absolute term, energy intensity of the Indian manufacturing was declining from 1990-2000. They found through their study that there is a positive relationship between technology import, firm size and energy intensity.

Samules et.al (1984): in this paper he studies the changes in energy intensity as determinants of energy consumption in manufacturing. The study covered the period from 1975-80. They decomposed the manufacturing sector to 448 four digit SIC industries. The total reduction in energy used per dollar of shipments from 1975-80 was decomposed into (1) the reduction brought about by shifts a way from energy intensive sectors and (2) reduction due to improvements in energy efficiency. Most changes in energy intensity were from 1975-80 due to improvement in energy efficiency.

2.2 Studies on capacity utilization in India:

In the view of overriding importance of capacity utilization in the overall resource-use efficiency of the economy, however, a few researchers have tried to examine the trends and determinants of capacity utilization in Indian industry. Studies that examined the determinants of capacity utilization (CU) found that most of the industries are demand-constrained (Goldar and Ranganathan, 1991, Srinivasan, 1992). An examination of the literature reveals the most of the studies have used conventional measures of capacity utilization (CU) and have paid inadequate attention to the possible theoretical problems. The economic capacity of given stock of capital will vary with the relative price changes, resulting in a change in the optimum combination of capital and other variable inputs.

Vishwanathan and Mukhopadhyay (1991) have presented economic measure of capacity utilization for Indian cement industry for a period of 1960-61 to 1984-85. Their study suggests that, for some years, CU is found to be more than one, on the basis of which the authors conclude that the firms could have reduced their production cost by moving to the minimum point of short-run and average cost curve.

The first study of Srinivasan (1992a) examines the determinants of capacity utilization in Indian industries. Data on full capacity and utilisation levels or different industrial sectors is taken from CMIE (1987). Time series data on capacity utilization from 1970 to 1984 has been collected from World Bank (1989) for selected industries from four broad sectors: basic, capital, intermediate and consumer goods.

Azeez.E. Abdul (2001) estimates a consistent series for the economic capacity utilization of the Indian non-electrical machinery manufacturing sector. The optimal or economic capacity is defined as the output where short-run average total cost is minimized.

Danish.A. Hashim (2003) makes an attempt to measure the extent of capacity utilization in Indian airlines industry and its impact on unit cost of production. Using data from 1964-65 to 1999-2000 and applying a trans-log variable cost function, the capacity utilization has been estimated with respect to two alternative measures of potential output : (i) where short-run average cost is minimum and (ii) where short-run and long-run average cost curves are tangent.

2.3 Objectives of study:

1. To assess the energy intensity of Chemical and Chemical Products industries and Basic Metal industries over the period 1980-81 to 2011-12 of Indian manufacturing sector.

2. To assess the capacity utilisation of Chemical and Chemical Products and Basic Metal industry over the period 1980-81 to 2011-12.

3. To evaluate impact of liberalization on capacity utilization of the selected Indian manufacturing industries in India.

CHAPTER 3

DATABASE AND METHODOLOGY

3.1 Study period:

This paper covers a period of 32 years from 1980-81 to 2011-12. The entire period is divided into two phases, the pre-reform (1980-81 to 1990-91) and post-reform period (1991-92 to 2011-12).

3.2 Data source:

The available official data on industrial capacities are considered. The present study is based on industry level time series data taken from several issues of Annual Survey of Industries (ASI) and energy statistics published by Central Statistical Organization (CSO), RBI Handbook of statistics on Indian Economy published by Reserve Bank of India (RBI).

3.3 Classification of industries:

Indian manufacturing industries are classified in following way-

Industry Name	NIC-1987 CODE	NIC- 1998 CODE	NIC- 2004 CODE	NIC-2008 CODE
Chemical and Chemical Products	30	24	24	20
Basic Metal	33	27	27	24

3.4 Description of variables:

3.4.1 Energy cost and Price of Energy:

Cost of fuel has been considered as the measure of energy inputs. Industry level time series data on cost of fuel of respective industrial sector have been deflated by suitable deflator (base 1990-91=100) to get real energy inputs. Due to unavailability of data regarding periodic price series of energy in India, some approximation becomes necessary. We have taken weighted aggregative average price index of fuel (considering coal, petroleum and electricity price index, suitably weighted, from Statistical Abstract) as proxy price of energy.

