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Productivity Growth in Some Energy Intensive Manufacturing Industries in India: An Analytical Assessment

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ABSTRACT: This paper estimates productivity performance of India's energy intensive industries in terms of total factor productivity growth for the entire period, 1979-80 to 2003-04. The productivity performance has been judged in view of translog indices under three input framework-material, labour and capital and a model has been evolved for assessing energy intensity in those industries. The result on the overall productivity shows declining total factor productivity growth during post-reform period as compared to pre-reform period. Total output growth in India's energy intensive an industry is found to be mainly input-driven rather than productivity-driven. The liberalization process is found to have its adverse impact on total factor productivity growth.

Keywords: Energy; Intensity; Productivity; Liberalization
JEL Classification: L65

1. Introduction

With the introduction of economic reforms in 1991, Indian industries have been viewing intense changes in the basic parameters governing its structure and functioning. Liberalization implies an increase in market force in the economy. Relaxing of licensing rule, reduction in tariff rates, removal of restriction on import of raw materials and technology, price decontrol, rationalization of customs and excise duty, enhancement of the limit of foreign equity participation etc are among those which have been introduced at early 90's. One major objective of trade liberalization in India has been to enhance industrial productivity and input-use efficiency. This has been made possible with the greater and cheaper access to imported know-how, capital goods, intermediate goods and global capital, relaxing constraints on various input use and technology choices, increased domestic and international competitive pressures by bringing in technological dynamism in industries and permitting more efficient firms to grow and competing out inefficient ones. With the introduction of economic policy reforms, Indian industries have been undergoing structural reforms and facing hard competition from external markets. Growth of a firm depends on the efficient and rational use of the scarce resources available to the firm. In other words, it is the level of productivity of the factors of production that determines the sustainability of the firm. It was recognized that output growth could not be enhanced by continuous input growth in the long run due to the nature of diminishing returns for input use. For sustained output growth, TFP growth is essential and therefore, TFP growth became synonymous with long-term growth as it reflects the potential for growth (Mahadevan, 2004).

Although there exists voluminous empirical research work regarding nexus between trade liberalization and factor productivity growth, overviews on the link between liberalization and TFPG find inadequate evidence on this issue, it is as yet a controversial issue and debate is still unsettled. The controversy on the impact of liberalization on TFPG and diverse conclusions resulting from empirical investigations are probably due to differing interpretations of liberalization and openness. These varied empirical results initiate us to investigate further into the links between liberalization and productivity growth of Indian industry.

Total Factor Productivity (TFP) is considered to be the superior indicator than labour productivity and multi-factor productivity in order to characterize industry-level productivity performance. Productivity is the key determinant of a nation's standard of living and an industry's competitiveness. As such, the ability to predict trends in TFP growth in the industry is very important. Estimating productivity level and growth rate to evaluate the efficiency in use of resources in the industry gained a renewed interest both among growth economists and trade economists. Theoretically, TFP is a relevant measure for technological change by measuring the real growth in production value, which cannot be explained by changes in the input of labour, capital and intermediate input. However in reality, due to lack of data, most of the works in TFP measurement are limited on the basis of two factor inputs, usually capital and labour. Thus, the term "multifactor productivity"(MFP) is prominently used instead of TFP. The increasingly role of materials input on productivity force researchers to reconstruct their productivity measurement model to incorporate all factor inputs, labour, capital and intermediate inputs.

Therefore, in 1991, the Indian economy underwent major economic reforms, after several decades of following an inward looking development strategy. The 1991 reforms were specifically targeted to the manufacturing sector as the sector offered significant prospects for capital accumulation, technical change and linkages and hence job creation, especially for the semi-skilled and poorly educated segment of the labour force, which comprises most of India's working poor. How much have the economic reforms delivered for the manufacturing sector, compared to their initial expectations? This study tries to explore the answer of the above question in view of certain yardsticks.

In this backdrop, this paper develops an analytical framework for measuring total factor productivity growth and tests empirically whether trade reforms improve productivity growth in some manufacturing industries in India-specifically energy intensive industries in India. In view of greater crisis of non renewable energy world wide as well as in India, we have selected some energy intensive manufacturing industries of India into our analytical consideration and evolves modeling framework for measuring energy intensity of those industries.

Previous findings for the contribution of total factor productivity growth to total output growth yielded contradictory result. Many developing countries grew via factor accumulation instead of improved technological change via total factor productivity growth and therefore attempt has also been made to investigate into the fact whether output growth is input driven or productivity driven. An investigation of the issue on analytical front may insert to our knowledge of the issue and throw lights on the distinct set of results produced by the existing studies.

The rest of the paper is organized as follows: Section 2 presents backdrop behind selecting energy-intensive industries in India under consideration of our productivity study**.** Section 3 depicts methodology for measuring TFPG and energy intensity and their data base. Estimates of productivity growth and energy intensity are documented and presented in section 4. Section 5 presents and analyses the impact of liberalization on total factor productivity growth and whether output growth is input driven or productivity driven is also presented in this section. Section 6 presents concluding remarks.

2. Backdrop behind selecting energy-intensive industries in India under consideration of our study

India ranks sixth in the total energy consumption and needs to accelerate the development of the sector to meet its growth aspirations. The country, though rich in coal and abundantly endowed with renewable energy in the form of solar, wind, hydro and bio-energy has very small hydro-carbon reserves (0.4 % of the world's reserve).India, like many other developing countries is a net importer of energy, more than 25percent of primary energy needs being met through imports mainly in form of crude oil and natural gas. The rising oil import bill has been the focus of serious concerns it has placed on scarce foreign exchange resources and also responsible for energy supply shortages. The sub-optimal consumption of commercial energy adversely affects the productive sectors, which in turn affects economic growth.

The use of energy from commercial sources (fossil fuels and electricity generation) in India has increased ten folds in sixty years since independence in 1947, and the total energy consumption from commercial sources was around 200 million tones of oil equivalent (mtoe) for the year 1998/99. The industrial sector consumes half of the total commercial energy available in India, 70% of which in energy intensive industries in India. An analysis of the share of commercial energy use by different sectors indicate that the industry is the most dominant sector, accounting for more than half of the total commercial energy use in the country (TERI. 2000c).

If the pattern of energy production is noticed, coal and oil accounts for 54 percent and 34 percent respectively with natural gas, hydro and nuclear contributing to the balance. In the power generation front, nearly 62 percent of power generation is from coal fired thermal power plants and 70 percent of coal produced every year in India has been used for thermal generation.

On the consumption front, the industrial sector in India is a major energy user accounting for about 52 percent of commercial energy consumption. Per capita energy consumption in India is one of the lowest in the world. But, energy intensity, which is energy consumption per unit of GDP, is one of the highest in comparison to other developed and developing countries. The increased energy intensity in Indian industry is partly due to investments in basic and energy intensive industries due to emphasis laid in the past development plans on achieving self reliance. It is 3.7 times that of Japan, 1.55 times that of United States, 1.47 times that of Asia, and 1.5 times that of the world average. Thus there is a huge scope for energy conservation in the country.

In view of scarce energy resources in India, it is necessary to examine the import dependence of fuel supply. The data of fuel consumption, production within the country and the imports each year in detail is set out in Table 1.

Table 1. Consumption, production and imports of commercial fuels

Sl.	Item	Units	1980-81	1990-91	1995- 96	2000- 01	2005- 06
1	Coal/Lignite consumption	mtoe	58.5	108.2	140.7	169.1	181.9
2	Coal Imports	mtoe	0.2	4.0	9.0	11.0	12
3	Dependency of Coal	%	0.3 %	2.8 %	4.4 %	7.0 %	6.7 %
4	Oil Product Consumption	mt	31	68.2	77.3	98.6	99.2
5	Oil Imports as Crude Products	mt	7	26.1	49.8	83.4	85.7
6	Oil imports Dependency	%	23	38	64	85	86
7	Consumption of Natural Gas (All domestic)	mtoe	0.2	10	16	25	27
8	Electricity Consumption (All domestic)	mtoe	5.0	6.0	8.0	8.0	9.0
9	Total fuel imports as % of total Consumption in toe terms.		8	16	24	24	31

Source: Compiled from several issues of Coal Bulletin, CMIE, Petroleum & Natural Gas Statistics, and Annual Survey of Industries.

