Trade Reform and Total Factor Productivity Growth in Indian Basic Metal Industry

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Abstract

This paper attempts to estimate the output growth and total factor productivity growth in the Basic metal industry in India and compare these results in the Pre-Liberalization and post-Liberalization periods (1981-82 to 1990-91 and 1991-92 to 2016-17). We have used trans-log production function for estimation of TFPG. We have done relevant time series analysis in this paper. For time series analysis we have done Augmented Dicky Fuller test and Phillips-Perron test for checking stationarity of variables. Series of all the variables are found to be stationary. Bai-Perron structural break analysis is also used in this paper where two structural break points have been found in the year 2005 and 2013. Annual average total factor productivity growth has decreased in the post- liberalization period when compared with the pre- liberalization period, though, Solow measure shows a reverse result. We have also calculated average capacity utilization (CU) for the whole period (1981-82 to 2016-17) which is found to be more than 0.90. In the post-liberalization period average capacity utilization has increased marginally compared to the pre-liberalization period. We have also tried to find out the determinants of total factor productivity growth in the Basic metal industry in India. It has been seen from our regression analysis that only real-effective exchange rate, inflation rate, capacity utilization, investment in fixed assets are significant factors influencing total factor productivity growth (TFPG).The other factors which are individually insignificant are also found to be jointly insignificant.

JEL Classification: *F13, L61, F68*
Keywords: *Basic metal industry, Productivity, Liberalization, Capacity utilization.*

1. Introduction

India adopted New Economic policy in the year 1991. Three main pillars of new economic policy are Liberalization, Privatization & Globalization (LPG). A massive trade liberalization measures adopted in this year is a mark of major departure from the relatively protectionist trade policies pursued in earlier years. So Liberalization & Globalization advocated free trade policy which seems to have been improving productivity & competitiveness of industry and at the same time adverse balance of payments situation in India. Main features of Indian trade policy reforms since 1991 are , free Imports and Exports , rationalization of Tariff Structure , devaluation of Indian currency, convertibility of rupee on current account, establishment of trading houses for export & import etc. Trade liberalization influenced Indian economy enormously which can be analyzed from several point of view. Naturally manufacturing sector of India is also assumed to be influenced by trade liberalization. Economists are interested to find the impact of trade liberalization on the growth and efficiency of manufacturing industries in India. In this paper we are also interested to examine the impact of trade liberalization on the efficiency and the growth of basic metal industry in India. The conventional theoretical view in favour of trade liberalization is that it can lead to significant gain in productivity. But there is no sufficient empirical evidence either in favour of this view or against it. The impact of trade liberalization on total factor productivity growth in the manufacturing sectors of developing countries remains a controversial issue. This controversy has intensified in India after the economic reforms in 1991. In this regard we are also interested to see the effect of trade liberalization on total factor productivity growth in the Basic Metal industry of India. This paper is an attempt to find the impact of trade liberalization on total factor productivity growth in the Basic Metal industry of India. It has been observed from our estimation that total factor productivity growth (average) in the post liberalization period is less than that in the pre-liberalization period which is against the conventional trade theories.

2. A brief description of Basic Metal Industry in India

The Basic Metal Industry of India is one of the very important and key industry in India as India has huge mineral deposits like iron ore, copper, manganese, chromium, bauxite etc. It builds the base of industrial economy of India and supplies major raw materials to other industries. The Basic Metal Industry can be divided into three groups: basic iron and steel, basic precious and other non-ferrous metals. India is also the fourth largest producer of iron and steel in the world. So for attaining high level of GDP growth India requires a sustained growth in iron and steel industry. The names of some important non- ferrous metal are Aluminium , Copper, Zinc, Lead etc.

3. Literature Survey

3.1 Studies on Indian manufacturing Industry

Roy & Pal (2010) examined productivity performance of India's aluminium industry in the pre and post-economic reforms and tried to relate economic capacity utilization with productivity growth. According to them the total factor productivity growth in the post-reform period declined. They found that the total output growth in the Indian aluminium industry was mainly input-driven rather than productivity-driven. The liberalization process was found to have adverse impact on total factor productivity growth. Roy & Pal (2012) judged productivity performance of Indian Glass Industry in view of Malmquist total factor productivity growth. Their result on the overall productivity showed a declining total factor productivity growth during post-reform period as compared to pre-reform period. Pal & Das (2014) measured productivity performance of Indian Basic Metal Industry during the period 1980-81to 2010-11 using Malmquist Data Envelopment Analysis. They found a declining trend of TFPG in post reform period as compared to pre reform period for the Indian Basic Metal industry. Kathuria et. al. (2013) computed the TFP growth of Indian manufacturing for both formal and informal sectors from 1994-95 to 2005-06. Their results indicated that the TFP growth for formal and informal sector had differed greatly during that period. Goldar and Kumari(2003) found that total factor productivity growth in Indian manufacturing decelerated in the 1990s. Their paper also indicated that the lowering of effective protection to industries favorably affected productivity growth.

Topalova et.al. (2010) tried to establish a link between changes in tariffs and firm productivity. They found an inverse relationship between tariff and firm level productivity. They also found that impact is larger for input tariffs rather than the tariffs on final goods. Krishna and Mitra(1998) got an inadequate indication of an increase in the rate of growth of total factor productivity for India due to trade related reforms. Chand and Sen(2002) witnessed a positive relationship between trade liberalization and TFP growth on the basis of their empirical test.

