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Trade Liberalization and Industry Level Productivity in Indian Iron-Steel and Cement Industries: Evidences from Post-Reform Period

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Abstract

The productivity growth has an important linkage with economic growth and standard of living. It not only increases output but also improves the efficiency level of firms/industries through better utilization of factors of production, and therefore public policies aim at improving productivity. This paper focusses on estimating productivity in iron-steel and cement industries in India and examines the impact of trade liberalization on productivity. The period of the study is from 1991-92 to 2012-13 which is sub-divided into two sub-periods; from 1991-92 to 2001-02 and from 2002-03 to 2012-13. Productivity has been estimated using Malmquist Productivity Index method. The productivity growth in iron-steel and cement industries are 1.4 percent and negative 0.7 percent respectively during the entire period of the study. It has been found that productivity growth of iron-steel has declined in sub period-2 from sub period-1, while that of the cement industry has improved a little during the same period. As far as the impact of trade liberalization measures on productivity is concerned, it has been found that declined input-tariff, output-tariff and effective rate of protection and increase trade openness leads to significant increase in productivity. The paper also concludes the positive impact of increase in construction growth rate and decline in rate of interest and inflation rate.

Keywords: productivity, trade liberalization, Malmquist productivity index, iron-steel, cement and India

JEL Classifications: D24, O24, O53

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1. INTRODUCTION

The economic growth of an economy is either driven by higher use of inputs or improvements in productivity. The economic growth resulted from employing more inputs is subject to diminishing returns in the long run (Krugman 1994, Young 1995), while productivity driven growth is emerged from better utilization of available factors of production. The inputs-driven growth requires a greater number of input units every time to increase production while productivity driven growth results in higher level of production with same level of inputs. Therefore, the second one is sustainable in the long run. Thus, productivity growth has an important linkage with economic growth and standard of living. It not only increases output but also improves the efficiency level of firms/industries through better utilization of factors of production. Public policies should aim at creating a competitive environment, removing hurdles in the availability of intermediate inputs, creating new markets for the sale of final products, bringing new advanced technology and capital in the country, making domestic companies internationally competitive and, above all, they should target to improve productivity.

India's economic development model after 1990s is featured by liberalized and market-oriented development framework. The major market-oriented liberalized economic policies/reforms undertaken in Indian economy, during the period of 1990s and thereafter, include (1) industrial reforms in terms of abolition of industrial licensing, dilution of public sector, free entry to foreign investment and technology, (2) financial sector reforms in terms of changes related to tax policies, exchange control and convertibility, banking and credit policy, capital market, interest rate deregulation and financial repression, structural deregulation, monetary policy and debt markets, and corporate law and (3) trade liberalization reforms in terms of lowering quantitative and other restrictions on trade.

Trade liberalization means liberalizing and/or eliminating the discretionary controls on international trade and reducing nominal and effective protection provided to the domestic industry. It includes lowering of various tariff and non-tariff barriers, opening of economy to international technology import and exposing domestic industry to the foreign competition. Trade liberalization reforms have provided the domestic manufacturing companies an easy access to foreign technology, intermediate inputs at lower prices and created new markets for the sale of manufactured products. In all these ways, it not only affects the productivity levels of companies/industries but also contributes to enhancing rate of economic growth.

Indian iron-steel and cement industries: Iron-steel and cement industries are considered to be the core of manufacturing sector in any economy and their output plays a major role in building a nation's physical infrastructure and industrial base. The weights of these two industries together in total industrial production of India has increased to 9.09 at Base 2004-05:100 from 7.12 at Base 1993-94:100 and 6.81 at Base 1980-81:100 [Handbook of Statistics on Indian Economy (HBSIE), 2013-14]. This shows that the contribution of these two industries in total industrial production has significantly increased over the years. The share of these industries has witnessed remarkable increase in terms of employment, value of output and gross capital formation (GCF) in complete Indian factory sector during the post-reform period from 1991-92 to 2012-13. "This share has increased (1) from 6.14 percent in 1991-92 to 6.45 percent in 2012-13 in total employment, (2) from 11.53 percent in 1991-92 to 12.11 percent in 2011-12 but declined to 10.89 percent in 2012-13 in total value of output and (3) from 15.67 percent in 1991-92 to 21.33 percent in 2012-13 in GCF. However, their share in total number of factories has declined from 3.46 percent in 1991-92 to 3.34 percent in 2012-13. These two industries contributed more than 10 percent in total factory sector output and provided employment to more than 0.80 million people in 2012-13", [Annual Survey of Industries, Vol. (1) 1982-83 - 2012-13]. Thus, these two industries occupy a prime place in the entire manufacturing sector.

Table 1: Primary Performance Indicators and Share in Complete Factory Sector: Iron-Steel Industry (Factory Sector) in India during the period from 1991-92 to 2012-13

Year	Primary Performance Indicators				Share in complete Factory Sector			
	Factories	Total Persons Engaged	Value of Output	Gross Capital Formation	Factories	Total Persons Engaged	Value of Output	Gross Capital Formation
	(Numbers)		(Rs. Billion)		(Percent)			
1991-92	3108	416352	275.94	54.86	2.77	5.00	9.22	14.27
1992-93	3388	490150	368.19	58.49	2.84	5.55	9.99	10.36
1993-94	3362	467283	380.23	62.01	2.76	5.29	8.93	18.94
1994-95	3379	454472	453.76	112.04	2.75	4.93	8.76	14.52
1995-96	3519	509971	565.11	85.44	2.61	4.99	8.43	9.43
1996-97	3415	443898	596.27	71.27	2.57	4.65	8.04	7.61
1997-98	3760	464274	748.11	78.63	2.76	4.61	8.95	9.58
1998-99	3703	425433	624.52	140.90	2.81	4.42	7.97	19.52
1999-00	3511	402659	707.35	12.23	2.67	4.93	7.88	1.89
2000-01	3568	379884	685.55	46.82	2.72	4.76	7.40	7.62
2001-02	3523	367066	715.25	41.78	2.74	4.74	7.43	5.66
2002-03	3322	357802	954.22	42.05	2.60	4.51	8.44	6.57
2003-04	3315	364801	1192.72	102.82	2.57	4.64	9.26	13.86
2004-05	3513	396365	1862.76	101.14	2.58	4.69	11.14	9.19
2005-06	3820	430053	1898.94	221.61	2.73	4.72	9.95	12.92
2006-07	4043	513400	2633.46	237.82	2.79	4.97	10.93	11.93
2007-08	4098	564208	3230.35	65.08	2.80	5.40	11.64	2.48
2008-09	4167	600966	3608.29	451.02	2.68	5.31	11.03	17.24
2009-10	4575	600029	3969.52	560.13	2.88	5.09	10.63	15.48
2010-11	5771	683351	4775.54	723.79	2.73	5.38	10.21	16.23
2011-12	5747	714307	6078.46	660.84	2.64	5.32	10.52	16.24
2012-13	6033	679869	5537.53	620.11	2.72	5.25	9.19	17.34
S-LTRG	**2.40**	**1.90**	**14.70**	**11.83**	**-0.03**	**0.24**	**1.10**	**0.87**
CAGR	**5.70**	**4.50**	**40.30**	**31.30**	**---**	**0.60**	**2.60**	**2.10**

Note: The value of employment in the year 1999-00 has been imputed using Linear Interpolation method.
Source: Annual Survey of Industries, MOSPI, Various Issues

Table 2: Primary Performance Indicators and Share in Complete Factory Sector: Cement Industry (Factory Sector) in India during the period from 1991-92 to 2012-13