The above table shows that the import dependence has increased in the decade of the 1980s and 1990s and this is due to the increased imports of oil products. The increase in oil import dependency has generated a phenomenal growth from a low 23 per cent in 1980-81 to 86 per cent in 2005-06.

From the above analysis, it is quite evident that India still is an importer of energy, particularly of oil. An increase in reliance on oil import, due to increase in demand will put severe pressure on foreign exchange reserves. Moreover, energy costs enter into the cost structure of all productive sectors of economy as universal input.

The quadrupling of oil prices and subsequent rise of coal and electricity cost during 90s and thereafter accompanied by gradual withdrawal of fuel subsidy by India Government had a profound, permanent impact on the Indian economy. The initial impact was an explosion in the prices of most of the goods and services. The large increase in the prices of energy during those periods permanently reduced economic capacity or the potential output of Indian economy. The productivity of existing capital and labour resources was sharply reduced. In order to clarify the gain which may be expected from the simulative new economic policy introduced in 1991, it is useful to examine the relevance of productivity in those industries in measuring input-use efficiency of the entire industry where demand for energy input as an ingredient of production is much more in production process than any other industries. Against this backdrop, while evaluating productivity of individual industry, highest priority has been given on those industries where energy intensity is greater than any other industries.

3. Methodology

3.1. Description of data and measurement of variables

The present study is based on industry-level time series data taken from several issues of Annual Survey of Industries, National Accounts Statistics, *CMIE* and economic survey, statistical abstracts (several issues), *RBI* bulletin on currency and finance, handbook of statistics on Indian economy, whole sale price in India prepared by the Index no of office of Economic Advisor, Ministry of Industry etc covering a period of 25 years commencing from 1979-80 to 2003-04. Selection of time period is largely guided by availability of data.[1]

As far as the data relating to energy sectors are concerned , we made use of the data published by the Centre for Electricity Authority (CEA) for electricity, Petroleum and Natural Gas Statistics (several issues) published by the Ministry of oil and natural gas for crude oil ,petroleum product and natural gas. While for the coal, we relied on the Coal India Dictionary besides different reports of central statistical organization (CSO), New Delhi, and Centre for Monitoring Indian Economy (CMIE), Annual Survey of Industries (ASI) etc.

Coal input to different sectors was divided by coal prices to convert rupee value of coal input into physical units (tons). The petroleum demand by production activities in the system consists of Furnace oil (FO), LSHS (both heavy distillates),HSD and LDO(middle distillates).Indian Petroleum and Natural Gas Statistics(1983-84,1989-90, 2003-04,2004-05) provided some idea about the usage pattern of refinery products for some production sectors. Similarly, volume of electricity consumption was taken into consideration. Energy consumed by different sectors in different forms and in different physical units is then converted into mtoe (million ton of oil equivalent) by applying some recent common conversion factors. Million ton of oil equivalent (MTOE) is the method of assessing work of calorific value of different sources of energy in terms of one ton oil. The following table shows the conversion procedure of different energy units into mtoe.

Table 2. Conversion factors for transforming different energy inputs into million ton of oil equivalent (mtoe)

Energy inputs	Present energy unit	Conversion factor (into mtoe)
Coal	1 million ton	0.67 million ton of oil equivalent
Electricity	12000 million KWH	0.86 million ton of oil equivalent
Petroleum	1 million ton petroleum	1 million ton of oil equivalent

- One million =10 ^{6} =10, 00,000
- Source: TATA energy Data Dictionary and Year Book.

It is assumed that due to non availability of detailed data about the average calorific content of various grades of coal, the same average calorific value of coal is used in converting coal tonnage into mtoe units.

In order to avoid over estimation due to ignoring contribution of material input on TFP, a third variable of intermediate inputs (material including energy input) [2] has been incorporated in the value-

[1] Till 1988 – 89, the classification of industries followed in ASI was based on the National Industrial classification 1970 (NIC 1970). The switch to the NIC-1987 from 1989-90 and also switch to NIC1998 requires some matching. Considering NIC1987 as base and further NIC 1998 as base, all energy intensive industries have been merged accordingly. For price correction of variable, wholesale price indices taken from official publication of CMIE have been used to construct deflators.

[2] Earlier studies that have not treated material including energy as separate factor of production, has failed to pick-up significant economies that are likely to generate in the use of such input. Jorgenson (1988) has observed that in a three input production framework, the contribution of intermediate inputs like material, energy etc. are significant sources of output growth.

added function as such to obtain gross output. Pradhan and Barik (1999) argued that the gross output, instead of value added, appears to be the appropriate choice of TFPG estimation in India. Generally, TFP growth estimates based on value added terms are over estimated since they ignore the contribution of intermediate inputs on productivity growth (Sharma, 1999). Therefore, modified gross value of output so calculated has been used as a measure of output suitably deflated by wholesale price index of manufactured. Deflated cost of fuel (Appendix-A-1) has been taken as measure of energy inputs. Deflated gross fixed capital stock at 1981-82 prices is taken as the measure of capital input. The estimates are based on perpetual inventory method. (Appendix-A-2) .Following the same line as adopted in deflating energy input, the reported series on materials has been deflated to obtain material inputs at constant prices. Total number of persons engaged in Indian rubber sector is used as a measure of labor inputs as is reported in ASI which includes production workers and non-production workers like administrative, technical and clerical staff (Goldar and Ranganathan, 1991). For recent issues, it is reported in ASI under the head 'persons engaged', for earlier issues, it is reported as 'number of employees'.

This paper covers a period of 25 years from 1979 -80 to 2003-04. The entire period is sub-divided into two phases as pre-reform period (1979 -80 to 1991-92) and post-reform period (1991-92 to 2003-04), sub-division of period being taken logically as such to assess conveniently the impact of liberalization on TFPG.

3.2. Econometric Specification for TFPG

Productivity is a marginal contribution of a factor to the output growth of a product. The productivity improvements along with the increase in quantities of factors will also be contributing an additional source of output increase (Brahmananda, 1982). Productivity increases when the growth in output is greater than the growth in input, or when the rate of growth of output minus the rate of growth of the composite input is positive. Economic growth can be obtained either by increasing inputs or by improving productivity factor. Productivity growth occurs when a higher output can be attained with a given amount of input, or a certain level of output can be attained with smaller amounts of factor input. This productivity growth is obviously preferable to growth due to increase in factor inputs, since the later might be subject to diminishing marginal return. Productivity growth is necessary not only to increase output but also to enhance competitiveness of a country. The estimation of factor productivity will be very useful to evaluate the variations in the performance of an industry over a period of time. The prosperity of a new developed nation has been attributed mainly to the sustained growth of their total factor productivity (Prescott, 1997).