3.2 Studies on manufacturing Industries of some foreign countries

Sheikh and Ahmed (2011) had shown a favorable impact of trade related reforms on the efficiency level of agro-based industries of Pakistan. Solow (1957) established output growth by the accumulation of factor inputs and total factor productivity growth. Endogenous growth models pioneered by Locus (1988) and Romer (1994) emphasized the role of education, research and development (R&D) and trade in determining the rate of growth. Urata and Yokota (1994), Tybout (1995) and Kim (2000) obtained robust evidence of increase in total factor productivity due to trade related reforms. Jajri(2007) observed that restructuring of the economy and the presence of foreign companies' in Malaysia were the major contributor to TFP growth in Malaysia. Isaksson and Ng (2006) found human and physical capital, financial development, infrastructure, and trade liberalization etc. as some important TFP determinants considering two modes of analysis — cross-country analysis and country case studies. Alfaro et.al.(2008) examined the effect of foreign direct investment (FDI) on growth and got positive effect in their earlier work and they also found that countries with well-developed financial markets gain significantly from FDI via TFP improvements. Liao et.al.(2002) examined total factor productivity (TFP) growth for eight East Asian economies during 1963-1998 applying stochastic frontier analysis. Their empirical results revealed that the TFP growth was an important source of output growth and among which the technical efficiency change played a crucial role. Hu and Liu (2012) examined the impact of tariff reduction on the productivity of Chinese manufacturing firms. They found that reduction of output tariff depressed Chinese firms' productivity significantly. Njikam and Cockburn (2007) found that the pre-liberalization period was a very successful relative to post-liberalization period for Cameroonian manufacturing firms. Isaksson (2007) identified some important determinants of TFP growth such as education, infrastructure, health, imports, competition, openness, financial development etc. Majeed et.al. (2010) observed that trade liberalization in Pakistan had not brought any favourable impact on Total Factor Productivity Growth of large scale manufacturing sector of Pakistan during the period 1971-2007. Amann and Virmani (2015) analyzed the "feedback effect" of Foreign Direct Investment (FDI) on Total Factor Productivity (TFP) growth in emerging economies via technology spillovers across borders. Their result established that FDI enhanced productivity growth.

4. Research Gap

Researchers got ambiguous results regarding the relationship between trade liberalization and total factor productivity growth in some major manufacturing Industries in India. Some manufacturing Industries in India had shown increasing total factor productivity growth in the post liberalization period but some had shown declining total factor productivity growth. Still now the debate regarding relationship between trade liberalization and total factor productivity growth has remained unsettled. So it needs to be analysed in depth .It is also to be noted that the determinants of total factor productivity is not, yet, identified completely. In this paper we have selected basic metal industry for our work and we have collected relevant data and have estimated total factor productivity growth (TFPG) and capacity Utilization (CU). Then we have analysed the estimated result and have tried to find the effect of trade liberalization on TFPG. We have also done rigorous work to find out determinants of total factor productivity growth (TFPG) in Indian basic metal industry.

5. Objectives of our study

i) To estimate total factor productivity growth (TFPG) of Basic Metal Industry in India.

ii) To estimate trend in Capacity Utilization (CU) of that Industry in India.

iii) To apply Time Series Approach to obtain and analyze various results regarding TFPG and CU.
iv) To find out determinants of TFPG.
v) To find out the impact of trade liberalization on total factor productivity growth in Indian basic metal industry.

6. Sources of Data

Our study would be mainly based on industry-level secondary data for a period of 37 years from 1980-81 to 2016-17 (Selection of time period is mostly guided by the availability of data). Out of these 37 years there are 11 years in the pre-liberalization period and 26 years in the post-liberalization period. The entire period is sub-divided into two phases: pre-liberalization period (1980-81 to 1990-91) and post-liberalization period (1991-92 to 2016-17). We have sub-divided the total period in the year 1991 because we want to assess the impact of trade liberalization on growth and productivity of output of Indian basic metal industry. The basic data sources for our study are as follows:

i) Various issues of Annual Surveys of Industries (ASI).
ii) National Accounts Statistics (NAS).
iii) Centre for Monitoring Indian Economy Reports and Economic Surveys (CMIE).
iv) Statistical abstracts (several issues).
v) RBI Bulletins.
vi) Reports on Currency and Finance.
vii) Handbooks of Statistics on Indian Economy.
viii) KLEM data from RBI.
ix) World Bank data.

The classification of industries followed in ASI is based on the national industrial classification made during 1970,1987,1998,2004 and 2008. We have taken basic metal industry at two digit level for our study. The code for basic metal industry at two digit level changed as per different national industrial classification which is given in the following table: 1.

Table: 1. NIC code of two digit Basic metal Industry

NIC	1970	1987	1998	2004	2008
Two digit Code	33	33	27	27	24

Source: NIC Code (various years)

7. Variables used

We have used output, labour and capital as three main variables in our study. To make the values of output and capital comparable over time, suitable deflators have been used. The definition of the variables and the deflators used and various issues involved in the selection of these variables are presented below.

Output

For estimation of TFPG, we have considered output as Real Gross Value Added. To get Real Gross Value Added we deflated Gross Value Added (GVA) by GDP deflator. GDP deflator is formed by considering 1991-92(year of Economic Liberalization in India) as base year. So,

$$\text{Output(Y)} = \text{Real Gross Value Added} = \frac{\text{GVA}}{\text{GDP Deflator}}$$

Where, GVA= Net Value Added + depreciation and

GDP Deflator = $\frac{\text{GDP at current Prices}}{\text{GDP at (selected) Base Year}}$

In order to avoid problem of double counting, we have preferred Gross Value Added (GVA) to Gross output. In order to avoid influence of price change, we have also preferred real Gross Value Added (RGVA) to Gross Value Added (GVA).

Labour input:

In our study Labour is segregated into two groups – workers (L_1) and other than workers (L_2) like administrative, technical and clerical staff. Remuneration of labour is also divided into two segments – wage for workers (W_1) and wage for persons other than workers (W_2).

Labour (L) is defined as:

$L = L_1 w_1^* + L_2 w_2^*$ where L_1 = Worker and L_2 = Persons other than workers

$$w_1^* = \frac{w1}{w1+w2} \quad \text{and } w_2^* = \frac{w2}{w1+w2}$$

w_1= wage to workers and w_2= wage for persons other than workers.

Capital input:

In the productivity analysis the measurement of capital input is very crucial and critical. In our study Capital is defined as deflated gross fixed capital stock (GFCS).

Capital input is measured by: K = $\frac{\text{GFCS}}{\text{Capital Deflator}}$

The capital deflator is formed from Gross Fixed Capital Formation (GFCF) using the following formula:

Capital Deflator = $\frac{\text{GFCF at current year}}{\text{GFCF at base year}}$, ratio of GFCF at current prices to that at constant base year prices where 1991-92 is considered as base year.

8. Methodology

Total factor productivity (TFP) is defined as the ratio of aggregate output to aggregate input. It can be calculated by dividing output by the weighted average of labour and capital input.

Therefore TFP = $\frac{Y}{\alpha L+\beta K}$ where Y is the output, α is the share of labour, β is the share of capital, L: labour input and K: capital input.