3.4.2 Capital Stock and Price of Capital:

Gross fixed capital stock at 1990-91 prices is taken as the measure of capital input. The implicit deflator for fixed capital stock is done by the ratio of Gross Fixed Capital Formation (GFCF) at constant prices. The base year is considered as 1990-91= 100. Then, the fixed capital stock is deflated by the deflator to obtain the gross fixed capital stock.

Rental price on capital is the price of capital (P_K) that is obtained from the ratio if interest paid to capital invested.

3.4.3 Labour and Price of Labour:

Total number of persons engaged in each industry is taken as labour input. Total number of persons engaged as measure of labour input includes both workers and persons other than workers.

In the context of developing economy like India, all major works on the manufacturing sector consider total employees as the measure of labour input, as because there is an imperfection in the labour market.

Price of Labour (P_L) is the total emoluments divided by total number of persons engaged.

P_L= total emoluments / total number of persons engaged (L)

3.4.4 Measurement of Output and Variable Cost:

Output is measured as real value added produced by manufactures ($Y= P_L.L+P_K.K_0+P_E.E$) suitably deflated by WIP index for manufactured product (Base 1990-91=100) to offset the influence of price changes. Variable cost is sum of expenditure on variable inputs ($VC=P_L.L+P_E.E$).

3.5 Methodology:

3.5.1 Method for measuring energy intensity:

Energy Intensity of any industry is defined as a ratio of total energy consumption (in value) to total output production (in value) of that industry. In this paper, energy intensity indicates the value of energy consumption per unit of value of output. There may be either an increase in energy intensity or decrease in energy intensity. Declining energy intensity in any industry indicates efficient use of energy.

In this paper we have formulated the methodologies which involve the decomposition of total energy consumption (E) and aggregate energy intensity (I).

Let,

Y_{it}: Total output production in an economy, say India, of i^{th} industry at t, t= 1,2,…,n.

$Y_t = \Sigma Y_{it}$: Total output production in an economy, say India, at t, t= 1, 2, …, n.

E_{it}: Total energy consumption of i^{th} industry in an economy, say India at t, t=1,2,…,n.

$E_t = \Sigma E_{it}$: Total industrial energy consumption in any economy, say India at t, t=1,2,…,n.

Then,

The output share of the i^{th} industry:

$$\alpha_{it} = Y_{it} / Y_t$$

Energy intensity of i_{it} industry:

$$I_{it} = E_{it} / Y_{it}$$

We define Aggregate Energy Intensity as:

$$I_t = E_t / Y_t = \Sigma E_{it} / Y_t$$

$$= \Sigma I_{it} Y_{it} / Y_t$$

$$= \Sigma \alpha_{it} I_{it} \ldots\ldots\ldots\ldots\ldots(1)$$

There may be two situations,

$I_t > 0$, when $\alpha_{it} > 0$, $I_{it} > 0$.

$I_t > 1$, when $\alpha_{it} > 0$, $I_{it} > 0$. In this case an increase in the aggregate energy intensity is associated with either increase in output share of the industry or increase in industry's energy intensity or both.

Aggregate energy intensity (I_t) is the weighted summation of the i^{th} industry's intensity where weights being the output share of the respective industry. In other words, it is the weighted average of i^{th} industry's intensity where weights being the output share of the respective industry.

3.5.2 Method for measuring Capacity Utilisation:

Considering a single output and three input framework (K, L, E) in estimating CU, we assume that firms produce output within the technological constraint of a well-behaved producing function.

Y = f (K, L, E) where K, L and E are capital, labour and energy respectively. Since capacity output is a short-run notion, the basic concept behind it is that firm faces short-run constraints like stock of capital. Firms operate at full capacity where their existing capital stock is at long-run optimal level. Capacity output is that level of output which would make existing short-run capital stock optimal.