The partial factor productivity generally is calculated by dividing the total output by the quantity of an input. The main problem of using this measurement of productivity is that it ignores the fact that productivity of an input depends on level of other inputs used. The TFP approach overcomes this problem by taking into account the levels of all the inputs used in the production of output. Therefore, in this paper, TFPG is estimated under three input framework applying Tran slog[3] index of TFP as below: -

$$\Delta LnTFP(t) = \Delta LnQ(t) - \left[\frac{S_L(t)+S_L(t-1)}{2} x \Delta LnL(t)\right] - \left[\frac{S_K(t)+S_K(t-1)}{2} x \Delta LnK(t)\right] - \left[\frac{S_M(t)+S_M(t-1)}{2} x \Delta LnM(t)\right]$$

Q denotes gross value added, L Labour, K Capital, M material including energy input.

$$\Delta Ln\ Q(t) = Ln\ Q(t) - Ln\ Q(t-1)$$
$$\Delta Ln\ L(t) = Ln\ L(t) - Ln\ L(t-1)$$
$$\Delta Ln\ K(t) = Ln\ K(t) - Ln\ K(t-1)$$

[3] The Tran slog index of TFP is a discrete approximation to the Division index of technical change. It has the advantage that it does not make rigid assumption about elasticity of substitution between factors of production (as done by Solow index). It allows for variable elasticity of substitution. Another advantage of Tran slog index is that it does not require technological progress to be Hicks- neutral. The Tran slog provides an estimate of the shift of the production function if the technological change is non-neutral.

$$\Delta \text{Ln } M(t) = \text{Ln } M(t) - \text{Ln } M(t-1)$$

S_K, S_L and S_M being income share of capital, labor and material respectively and these factors add up to unity. TFP is the rate of technological change.

3.3. Model for assessing energy intensity of the industries taken up for the present study

The concept of industrial energy intensity denotes the amount of energy required to produce one unit of output**.** Two basic approaches are in use to express industrial energy intensity − per unit of physical product and per unit of economic output. When output is measured in physical units, an estimate of physical energy intensity is obtained (e.g., PJ/tonne). Economic energy intensity, on the other hand, is calculated using monetary value of output measures (e.g., PJ/Rs.billion).

Energy intensity can be measured following various alternative methodologies.

A review of literature suggests that there are various alternative measures of energy intensity.

1. Energy -output ratio
2. Energy-value added ratio
3. Energy- capital ratio.

The practical use of energy-capital ratio as a measure of energy intensity gives rise to certain problems which arises from the problems related to the measurement of capital itself in the production process.

Misunderstanding around the use of energy-value added ratio comes from the theoretical contradiction between the very concept of value added approach and the definition of energy input. While former is defined as the total value added by the capital and labour excluding the contribution of other intermediate products, the latter 'energy input'- is an intermediate good in itself. From their empirical findings, Berndt and Wood (1975) call in question the reliability of factor demand studies based on value added specification as they invalidate the conventional value added specification of technology.

In this section, an attempt has been made to study the energy intensities of different sectors at an aggregate level which represents a set of measurable coefficients of the energy requirement for the formation of a unit of produced goods or services. Energy intensity is a prerequisite numerical exercise for the discussion on structural change in energy demand evaluation of a particular industry or area. Our energy intensity analysis covers the period from 1996-97 to 2004-05 which will definitely provide an insight into the both short-term as well as long term responses.

Iron and steel, cement, aluminum, fertilizers, paper and pulp, chemical, glass are some of the energy intensive industries in India. This section focuses on these seven industries regarding energy consumption vis-à-vis energy intensity.

In our study, energy intensity is defined as energy consumption in physical units of 'j'th industry per crore rupees of value added in that industry.

E_{jkt} = Energy consumed in physical units in time't' by sector 'j' for energy type 'k'.

P_{jt} = 'j'th industry's value added.

Energy intensity (of energy type 'k') of 'j'th industry is given by

$e_{jkt} = E_{jkt} / P_{jt}$

[Energy intensity for non-energy sector = '000 mtoe /crore Rs. where 'mtoe / Rs' is the mtoe(million ton of oil equivalent) required to produce one unit of output measured in value term , this coefficient is the measure of direct energy intensity].

Alternatively, we also make use of energy-output ratio in estimating energy intensity for seven Indian manufacturing industries-Cement, Glass, Paper and paper products, Fertilizer, Aluminium, Iron and Steel and chemical- under consideration of our study. Therefore, the present study also examines energy-output ratio towards evaluation of energy intensity for individual manufacturing industry.

4. Empirical Estimation

4.1. Results showing energy intensity

The following two tables (3 & 4 below) depict the result of coal, electricity and petroleum intensity as well as total intensity of seven Indian manufacturing industries under our consideration over a period of 1996-97 to 2004-05.

Table 3. Energy intensity in energy intensive industries in India ('000 mtoe/Rs crores)

Industry/ Years	Energy intensity	1996-'97	1997-'98	1998-'99	1999-'00	2000-'01	2001-'02	2002-'03	2003-'04	2004-'05	Average of entire time periods
Cement	Coal Intensity ('000 mtoe/Rs crores)	3.5637	2.5509	3.2219	2.6714	2.3289	2.7919	2.9882	3.521	3.8703	3.0565
	Electricity Intensity ('000 mtoe/Rs crores)	0.1803	0.1539	0.1626	0.1362	0.1101	0.1240	0.1356	0.1406	0.1303	0.1415
	Petroleum Intensity ('000 mtoe/Rs crores)	0.1811	0.1865	0.4044	0.6142	0.5416	0.6211	0.7289	0.6562	0.7293	0.5181
	Total Intensity('000 mtoe/Rs crores)	3.9250	2.8914	3.7888	3.4217	2.9806	3.5369	3.8525	4.3178	4.7299	3.7161
Iron& Steel	Coal Intensity('000 mtoe/Rs crores)	0.84041	0.35892	0.8974	0.89047	0.8612	0.62374	0.68935	0.84107	0.85108	0.7615
	Electricity Intensity ('000 mtoe/Rs crores)	0.01400	0.08226	0.1070	0.10574	0.0955	0.11442	0.13950	0.14257	0.17148	0.1081
	Petroleum Intensity ('000 mtoe/Rs crores)	0.00726	0.34373	0.1916	0.18174	0.2446	0.19494	0.17552	0.25826	0.38749	1.0901
	Total Intensity ('000 mtoe/Rs crores)	0.8616	0.7849	1.1961	1.1779	1.2013	0.9331	1.0044	1.2419	1.410	1.090
Aluminium	Coal Intensity ('000 mtoe/Rs crores)	0.1522	0.1377	0.154	0.1706	0.1139	0.1416	0.0529	0.0677	0.1005	0.1212
	Electricity Intensity ('000 mtoe/Rs crores)	0.3915	0.1837	0.2124	0.1434	0.1408	0.167	0.1852	0.1335	0.2355	0.1992
	Petroleum Intensity ('000 mtoe/Rs crores)	0.26413	0.16768	0.0860	0.05539	0.0960	0.12873	0.1298	0.16158	0.16861	0.1398
	Total Intensity ('000 mtoe/Rs crores)	0.80783	0.48908	0.4525	0.36939	0.3507	0.43733	0.3679	0.36278	0.50461	0.4602
Paper	Coal Intensity ('000 mtoe/Rs crores)	1.20129	0.89006	0.9872	0.99980	1.0720	1.15195	1.22390	1.46147	1.09060	1.1198
	Electricity Intensity ('000 mtoe/Rs crores)	0.09592	0.08575	0.0853	0.07214	0.0687	0.06435	0.07315	0.07251	0.07499	0.0769
	Petroleum Intensity ('000 mtoe/Rs crores)	0.10640	0.26588	0.2504	0.31710	0.3818	0.34705	0.40085	0.4559	0.43943	0.3294
	Total Intensity ('000 mtoe/Rs crores)	1.4036	1.24169	1.3230	1.38904	1.5225	1.56335	1.69790	1.98988	1.60502	1.5262
Fertilizer	Coal Intensity('000 mtoe/Rs crores)	0.48403	0.42044	0.5537	0.55577	0.5114	0.59221	0.49925	0.66869	0.64162	0.5475
	Electricity Intensity ('000 mtoe/Rs crores)	0.09282	0.07430	0.0643	0.05526	0.0472	0.04396	0.02920	0.03759	0.03124	0.0529
	Petroleum Intensity ('000 mtoe/Rs crores)	0.36791	0.26315	0.1927	0.26515	0.4673	0.17157	0.16738	0.37982	0.32025	0.2884
	Total Intensity ('000 mtoe/Rs crores)	0.94476	0.75789	0.8108	0.87618	1.0258	0.80774	0.69583	1.0861	0.99311	0.8887
Glass	Coal Intensity ('000 mtoe/Rs crores)	0.33567	0.21179	0.2776	0.25839	0.1825	0.12904	0.11656	0.15728	0.17549	0.20492
	Electricity Intensity ('000 mtoe/Rs crores)	0.07336	0.07269	0.0708	0.06681	0.0586	0.04841	0.06506	0.06467	0.07498	0.06615
	Petroleum Intensity ('000 mtoe/Rs crores)	0.37191	0.59046	0.4623	0.69446	1.1106	0.77407	1.18428	1.26632	1.12479	0.84214
	Total Intensity('000 mtoe/Rs crores)	0.78094	0.87494	0.8108	1.01966	1.3516	0.95152	1.3659	1.48827	1.37526	1.1132
Chemical	Coal Intensity('000 mtoe/Rs crores)	0.13262	0.13606	0.2091	0.07409	0.1047	0.10327	0.25340	0.14201	0.12149	0.1419
	Electricity Intensity ('000 mtoe/Rs crores)	0.06136	0.06373	0.0496	0.03915	0.0329	0.04235	0.06059	0.04083	0.04674	0.04858
	Petroleum Intensity ('000 mtoe/Rs crores)	0.31229	0.24538	0.2330	0.22780	0.4503	0.29220	0.46018	0.32520	0.45714	0.3337
	Total Intensity('000 mtoe/Rs crores)	0.50627	0.44517	0.4917	0.49168	0.5879	0.43782	0.77417	0.50804	0.62537	0.5242
Aggregate manufac-turing	Coal Intensity('000 mtoe/Rs crores)	0.1415	0.1396	0.1475	0.1522	0.174	0.1607	0.1648	0.1553	0.1399	0.1528
	Electricity Intensity ('000 mtoe/Rs crores)	0.03013	0.03006	0.0307	0.03013	0.0302	0.0329	0.0288	0.0258	0.0223	0.0290
	Petroleum Intensity ('000 mtoe/Rs crores)	0.1241	0.2954	0.3617	0.1353	0.1929	0.1878	0.1411	0.1418	0.1305	0.2045
	Total Intensity ('000 mtoe/Rs crores)	0.2957	0.4650	0.5389	0.3176	0.3971	0.3814	0.3347	0.3229	0.2927	0.3863