Total Factor Productivity Growth (TFPG) can be defined as the residue of output growth which is not explained by the growth of labour and capital factor inputs.

We can also calculate annual growth rate, average annual growth rate and trend growth rate for measuring growth performance of output and productivity.

Annual Growth rate can be calculated by using the following formulae:

$G_t = \frac{Xt-Xt-1}{Xt-1}$ where X is the variable for which annual Growth rate can be calculated.

To estimate trend growth rate we will use semi logarithmic (log y = a + bt) using ordinary least square method.

In our study, the productivity performances for Indian Basic Metal industry can be explained with the help of two concept of productivity, viz. partial or single factor productivity and total factor productivity. Partial or single factor productivity is defined as the ratio of output to the quantity of input factor for which partial or single factor productivity is to be measured. Partial or single factor productivity of labour is measured by the ratio Y/L and Partial or single factor productivity of capital is measured by the ratio Y/K. Partial factor productivity is however considered to be one of the oldest and widely used measures of productivity (Trivedi et al, 2000). Partial factor productivity can be changed by substituting one factor of production for another (Majumdar, 2004). Improvements in partial factor productivity could be achieved by changing the economies of scale (Mahadevan, 2004). Partial or single factor

productivity, though very easy for calculation, has some limitation in the analysis of productivity and growth of output as it analyses the productivity from partial view point.
There is another productivity concept which is known as total factor productivity. Total factor productivity (TFP) is defined as the ratio of aggregate output to aggregate factor inputs. It can be calculated by dividing output by the weighted average of labour and capital input. But economists are more interested in the analysis of Total Factor Productivity Growth (TFPG).
The portion of output growth which is not explained by the growth of factor inputs (L & K) is, actually, known as total factor productivity growth. There are two different approach for measuring Total Factor Productivity Growth namely, growth accounting approach and production function estimation approach. Growth accounting measure estimates the TFP Growth by subtracting weighted input growth from output growth. In the growth accounting approach we have used Solow measure of Total Factor Productivity growth (TFPG). Solow measure of Total Factor Productivity growth (TFPG) can be written as
$G^s = \frac{\dot{A}}{A} = \frac{\dot{Y}}{Y} - [S_K \frac{\dot{K}}{K} + S_L \frac{\dot{L}}{L}]$ where $S_K = \frac{\delta Y}{\delta K}\frac{K}{Y}$ and $S_L = \frac{\delta Y}{\delta L}\frac{L}{Y}$ .The difference, obtained in this way, includes the effects of technological progress, scale of production, capacity utilization, learning by doing, technical efficiency etc. Christensen and Jorgenson (1973), Denison (1962, 1974, 1979), Jorgenson and Griliches (1967), Kendrick (1961, 1973), Kendrick and Grossman (1980) and Solow (1957) have adopted the conventional growth accounting approach. But there is some limitation of growth accounting method for estimation of TFPG as this method is based on two restrictive assumptions - i) existence of perfect competition in the factor market and ii) existence of constant returns to scale(CRS). But this will hold good only in the presence of perfect competition though it is impossible for a developing country like India where market structures are oligopolistic in nature. Therefore production function estimation approach is undertaken for estimation of TFPG. There are also some advantages for choosing this method as it does not require the assumption of constant returns to scale (CRS) and exhibits non-unitary or non-constant elasticity of substitution. According to Hulten (2000), the production function approach to productivity measurement can be treated as complementary to the growth accounting approaches. The most important advantages of production function approach is that it does not require the assumption of CRS and perfect competition.

The estimates of the parameters of the production function directly provide us the information about the factor shares. Further, if more flexible forms of production functions are used, returns to scale or Homotheticity property of production functions can be directly tested. Christensen, Jorgenson and Lau (1971, 1973) developed a production function that was more flexible than Cobb-Douglas production function (CDPF) and CES. This type of production function is known as Transcendental logarithmic or the translog production function. This production function does not need Hicks-neutral type technology, unit or constant elasticity of substitution (as in the case of CDPF or CES production function). The Translog production function is written in the form:

$$\ln Y=\alpha_0+\alpha DT+\alpha_1\ln K+\alpha_2\ln L+\alpha_3 T+1/2\ \beta_{11}(\ln K)^2+1/2\beta_{22}(\ln L)^2+1/2\beta_{33}T^2+\beta_{12}(\ln K)(\ln L) + \beta_{13}(\ln K)T+\beta_{23}(\ln L)T$$

In this equation, Y denotes output (i.e. gross real value added), L denotes labor, K denotes capital and T denotes time (Year) and D denotes dummy variable for trade liberalization. α_0, α, α_1, α_2, β_{11}, β_{22}, β_{33}, β_{12}, β_{13}, β_{23} are the co-efficient of different variable. To find out the values of the co-efficient of different variable we have applied Ordinary Least Square (OLS) technique.

Before applying OLS we have done Stationarity Test for all the variables. Using this Stationarity Test we have tried to see whether there is unit root or not in the time series data for variables. At first we have done Unit Root Test for stationarity of variables. There are two type of Unit Root Test for stationarity of variables- Augmented Dicky Fuller Test (ADF) and Phillips Parron Test (PP). Null hypothesis states that there is unit root in the series of the variable. If there is unit root in the series then the time series data for the variable will be non-stationary .If the probability in the Augmented Dicky Fuller Test (ADF) and Phillips Parron Test (PP) is in between 1% - 10%, then null hypothesis will be rejected and the time series data for the variable will be stationary at 1% or 5% or 10% level of confidence. We have tested it at level and also at first difference with intercept, trend and intercept & trend and compared all the respective probability value. After getting satisfactory Stationarity result we have used co-integration test to see the existence of long run relationship among all the variables. For multi-variables case we have used Johansen co-integration Test. Here Null hypothesis states that Series of all the variables are not co-integrated. If the probability in the co-integration test is in between 1% - 10%, then null hypothesis will be rejected and Series of all the variables will be co -integrated. For applying OLS technique we need co-integrated stationary time series data of variables. We can estimate the value of co-efficient of different variables by applying OLS and then can calculate TFPG.

Total factor productivity growth (TFPG), derived from the production function, can be expressed above in the following way:

$$TFPG= (1/Y)(\delta Y/\delta T) = \delta \ln Y/\delta T=\alpha D+ \alpha_3+ \beta_{33}T+\beta_{13}\ln K+\beta_{23}\ln L$$

Using Trans-log production, we have followed backward elimination technique to get the best-fitted production function for basic metal industry.