Year	Primary Performance Indicators				Share in complete Factory Sector			
	Factories	Total Persons Engaged	Value of Output	Gross Capital Formation	Factories	Total Persons Engaged	Value of Output	Gross Capital Formation
	(Numbers)		(Rs. Billion)		(percent)			
1991-92	779	94741	69.15	5.37	0.69	1.14	2.31	1.40
1992-93	854	105318	73.32	13.30	0.71	1.19	1.99	2.36
1993-94	918	104270	73.66	11.32	0.75	1.18	1.73	3.46
1994-95	915	103421	90.82	18.49	0.74	1.12	1.75	2.40
1995-96	1035	118316	126.72	23.02	0.77	1.16	1.89	2.54
1996-97	1031	118574	163.61	26.66	0.78	1.24	2.21	2.85
1997-98	1034	104901	137.44	2.39	0.76	1.04	1.64	0.29
1998-99	993	105336	165.12	6.78	0.75	1.10	2.11	0.94
1999-00	952	105771	192.80	11.17	0.72	1.29	2.15	1.73
2000-01	916	88190	173.60	11.59	0.70	1.10	1.87	1.89
2001-02	843	86455	190.12	61.87	0.66	1.12	1.98	8.38
2002-03	942	88653	182.29	20.22	0.74	1.12	1.61	3.16
2003-04	884	87253.5	203.85	13.75	0.68	1.11	1.58	1.85
2004-05	855	85854	258.57	25.38	0.63	1.02	1.55	2.31
2005-06	896	90116	281.95	28.65	0.64	0.99	1.48	1.67
2006-07	887	97293	409.17	59.98	0.61	0.94	1.70	3.01
2007-08	800	104559	539.67	106.93	0.55	1.00	1.94	4.08
2008-09	970	126930	651.01	163.48	0.62	1.12	1.99	6.25
2009-10	984	118668	661.80	144.42	0.62	1.01	1.77	3.99
2010-11	1372	147898	709.60	129.84	0.65	1.17	1.52	2.91
2011-12	1414	155783	921.10	169.75	0.65	1.16	1.59	4.17
2012-13	1367	155266	1023.13	142.53	0.62	1.20	1.70	3.99
S-LTRG	**1.30**	**1.27**	**12.58**	**15.41**	**-1.10**	**-0.38**	**-1.02**	**4.44**
CAGR	**3.00**	**3.00**	**33.60**	**42.60**	**---**	**---**	**---**	**10.80**

Note: The values of all primary performance indicators in 1998-99 and total persons engaged in 2003-04 have been imputed using Linear Interpolation method.
Source: Annual Survey of Industries, MOSPI, Various Issues

The iron-steel industry accounts for 6.684 percent weightage in the whole industrial sector of India at Base 2004-05:100. Iron-steel industry presently contributes about 3 percent to the GDP and provides employment to more than 0.5 million people (Annual Report 2013-14, Ministry of Steel, Government of India). The semi-log trend rate of growth (S-LTRG) and compound annual growth rate (CAGR) of index of industrial production (IIP) of steel at Base 2004-05:100 are 7.82 percent and 19.80 percent respectively during the post-reform period from 1991-92 to 2012-13. The performance of iron-steel industry (factory sector) and its share in complete factory sector during the post-reform period in terms of number of factories, employment, value of output and gross capital formation (GCF) is given in Table 1.

- The number of iron-steel factories has increased from 3108 in 1991-92 to 6033 in 2012-13. The S-LTRG and CAGR of the same are 2.40 percent and 5.70 percent respectively. The share of this industry in total factories has been varying from 2.57 percent to 2.88 percent with negative S-LTRG during the same period.
- The total persons engaged (employment) in iron-steel industry has increased from 0.416 million in 1991-92 to 0.680 million in 2012-13. The S-LTRG and CAGR of the same are 1.90 percent and 4.50 percent respectively. The share of this industry in total persons engaged in the complete factory sector has increased from 5.00 percent in 1991-92 to 5.25 percent in 2012-13 (at S-LTRG and CAGR of 0.24 percent and 0.60 percent respectively).

- The value of output of iron-steel industry has increased from Rs. 275.94 billion in 1991-92 to Rs. 5537.53 billion in 2012-13. The S-LTRG and CAGR of the same are 14.70 percent and 40.30 percent respectively. The share of this industry in the value of the output of the complete factory sector has increased from 9.22 percent in 1991-92 to 10.52 percent in 2011-12 but declined to 9.19 percent in 2012-13. The S-LTRG and CAGR of this share are 1.10 percent and 2.60 percent respectively during the period from 1991-92 to 2012-13.
- The GCF made by iron-steel industry has increased from Rs. 54.86 billion in 1991-92 to Rs. 620.11 billion in 2012-13 (at S-LTRG and CAGR of 11.83 percent and 31.30 percent respectively). The share of this industry in GCF of the complete factory sector has increased from 14.27 percent in 1991-92 to 17.34 percent in 2012-13 (at S-LTRG and CAGR of 0.87 percent and 2.10 percent respectively).

Cement is the most essential raw material for any kind of construction activity. According to the Background Note, Ministry of Commerce and Industry, Government of India, "Presently, India is the second largest cement producer in the world, next only to China. India's share in world's total cement production is about 6 percent. There are presently 154 large cement plants with an installed capacity of 230.82 million tonnes. The industry provides direct employment to 1.35 lakh persons". The S-LTRG and CAGR of IIP of cement at Base 2004-05:100 are 6.10 percent and 15.10 percent respectively during the post-reform period from 1991-92 to 2012-13. The performance of cement industry (factory sector) in India and its share in complete factory sector during the post-reform period in terms of number of factories, employment, value of output and GCF is given in Table 2.

- The number of cement factories has increased from 779 in 1991-92 to 1367 in 2012-13. The S-LTRG and CAGR of the same are 1.30 percent and 3.00 percent respectively. The share of this industry in total factories has been varying from 0.55 percent to 0.78 percent with negative S-LTRG during the same period.
- The total persons engaged in cement industry has increased from 0.095 million in 1991-92 to 0.155 million in 2012-13. The S-LTRG and CAGR of the same are 1.27 percent and 3.00 percent respectively. The share of this industry in total persons engaged in the complete factory sector has increased from 1.14 percent in 1991-92 to 1.20 percent in 2012-13 with negative S-LTRG.
- The value of output of cement industry has increased from Rs. 69.15 billion in 1991-92 to Rs. 1023.13 billion in 2012-13. The S-LTRG and CAGR of the same are 12.58 percent and 33.60 percent respectively. However, the value of the output of the cement industry has increased, but its share in the value of the output of the complete factory sector has declined from 2.31 percent to 1.70 percent during the same period at S-LTRG of -1.02 percent.
- The GCF made by cement industry has increased from Rs. 5.37 billion in 1991-92 to Rs. 142.53 billion in 2012-13 (at S-LTRG and CAGR of 15.41 percent and 42.60 percent respectively). The share of this industry in GCF of the complete factory sector has increased from 1.40 percent in 1991-92 to 3.99 percent in 2012-13 (at S-LTRG and CAGR of 4.44 percent and 10.80 percent respectively).

The Tables 1 and 2 indicate that the share of iron-steel and cement industries in the complete factory sector has witnessed remarkable increase during the post-reform period from 1991-92 to 2012-13 in terms of employment, value of output and GCF. The share of these two industries together in the complete factory sector has increased (1) from 6.14 percent in 1991-92 to 6.45 percent in 2012-13 in total employment, (2) from 11.53 percent in 1991-92 to 12.11 percent in 2011-12 but declined to 10.89 percent in

2012-13 in the total value of the output and (3) from 15.67 percent in 1991-92 to 21.33 percent in 2012-13 in GCF. However, their share in total number of factories has declined from 3.46 percent in 1991-92 to 3.34 percent in 2012-13. These two industries contributed more than 10 percent in total factory sector output and provided employment to more than 0.80 million people in 2012-13. Thus, iron-steel and cement industries occupy a prime place in the entire manufacturing sector. In line with the rationalization and reduction of tariff rates on various inputs and output items of agriculture and manufacturing sectors after 1991 economic reforms, tariff rates have also been considerably rationalized and reduced on inputs and main products of iron-steel and cement industries. "In iron-steel industry, input-tariffs, output-tariffs and effective rate of protection (ERP) have declined from 49.12 percent, 94.05 percent and 144.09 percent in 1991-92 to 3.37 percent, 7.86 percent and 14.39 percent in 2012-13 respectively; and in cement industry, input-tariffs, output-tariffs and ERP have declined from 26.96 percent, 77.00 percent and 141.74 percent in 1991-92 to 3.61 percent, 7.20 percent and 10.18 percent in 2012-13 respectively", (Authors' calculations from WITS-Tariff Database).

Thus, considering the increasing importance and contribution, and substantial decline in key tariff rates in these two industries, this paper estimates industry level productivity in these two industries and examines the impact of trade liberalization on their productivity.

2. REVIEW OF LITERATURE

Estimation of industrial productivity has since long been an issue of prime importance across the globe. There are mainly two types of productivity viz.; partial factor productivity (PFP) and total factor productivity (TFP). The earlier measures the average productivity of a particular input in question, while the latter is a measure of technical progress and shows the efficiency with which all inputs are used in a production function. Industrial productivity is generally estimated at either aggregate manufacturing /industry or firm / plant levels. Several studies pertaining to estimation of industrial productivity at both the above-mentioned levels have been conducted in India during pre as well as post reform periods. Since this paper aims at estimating industrial productivity (total factor productivity, TFP) in the Indian iron-steel and cement industries, important available studies measuring productivity in iron-steel and cement industries have been reviewed and summarized as follows in Table 3.