Source: Author's own estimate

In table 3, average total energy intensity is computed by taking combined average of coal, electricity and petroleum intensity in each sector taken up for our study. It has been found out that aggregate manufacturing displays an average total intensity of 0.3863 (‘000 mtoe/ Rs crore).The industries considered for our study – cement, iron & steel, fertilizer, aluminum, chemical, paper & pulp and glass sectors – are treated as energy intensive because average total intensity in those industries are considerably higher in comparison with that of aggregate manufacturing sectors.

Alternatively, the step towards identifying energy intensity trends is to calculate overall energy intensity, a general indicator of energy end-use. Energy intensity is defined here as the amount of energy (in Rs) used to produce a unit of output (in monetary units, Rs.). This is simply obtained by dividing deflated energy consumption by deflated output. Energy intensity values in Indian industries under consideration over the period (1996-97 to 2004-05) are provided in Table 3.

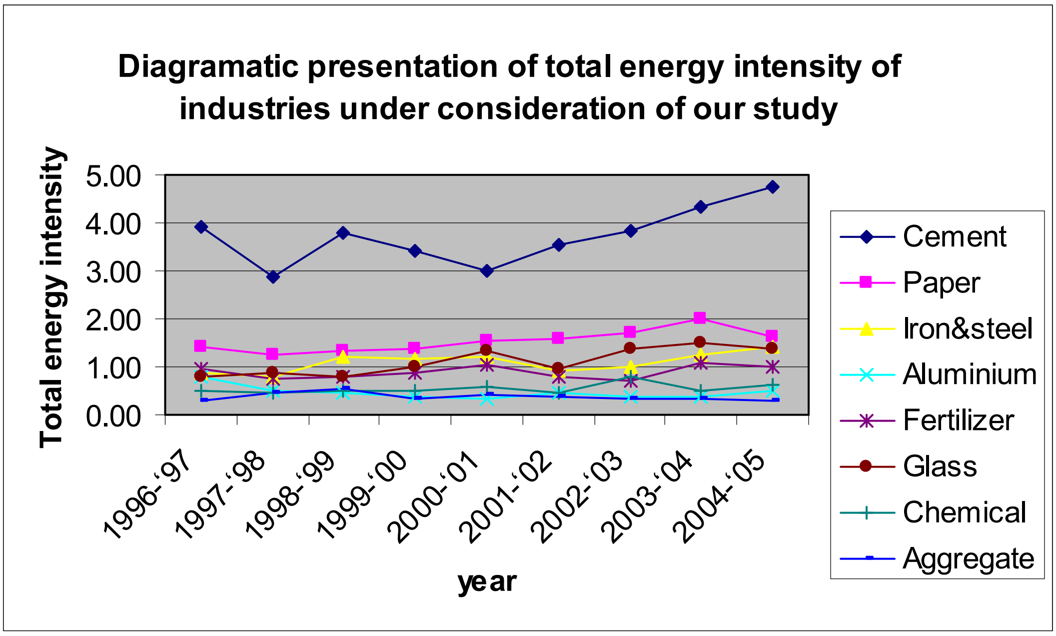
Table 4. Measurement of Energy intensity by Energy-Output ratio (%)

Year	Cement Industry	Aluminium Industry	Glass Industry	Fertilizer Industry	Paper Industry	Iron&Steel Industry	Chemical Industry	Aggregate manufacturing
1979-80	28.37	23.24	21.71	14.40	12.59	16.73	10.13	6.47
80-81	27.68	24.27	20.97	14.29	15.34	16.05	9.45	6.93
81-82	28.64	24.56	24.08	15.01	15.92	13.57	10.44	7.12
82-83	27.42	23.66	24.91	14.75	16.53	13.48	10.54	7.54
83-84	29.19	29.52	22.2	14.89	16.56	15.37	11.78	8.39
84-85	27.26	30.36	21.69	15.19	16.54	13	11.29	8.70
85-86	28.86	27.26	22.99	14.91	14.66	13.39	10.85	9.15
86-87	30.85	28.73	22.5	14.65	15.69	12.37	11.69	9.06
87-88	31.65	30.12	22.27	18.12	15.01	12.32	11.83	9.30
88-89	26.83	28.63	22.33	16.31	15.22	11.47	10.27	7.69
89-90	30.53	29.39	22.58	20.27	14.30	10.43	11.35	7.76
90-91	32.41	25.44	18.53	16.27	13.76	11.35	11.08	7.72
91-92	30.93	29.99	21.69	15.25	14.53	10.88	10.18	8.04
92-93	30.80	25.03	19.57	14.82	14.28	10.44	10.32	8.43
93-94	32.34	20.61	18.84	14.24	13.36	10	9.66	7.92
94-95	31.37	24.35	18.12	14.17	14.45	10.93	10.25	7.80
95-96	32.60	25.87	19.05	13.36	14.29	11.47	10.23	7.23
96-97	27.67	24.21	16.82	14.18	13.12	12.12	10.18	7.87
97-98	26.97	15.83	15.17	12.52	11.8	10.36	9.68	7.12
98-99	26.28	18.4	15.48	10.35	10.98	10.68	7.25	5.90
99-00	24.64	18.9	16.08	10.58	11.22	9.99	7.85	6.15
00-01	19.81	18.87	15.89	11.84	9.28	9.19	8.26	6.36
01-02	25.28	21.17	12	10.93	8.76	8.55	8.14	6.21
02-03	20.67	21.19	16.02	10.42	9.12	9.79	8.89	5.89
03-04	21.57	17.57	15.68	12.46	8.68	10.33	8.31	5.73
average	28.04	24.29	19.49	14.17	13.44	11.77	9 .97	7.46

Source: Own estimate from ASI (several issues)

From our analysis of energy-output ratio (table-4), it has been noticed that all the seven industries taken into our consideration have greater energy intensity in comparison with energy intensity of aggregate manufacturing sector.