We have applied four criteria to obtain the best-fitted production function:

1) The best-fitted production function should contain all the variables, namely, capital input, labor input and time.

2) The best-fitted production function should be observationally robust in the sense that all the coefficients should be significant and its estimated values will not change significantly even when one or two observations either from the beginning or from the end of the sample set are excluded from the model or included in the same.

3) The chosen form should have the desired property that the contributions of the inputs to the estimated output are positive.

4) All the variables excluded should be jointly insignificant.

Our objective is to observe TFPG which is obtained by differentiating the best-fitted production function with respect to time.

We have also done structural break analysis in this paper. After testing serial correlation we have used Bai-perron method of structural break analysis and found two structural break points of output growth (lnY) in the year 2005 and 2013.

We have also calculated value of Capacity Utilization (CU).

Capacity Utilization (CU) is given by

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

where Y is actual output and Y* is capacity output. Capacity output is defined as the level of output at which costs are minimized, given fixed capital equipments, the techniques of production, the factor prices and the available quota of inputs in the cases when they are rationed.

In association with variable profit function, Variable Cost (VC) functions can be written as

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

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

$STC = f(P_L, P_E, K, Y) + P_K K$ … (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 form for (2) that provide a closed form expression for Y* is specified as

$$VC = \alpha_0 + K_0 \, [\, \alpha_K + \tfrac{1}{2}\beta_{KK} [\tfrac{K_0}{Y}] + \beta_{KL} . P_L + \beta_{KE} . P_E \,]$$
$$+ P_L(\, \alpha_L + \tfrac{1}{2}\beta_{LL} . P_L + \beta_{LE} . P_E + \beta_{LY} . Y\,)$$
$$+ P_E\,(\, \alpha_E + \tfrac{1}{2}\beta_{EE} . P_E + \beta_{EY} . Y) + Y(\alpha_Y + \tfrac{1}{2}\beta_{YY} . Y) \quad \ldots (4)$$

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

$$\frac{\partial STC}{\partial K} = \frac{\partial VC}{\partial K} + P_K = 0 \quad \ldots (5)$$

In estimating Y*, we differentiate VC equation (4) with respect to K_0 and substitute expression in equation (5)

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

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

So $CU = Y/Y^* = [-Y\,(\alpha_K + \beta_{KL}.P_L + \beta_{KE}.P_E + P_K)] / (\beta_{KK}.K_0)$

We have calculated the value of CU for basic metal industry of India. We have defined different variable in the following manner.

Variable costs (VC) is the sum of the expenditure on variable inputs viz, labour(L) and energy(E). VC can be written as

$$VC = P_L L + P_E E.$$

Output(Y) can be measured as real value added produced by Indian manufacturer and can be written as

$$Y = P_L L + P_K K + P_E E$$

To get the real value and to minimize the effect of price changes we have taken gross output at constant 2011-12 prices which is available in the website of RBI.

Therefore, output(Y) = Gross Output at constant 2011-2012 prices (in Crores of ▪)

Price of labour (P_L) is obtained by dividing total emoluments by total labour employed.

So $P_L = \frac{\text{Total Emoluments}}{\text{Total labour employed}}$

The data regarding Total emoluments and total labour employed is available from ASI (various issues).

Price of Energy (P_E) is taken from RBI Data. The data regarding wholesale price index (WPI) of all commodities, manufactured products, energy (power & fuel) etc. are available from RBI website. But in case of yearly WPI from 1980-81 to 2016-17, there are several base year. We have transformed this data to a single base tear data from multiple base years and 1991-92 is taken as single base year.

Measurement of quasi-fixed Capital stock (K_0): Real Fixed capital is considered as quasi-fixed Capital stock (K_0). It is properly deflated by the deflated gross fixed capital formation (DGFCF) and it is the real value of quasi-fixed Capital stock.

Price of Capital (P_k): Price of capital is obtained by dividing amount of rent paid by the industry by real value of quasi-fixed capital stock.

9. Results and Findings

In the analysis of the Time series econometrics the time series data of all the variables need to be stationary. If the time series data of the variable is not stationary, the computed t-statistics under OLS regression fails to converge to their true values as sample size increases. In this situation the conventional confidence intervals become invalid and hypothesis tests cannot be conducted as usual. Recent econometricians observed that most economic time series are non-stationary as they have unit roots. We have done two types of unit root test viz, Augmented Dicky Fuller (ADF) test and Phillips-Perron(PP) test to see the stationarity of variables. Both Augmented Dicky-Fuller Test and Phillips Perron Test show that all the variables are stationary at first difference (Table-2 & Table-3).

Table-2: Results of Augmented Dicky Fuller (ADF) Unit root test

	ADF Test at Level		ADF Test at First Difference	
Variable	P-value	Statistic	P-value	Statistic
ln K	0.8680	0.730498	0.0000	-8.339621
ln K.ln K	0.8557	0.668290	0.0000	-8.384311
ln K.T	1.000	6.474729	0.0000	-6.757847
ln L	0.8772	0.779020	0.0000	-5.742825
ln L.T	0.7772	0.338071	0.0004	-4.814886
ln L.ln L	0.8757	0.770880	0.0000	-5.757496
ln L.ln K	0.9022	0.927629	0.0000	-8.803664
ln Y	0.5085	-0.460326	0.0000	-9.224370

Source: Authors' own estimation

Table-3: Results of Philips-Perron (PP) Unit root test

	Philips-Perron(PP) Test at Level		Philips-Perron(PP) Test at First Difference	
Variables	P-value	Statistic	P-value	Statistic
ln K	0.8601	0.689518	0.0000	-8.317723
ln K.ln K	0.8490	0.635625	0.0000	-8.383969
ln K.T	1.0000	5.377320	0.0000	-6.781397
ln L	0.8772	0.779020	0.0000	-5.742825
ln L.T	1.0000	4.775423	0.0003	-4.930451
ln L.ln L	0.8757	0.770880	0.0000	-5.757496
ln L.ln K	0.9062	0.953017	0.0000	-8.989714
ln Y	0.5482	-0.359468	0.0000	-9.224370

Source: Authors' own estimation

Our Johansen co-integration Test indicates that there exist 3 co-integrating equations at the 0.05 level. So co-integration Test shows that there is meaningful long run relationship among all the variables (Table-4). Series of all the variables are co-integrated. So lnY is co-integrated with other variables such as lnK, lnL, lnK.lnK, lnK.T, lnL, lnL.lnL, lnL.T, lnK.lnL etc.