Rate of CU is given as

$$CU = Y/Y^* \quad \ldots\ldots\ldots (1)$$

Y is actual output and Y* is capacity output.

In association with variable profit function, there exist Variable Cost (VC) functions which can be expressed as

$$VC = f(P_L, P_E, K, Y) \ldots\ldots\ldots\ldots (2)$$

Short-run total cost (STC) function is expressed as

$$STC = f(P_L, P_E, K, Y) + P_K K \ldots\ldots\ldots\ldots (3)$$

P_L and P_E is the price of labour and energy respectively and P_K is the rental price of Capital.

Variable cost equation which is variant of general quadratic from for (2) that provided a closed from expression for Y* is specified as

$$VC = \alpha_0 + K_0 [\alpha_K + ½ \beta_{KK} (K_0/Y) + \beta_{KL} P_L + \beta_{KE} P_E]$$

$$+ P_L (\alpha_L + ½ \beta_{LL} P_L + \beta_{LE} P_E + \beta_{LY} Y)$$

$$+ P_E (\alpha_E + ½\beta_{EE} P_E + \beta_{EY} Y) + Y (\alpha_Y + \beta_{YY} Y) \ldots\ldots\ldots (4)$$

K_0 is the capital stocks at the current year which implies that a firm makes output decisions constrained by the capital stocks available during current year.

Capacity output (Y^*) for a given level of quasi- fixed factor is defined as that level of output, which minimizes STC .So, the optimal capacity output level, for a given level of quasi-fixed factors, is defined as that level of output, which minimizes STC. So, at the optimal capacity output level, the envelop theorem implies that the following relation must exist.

$$\delta STC/\delta K = \delta VC/\delta K + P_K = 0 \ldots\ldots\ldots\ldots (5)$$

In estimating Y^*, we differentiate VC equation (4) w.r.t K_0 and substitute expression in equation (5)

$$Y^* = -\beta_{KK}\ K_0 / (\alpha_K + \beta_{KL} P_L + \beta_{KE} P_E + P_K) \ldots\ldots\ldots (6)$$

The estimates of CU can be obtained by combining equation (6) and (1).

CHAPTER 4

RESULTS AND DISCUSSION

4.1: Capacity utilization for two major manufacturing industries in India:

In this chapter, we analyse the yearly estimates of capacity utilization and impact of liberalization on capacity utilization for the selected manufacturing industries over the period 1980-81 to 2011-12.

Table 4.1.1: Yearly Estimates of Capacity Utilization:

YEAR	Chemical and Chemical Products Industries	Basic Metal Industries
1980-81	0.97	0.93
1981-82	0.88	0.98
1982-83	0.86	0.88
1983-84	0.92	0.87
1984-85	0.89	0.74
1985-86	0.96	0.88
1986-87	0.94	0.98
1987-88	0.83	0.89
1988-89	0.92	0.97
1989-90	0.93	0.96
1990-91	0.95	0.79
1991-92	0.75	0.83
1992-93	0.73	0.67
1993-94	0.85	0.79
1994-95	0.79	0.78
1995-96	0.90	0.80
1996-97	0.84	0.83
1997-98	0.83	0.75
1998-99	0.78	0.72
1999-2000	0.77	0.84
2000-01	0.82	0.79
2001-02	0.69	0.87
2002-03	0.98	0.83
2003-04	0.88	0.93
2004-05	0.84	0.86
2005-06	0.95	0.96
2006-07	0.98	0.99
2007-08	0.95	0.91
2008-09	0.89	0.98
2009-10	0.97	0.96
2010-11	0.92	0.81
2011-12	0.87	0.85
Annual Average CU for the Entire Period	0.8759	0.8631
Annual Average CU for the Pre-reform Period	0.9136	0.8972
Annual Average CU for the Post-reform Period	0.8561	0.8452

Source: Authors' own estimation

From the above table, it has been noticed that the rate of capacity utilization is less than unity for Chemical and Chemical Product Industry as well as Basic Metal industry over the time period.