Diagram 1.



Cement industry is the most energy intensive showing intensity of around 28 percent and others are ranked accordingly and chemical is the least energy-intensive. Therefore, there is no difficulty in considering those industries having comparatively greater intensity as energy intensive industries.

4.2. Results showing Total Factor Productivity Growth

Estimation of annual TFP growth rate of India's energy intensive industries at aggregate level are presented in Table 5.

Table 5. Growth rate of TFP at aggregate level (Pre-reform period: 1979-80 to 1991-'92)

Year	Cement		Aluminium		Iron&steel		Chemical		Fertilizer		Paper&pulp		Glass	
	TFP Indices	Growth rate in TFP (%)	TFP Indices	Growth rate in TFP (%)	TFP Indices	Growth rate in TFP (%)	TFP Indices	Growth rate in TFP (%)	TFP Indices	Growth rate in TFP (%)	TFP Indices	Growth rate in TFP (%)	TFP Indices	Growth rate in TFP (%)
79-80	1	-	1	-	1	-	1	-	1	-	1	-	1	-
80-81	0.9859	-1.41	1.035	3.44	0.9935	-0.65	1.0962	9.62	1.0344	3.44	1.0180	1.80	0.9849	-1.51
81-82	1.0446	5.95	0.9650	-6.96	1.0706	7.76	1.0346	-5.62	0.9648	-6.73	1.0421	2.36	1.0356	5.15
82-83	1.2133	16.15	1.0063	4.15	1.0642	-0.60	0.9898	-4.33	1.0063	4.30	0.9917	-4.84	0.9545	-7.83
83-84	1.1056	-8.88	1.0154	0.909	0.9412	-11.56	0.9657	-2.43	1.0155	0.90	1.0375	4.62	1.1364	19.05
84-85	1.0323	2.66	1.021	0.595	1.0155	7.89	1.0129	4.89	1.0213	0.59	0.9812	-5.43	0.9572	-15.76
85-86	1.0022	-2.92	0.9786	-4.29	0.9858	-2.92	0.9699	-4.25	0.9784	-4.20	1.0963	11.73	0.9393	-1.88
86-87	1.0809	7.85	1.008	2.97	1.0066	2.11	1.0446	7.70	1.0081	3.04	0.9814	-10.48	1.0228	8.89
87-88	1.0364	-4.12	1.015	0.68	1.0793	7.22	0.9977	-4.49	1.0149	0.67	1.02	3.93	0.9521	-6.91
88-89	1.0310	-0.52	0.8799	-13.53	0.9886	-8.40	0.9952	-0.26	0.8796	-13.33	0.9555	-6.32	0.9758	2.49
89-90	1.1647	12.98	1.21	32.04	0.9914	0.28	0.9391	-5.63	1.2	36.43	1.0277	7.55	0.9480	-2.86
90-91	0.9313	-20.04	1.059	-14.08	0.9429	-4.89	1.0071	7.25	1.0592	-11.73	0.8964	-12.77	1.1104	17.13
91-92	1.0336	10.98	0.9739	-8.53	1.0423	10.54	1.0614	5.38	0.9739	-8.05	1.0356	15.53	0.9216	-17.00
average		1.44		-0.2008		0.5650		0.6525		0.44		0.64		-0.09

Source: Own estimate

Table 6. Growth rate of TFP at aggregate level (Post-reform period: 1991-92 to 2003-04)

Year	Cement		Aluminium		Iron&steel		Chemical		Fertilizer		Paper&pulp		Glass	
	TFP Indices	Growth rate in TFP (%)	TFP Indices	Growth rate in TFP (%)	TFP Indices	Growth rate in TFP (%)	TFP Indices	Growth rate in TFP (%)	TFP Indices	Growth rate in TFP (%)	TFP Indices	Growth rate in TFP (%)	TFP Indices	Growth rate in TFP (%)
91-92	1.0336	10.98	0.9740	-8.53	1.0423	10.54	1.0614	5.38	0.9739	-8.05	1.0356	15.53	0.9216	-17.00
92-93	0.9888	-4.33	1.064	9.04	0.9328	-10.51	1.0195	-3.94	1.0643	9.28	0.9959	-3.83	1.0054	9.09
93-94	0.9953	0.66	0.9580	-10.62	1.0054	7.78	1.0049	-1.43	0.9581	-9.98	0.9381	-5.80	0.9390	-6.60
94-95	0.9584	-3.71	0.9390	-1.93	1.181	5.73	0.9434	-6.13	0.9388	-2.01	0.9024	-3.81	0.9547	1.67
95-96	1.0110	5.49	1.035	9.6	0.9107	-14.33	0.9430	-0.04	1.0348	10.23	0.9624	6.65	0.9705	1.66
96-97	0.9943	-1.65	1.039	0.44	1.063	16.72	1.0791	14.43	1.0392	0.43	0.9854	2.38	1.0443	7.60
97-98	1.0835	8.97	0.9360	-10.36	1.0635	0.05	0.9795	-9.23	0.9356	-9.97	1.0124	2.74	0.9515	-8.89
98-99	0.8161	-24.68	1.00	6.34	0.8931	-16.02	1.0582	8.03	0.999	6.78	1.0022	-1.00	1.0876	14.31
99-‘00	1.0573	29.56	1.046	4.67	1.0562	18.26	1.0634	0.49	1.0457	4.67	1.0361	3.38	0.9689	-10.91
00-01	1.0391	-1.73	1.021	-2.49	1.0412	-1.42	1.0998	3.42	1.0208	-2.38	0.9828	-5.14	0.9455	-2.42
01-02	0.9481	-8.75	0.9740	-4.73	1.0178	-2.25	0.9924	-9.77	0.9735	-4.63	0.9648	-1.83	1.0547	11.54
02-03	0.9593	1.18	1.052	7.83	0.9495	-6.71	1.0066	1.44	1.0518	8.04	0.9767	1.23	0.9303	-11.79
03-04	0.9706	1.18	0.8730	-17.89	0.9337	-1.66	0.9377	-6.85	0.8729	-17.01	0.9481	-2.93	0.9578	2.95
average		1.013		-1.43		0.4761		-0.3231		-1.12		0.58		-0.68

Source: Own estimate

Therefore, in this section, we present our findings regarding total factor productivity growth (TFPG) obtained by translog approaches. The period covered by our study is from 1979-80 to 2003-04. For facilitating comparison of the estimates, we have also computed average annual TFPG for the entire period as well as for two sub- periods, 1979-80 to 1991-92 and 1991-92 to 2003-04.