Table 3: Summarization of Studies Pertaining to Productivity Estimation in Iron-Steel and Cement Industries conducted in India

Authors	Study Period	Techniques used	Industry	Findings
Sawhney (1967)	1050 to 1963	Kendrick Arithmetic Index	Cement industry in India	TFPG and PFP for capital, labour and materials were estimated at 1.90%, 1.50%, 7.30%, and 1.2% per annum on average respectively during the period of study.
Sinha and Sawhney (1970)	1950 to 1963	Kendrick Arithmetic Index	Cement industry in India	Average annual TFPG and PFP for capital and labour were 1.70%, 1.91%, and 4.70% respectively.
Mahopatra (1970)	1949 to 1964	Solow' Growth Accounting Approach	Cement industry in India	Average annual TFPG was 1.8%
Gupta (1973)	1946 to 1965	Kendrick Arithmetic Index	Cement industry in India	During 1946 to 1965, TFPG and PFP for both capital and materials were negative at -1.06%, -0.55%, and -1.26% per annum on average respectively.
Mehta (1980)	1953-54 to 1964-65	Solow index in Cobb-Douglas production function	Iron-steel and cement industries in India	There was some evidence of capital deepening in the production process but no clear trend of efficiency improvements. TFPG (semi-log trend) was 6.1% per annum in cement industry while TFPG (semi-log trend) and PFP for capital and labour were -6.30%, -22.8% and -5.2% in iron-steel industry.
Arya (1981)	1956 to 1972	Cobb-Douglas production function	15 cement manufacturing companies in India	Capital intensity increased at an annual average rate of 2.8% for the sample of 15 companies. The trend rates of growth had wide variation across the sample and fall in the range of 0.8% to 6.8% per annum.
CSO (1981)	1960 to 1977	Kendrick Arithmetic Index	Iron-steel and cement industries in India	TFPG (compound annual growth rate) and PFP for capital and labour were estimated as 0.07%, -0.81% and 0.89% respectively in iron-steel industry while the same were 1.62%, 1.86% and 1.12% respectively in cement industry during 1960 to 1977.
Goldar (1986)	1960 to 1970	Kbendrick Arithmetic Index	Iron-steel and cement industries in India	TFPG and PFP for capital and labour were -1.66%, -3.23% and 0.96% in iron-steel industry while the same for cement industry were 0.50%, -0.37% and 2.66% respectively
Arora (1987)	1973 to 1981	Translog index	Cement industry in India	TFPG and PFP for capital and labour were -1.96%, -1.66% and 2.29% per annum respectively.
Ahluwalia (1991)	1959-60 to 1984-85	Translog index	Indian iron-steel and cement industries	TFPG and PFP for capital and labour are -1.60%, -2.8% and 0.10% for iron-steel industry while the same for cement industry are -0.50%, -1.4% and 1.3% respectively.
Kumari (1993)	1971 to 1987	Translog index	Indian iron-steel industry	TFPG and PFP for capital and labour were -1.2%, -2.54% and -0.74% respectively.

Authors	Study Period	Techniques used	Industry	Findings
Pradhan and Barik (1998)	1963 to 1992	Translog index	Indian iron-steel and cement industries	TFP was -2.09% and 1.71% per annum in iron-steel and cement industries respectively.
Schumacher and Sathaye (1999)	1973-74 to 1993-94	Translog, Kendrick and Solow indices	Indian cement sector	TFPG was -0.03%, 0.16% and -1.66% per annum using Translog, Kendrick and Solow indices respectively during 1973-9. Technical progress was biased towards the use of capital and energy while it was labour and material saving.
Sharma (2007)	1989 to 2005	Divisia Tornquist index	Cement industry in India	TFPG declined sharply in cement industry during the period of study.
Mandal and Madheswaran (2009)	1989-90 to 2006-07	Stochastic Frontier Approach	Cement industry in India	TFPG was 5.37% per annum on average and its main drivers are changes in scale component and technical progress not technical efficiency change since it is time variant in nature.
Ray & Pal (2010)	1979-80 to 2003-04	Translog index	Indian iron-steel industry	Average TFPG in pre-reform period (1979-80 to 1991-92) was 0.5650 % and in post reform period (1991-92 to 2003-04) was 0.4761%. Labour and capital productivity growth rate at an annual average for the whole period were 5.81% and 0.80% respectively. **Determinants:** export, import, growing output, tariff, REER, capacity utilization, trade openness, investment in fixed machineries.
Ray (2012)	1979-80 to 2003-04	Translog index	Seven selected manufacturing industries in India with iron-steel and cement	**Determinants:** export-output ratio, import penetration ratio, growth in output, tariff rate, real effective exchange rate, inflation, terms of trade, capacity utilization, investment in fixed machinery, and gross make up
Ray (2012a)	1979-80 to 2003-04	Translog index	India's energy intensive industries with iron-steel and cement	Average annual TFPG of iron-steel and cement industries were 1.44% and 0.5650% respectively during pre-reform period (1979-80 to 1991-92) and 1.013% and 0.4761% respectively during post-reform period (1991-92 to 2003-04).
Mangla (2017)	1991-92 to 2012-13	Levinshon Petrin Method	Estimates firm-level productivity in cement industry in India	The firm levels productivity growth in cement industry in balanced and unbalanced panels are negative 0.14 per cent and 0.01 per cent respectively. A significant difference in productivity growth among large, medium and small-scale firms was found and increased trade openness is positively associated with productivity. Trade liberalization has led to decline in input-tariffs, output-tariffs and effective rate of protection.

Authors	Study Period	Techniques used	Industry	Findings
Mangla (2018)	1991-92 to 2012-13	Levinshon Petrin Method	Estimates total factor productivity in Indian iron-steel industry	The study found positive productivity growth during 1991–1992 to 2012–2013 but negative productivity growth during 1991–1992 to 2001–2002 and 2002–2003 to 2012–2013. Productivity growth was only positive in medium-scale firms, firms producing ferro-alloys, metal products, and sponge iron, while steel-producing firms registered negative productivity growth, and the productivity of privately managed/owned firms increased, while the productivity of government-owned firms and joint ventures declined.

Source: Author's review of the above-mentioned studies

3. OBJECTIVES

Below are the detailed objectives of this paper:

1. To estimate industry level productivity (TFP) in iron-steel and cement industries in India during the period from 1991-92 to 2012-13. The productivity growth rates have been calculated in three periods viz.; Period-I (1991-92 to 2001-02), Period-2 (2002-03 to 2012-13) and Period-3 (1991-92 to 2012-13).
2. To examine the impact of trade liberalization (measured as decline in input-tariffs, output-tariffs, ERP and increase in trade openness) and other macroeconomic variables viz.; real effective exchange rate (REER), interest rate, inflation rate and construction sector growth rate (CSGR) on industry level productivity in iron-steel and cement industries in India during the period from 1991-92 to 2012-13.

4. DATA MEASUREMENT AND METHODOLOGY SPECIFICATION

4.1 Definition of industries

This paper has used National Industrial Classification (NIC) codes to define iron-steel and cement industries in India; NIC-1970, NIC-1987, NIC-1998, NIC-2004 and NIC-2008 classification. For iron-steel industry, 3-digit data has been used while for cement industry, 3-digit data during the period from 1982-83 to 1997-98 and 4-digit data during the period from 1997-98 to 2012-13 has been used. NIC classifications have frequently changed during the period from 1991-92 to 2012-13, therefore, a proper mapping has been done among various NICs, and concordance has been prepared to maintain the uniformity of data used in both the industries. Here, iron-steel and cement industries comprise manufacture of basic iron & steel and manufacture of cement, lime & plaster respectively.

4.2 Construction of Input-Output Variables

This paper has used five inputs viz. labour, capital, energy, raw materials, and services (LKERMS) model for estimating productivity. The data has been taken from Annual Survey of Industries (ASI), Volume 1 from 1982-83 to 2012-13. The following methodology has been adopted to construct output-input variables:

Output: This paper has used gross output as a measure for the output and the value of the output as reported in various issues of ASI, published by Central Statistical Office, Government of India.

Labour: Labour represents the number of people working directly or indirectly in any industry or firm. Various studies pertaining to productivity estimation in Indian manufacturing (Goldar & Kumari 2003, Ray 2012b, 2012a, Goldar, Pradhan & Sharma 2013) have used total persons engaged as a measure of labour input. This paper has used total emoluments paid to total persons engaged as reported in various issues of ASI as a measure of labour input. In order to make labour input comparable with series of output and other inputs, total emoluments representing the expenses on account labour input has been deflated with index of labour price (base 2004-05=100). Price of labour has been obtained by dividing total emoluments by total persons engaged (Hashim, Kumar & Virmani, 2009) in both iron-steel and cement industries separately.