Table-4: Results of Johansen co-integration Test

Hypothesized No. of CE(s)	Eigen value	Trace Statistic	Probability
None *	0.783022	209.2367	0.0000
At most 1 *	0.719768	155.7582	0.0002
At most 2 *	0.702841	111.2334	0.0028

Source: Authors' own estimation

The estimated result revealed that annual average growth rate of output (real GVA) of basic metal industry in India has not increased regularly and uniformly (Table-5).The annual average growth rate was negative for 18 years and was positive for 19 years out of 37 years (from 1980-81 to 2016-17).Highest growth rate of output (real GVA) of basic metal industry in India was in the year 2000-01(50.62) and highest negative growth rate was in the 2001-02(-57.73).

Table-5: Annual average growth rate of output (real GVA)

year	RealGVA G_Y in %	year	RealGVA G_Y in %	year	RealGVA G_Y in %	Year	Real GVA G_Y in %
1980-81	-0.5799	1990-91	12.284	2000-01	50.618	2010-11	-5.2435
1981-82	14.5701	1991-92	-29.193	2001-02	-57.725	2011-12	39.8844
1982-83	14.0801	1992-93	30.884	2002-03	34.7395	2012-13	-44.246
1983-84	-18.775	1993-94	-4.0065	2003-04	22.7218	2013-14	23.1484
1984-85	-10.212	1994-95	13.9052	2004-05	47.0152	2014-15	-18.946
1985-86	9.13285	1995-96	14.7603	2005-06	-21.953	2015-16	-30.836
1986-87	-17.686	1996-97	-2.01	2006-07	22.6449	2016-17	6.30077
1987-88	26.668	1997-98	8.41592	2007-08	17.7733		
1988-89	9.2324	1998-99	-23.99	2008-09	-26.424		
1989-90	-9.202	1999-2000	-0.8785	2009-10	-7.5301		

Source: Authors' own estimation

Note: $G_{Y:}$ growth rate of output

Annual average partial productivity of labour and capital is estimated and shown in the Table-6. The estimated result shows that annual average partial productivity of both labour and capital increases marginally in the post – liberalization period compared to pre-liberalization period.

Table-6: Annual average Partial productivity of factor inputs

Period	Annual Avg Y/L	Annual Avg Y/K
1980-81 to 1990-91	0.01179	0.22011
1991-92 to 2016-17	0.01185	0.23477
1980-81 to2016-17	0.01183	0.23014

Source: Authors' own estimation

Annual average growth rate in partial productivity of labour and capital is estimated and shown in Table-7. The estimated result shows that Annual average partial factor productivity growth of both labour and capital increases significantly in the post – liberalization period compared to pre-liberalization period.

Table-7: Growth rate of partial productivity of labour and capital

Period	Annual Avg growth rate (Y/L)	Annual Avg growth rate(Y/K)
1980-81 to 1990-91	0.0245	0.0673
1991-92 to 2016-17	0.0891	0.0891
1980-81 to2016-17	0.0100	0.08270

Source: Authors' own estimation

Annual average growth rate of output (real GVA), labour and capital is estimated and shown in Table-8. Neither growth rate in labour nor growth rate in capital is able to explain the growth rate in output (real GVA). Again, joint growth of K & L also fails to explain the growth in output.

Table-8: Growth rate in output, labour and capital

period	Annual avg G_L	Annual avg G_K	Annual avg G_Y
1980-81 to 1990-91	0.016364	-0.00636	2.682959
1991-92 to 2016-17	0.020769	0.233846	2.300769
1980-81 to 2016-17	0.019459	0.162432	2.414054

Source: Authors' own estimation

G_L = growth rate of labour, G_K = growth rate of capital, G_Y = growth rate of output.

Traditionally, the sources of output growth can be decomposed into two components: one component is the contribution of inputs growth and other is contribution of total factor productivity growth. It is seen from table 8 and 9 that average contribution of inputs (labour & capital) increases in the post-liberalization period than pre-liberalization period and average contribution of TFPG decreases in the post-liberalization period than pre-liberalization period.

Table-9: contributions of inputs and TFPG

Period	Inputs growth	Output growth	TFPG
1980-81 to 2016-17	0.18 (7.47 %)	2.41	2.23 (92.53%)
1980-81 to 1990-91	0.01 (0.37 %)	2.68	2.67 (99.63%)
1991-92 to 2016-17	0.25 (10.87 %)	2.30	2.05 (89.13%)

Source: Authors' own estimation

To observe the unexplained part of the growth in output (real GVA) we have estimated the value of total factor productivity growth (TFPG) using growth accounting approach and production function approach. We have used Solow measure for computation of value of total factor productivity growth (TFPG) with growth accounting approach and the computed result is shown in the Table-11.1. In the production function approach we have used Trans-log production function and computed result of TFPG is shown in the Table-11.1.We have applied OLS method for obtaining estimated value of co-efficient of different variables. In this case we have used backward elimination technique. In this technique we have eliminated one variable in each model whose t–statistic is minimum and probability is maximum. Finally we got four variables (T,lnK*lnL,lnK*T,lnL*T) to be significant (Table-10). On the basis of their co-efficient we have computed TFPG (Table-11.1).

Table-10: OLS for TFPG estimation (Backward Elimination Method).