In cement industry, broad variations in the magnitude of TFPG are found in the estimation. The estimated TFPG of Indian cement sector at the aggregate reveals contradictory rates of TFPG growth (both positive and negative) and it varies over years within the same sector. But, our aggregate analysis also depicts sign of declining trend in average TFP growth rate during post-reform period as compared to pre-reform period. It is evident from tables 5 and 6 that the estimated average growth rate of TFP at aggregate level in cement sector for the period 1979-80 to 1991-92 is 1.44 percent p.a whereas post-reform period covering 1991-92 to 2003-04 in our study witnessed a further decreasing growth of 1.013 percent p.a., a noticeable decline from growth rate as in pre-reform period. The trend growth rate of TFP in Indian cement sector is assessed to be -0.0043 percent for the entire period 1979-80 to 2003-04(estimated from semi-log trend) implying average overall annual deceleration of -0.0043 percent p.a. On the whole, impact of economic reforms on TFPG at aggregate level was adverse as the average rate of TFPG estimated in the pre-reform period furthermore decreased in post-reform period. Moreover, difference between mean TFPG of two periods is statistically significant at 0.05 levels thereby indicating that average TFPG between two periods are statistically different. The estimated TFPG rate at the aggregate level of Indian aluminium industry for the entire period, 1979-80 to 2003-04 reveals paradoxical pictures with positive as well as negative rates. During pre-reforms period (1979-80 to 2003-’04), aluminium sector has recorded a negative growth rate of -0.2008 %. It could be noticed from the average TFPG estimated during the post- reforms period that the reform process yielded negative results on the productivity levels of the aluminium sector because it is visible from the estimated average TFPG that there is a significant drop in the extent of negative TFPG which is -1.43% when compared to that in the pre-reform period. Total factor productivity growth in iron and steel industry displays declining growth rate in post-reforms period compared to pre-reform period. It is evidenced from table 6 and 7. that the estimated growth rate of TFP at aggregate level for the period 1979-80 to 1991-92 is 0.5650 percent p.a whereas post-reform period covering 1991-92 to 2003-04 in our study witnessed a declining positive growth of 0.4761 percent p.a., a noticeable downfall from growth rate as shown in pre-reform period. On the whole, impact of economic reforms on TFPG of iron industry at aggregate level was adverse as the average rate of TFPG estimated in the pre-reform period furthermore decreased in post-reform period. Within the same industry, over the years, there exist severe variations in total factor productivity growth. Analysis of the TFPG of Indian chemical industry shows declining growth rate in negative fashion during post- reforms period. The pre-reform era (1979-80 to 1991-92) witnessed a positive growth rate of 0.6525 percent but during post-reforms period (1991-92 to 2003-04), it is estimated to be -0.3231 percent p.a. Moreover, total factor productivity growth shows contradictory positive and negative trends over years within the same industry. Inspection of average TFPG of fertilizer industry in India exhibits an overall negative growth rate in TFP. It is obvious from table 6 that the estimated growth rate of TFP for the period 1979-80 to 1991-92 is 0.44 percent p.a which signifies a positive rate of growth in TFP where as post-reform period covering 1991-92 to 2003-04 in our study witnessed a sharp negative growth of -1.12 percent p.a., a steeper fall from growth rate as revealed in pre-reform period. This decline is due to reduced capacity utilization caused by downfall in production rather than being a consequence of lack of technical progress. The growth rate of TFP in Indian fertilizer sector is assessed to be –0.055 percent p.a. implying average overall annual deceleration for the entire period 1979-80 to 2003-04. On the whole, impact of economic reforms on TFPG at aggregate level was poor as the positive average rate of TFPG estimated in the pre-reform period declined to negative growth in post-reform period. More over, difference between mean TFPG of two periods is statistically significant at 0.05 levels thereby indicating that average TFPG between two periods are statistically different.

Table 7. Trend Growth rate of total factor productivity of energy intensive industries in India

Pre-reform period(1979-80 to1990-91)		Post reform period(1991-92 to2003-04)	
Industry/year	TFPG	Industry/year	TFPG
Cement	-0.00091* (0.14)** 0.20***	**Cement**	-0.0032 (-1.61) 0.32
Aluminum	0.0022 (0.44) 0.16	**Aluminium**	-0.0023 (-1.52) 0.24
Iron&steel	-0.0034 (-0.92) 0.18	**Iron&steel**	-0.0043 (-1.72) 0.44
Chemical	-0.00097 (-0.6) 0.18	**Chemical**	-0.0018 (-1.43) 0.48
Fertilizer	0.0053 (0.86) 0.17	**Fertilizer**	-0.0023 (-1.52) 0.24
Paper & pulp	-0.0057 (-1.43) 0.17	**Paper & pulp**	-0.006 (-2.07) 0.37
Glass	0.00016 (0.30) 0.24	**Glass**	-0.001 (-1.29) 0.18

Source: Estimated from semi log trend
*trend growth rate,
** t values,
*** adjusted R^2 .

In paper and pulp sector, the estimated growth rate of TFP for the period 1979-80 to 1991-92 is 0.64 percent per annum whereas during the post-reform period, 1991-92 to2003-04, TFPG shows slight downward trend which is estimated to be 0.58 percent per-annum but average growth rate for the entire period is significantly negative (-0.014 percent). Moreover, TFPG varies widely among years within the same paper sector. Table 5 and 6 above show that total factor productivity growth of

Indian glass industry during pre-reform period declined in a negative fashion which is posted as -0.09 and in post-liberalization period, it further declined to -0.68.Large variations in the magnitude of TFPG are found in the evaluation. The estimated TFPG of the Indian glass industry at the aggregate level reveals differing rates of productivity growth over years. Over our study period, negative trend in the TFPG is observed at aggregate level.

Therefore, overall analysis of average TFPG growth suggests that in all the industries taken up under our study, average TFPG growth depicts declining growth rate during post-reform periods as compared to pre-reform periods.

This does not mean, however, that reforms failed to have a favorable effect on industrial productivity. Rather, some research undertaken recently (Goldar and Kumari, 2003; Topalova, 2004) has shown that trade liberalization did have a positive effect on industrial productivity. The explanation for the slowdown in TFP growth in Indian manufacturing in the post-reform period seems to lie in the adverse influence of certain factors that more than offset the favorable influence of the reforms. Two factors that seem to have had an adverse effect on industrial productivity in the post-reform period are (a) decline in the growth rate of agriculture and (b) deterioration in capacity utilization in the industrial sector (Goldar and Kumari, 2003). Uchikawa (2001) has pointed out that there was an investment boom in Indian industry in the mid-1990s. While the investment boom raised production capacities substantially, demand did not rise which led to capacity under-utilization. Goldar and Kumari (2003) have presented econometric evidence that indicates that the slowdown in TFP growth in Indian manufacturing in the post-reform period is attributable to a large extent to deterioration in capacity utilization.

5. Impact of Liberalization on Total Factor Productivity Growth

The process of liberalization can be linked to the manufacturing productivity. With the initiation of a wide range of economic reforms by the India Government on various fronts to make domestic industries more efficient and internationally competitive, Indian firms were expected to respond positively these measures. The liberalization process was to expose firms to international competition and force them to introduce new methods of production, import quality inputs, capital equipment or technology and compel them to improve their efficiency. Trade liberalization is captured by either an explicit measure of liberalization or by a dummy variable capturing a change in the economic policies. The use of dummy variable to demarcate the post-reform period from pre-reform period (as had done earlier by Ahluwalia, 1991; Harrison, 1994; Krishna and Mitra, 1998) is subject to criticism. Dummy variable technique assumes that trade reform was one time phenomenon and it was complete and at the same time it fails to capture that reform has been gradual over time, rather an on-going process. In order to understand the impact of liberalization on TFPG more precisely, we use a piecewise linear regression equation (popularly known as spline function) which is depicted as follows.

$$\text{Ln } Y_t = \alpha + \beta t + \beta'(t - t_0)\, Dt, \quad \text{where } Y_t \text{ is TFP.}$$

In this section, we have tried to judge the effect of economic reforms on total factor productivity growth by using piece wise linear regression equation. If, in the result, the coefficients of difference between two time periods show positivity or negativity and they are statistically significant, then it can be inferred that liberalization may have either favourable or adverse impact of trade reforms on TFPG respectively. The results of piece wise linear regression is depicted and interpreted below.