Capital: This paper considers stock of capital rather than the service of capital as a measurement of capital input. Here, net fixed capital stock (NFCS) at constant price (Base 2004-05) has been constructed as a proxy for capital input for estimating productivity at industry level in both the iron-steel and cement industries using the standard perpetual inventory methods (PIM) as follows:

$$K_{jt} = K_{jt-1} - \delta(K_{jt-1}) + I_{jt}$$
$$K_{jt} = (1-\delta)K_{jt-1} + I_{jt}$$

Here, K_t is the level of capital stock at time t, δ is annual rate of depreciation, I_t is the real investment at time t and j represents industry. Rate of depreciation has been taken as constant 5 percent throughout since (1) the life of machinery is assumed to be 20 years as noted in the Report of Census of Machine Tools, 1986, Central Machine Tools Institute, Bangalore and (2) the same is taken in recent studies such as Unel (2003) and Goldar et al. (2013) etc.

Energy: Fuels consumed as reported in various issues of ASI has been taken as a measure of energy input. In order to make energy input series comparable to other inputs, it has been deflated with weighted WPI (Base year 2004-05) of energy input where weights have been obtained from I-O-TM 2004-05 of India.

Raw Materials: 'Materials consumed' as reported in various issues of ASI has been taken as a measure of raw materials input. In order to make raw materials series comparable to other inputs, it has been deflated with weighted WPI (Base year 2004-05) of raw materials input where weights have been obtained from I-O-TM 2004-05 of India.

Services: ASI does not provide a separate data series on services as an input used in the manufacturing process. It provides a data series on total inputs. Banga and Goldar (2004) and Hashim et al. (2009) have suggested an alternative measure to obtain the services input series as subtracting materials and fuels consumed from total input. Considering the ASI definition of total input and following Banga and Goldar (2004) and Hashim et al. (2009), services input has been obtained by subtracting the value of materials/raw materials and fuels/power and fuels consumed from total input/total expenses as reported in various issues of ASI. In order to make services input comparable with other inputs, it has been deflated with price index (Base year 2004-05) of services inputs where weights have been obtained from I-O-TM 2004-05 of India. Therefore, since WPI series for services are not available in India, price deflators for services cannot be constructed. In order to resolve this problem, implicit price deflators for major items of services have been constructed using the service sector gross domestic product (GDP) series at factor cost constant price (Base Year: 2004-05) and current price as obtained from Central Statistical Office, Government of India as follows:

Service Sector GDP Deflator *= [Nominal Service Sector GDP / Real Service Sector GDP] *100*

Notes on, Item included in Inputs, their WPI and Price Deflator:

1. Items included in capital, raw materials, energy and services inputs cover 99.99% and 99.97% share of total inputs in iron-steel and cement respectively as derived from I-O-TM 2004-05 of India.
2. WPI has been calculated at Base Year 2004-05:100 through splicing of WPI Base Year 1981-82:100 and 1993-94:100. Weighted WPI of all the items output and all inputs have been constructed to deflated the series.
3. Commodities which have been included in each item of output and inputs WPI for both iron-steel and cement industries have been taken as specified in I-O-TM, National Accounts Statistics-Sources and Methods, 2007.
4. Output and Inputs series have been deflated on Base Year 2004-05:100 using the following formula:

$$\textit{Deflated Output and Inputs Series} = \text{Current Year Value} \times \frac{\text{WPI at 2004 - 05}}{\text{Current Year WPI}}$$

4.3 Research Model for Estimating Productivity

This paper has used Malmquist Productivity Index (MPI) method to estimate productivity as:

1. MPI decomposes productivity changes into technical efficiency change and technological change. Thus, it also identifies sources of productivity growth. If the panel data is available, it allows the decomposition of productivity changes (TFPCH) into two components; first, technical change index (TECHCH) and second, the technical efficiency change index (EFFCH). Technical efficiency changes can be further decomposed into pure technical efficiency change (PEEFCH) and scale technical efficiency change (SCH) using DEA framework of Fare et al. (1994).
2. It requires data on input and output quantities only and does not require information on their prices to determine appropriate weights which is necessary with either econometric or index number approaches (Lambert & Parker, 1998).
3. It does not require pre-specified optimizing criterion i.e., profit maximization or cost minimization.
4. It reveals the best practice frontier rather central tendency properties of frontier.

MPI was originally propounded by Swedish statistician Malmquist in 1953 using Data Envelopment Analysis (DEA). The application of DEA based MPI in panel data was initially introduced by Caves, Christensen and Diewert in 1982. MPI can be constructed in either output or input-oriented distance functions. “The earlier considers a maximal proportional expansion of the output vector given an input vector while the later characterizes the production technology by looking at a minimal proportional contraction of the input vector given an output vector” (Arora, 2013).

This paper has applied output-oriented MPI because (1) iron-steel and cement industries more likely aim at increasing their output given input quantities, rather than decreasing input quantities employed to produce a given output level and (2) most of the industries too aim at maximizing output in the form of revenue or profit (Jajri 2007, Manjappa & Manjesha 2008, Ray 1997, Ray 2012, Deb 2011, Sehgal & Sharma, 2011).

This paper has used standard procedure for calculating Malmquist based productivity index using DEAP 2.1 software prepared by Coelli (1996). Since MPI provides change index (technical efficiency change, technological change and TFP change) in period $t+1$ over period t, therefore, in order to assess the impact of trade liberalization and other factors on productivity, TFPCH index has been converted into total factor productivity index (TFPI) taking 1991-92=100 (which is finally converted into Base 2004- 05= 100 which is the base year for the entire study) as: $TFPI_{jt} = (TFPCH_{jt} - 1) + TFPI_{jt-1}$

4.3.1 Malmquist Productivity Index Method

Productive efficiency of a firm or DMU (decision making unit) takes place when it combines inputs in such a way that they produce a given level of output at the lowest possible cost. The modern concept of efficiency measurement originates with the seminal work of Farrell (1957). He proposed two components of firm's efficiency: (1) *technical efficiency*, which measures the firm's ability to obtain maximum output from a given set of inputs and (2) *price efficiency*, which shows the ability of a firm to employ inputs in optimum proportions, given their prices. The combination of these two measures provides a measure of *total overall efficiency*. In most literature, the terms allocative efficiency and economic efficiency have been used instead of price efficiency and overall efficiency respectively (Coelli, 1996). DEA, propounded by Charnes, Cooper and Rhodes (1978), is a linear programming based non-parametric approach that measures productivity through frontier estimation. In case of panel data, DEA based MPI has been widely used to measure productivity change and its decomposition into technical change and technical efficiency change.

The present study has used MPI to measure industry level TFPG in both iron-steel and cement industries in India.

Suppose n inputs are used to produce m outputs, then, $x \in R_{+}^{n}$ and $y \in R_{+}^{m}$ denote input vector and output vector respectively. In the present study, n stands for [labour, capital, raw materials, energy and service] inputs and m stands for gross output for both iron-steel and cement industries. The set of production possibilities at time t can be written as:

$$L^t = \left\{ (x^t, y^t) \mid x^t \text{ can produce } y^t \right\} \tag{1}$$

Fare, Grosskopf and Lovell (1994) followed Shephard (1970) to define the output distance function at time as:

$$D_o^t(x^t, y^t) = \inf\left\{\theta \mid (x^t, y^t/\theta) \in L^t\right\} = \left(\sup\left\{\theta \mid (x^t, \theta y^t) \in L^t\right\}\right)^{-1} \tag{2}$$

The subscript o denotes output-based distance function. Note that $D_o^t(x^t, y^t) \leq 1$ if and only if $(x^t, y^t) \in L^t$, and $D_o^t(x^t, y^t) = 1$, if and only if (x^t, y^t) is on the frontier of the technology. Farrell (1957) stated that in the earlier case, firm/industry is technically inefficient, and in the later case, technically efficient. Thus, following Farrell (1957), iron-steel and cement industries in India are considered technically efficient if their output distance function equals to one, and value less than one signify the presence of technical inefficiency.

Fare at el. (1994) defined following distance functions with respect to time periods in order to construct MPI:

$$D_o^t(x^{t+1}, y^{t+1}) = \inf \{\theta \mid (x^{t+1}, y^{t+1}/\theta) \in L^t\} \tag{3}$$

$$D_o^{t+1}(x^t, y^t) = \inf \{\theta \mid (x^t, y^t/\theta) \in L^{t+1}\} \tag{4}$$

The distance function shown in equation (3) measures the maximal proportional change in output required to make (x^{t+1}, y^{t+1}) feasible in relation to technology at time t. Similarly, the distance function in (4) measures the maximal proportional change in output required to make (x^t, y^t) feasible in relation to technology at time $t+1$.