Model		D*T	ln K	ln L	T	lnK* ln K	ln L * ln L	T * T	ln K * ln L	ln K * T	ln L * T	Eliminated variables
Model 1	*t Stat*	0.68	-0.19	0.25	0.97	0.03	-0.29	-0.34	0.22	-1.03	-0.57	ln K * ln K
	P-value	0.50	0.85	0.80	0.34	0.97	0.77	0.73	0.83	0.31	0.58	
model 2	*t Stat*	0.73	-0.20	0.32	1.02		-0.37	-0.35	0.22	-1.05	-0.59	ln K
	P-value	0.47	0.84	0.75	0.32		0.71	0.73	0.82	0.30	0.56	
model 3	*t Stat*	0.72		0.49	1.03		-0.48	-0.37	0.84	-1.46	-0.59	T * T
	P-value	0.48		0.62	0.31		0.64	0.72	0.41	0.15	0.56	

model 4	*t Stat*	0.73		0.62	1.32		-0.60		1.01	-1.72	-0.77	ln L * ln L
	P-value	0.47		0.54	0.20		0.55		0.32	0.10	0.45	
model 5	*t Stat*	0.72		0.69	1.75				0.97	-1.72	-1.10	ln L
	P-value	0.48		0.50	0.09				0.34	0.10	0.28	
model 6	*t Stat*	0.68			2.73				1.75	-2.87	-1.81	D*T
	P-value	0.50			0.01				0.09	0.01	0.08	
model 7	*Coefficients*				0.52				0.03	-0.03	-0.02	Significant variables: T,lnK*lnL,lnK*T,lnL*T
	t Stat				2.88				1.68	-2.83	-1.98	
	P-value				0.01				0.10	0.01	0.06	

Source: Authors' own estimation

It is also seen from Table-11.2 that Pre-liberalization average TFPG calculated using trans-log production function is 0.0103 whereas it is 0.0031 in the post- liberalization period. From the estimated result we can say that on an average there is negative impact of trade liberalization on TFPG which is contrary to traditional trade theory. But Solow measurement of TFPG shows that there is significant increase in average TFPG after the implementation of trade liberalization.

Table-11.1: TFPG (production function & Solow)

year	Trans- log TFPG	G^s	year	Trans- log TFPG	G^s
1980-81	0.0130	0.005	1999-2000	-0.0327	0.052
1981-82	0.0167	-0.093	2000-01	-0.0070	0.067
1982-83	0.0131	-0.125	2001-02	-0.0034	1.973
1983-84	0.0044	0.4	2002-03	-0.0143	-0.304
1984-85	0.0098	0.092	2003-04	0.0076	-0.042
1985-86	0.0145	-0.057	2004-05	0.0079	-0.173
1986-87	0.0053	0.342	2005-06	0.0158	0.289
1987-88	0.0063	-0.146	2006-07	0.0110	-0.192
1988-89	0.0070	-0.074	2007-08	0.0117	-0.124
1989-90	0.0113	0.096	2008-09	0.0149	0.435
1990-91	0.0113	-0.099	2009-10	0.0154	0.086
1991-92	0.0180	0.435	2010-11	0.0110	0.071
1992-93	0.0149	-0.219	2011-12	0.0004	-0.311
1993-94	0.0147	0.043	2012-13	-0.0015	1.172
1994-95	0.0185	-0.078	2013-14	-0.0007	-0.136
1995-96	0.0058	-0.192	2014-15	-0.0095	0.369
1996-97	0.0061	0.02	2015-16	-0.0107	0.598
1997-98	0.0053	-0.076	2016-17	-0.0329	-0.133
1998-99	0.0149	0.29			

Source: Authors' own estimation

Table-11.2: Annual Average TFPG (production function & Solow)

Period	Production function TFPG	Solow TFPG
1980-81 to 1990-91	0.0103	0.0310
1991-92 to 2016-17	0.0031	0.1508
1980-81 to 2016-17	0.0053	0.1152

Source: Authors' own estimation

It is seen from Breusch-Godfrey Serial Correlation LM Test (Table: 12) that Prob. Chi-Square(2) is 0.0449 which is less than 0.05. So the null hypothesis of presence of Serial Correlation is rejected at 5% level of significance and hence there is no Serial Correlation.

Table-12: Results of Serial Correlation Test

F-statistic	3.427932	Prob. F(2,34)	0.0440
Obs R-squared	6.208827	Prob. Chi-Square(2)	0.0449

Source: Authors' own estimation

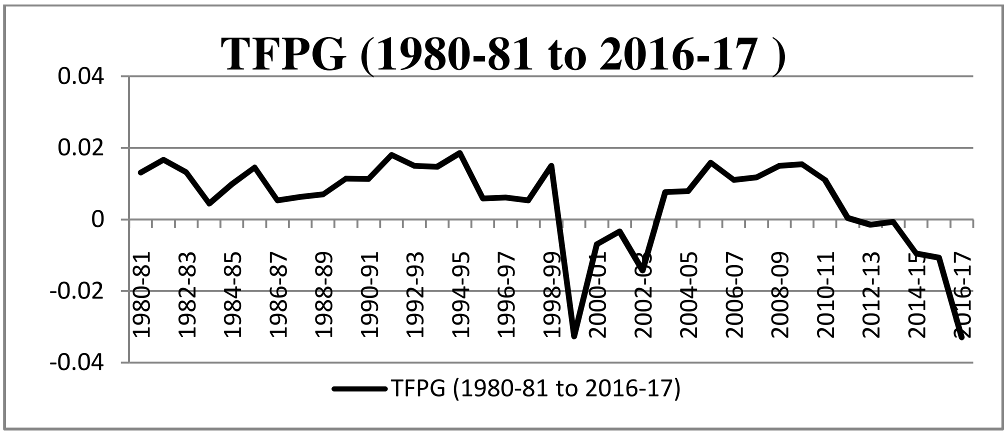
The result of Bai-perron structural break analysis (Table-13) suggests that the growth of output is having two structural break points in 2005 and 2013.

Table-13: Results of test of Bai-perron method of structural break

Schwarz criterion selected breaks			2
LWZ criterion selected breaks			2
Breaks	Sum of sq. resids.	Schwarz Criterion	LWZ Criterion
0	2.253759	-2.700726	-2.651117
1	1.860925	-2.697067	-2.545879
2*	1.219632	-2.924407*	-2.668174*
3	1.131498	-2.804229	-2.439037
4	1.042124	-2.691325	-2.212719
5	1.037972	-2.500133	-1.902998
*Estimated break dates		2005, 2013	

Source: Authors' own estimation

Figure -1: TFPG (pre & post Liberalization era)



Source: Authors' own estimation.

The line diagram of figure: 1 indicates that in the Pre-liberalization period TFPG was positive and more or less stable where as Post-liberalization period it was much more fluctuating.

Year wise calculated value of economic capacity utilization (CU) is shown in the table - 14.The result shows that the value of average capacity utilization (CU) in the post-liberalization period decreases marginally.