Figures in the parentheses are the absolute values of t statistics and R^2 is the goodness of fit Here B gives the slopes of the regression line in pre-reform period which are negative and insignificant at 5% level in all four industries excepting iron steel, fertilizer and paper industry. This implies that growth in TFPG displays negligible negative trend immediately before liberalization starts, in cement, aluminium, chemical and glass industries.

Table 8. Results of piece-wise linear regression of energy intensive industries in India by Spline function (TFPG as dependent variable)

Variables	Cement	Aluminium	Iron & steel	Chemical	Fertilizer	Paper&pulp	Glass
Intercept	0.063	-0.008	0.048	0.0234	-0.0089	0.037	0.0055
B	-0.00183 (-0.37)	-0.003 (-0.58)	0.0018 (0.368)	-0.0022 (-0.66)	0.0027 (0.62)	0.0052 (1.30)	- 0.0014 (-0.37)
$B'(t - t_0)$	-0.0028 (-2.28)	-0.007 (-2.89)	-0.0033 (-2.41)	-0.00376 (-2.69)	-0.00685 (-1.99)	-0.0050 (-2.72)	-0.0008 (-2.11)
R^2	0.14	0.54	0.14	0.24	0.54	0.16	0.60
D-W value	2.21	2.35	2.59	2.62	2.49	254	2.68

Source: Own estimate

From the table 8 above, it is found that in case of cement, aluminum, iron and steel, chemical, fertilizer, paper&pulp and glass industry, liberalization has significant negative impact as because the coefficients of the difference between two time periods are statistically significant at 0.05 level and negative (coefficients being -0.0028, -0.007,-0.0033,-0.00376,-0.00685, -0.005, -0.0008 respectively) . Therefore, it has been observed from our analysis that productive performance of most of the energy intensive industries in India has been showing gradual declining trend since the initiation of economic reforms in 1991explicitly reflecting the adverse impact of liberalization on total factor productivity growth.

Output growth- productivity driven or input accumulation:

Theoretically, sources of economic growth are composed of factor accumulation and productivity growth. The first source may lead to high growth rates, but only for a limited period of time. Thereafter, the law of diminishing returns inevitably occurs. Consequently, sustained growth can only be achieved through productivity growth, that is, the ability to produce more and more output with the same amount of input. Some researchers argued that the Soviet Union of the 1950s and the 1960s, and the growth of the Asian 'Tigers' are as examples of growth through factor accumulation (e.g. Krugman, 1994). On the other hand, growth in the industrialized countries appears to be as the result of improved productivity (e.g. Fare et *al*, 1994).

Traditionally (owing to Solow), the sources of output growth are decomposed into two components: a component that is accounted for by the increase in factors of production and a component that is not accounted for by the increase in factors of production which is the residual after calculating the first component. The latter component actually represents the contribution of TFP growth.

Therefore, the pertinent question of whether output growths of these industries are the result of factor accumulation or productivity-driven has been tested for these energy intensive industries. Table 9 shows the relative contribution of TFP growth and factor input growth for the growth of output during 1979-80 to 2003-04. Observing the growth path, it is apparent that in all the industries under our study, TFP growth contribution is either negative or negligible and insignificant across the entire time frame. Therefore, it is true that increase in factor input is responsible for observed output growth and TFP contribution plays negligible role in enhancing output growth. Therefore, output growth in energy intensive industries in India was fundamentally dominated by accumulation of factors resulting input-driven growth.

Table 9. Contribution of TFPG to output growth under liberalized trade regime

Industry	Contribution of TFPG and inputs to output growth	Phase 1 (1979-'80 to '85-'86)	Phase 2 (1986-'87 to '91-'92)	Phase 3 (1992-'93 to '97-'98)	Phase 4 (1998-'99 to 2003-04)	Pre-reform period (1979-'80 to 1991-'92)	Post-reform period (1991-'92 to 2003-'04)	Entire period (1979-'80 to03-'04)
Cement	Output growth	11.05	9.93	6.03	4.75	10.49	5.74	7.94
	Contribution of Input growth	10.05 (95.02%)	8.74 (88.02%)	5.12 (84.91%)	5.29 (111.37%)	9.62 (91.71%)	4.73 (82.35%)	7.944 (100.054%)
	Contribution of TFPG	0.55 (4.98%)	1.19 (11.98%)	0.91 (15.09%)	-0.54 (-11.37%)	0.87 (8.29%)	1.013 (17.65%)	-0.0043 (-0.054%)
Aluminium	Output growth	5.89	6.65	-3.66	-1.23	6.27	-2.20	5.21
	Contribution of Input growth	3.09 (52.46 %)	10.19 (153.23%)	-5.41 (-147.81%)	-0.18 (-14.63%)	6.64 (105.9%)	-2.23 (-101.36%)	5.32 (102.11%)
	Contribution of TFPG	2.80 (47.53%)	-3.54 (-53.23%)	1.75 (47.81%)	-1.05 (-85.37%)	-0.37 (-5.90%)	0.03 (1.36%)	-0.11 (-2.11%)
Iron&steel	Output growth	4.43	7.33	7.79	6.91	6.29	6.9	6.76
	Contribution of Input growth	3.69 (83.21%)	6.51 (88.81%)	7.09 (90.98%)	6.2 (89.67%)	5.72 (91.02%)	6.42 (93.1%)	6.89 (101.92%)
	Contribution of TFPG	0.74 (16.79%)	0.82 (11.19%)	0.70 (9.02%)	0.71 (10.33%)	0.57 (8.98%)	0.48 (6.90%)	-0.13 (-1.92%)
Chemical	Output growth	7.29	8.06	9.15	5.20	8.04	7.68	7.61
	Contribution of Input growth	7.64 (104.80%)	6.4 (79.40%)	11.04 (111.59%)	5.74 (110.38%)	7.39 (91.92%)	8.0 (104.17%)	7.68 (100.92%)
	Contribution of TFPG	-0.35 (-4.80%)	1.66 (20.60%)	-1.06 (-11.59%)	-0.54 (-10.38%)	0.65 (8.08%)	-0.32 (-4.17%)	-0.07 (-0.92%)
Fertilizer	Output growth	3.67	26.99	7.09	-2.05	15.33	3.74	8.93
	Contribution of Input growth	3.95 (107.63%)	25.82 (95.66%)	7.43 (100.46%)	-1.30 (63.41%)	14.89 (97.13%)	4.86 (127.08%)	8.98 (127.63%)
	Contribution of TFPG	-0.28 (-7.63%)	1.17 (4.34%)	-0.34 (-0.46%)	-0.75 (36.59%)	0.44 (2.87%)	-1.12 (-27.08%)	-0.05 (-27.63%)
Paper&pulp	Output growth	6.38	9.40	5.70	2.72	7.79	4.5	6.47
	Contribution of Input growth	4.67 (73.2%)	9.83 (104.58%)	5.55 (97.37%)	3.43 (100.71%)	7.15 (91.78%)	3.56 (79.11%)	6.472 (100.03%)
	Contribution of TFPG	1.71 (26.80%)	-0.43 (-4.58%)	0.15 (2.63%)	-0.71 (-26.10%)	0.64 (8.22%)	0.94 (20.89%)	-0.002 (-0.03%)
Glass	Output growth	7.92	12.77	2.62	2.86	10.34	4.76	6.19
	Contribution of Input growth	8.38 (105.81%)	12.48 (97.73%)	1.86 (70.99%)	2.25 (78.67%)	10.43 (100.87%)	5.44 (114.29%)	6.29 (101.62%)
	Contribution of TFPG	-0.46 (-5.81%)	0.29 (2.27%)	0.76 (29.01%)	0.61 (21.33%)	-0.09 (0.87 %)	-0.68 (-14.29%)	-0.10 (-1.62%)

Source: Own estimate

6. Concluding Remarks

This study attempts to measure productivity performance of energy intensive industries in India in terms of total factor productivity for the entire period, 1979-80 to 2003-04. The result on the overall productivity displays that TFPG has declined in post-reform period as compared to pre-reform period. Total output growth in those Indian industries is found to be mainly input-driven.