The change in TFP as measured by MPI, between periods t and $t+1$, can be defined as:

Using period t technology: $M_o^t(x^{t+1}, y^{t+1}, x^t, y^t) = \dfrac{D_o^t(x^{t+1}, y^{t+1})}{D_o^t(x^t, y^t)}$ (5)

Similarly, using period $t+1$ technology: $M_o^{t+1}(x^{t+1}, y^{t+1}, x^t, y^t) = \dfrac{D_o^{t+1}(x^{t+1}, y^{t+1})}{D_o^{t+1}(x^t, y^t)}$ (6)

In order to avoid the choice of MPI in an arbitrary period, Fare et al. (1994) defined the output-oriented *TFPCH (Malmquist Total Factor Productivity Change Index)* as the geometric mean of equations (5) and (6) as:

$$TFPCH = M_o(x^{t+1}, y^{t+1}, x^t, y^t) = \frac{D_o^{t+1}(x^{t+1}, y^{t+1})}{D_o^t(x^t, y^t)} \left[\frac{D_o^t(x^{t+1}, y^{t+1})}{D_o^{t+1}(x^{t+1}, y^{t+1})} \frac{D_o^t(x^t, y^t)}{D_o^{t+1}(x^t, y^t)} \right]^{\frac{1}{2}} \tag{7}$$

The ratio outside the brackets on R.H.S. of equation (7) measures the changes in *technical efficiency (EFFCH)* between the two periods t and $t+1$ as a catching-up to the frontier effect. While the geometric mean of the two ratios inside the brackets measures the change in production technology i.e., *technological change (TECHCH)* between the two periods t and $t+1$; usually referred as a shift in production frontier and known as technological progress. The catching up effects measures the distance that a firm has from the frontier by capturing extent of diffusion of technology or knowledge of technology use. On the other hand, frontier effect measures the movement of frontier between two periods with regards to rate of technology adoption. Thus:

Technical Efficiency Change (EFFCH) = $\dfrac{D_o^{t+1}(x^{t+1}, y^{t+1})}{D_o^t(x^t, y^t)}$ (8)

Technological Change (TECHCH) = $\left[\dfrac{D_o^t(x^{t+1}, y^{t+1})}{D_o^{t+1}(x^{t+1}, y^{t+1})} \dfrac{D_o^t(x^t, y^t)}{D_o^{t+1}(x^t, y^t)} \right]^{\frac{1}{2}}$ (9)

The positive value of M_o in equation (7) reflects a positive TFPG between two consecutive years. Similarly, in any component of M_o shown in equation (8) and (9), a value greater than one shows positive TFPG and a value less than one indicates negative TFPG from period t to period $t+1$. Positive growth shows an improvement and negative growth shows deteriorations in performance over the periods.

In order to calculate TFPCH for industry j (iron-steel and cement) between period t and $t+1$, as specified in equation (7), the four different distance functions that make the MPI, i.e. $D_o^t(x^{j,t}, y^{j,t})$, $D_o^{t+1}(x^{j,t+1}, y^{j,t+1})$, $D_o^t(x^{j,t+1}, y^{j,t+1})$ and $D_o^{t+1}(x^{j,t}, y^{j,t})$, are calculated using linear programming approach. Thus, four linear programming problems to estimate above four distance functions can be stated as:

$$D_o^{t+k}(x^{j,t+k}, y^{j,t+k})^{-1} = \max \theta^j \tag{10}$$

Subject to

$$\theta^j y_m^{j,t+k} \leq \sum_{j=1}^{J} z^{j,t+h} y_m^{j,t+h}, \qquad m = 1,....,M;$$

$$\sum_{j=1}^{J} z^{j,t+h} x_n^{j,t+h} \leq x_n^{j,t+k}, \qquad n = 1,....,N;$$

$$z^{j,t+h} \geq 0, \qquad k = 1,....,K.$$

Where $(h,k) = (0,0)$ for solving $[D_o^t(x^{j,t}, y^{j,t})]^{-1}$;

$(h,k) = (1,1)$ for solving $[D_o^{t+1}(x^{j,t+1}, y^{j,t+1})]^{-1}$;

$(h,k) = (0,1)$ for solving $[D_o^t(x^{j,t+1}, y^{j,t+1})]^{-1}$; and

$(h,k) = (1,0)$ for solving $[D_o^{t+1}(x^{j,t}, y^{j,t})]^{-1}$

In the above four linear programming problems, $z^{j,t}$ is and intensity variable which indicates the intensity at which a particular industry is employed in constructing the frontier of technology set. Here, non-parametric technology applied assuming constant returns to scale (CRS) and strong disposability of inputs and outputs. In the above linear programming formulation, θ is the efficiency score taking value between 0 and 1. Thus, *EFFCH* can be decomposed into *pure technical efficiency change (PECH) and scale efficiency change (SECH)* by estimating distance functions as specified in equation (10) along with the restriction $\sum z_j = 1$ as:

$$EFFCH = \frac{D_o^{t+1}(x^{t+1}, y^{t+1} / VRS)}{D_o^t(x^t, y^t / VRS)} \times \frac{S_o^{t+1}(x^{t+1}, y^{t+1})}{S_o^t(x^t, y^t)} \tag{11}$$

The first ratio on R.H.S. of equation (11) estimates the change in *PECH* between the two periods t and $t+1$ which measures the improvement in managerial efficiency. The second ratio measures the change *SECH* between the two periods t and $t+1$ which shows improvement in the scale inefficiencies arising from operating at a super-optimal (decreasing returns) or at a sub-optimal (increasing returns) scale. The productivity of all inputs taken together is maximised when operation takes place at CRS (Cooper, Seiford & Tone, 2007). Thus:

$$\textit{Pure Technical Efficiency Change (PECH)} = \frac{D_o^{t+1}(x^{t+1}, y^{t+1} / VRS)}{D_o^t(x^t, y^t / VRS)} \tag{12}$$

$$\textit{Scale Efficiency Change (SECH)} = \frac{S_o^{t+1}(x^{t+1}, y^{t+1})}{S_o^t(x^t, y^t)} \tag{13}$$

Here, it should be noted that decomposition of *EFFCH* shown in equation (11) is based on CRS and Variable Returns to Scale (VRS) technology. The *EFFCH* may confound both *PECH* and *SECH* in the absence of CRS assumption. *SECH* is measured as the ratio of two output-oriented distance functions i.e. relative to VRS technology and relative to CSR technology. The *SECH* in period t can be specified as:

$$S_o^t(x^t, y^t) = \frac{D_o^t(x^t, y^t / CRS)}{D_o^t(x^t, y^t / VRS)} \tag{14}$$

The values of *PECH* and *SECH* greater than 1 show improvement in pure technical efficiency and scale efficiency respectively, and vice-versa.

The MPI based technological growth rate (TECHG) and TFPG of industry j in time t can be estimated as:

$$TECHG_{jt} \text{ (percent)} = (TECHCH_{jt} - 1) \times 100 \tag{15}$$

$$TFPG_{jt} \text{ (percent)} = (TFPCH_{jt} - 1) \times 100 \tag{16}$$

Since MPI provides change index (technical efficiency change, technological change and TFP change) in period $t+1$ over period t, therefore, in order to assess the impact of trade liberalization and other factors on productivity, TFPCH index has been converted into total factor productivity index (TFPI) taking 1991-92=100 (which is finally converted into Base 2004-05=100 which is the base year for the entire study) as follows:

$$TFPI_{jt} = (TFPCH_{jt} - 1) + TFPI_{jt-1} \tag{17}$$

Note: Equation (17) gives consistent results for TFPG as defined in equation (16). Similarly, TECH index has also been constructed for decomposing the TFPG. In the present study, MPI has been constructed using DEAP 2.1 software prepared by Coelli (1996).

4.4 Determinants of Productivity

This paper also examines the impact of trade liberalization and other macroeconomic variables on productivity of iron-steel and cement industries. Prior to economic liberalization, India had imposed very high tariff rates on inputs as well as output of iron-steel and cement industries but since then they have been reduced in a phased manner. This paper has used weighted (trade based) effectively applied tariff (EAT) as a measure of trade liberalization in Indian iron-steel and cement industries. EAT is defined as the lowest available tariff and uses preferential tariff if exists otherwise Most Favoured Nation applied tariff. The dataset on tariff rates has been obtained from World Integrated Trade Solution (WITS)-TRAINS database. Here, trade liberalization has been measured in terms of reduction in tariff rates i.e., input-tariffs, output-tariffs and effective rate of protection (ERP) for both iron-steel and cement industries separately and increase in trade openness.