Table -14: Economic capacity utilization (CU)

<table>
<tr><th>year</th><th>CU</th><th>Year</th><th>Average CU</th></tr>
<tr><td>1980-81</td><td>0.97</td><td rowspan="8">1980-81 TO 2016-17</td><td rowspan="8">0.941</td></tr>
<tr><td>1981-82</td><td>0.96</td></tr>
<tr><td>1982-83</td><td>0.96</td></tr>
<tr><td>1983-84</td><td>0.95</td></tr>
<tr><td>1984-85</td><td>0.95</td></tr>
<tr><td>1985-86</td><td>0.94</td></tr>
<tr><td>1986-87</td><td>0.93</td></tr>
<tr><td>1987-88</td><td>0.93</td></tr>
<tr><td>1988-89</td><td>0.95</td><td rowspan="15">1980-81 to 1990-91</td><td rowspan="15">0.948</td></tr>
<tr><td>1989-90</td><td>0.94</td></tr>
<tr><td>1990-91</td><td>0.95</td></tr>
<tr><td>1991-92</td><td>0.94</td></tr>
<tr><td>1992-93</td><td>0.93</td></tr>
<tr><td>1993-94</td><td>0.92</td></tr>
<tr><td>1994-95</td><td>0.93</td></tr>
<tr><td>1995-96</td><td>0.94</td></tr>
<tr><td>1996-97</td><td>0.94</td></tr>
<tr><td>1997--98</td><td>0.93</td></tr>
<tr><td>1998--99</td><td>0.92</td></tr>
<tr><td>1999-00</td><td>0.93</td></tr>
<tr><td>2000-01</td><td>0.94</td></tr>
<tr><td>2001-02</td><td>0.94</td></tr>
<tr><td>2002-03</td><td>0.95</td></tr>
<tr><td>2003-04</td><td>0.95</td><td rowspan="14">1991-92 to 2016-17</td><td rowspan="14">0.938</td></tr>
<tr><td>2004-05</td><td>0.95</td></tr>
<tr><td>2005-06</td><td>0.94</td></tr>
<tr><td>2006-07</td><td>0.95</td></tr>
<tr><td>2007-08</td><td>0.95</td></tr>
<tr><td>2008-09</td><td>0.93</td></tr>
<tr><td>2009-10</td><td>0.94</td></tr>
<tr><td>2010-11</td><td>0.94</td></tr>
<tr><td>2011-12</td><td>0.93</td></tr>
<tr><td>2012-13</td><td>0.93</td></tr>
<tr><td>2013-14</td><td>0.94</td></tr>
<tr><td>2014-15</td><td>0.93</td></tr>
<tr><td>2015-16</td><td>0.93</td></tr>
<tr><td>2016-17</td><td>0.94</td></tr>
</table>

Source: Authors' own estimation

Determinants of TFPG

Now we are going to identify and analyze the determinants that affect total factor productivity growth in Indian Basic metal industry. In this connection we can link the measure of economic liberalization in India which affects total factor productivity growth in Indian Basic metal industry. Trade liberalization can be incorporated either by explicit measure or by introducing a dummy variable indicating a change in economic policies. To demarcate pre-liberalization and post-liberalization era dummy variable can be introduced in the equation. Some researchers such as Ahluwalia (1991), Harrison (1994) Krishna and Mitra (1998) had used this technique earlier. But it is not unquestionable as Trade liberalization is not a onetime phenomena and this technique cannot be applied when the economic policies are changing over time. So it is better to use explicit measure of Trade liberalization.

In this context we have used some variables such as Export - output ratio (EXPOR), Import - penetration ratio (IMPEN), Tariff rate (TAR), real effective exchange rate of Indian rupee (REER), Inflation (INFL), Terms of trade (TOT), Capacity utilization (CU), Investment in fixed machinery (IFM) , Gross mark - up (GMUP) and (DUMLIB) Dummy variable of the post liberalization period (taking value one for 1991-92 and onward and zero for earlier years).

Factors Determining TFP Growth

Our regression equation contains the following variables.

TFP_t = F(EXPOR, IMPEN, GO,TAR, REER,TOT, INFL,CU, IFM,GMUP, DUMLIB, u_t)
The basic empirical framework employed in this study is based on a simple model of TFP
$TFP_t = A + X_{it} B + u_t$
Where TFP refers to total factor productivity. *X i* refers to the vector of determinants of TFP and u_t is the error term.
In order to understand the impact of liberalization on TFPG more precisely, the above equation is elaborated as follows:
$TFP_t = A_1 + B_1\ EXPOR + B_2\ IMPEN + B_3 GO + B_4\ TAR + B_5\ REER + B_6\ TOT + B_7 INFL + B_8 CU + B_9\ IFM + B_{10} GMUP + LIBDUM.$
Export - output ratio (EXPOR) $= \frac{\text{Total exports}}{\text{Gross total output values of the domestic industries}}$
Import - penetration ratio (IMPEN) $= \frac{\text{Total import}}{\text{Total domestic demand}}$
[Export and import penetration has been calculated from data available in Statistical abstract & ASI].
GO = growth in output.
Tariff rate (TAR) $= \frac{\text{Aggregate of customs payment}}{\text{Value of imports}}$
[Collected from Statistical Abstract (several issues) & Monthly Abstract of Statistics, compiled]
REER = Real effective exchange rate of Indian rupee with base year 1985=100 [Hand Book of Statistics on Indian Economy, RBI, 2005-06]
Inflation (INFL) = Change in the consumer price index [taken from the Hand Book of Statistics on Indian Economy, RBI, 2005-06 & Report on currency& Finance (several issues)].
Terms of trade (TOT) $= \frac{\text{Volume index of imports x 100}}{\text{Volume index of exports}}$
(Collected from the Hand Book of Statistics on Indian Economy, 2005-06).
Capacity utilization (CU) = Economic measure of capacity utilization as estimated by us.
Investment in fixed machinery (IFM used as a proxy of technology acquisition) $= \frac{\text{Recent investment in fixed machinery}}{\text{Existing fixed capital stock}}$
Gross mark - up (GMUP) $= \frac{\text{Gross value added minus total emolument}}{\text{Gross output}}$
DUMLIB = Dummy variable of the post liberalization period (taking value one (1) for 1991-92 and onward and zero (0) for earlier years.
We have done OLS regression technique to find out the determinants of TFPG (Table-15). We have also used backward elimination method for finding out determinants of TFPG. Out of 10 variables 4 variables, viz. REER, INFL, CU, and IFM are significant as the determinants of total factor productivity growth.