Careful analysis of the relative contribution of TFP growth and factor input growth for the growth of output during 1979-80 to 2003-04 provides us insight that TFP growth contribution to the growth in output is either negative or insignificant across the entire time frame. Therefore, it is true that increase in factor input is responsible for observed output growth and TFP contribution plays negligible role in enhancing output growth. Therefore, growth of output in Indian energy intensive industries was fundamentally dominated by factor accumulation resulting input-driven growth rather than productivity-driven.

TFP growth in the energy intensive industries under our study shows positive as well as negative growth rates over years within the same individual industry and it varies widely over years. Apart from this, the present analysis also reveals that there exists greater heterogeneity in TFP performance across industry groups.

Total factor productivity growth displays upward and downward trend during post-reform period .In all the industries like cement, aluminum, iron and steel, fertilizer, glass and chemical and paper & pulp industries, post-reform TFP growth rate reflects dismal declining growth rate which reflects negative impact of liberalization thereon. Given the fact that there exists high degree of intra industrial disparity of TFPG, it is expected that no single explanation for variations in TFPG in each industry group will hold true. Nevertheless, it seems that due to heavy investment in the 1990s, unaccompanied by commensurate expansion of demand, capacity utilization went on worsening in those manufacturing industries. That might have adversely affected the productivity growth. The liberalization process is found to have its adverse impact on total factor productivity growth.

All the observations, in turn, place the need for formulating industry specific policies for enhancing total factor productivity growth of energy intensive industries in India. The negative and significant impact of liberalization on productivity suggests that trade policy should focus on productivity enhancing industrial policies that will, in turn, help firm to enter export market after gaining real competitive edge. Moreover, the chances of survival in the highly competitive era are high for more productive firms than less productive firms. The economic theory mentions of different possible reasons for keeping idle capacity in a competitive economy. Therefore, it can be said that the tendency to attribute all economic outcomes in a period, which coincide with economic reforms may not match with the empirical facts. Nevertheless, the industries taken up under our study which keep idle capacity should utilize its capacity to the fullest possible for meeting growing market-demand. India's tariff rates are still among the highest in the world and continue to block India's attractiveness as export platform for energy-intensive manufacturing production. It is also suggested that tariff rates on imported capital goods should be made duty free. It is worth remembering that India has been gradually achieving a high per capita income level so that productivity growth will become more important relative to factor accumulation as a source of economic growth. The unmistakable implication for Indian policymakers is the need to open up more to foreign imports, which will help to bring about institutional and technological progress conducive to TFP growth.

The seven key industries under consideration of our study- namely cement, iron & steel, chemical, aluminum, paper & pulp, glass and fertilizer- consumes about 65% of the total energy use in India. The energy intensity in some of those industries is reported to be higher than the industries in developed countries. One of the main reasons for higher energy use is the presence of obsolete and energy inefficient processes in some of these sectors. Therefore, measures have to be initiated for modernizing the obsolete plants within the industries that will surely be the productivity enhancing mechanism. Immediate initiatives have to be taken for drawing up energy consumption norms for various kinds of fuel using equipment. In the absence of energy consumption norms for various energy intensive industries in India, these industries have adopted their own benchmarks. The common practice is to compare their performance with the best specific energy consumption figure in that particular sector/region or their own best figure achieved in the recent past. This attempt may not be adequate. The plants within those industries should also set their long-term goals and year-wise targets may be framed to achieve these goals. Few plants in India have achieved specific energy consumption figures which are very close to the best in the world, despite all the constraints. All plants should carefully plan out a roadmap leading to similar objective which will help them to be least cost producer of their product and become competitive globally. The strategies should be to introduced to use alternative fuel like CN.G, Natural gas and bio gas fuel instead of oil to cover up the extra strain arising due to severe oil price hike.

India needs a sustainable energy policy that will not only meet the future energy demand for rapid economic growth but also protect the environment and conserve scarce resources. By making our thermal power sector more efficient, increasing the use of environmental management systems in energy-intensive industries, imposing stringent emission norms industrial sector, expanding the use of renewable energy technologies and introducing the Energy Conservation Bill, 2000 by Government of India, India has already taken major steps in the right direction. Industry associations can play an important role to spread the culture of energy efficiency among its plants on a larger scale. In few selected energy intensive industrial sectors, such as, aluminium, cement, chlor-alkali, fertilizer, pulp & paper, petrochemicals, refinery, and textiles, industry association has set up a 'task force' of selected plants and association from that sector with an objective to promote energy efficiency on a sectoral basis. These forums could be utilized by these plants to showcase successful case studies on energy conservation in their premises, share best practices, keep track of international scenario, technological advances occurring in their field and market conditions etc. These forums can also help in framing energy consumption norms and targets for that particular sector.

In terms of future applied research directions on Indian context, regional level study with plant level data sets would be more informative in decision making process.

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Appendix

Appendix: A-1 Energy Inputs:

Industry level time series data on cost of fuel of Indian energy intensive sectors have been deflated by suitable deflator (base 1981-82 = 100) to get real energy inputs. An input output table provides the purchase made by manufacturing industry from input output sectors. These transactions are used as the basis to construct weight and then weighted average of price index of different sectors is taken. Taking into consideration 115 sector input -output table (98-99) prepared by CSO, the energy deflator is formed as a weighted average of price indices for various input-output sectors which considers the expenses incurred by manufacturing industries on coal, petroleum products and electricity as given in I-O table for 1998-99. The WIP indices (based 1981- 82) of Coal, Petroleum and Electricity have been used for these three categories of energy inputs. The columns in the absorption matrix for 66 sectors belonging to manufacturing (33- 98) have been added together and the sum so obtained is the price of energy made by the manufacturing industries from various sectors. The column for the relevant sector in the absorption matrix provides the weights used.

Appendix: A-2 Capital Stock:

The procedure for the arriving at capital stock series is depicted as follows:

First, an implicit deflator for capital stock is formed on NFCS at current and constant prices given in NAS. The base is shifted to 1981-82 to be consistent with the price of inputs and output.

Second, an estimate of net fixed capital stock (NFCS) for the registered manufacturing sector for 1970-71 (benchmark) is taken from National Accounts Statistics. It is multiplied by a gross-net factor to get an estimate of gross fixed capital stock (GFCS) for the year 1970-71. The rate of gross to net fixed asset available from RBI bulletin was 1.86 in 1970-71 for medium and large public Ltd. companies. Therefore, the NFCS for the registered manufacturing for the benchmark year (1970-71) as reported in NAS is multiplied by 1.86 to get an estimate of GFCS which is deflated by implicit deflator at 1981-82 price to get it in real figure. In order to obtain benchmark estimate of gross real fixed capital stock made for registered manufacturing, it is distributed among various two digit industries (in our study, 7 energy intensive industries) in proportion of its fixed capital stock reported in ASI, 1970-71)

Third, from ASI data, gross investments in fixed capital in all seven energy intensive sectors are computed for each year by subtracting the book value of fixed in previous year from that in the current year and adding to that figure the reported depreciation on fixed asset in current year. (Symbolically, $I_t = (\beta_t - \beta_{t-1} + D_t) / Pt$) and subsequently it id deflated by the implicit deflator to get real gross investment.

Fourth, the post benchmark real gross fixed capital stock is arrived at by the following procedure. Real gross fixed capital stock (t) = real gross fixed capital stock (t – 1) + real gross investment (t). The annual rate of discarding of capital stock (D_{st}) is assumed to be zero due to difficulty in obtaining data regarding D_{st}.