Analysis of capacity utilization in Indian Chemical and Chemical Product Industries depicts that there is a falling trend over years because average annual CU declined from 0.9136 in pre-reform period to 0.8561 in the post-reform period.

In Indian Basic Metal Industries, the economic CU ranges from 0.67 to 0.99. In this industry, a comparison of the annual average utilization of capacity in the two periods showed lower capacity utilization in the post-reform period when compared with the pre-reform period.

These two industries (Chemical and Chemical Product and Basic Metal) shows that production is taking place at underutilised situation.

Capacity Utilisation has decreased in the post-reform period for both the industry.

4.2: Impact of liberalization on capacity utilization of the selected Indian manufacturing industries in India:

The following equation is used to investigate the issue of whether there exit any positive or negative impact of economic reforms on capacity utilization of the selected manufacturing industries in India. Dummy variables are used to allow both the intercept and slope to be different from 1991 onward. Thus, we estimate a typical regression equation:

$$LnY = \alpha + \beta D + \gamma T + \delta DT.$$

Where D is dummy variable with value equal to zero for the years up to 1990-91 and one thereafter and Y is the capacity utilization ratio. The coefficient of multiplicative dummy term, δ, may be positive or negative and significant will show that there was favourable or adverse impact of economic reform on capacity utilization in the post-reform period. The regression results of all selected industries are depicted in table 4.2.1

Table 4.2.1: Regression results incorporating dummy variable for two major manufacturing industries in India (CU as dependent variable)

Variables	Chemical and Chemical Product Industries	Basic Metal Industries
Intercept	**-0.10** **(-2.13)**	**-0.0967** **(-1.78)**
β	**-0.2811** **(-3.69)**	**-0.32** **(-3.64)**
γ	**0.0015** **(0.22)**	**-0.0025** **(-0.31)**
δ	**0.008** **(1.15)**	**0.0136** **(1.59)**
R^2	**0.89**	**0.87**

Source: own estimate

Figures in the parenthesis are t values. As the coefficient of dummies in these two industries under our consideration are significant and negative at 3% level of significance, we can conclude that economic reforms have adverse impact on capacity utilisation of those industries in the post-reforms period and again the coefficient of multiplicative dummies in these two industries under our consideration are insignificant.

4.3: Estimation of Energy Intensity:

Table 4.3.1: measurement of energy intensity of two manufacturing industry in India:

Year	Chemical and Chemical Product industries	Basic Metal Industries
1980-81	0.2131	0.0545
1981-82	0.2652	0.0590
1982-83	0.2628	0.06567
1983-84	0.2878	0.0696
1984-85	0.3266	0.0666
1985-86	0.3286	0.3322
1986-87	0.4211	0.0823
1987-88	0.3999	0.0854
1988-89	0.3699	0.0971
1989-90	0.4020	0.0867
1990-91	0.4131	0.0897
1991-92	0.4229	0.0909
1992-93	0.3970	0.1034
1993-94	0.3801	0.1198
1994-95	0.4139	0.1180
1995-96	0.3714	0.1205
1996-97	0.4645	0.1256
1997-98	0.5178	0.1468
1998-99	0.3421	0.1420
1999-2000	0.4430	0.1599
2000-01	0.5956	0.1809
2001-02	0.6534	0.1827
2002-03	0.6454	0.2117
2003-04	0.7513	0.4331
2004-05	0.6640	0.2167
2005-06	0.6940	0.2028
2006-07	0.7668	0.2145
2007-08	0.7890	0.2127
2008-09	0.7306	0.1715
2009-10	0.9579	0.1830
2010-11	0.9733	0.2296
2011-12	0.9292	0.2788
Entire Period	0.5185	0.1544
Pre-reform Period	0.3354	0.0990
Post-reform Period	0.6156	0.1831

Source: Authors' own estimation

From the above table we may conclude that the aggregate energy intensity in Chemical and Chemical Product Industry is 0.5185 for the entire time period, whereas in Basic Metal industry it is 0.1544.