India's weighted tariff rates of important intermediate inputs for world (trade based weighted effectively applied tariff) have been prepared on Harmonised System (HS) nomenclature as a measure of input-tariff. The simple average of trade based weighted effectively applied tariff of main output products of both iron-steel and cement industries separately has been taken as a measure output-tariff. ERP captures the net effect of lowering tariffs on output and intermediate inputs. ERP has been calculated following Corden (1966) which has been adopted by Topalova and Khandelwal (2011).

$$ERP_{jt} = \frac{OUTPUTTARIFFS_{jt} - INPUTTARIFFS_{jt}}{1 - \sum_s \alpha_{js}}$$

Here, α_{js} is the share of input s in output of industry j, $output\ tariff_{jt}$ and $input\ tariff_{jt}$ are the output and input tariff of industry j in time t.

Trade openness is calculated as the ratio of non-oil export plus import to GDP at Factor Cost (Constant Price 2004-05=100). Real Effective Exchange Rate (**$REER$**) has been taken as a measure of exchange rate. REER is an index based on thirty-six country bilateral trade weights. The data series on REER (Base 2004-05=100) has been taken from Handbook of Statistics on Indian Economy (HBSIE), 2013-14. The REER indices are based on wholesale prices. Interest Rate (IR) is calculated as the average of lending rate range provided *by HBSIE, 2013-14.* Inflation Rate ($INFL$) has been constructed as the rate of change in wholesale price index (WPI), Base 2004-05=100, of manufactured products taken from HBSIE, 2013-14. Construction Sector Growth Rate ($CSGR$) has been measured as the rate of change in gross domestic product of the construction at constant price of 2004-05=100 at factor cost taken from HBSIE, 2013-14.

The following function has been considered to examine the impact of above-mentioned determinants on productivity:

$$TFPI_{jt} = f(x_{jt}, \varepsilon_{jt}; \beta) \tag{18}$$

Here, $TFPI_{jt}$ is (18) total factor productivity index of industry j (i.e., iron-steel and cement industry), x_{jt} is the vector of determinants (liberalization measures, INFL and CSGR) and β is the vectors of the parameters to be estimated. The vector of x includes input-tariffs, output-tariffs, ERP, trade-openness, REER, IR, INFL and CSGR. The specified equation for measuring the impact of above-mentioned determinants is as follows:

$$TFPI_{jt} = \beta_0 + \beta x_{jt} + \mu_{jt} \tag{19}$$

Here, $TFPI_{jt}$ is the Malmquist total factor productivity index of industry j in year t, x_{jt} is the vector of determinants, β is the parameter to be estimated and μ is the error term. The equation (19), for iron-steel and cement industries separately, has been estimated using Ordinary Least Square (OLS) method while it, for iron-steel and cement industries together in a panel data (balanced) set, has been estimated using pooled-OLS/Fixed Effects regression methods.

Further, equation (19) has been estimated for a total of 13 Models. In each case, Model (1) to (8) presents the impact of each determinant on productivity when regressed separately, Model (9) to (11) presents the impact of trade-openness when regressed with input-tariffs, output-tariffs and ERP on productivity, Model (12) presents the impact of trade liberalization measures i.e. input-tariffs, output-tariffs, ERP and trade-openness on productivity when regressed together and Model (13) presents the impact of all determinants on productivity when regressed together.

Model-1: $TFPI_{jt} = \beta_0 + \beta_1 inputtariffs_{jt} + \mu_{jt}$
Model-2: $TFPI_{jt} = \beta_0 + \beta_1 outputtariffs_{jt} + \mu_{jt}$
Model-3: $TFPI_{jt} = \beta_0 + \beta_1 ERP_{jt} + \mu_{jt}$
Model-4: $TFPI_{jt} = \beta_0 + \beta_1 trdopenness_t + \mu_{jt}$
Model-5: $TFPI_{jt} = \beta_0 + \beta_1 REER_t + \mu_{jt}$
Model-6: $TFPI_{jt} = \beta_0 + \beta_1 IR_t + \mu_{jt}$
Model-7: $TFPI_{jt} = \beta_0 + \beta_1 INFL_t + \mu_{jt}$
Model-8: $TFPI_{jt} = \beta_0 + \beta_1 CSGR_t + \mu_{jt}$
Mode-9: $TFPI_{jt} = \beta_0 + \beta_1 inputtariffs_{jt} + \beta_2 trdopenness_t + \mu_{jt}$
Model-10: $TFPI_{jt} = \beta_0 + \beta_1 outputtariffs_{jt} + \beta_2 trdopenness_t + \mu_{jt}$
Model-11: $TFPI_{jt} = \beta_0 + \beta_1 ERP_{jt} + \beta_2 trdopenness_t + \mu_{jt}$
Model-12:

$$TFPI_{jt} = \beta_0 + \beta_1 inputtariffs_{jt} + \beta_2 outputtariffs_{jt} + \beta_3 ERP_{jt} + \beta_4 trdopenness_t + \mu_{ijt}$$

Model-13:

$$TFPI_{jt} = \beta_0 + \beta_1 inputtariffs_{jt} + \beta_2 outputtariffs_{jt} + \beta_3 ERP_{jt} + \beta_4 trdopenness_t + \beta_5 REER_t + \beta_6 IR_t + \beta_7 INFL_t + \beta_8 CSGR_t + \mu_{jt}$$

5. PRODUCTIVITY TRENDS

TFP has been estimated using Malmquist Productivity Index (MPI). The MPI not only provides the estimates of TFP but it also decomposes TFP into efficiency change and technological change. Thus, it provides sources of TFP growth. According to MPI, TFP can increase not only due to technical progress i.e., shift in production frontier but also due to improvements in technical efficiency. The technical efficiency (EFFCH) is also known as catching up effects and measures the distance from the frontier by capturing extent of diffusion of technology or knowledge of technology use. The technological change (TECHCH) is usually referred to as a shift in the production frontier and is known as technological progress, thus called 'the frontier effect'. TECHCH measures the movement of the frontier between two time periods with regards to the rate of technology adoption. Further, MPI decomposes EFFCH into (1) pure technical efficiency change (PECH) which measures the improvement in managerial efficiency and (2) scale efficiency change (SECH) which measures the improvement in scale inefficiencies arising from operating at a super-optimal (decreasing returns) or at a sub-optimal (increasing returns) scale.

The MPI does not assume all firms/ industries/ sectors to be efficient. Thus, there can be some firms/ industries/ sectors which may not perform efficiently or a single firm/ industry/ sector may/may not perform efficiently in one or more years. Any change index i.e., EFFCH, TECHCH, PECH, SECH and total factor productivity change (TFPCH) having value one or more indicates that the firm/industry/sector is performing efficiently while value less than one indicates the inefficient operation.

5.1 Productivity Trends in Iron-Steel Industry

The year-wise Malmquist Productivity change index of TFP and its component in iron-steel industry in India during the period from 1991-92 to 2012-13 is given in table 5.9. The table reveals that the value of EFFCH is one in all the years indicating that the industry has operated efficiently in terms of technical efficiency or catching up effects.

Further, value of PECH and SECH are also one in all the years meaning that industry is efficient in terms of pure technical/ managerial efficiency and scale efficiency. However, the industry's performance on technological change has varied over the years and, therefore, the change in TFP is attributed to technological change only.