Table-15: Determinants of TFPG (Backward Elimination method).

Variable	Definition	Regression							
		Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
EXPOR	Export-output ratio	0.0488 (0.18)	0.0465 (0.71)	0.0463 (0.73)	-------	-------	-----	-----	------
IMPEN	Import – penetration ratio	-0.0979 (-0.33)	-0.0955 (-1.33)	-0.0972 (-1.49)	-0.0947 (-1.48)	-0.1136 (-1.94)	-0.0826 -1.56	-0.0653 (-1.26)	-------
GO	Growth-in output	0.0080 (-0.79)	-0.0080 (-0.83)	-0.0082 (-0.89)	-0.0105 (-1.23)	-0.0121 (-1.50)	-0.0097 (-1.23)	------	-----
TAR	Tariff rate	0.0001 (0.52)	0.0001 (0.95)	0.0001 (1.01)	0.0001 (0.77)	-----	-----	------	------
REER	Real-effective exchange rate	-0.0004 (-2.19)	-0.0004 (-2.27)	-0.0004 (-2.43)	-0.0003 (-2.35)	-0.0004 (-3.30)	-0.0004 (-3.90)	-0.0004 (-3.94)	-0.0006 (-8.07)
TOT	Terms of trade	0.0000 (0.01)	-------	------	------	-----	-----	------	--------
INFL	Inflation rate	-0.0012 (-1.72)	-0.0012 (-2.15)	-0.0012 (-2.32)	-0.0014 (-3.36)	-0.0013 (-3.31)	-0.0014 (-3.35)	-0.0013 (-3.19)	-0.0013 (-3.05)
CU	Capacity utilization	0.2069 (0.76)	0.2082 (0.97)	0.2113 (1.04)	0.2883 (1.69)	0.3257 (2.01)	0.2908 (1.81)	0.1833 (1.34)	0.2580 (2.07)
IFM	Investment in fixed assets	0.2313 (10.12)	0.2312 10.86	0.2316 (11.59)	0.2316 (11.75)	0.2325 (11.95)	0.2299 (11.76)	0.2245 (11.65)	0.2205 (11.45)
GMUP	Gross-mark-up	0.0015 (0.06)	0.0015 (0.06)	------	------	-----	-----	-------	--------
DUMLIB	Dummy Variable	0.0070 (0.25)	0.0068 (0.83)	0.0067 (0.86)	0.0096 (1.41)	0.0064 (1.19)	--------	-------	--------
	Intercept	-0.1844 (-0.83)	-0.1853 (-0.97)	-0.1873 (-1.02)	-0.2576 (-1.67)	-0.2787 (-1.86)	-0.2385 (-1.62)	-0.1401 (-1.12)	-0.2064 (-1.79)

Source: Authors' own estimation

Note: figures in the parenthesis are the value of t-statistic.

To see over all significance of individually insignificant variables we have done F test using the following formula:

$$F_{q,n-k} = \frac{R2g - R2c}{1-R2g} \cdot \frac{n-k}{q}$$

Where n = number of observations, k = the number of co-efficient in the general form of equation including intercept and q = number of independent linear restrictions, i.e., the number of co-efficient assumed to be zero in the present case. R^2_g is the R^2 value for the general case regression and R^2_c is the R^2 value for the final form regression. (n-k) and q are the degree of freedom for general case and the final form regression respectively.

n = 27, k=12,q= 7 ,R^2_g = 0.938827995 , R^2_c = 0.918934

$$F_{7,\,15} = \frac{0.938827995 - 0.918934}{1-0.938827995} \cdot \frac{15}{7}$$

$= \frac{0.020}{0.061} * 2.14$

$= 0.33 * 2.14$

$= 0.70$

The table value of F-test for 15 degree of freedom (n-k) at 5% level of significance is 2.71 and at 1% level of significance is 4.14. As our calculated value of F-test is less than the table value, we accept the null hypothesis i.e. all the excluded variables are also jointly insignificant.

Summary and Conclusions

The objectives, in our study, were to estimate total factor productivity growth and capacity utilization in Indian basic metal industry. Our objective was also to find out the impact of trade liberalization on total factor productivity growth and also to find out true determinants of total factor productivity growth. The major findings of our study are summarized below.

Firstly, both augmented Dickey Fuller (ADF) Test and Phillips Perron Test showed that the data of all the variables are stationary at first difference. CO-integration Test showed that there is long run dependency between all the pair of variables and ln Y can be treated as depended variable. Secondly, the annual growth rate of output (real GVA) of basic metal industry in India has not increased in a uniform manner. The growth rate was negative for 18 years and was positive for 19 years out of 37 years. Thirdly, average partial productivity of both labour and capital increased marginally in the post – liberalization period compared to pre-liberalization period but average partial factor productivity growth of both labour and capital increased significantly in the post – liberalization period compared to pre-liberalization period. Fourthly, Pre-liberalization annual average TFPG calculated by using trans-log production function is 0.004273 whereas it is -0.00088 in the post- liberalization period. From the estimated result it can be concluded that on an average there is a negative impact of trade liberalization on TFPG though Solow measurement of TFPG shows a significant increase in average TFPG in the post-liberalization period. Fifthly, average capacity utilization (CU) in the post- liberalization period decreases marginally compared to pre-liberalization period. Sixthly, out of 10 variables 4 variables, viz. REER, INFL, CU, and IFM are significant as determinant of total factor productivity growth. F test result of our study shows that individually insignificant variables are also not jointly significant. Finally, two structural break points in output growth of India's Basic metal industry have been detected in the years 2005 and 2013.In 2005 the output growth rate accelerated whereas it decelerated in 2013. The acceleration of 2005 may be due to high GDP growth rate, high foreign exchange reserve and very low inflationary situation in India. On the other hand the deceleration of 2013 may be due to low saving-investment situation in India leading to an abnormally low growth of output in the manufacturing industry. Our study reveals that post-liberalization performance of Indian Basic metal industry has been more vulnerable than the pre liberalization era. In this situation role of research and development sector may be crucial and for this huge investments are needed in this Industry. Along with this proper measures should be taken to enhance the efficiency of Indian labourers.

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