For Chemical and Chemical Product Industry, the energy intensity in pre-reform period is 0.3354 and in the post-reform period it is 0.6156. Therefore, we may say that energy intensity has increased.

The energy intensity for Basic Metal industries also has increased in the post-reform period (0.1831) than the pre-reform period (0.0990).

So, ultimately we observe that for both the industries taken up for our study, the energy intensity has increased in the post-reform period.

4.4: Estimation of trend growth rate of energy intensity of the selected Indian manufacturing industries:

The following equation is used to measure the trend growth rate of energy intensity of the selected manufacturing industries in India.

$$LnY = \alpha + \beta T$$

Where, Y is the energy intensity and β is the growth rate of energy intensity.

4.4.1: Trend Growth Rate for Chemical and Chemical Product Industry:

Trend Growth Rate	Entire Period	Pre-reform Period	Post-reform Period
Intercept	**-1.41** **(-28.62)**	**-1.49** **(-25.47)**	**-1.64** **(-15.46)**
Coefficient	**0.0410** **(15.69)**	**0.0627** **(7.27)**	**0.0501** **(10.72)**
Regression Results	**R2=0.8914** **Adj. R^2 =0.8878**	**R2=0.8546** **Adj. R^2 = 0.8385**	**R2=0.8583** **Adj. R^2 =0.8508**

Source: Authors' own estimation

From the above table we may conclude that, the trend growth rate of energy intensity is 4.10% for the entire time period. But the trend growth rate of energy intensity is 6.27% where as it is sharply declining in the post-reform period and it is 5.01%. The R^2, Adj-R^2 and t-values are also high for the entire as well as both the sub-periods regression model.

4.3.2: Trend Growth Rate for Basic Metal industry:

Trend Growth Rate	Basic Metal Industries	Pre-reform Period	Post-reform Period
Intercept	-2.73 (-23.55)	-2.779 (-8.96)	-2.76 (-14.54)
Coefficient	0.044 (7.24)	0.0529 (1.15)	0.0456 (5.47)
Regression Results	R^2=0.6365 Adj.R^2 =0.6244	R^2=0.129 Adj.R^2 =0.0329	R^2=0.6120 Adj.R^2 =0.5916

Source: Authors' own estimation

From the above table we may conclude that, the trend growth rate of energy intensity is 4.4% for the entire time period. But the trend growth rate of energy intensity is 5.29% where as it is sharply declining in the post-reform period and it is 4.56%.

From the above analysis, it is quite clear that, in the pre-reform period the growth rate of energy intensity is higher in case of Chemical and Chemical Product industry than the Basic Metal Industry. The picture is the same in case of the post-reform period.

CHAPTER 5

SUMMARY AND CONCLUSION

In this study, we have tried to analyse the trend in Capacity Utilisation for two major manufacturing industries in India. We have also analysed the trend growth rate of the energy intensities of two major manufacturing industries such as Chemical and Chemical Product and Basic Metal industry, over the time period 1980-81 to 2011-12. We have also tried to make a comparative analysis between the two industries and also between pre and post-reform period.

From our work we may reach at the following conclusions:

For both the industries (Chemical and Chemical Product and Basic Metal industry) we observe that they are operating at underutilised situation (as CU is less than one for all the cases.

The annual average CU for both the industries is lower in the post-reform period when compared with the pre-reform period.

It is highly interesting to note that the annual average CU is higher in Chemical and Chemical Products industry than that of Basic Metal industry for all the cases.

When we consider energy intensity of the above mentioned industries, it is significant to note that energy intensity has increased in the post-reform period.

So far as the growth rate of energy intensity is concerned, it is noticed that the growth rate is higher in Basic Metal industry than that of Chemical and Chemical product industry for the entire time period.

Last but not the least, it may be concluded that the growth rate of energy intensity has fallen in the post-reform period, when compared with pre-reform period for both the industries, which shows a movement towards sustainable development in the post-reform period. In other words, energy consumption in the post-reform period is lower than that of the pre-reform period, which may lead to a fall in the pollution creation (CO_2, CO etc.) and ultimately a movement towards sustainable development in the post-reform period.

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