Table 4: Year-wise Malmquist Productivity Change Index of TFP and its Components: Iron-Steel Industry in India during the period from 1991-92 to 2012-13

YEAR	EFFCH	TECHCH	PECH	SECH	TFPCH
1991-92	---	---	---	---	---
1992-93	1.000	1.124	1.000	1.000	1.124
1993-94	1.000	0.953	1.000	1.000	0.953
1994-95	1.000	1.112	1.000	1.000	1.112
1995-96	1.000	1.026	1.000	1.000	1.026
1996-97	1.000	0.835	1.000	1.000	0.835
1997-98	1.000	1.134	1.000	1.000	1.134
1998-99	1.000	0.845	1.000	1.000	0.845
1999-00	1.000	1.543	1.000	1.000	1.543
2000-01	1.000	0.811	1.000	1.000	0.811
2001-02	1.000	1.160	1.000	1.000	1.160
2002-03	1.000	1.150	1.000	1.000	1.150
2003-04	1.000	0.818	1.000	1.000	0.818
2004-05	1.000	1.042	1.000	1.000	1.042
2005-06	1.000	0.848	1.000	1.000	0.848
2006-07	1.000	1.072	1.000	1.000	1.072
2007-08	1.000	1.582	1.000	1.000	1.582
2008-09	1.000	0.585	1.000	1.000	0.585
2009-10	1.000	1.142	1.000	1.000	1.142
2010-11	1.000	0.900	1.000	1.000	0.900
2011-12	1.000	1.241	1.000	1.000	1.241
2012-13	1.000	0.903	1.000	1.000	0.903

Source: Author's own estimates

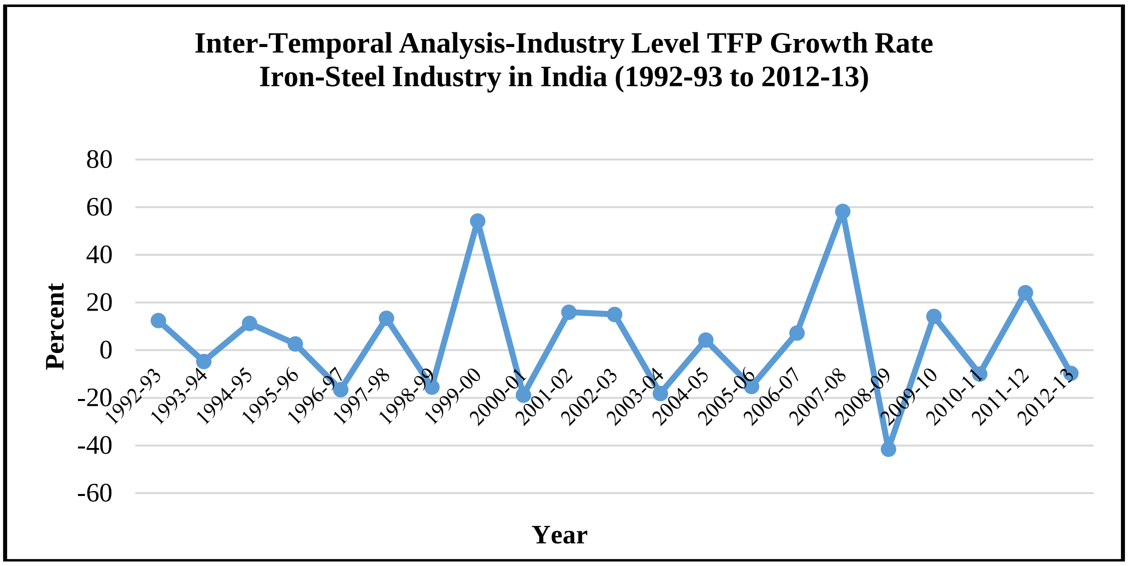
Table 5: Malmquist Technological and TFP Index (Base 2004-05: 100) and their YoY Growth Rate: Iron-Steel Industry in India during the period from 1991-92 to 2012-13

YEAR	TECHI	TFPI	TECHG	TFPG
1991-92	99.450	99.450	---	---
1992-93	99.573	99.573	12.400	12.400
1993-94	99.527	99.527	-4.700	-4.700
1994-95	99.638	99.638	11.200	11.200
1995-96	99.664	99.664	2.600	2.600
1996-97	99.500	99.500	-16.500	-16.500
1997-98	99.633	99.633	13.400	13.400
1998-99	99.479	99.479	-15.500	-15.500
1999-00	100.019	100.019	54.300	54.300
2000-01	99.831	99.831	-18.900	-18.900
2001-02	99.990	99.990	16.000	16.000
2002-03	100.139	100.139	15.000	15.000
2003-04	99.958	99.958	-18.200	-18.200
2004-05	100	100	4.200	4.200
2005-06	99.849	99.849	-15.200	-15.200
2006-07	99.920	99.920	7.200	7.200
2007-08	100.499	100.499	58.200	58.200
2008-09	100.087	100.087	-41.500	-41.500
2009-10	100.228	100.228	14.200	14.200
2010-11	100.128	100.128	-10.000	-10.000
2011-12	100.368	100.368	24.100	24.100
2012-13	100.271	100.271	-9.700	-9.700

Source: Author's own estimates

The Tables 4 and 5 show that TECHCH index and, thereby, TFPCH index is less than one in 1993-94, 1996-97, 1998-99, 2000-01, 2003-04, 2005-06, 2008-09, 2010-11 and 2012-13 meaning that iron-steel industry has not performed efficiently and TFP growth is negative in these years. While TFPCH is more than one in 1992-93, 1994-95, 1995-96, 1997-98, 1999-00, 2001-02, 2002-03, 2004-05, 2006-07, 2007-08, 2009-10 and 2011-12 indicating the efficient operation and positive TFP growth of the industry in these years. The important observation is that as the value of EFFCH is one in all the years, therefore, the source of TFP is technological change i.e., the technology adoption.

Figure 1: Inter-temporal Analysis of Industry Level TFP Growth Rate: Iron-Steel Industry in India during the period from 1992-93 to 2012-13



Source: Author's own estimates

The inter-temporal analysis of industry level TFP growth rate in iron-steel industry in India during the post-reform period from 1992-93 to 2012-13 has been shown in Figure 1. The inter-temporal analysis depicts highly fluctuating trends in TFP growth. The highest TFP growth rate has been observed in 2007-08 (58.20 percent) and 1999-00 (54.30 percent) and the lowest in 2008-09 (-41.50 percent).

Table 6: Period-wise Malmquist Productivity Change Index and Growth Rate of TFP and its Components: Iron-Steel Industry in India during the period from 1991-92 to 2012-13

	Period-1 1991-92 to 2001-02	**Period-2 2002-03 to 2012-13**	**Period-3 1991-92 to 2012-13**
Productivity Change Index			
EFFCH	1.000	1.000	1.000
TECHCH	1.036	0.981	1.014
PECH	1.000	1.000	1.000
SECH	1.000	1.000	1.000
TFPCH	1.036	0.981	1.014
Productivity Growth Rate (percent)			
EFF	0.000	0.000	0.000
TECH	3.600	-1.900	1.400
PE	0.000	0.000	0.000
SE	0.000	0.000	0.000
TFP	3.600	-1.900	1.400

Source: Author's own estimates

The period-wise industry level TFP growth rate in iron-steel industry in India during the post-reform period is given in Table 6. The TFP growth rate in Period-1, Period-2 and Period-3 is 3.60 percent, -1.90 percent and 1.40 percent per annum respectively. This shows that TFP growth rate is positive during the entire period of the study from 1991-92 to 2012-13 which has been driven by growth in Period-1 as it has decreased and become negative in Period-2. One of the prominent reasons for negative TFP growth in Period-2 could be global financial crisis of 2008 which led to a decrease in global output, and iron-steel industry is one of the highly used inputs directly or indirectly for producing goods and services. The source of TFP growth in iron-steel industry is growth in technology adoption as the growth of technical efficiency is zero. Thus, the important observation is that TFP growth rate in iron-steel industry has declined during the second decade of trade and other economic reforms.

5.2 Productivity Trends in Cement Industry

TFP in cement industry in India during the post-reform period from 1991-92 to 2012-13 has been estimated using Malmquist Productivity Index (MPI). The year-wise Malmquist Productivity change index of TFP and its component in cement industry in India during the post-reform is given in Table 7. The table reveals that the value of EFFCH is one in all the years indicating that the industry has operated efficiently in terms of technical efficiency or catching up effects. Further, the value of PECH and SECH are also one in all the years meaning that industry is efficient in term of pure technical/ managerial efficiency and scale efficiency.

However, the industry's performance on technological change has varied over the years and, therefore, the change in TFP is attributed to technological change only. The Tables 7 and 8 show that TECHCH index and, thereby, TFPCH index is less than one in 1992-93, 1993-94, 1995-96, 1997-98, 2000-01, 2001-02, 2005-06, 2006-07, 2007-08, 2008-09, 2010-11 and 2012-13 meaning that cement industry has not performed efficiently and TFP growth is negative in these years. While TFPCH is more than one in 1994-95, 1996-97, 1998-99, 1999-00, 2002-03, 2003-04, 2004-05, 2009-10 and 2011-12 indicating the efficient operation and positive TFP growth of the industry in these years. The important observation is that as the value of EFFCH is one in all the years, therefore the source of TFP is technological change i.e., the technology adoption.

Table 7: Year-wise Malmquist Productivity Change Index of TFP and its Components: Cement Industry in India during the period from 1991-92 to 2012-13

YEAR	EFFCH	TECHCH	PECH	SECH	TFPCH
1991-92	---	---	---	---	---
1992-93	1.000	0.788	1.000	1.000	0.788
1993-94	1.000	0.953	1.000	1.000	0.953
1994-95	1.000	1.152	1.000	1.000	1.152
1995-96	1.000	0.992	1.000	1.000	0.992
1996-97	1.000	1.121	1.000	1.000	1.121
1997-98	1.000	0.867	1.000	1.000	0.867
1998-99	1.000	1.024	1.000	1.000	1.024
1999-00	1.000	1.225	1.000	1.000	1.225
2000-01	1.000	0.975	1.000	1.000	0.975
2001-02	1.000	0.880	1.000	1.000	0.880
2002-03	1.000	1.040	1.000	1.000	1.040
2003-04	1.000	1.046	1.000	1.000	1.046
2004-05	1.000	1.041	1.000	1.000	1.041
2005-06	1.000	0.978	1.000	1.000	0.978
2006-07	1.000	0.943	1.000	1.000	0.943
2007-08	1.000	0.944	1.000	1.000	0.944
2008-09	1.000	0.920	1.000	1.000	0.920
2009-10	1.000	1.060	1.000	1.000	1.060

YEAR	EFFCH	TECHCH	PECH	SECH	TFPCH
2010-11	1.000	0.954	1.000	1.000	0.954
2011-12	1.000	1.079	1.000	1.000	1.079
2012-13	1.000	0.977	1.000	1.000	0.977

Source: Author's own estimates

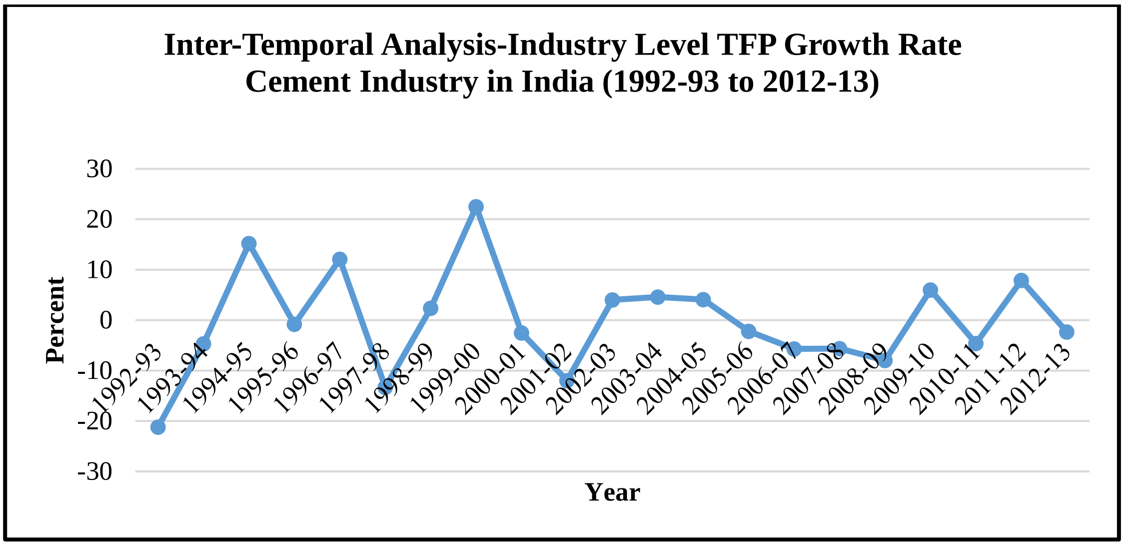
Table 8: Malmquist Technological and TFP Index (Base 2004-05: 100) and their YoY Growth Rate: Cement Industry in India during the period from 1991-92 to 2012-13

YEAR	TECHI	TFPI	TECHG	TFPG
1991-92	99.896	99.896	---	---
1992-93	99.684	99.684	-21.200	-21.200
1993-94	99.637	99.637	-4.700	-4.700
1994-95	99.789	99.789	15.200	15.200
1995-96	99.781	99.781	-0.800	-0.800
1996-97	99.902	99.902	12.100	12.100
1997-98	99.769	99.769	-13.300	-13.300
1998-99	99.793	99.793	2.400	2.400
1999-00	100.018	100.018	22.500	22.500
2000-01	99.993	99.993	-2.500	-2.500
2001-02	99.873	99.873	-12.000	-12.000
2002-03	99.913	99.913	4.000	4.000
2003-04	99.959	99.959	4.600	4.600
2004-05	100	100	4.100	4.100
2005-06	99.978	99.978	-2.200	-2.200
2006-07	99.921	99.921	-5.700	-5.700
2007-08	99.865	99.865	-5.600	-5.600
2008-09	99.785	99.785	-8.000	-8.000
2009-10	99.845	99.845	6.000	6.000
2010-11	99.799	99.799	-4.600	-4.600
2011-12	99.878	99.878	7.900	7.900
2012-13	99.855	99.855	-2.300	-2.300

Source: Author's own estimates

The inter-temporal analysis of industry level TFP growth rate in cement industry in India during the post-reform period from 1992-93 to 2012-13 has been shown in Figure 2. The inter-temporal analysis depicts highly fluctuating trends in TFP growth. The highest TFP growth rate has been observed in 1999-00 (22.50 percent) and the lowest in 1992-93 (-21.20 percent).

Figure 2: Inter-temporal Analysis of Industry Level TFP Growth Rate: Cement Industry in India during the period from 1992-93 to 2012-13



Source: Author's own estimates

Table 9: Period-wise Malmquist Productivity Change Index and Growth Rate of TFP and its Components: Cement Industry in India during the period from 1991-92 to 2012-13

	Period-1 1991-92 to 2001-02	**Period-2 2002-03 to 2012-13**	**Period-3 1991-92 to 2012-13**
Productivity Change Index			
EFFCH	1.000	1.000	1.000
TECHCH	0.989	0.993	0.993
PECH	1.000	1.000	1.000
SECH	1.000	1.000	1.000
TFPCH	0.989	0.993	0.993
Productivity Growth Rate (percent)			
EFF	0.000	0.000	0.000
TECH	-1.100	-0.700	-0.700
PE	0.000	0.000	0.000
SE	0.000	0.000	0.000
TFP	-1.100	-0.700	-0.700

Source: Author's own estimates

The period-wise industry level TFP growth rate in cement industry in India during the post-reform period is given Table 9. The TFP growth rate in Period-1, Period-2 and Period-3 is -1.10 percent, -0.70 percent and -0.70 percent per annum respectively. Thus, TFP growth rate is negative in all three periods, however it has improved a little in Period-2 as compared to Period-1. The source of TFP growth in cement industry is the growth in technology adoption as the growth of technical efficiency is zero.

6. IMPACT OF TRADE LIBERALIZATION

The impact of trade liberalization on productivity in Indian manufacturing has been an issue of prime importance among researchers during the past two decades. The present study examines the impact of trade liberalization on industry level productivity in iron-steel and cement industries in India during the post-reform period from 1991-92 to 2012-13. Input-tariffs, output-tariffs, effective rate of protection (ERP) and trade-openness (ratio of non-oil export plus import to GDP) have been used to capture the effect of trade liberalization on productivity. The study also examines the impact of real effective exchange rate (REER), interest rate (IR), inflation rate (INFL) of manufactured products and construction sector growth rate (CSGR) on productivity in both industries. Because (1) REER makes a substantial impact on prices of products imported or exported, (2) IR affects the cost of money invested, (3) INFL has significant impact on prices of intermediate inputs/products purchased/sold and (4) construction sector is the largest consumer of output of iron-steel and cement industries.

It is generally argued that if the extent of quantitative restrictions on imports is low (high), then the effect of reduction in tariff rates on productivity will be larger (smaller) (Goldar & Kumari, 2003). It may be argued that lower input-tariffs and output-tariffs rates are associated with higher productivity because low input-tariffs enable manufacturers to import foreign technology, capital and intermediate inputs at a lower price, which reduces their cost of production while low output-tariffs expose domestic industries to foreign competition and pressurize them to adopt better technology to produce at a lower cost. The ERP is the net competition effect of input-tariffs and output-tariffs. The lower ERP has productivity enhancing effect also. The trade-openness is supposed to have a positive relationship with productivity as it opens new market avenues for selling final products and provides access to import of various inputs.

ERP is supposed to have a negative relationship with productivity, therefore REER should show a positive effect as depreciation in exchange rate will counter the effect of tariff reduction (Goldar & Kumari, 2003). IR and INFL should establish a negative relationship with productivity as higher IR increases cost of investment and higher inflation lowers demand for final products. The CSGR is supposed to have positive relationship with productivity as higher growth of construction sector increases demand for iron-steel and cement products.

Table 10: Descriptive Statistics of Determinants of Industry Level Productivity in Iron-Steel and Cement Industries in India during the Post-Reform Period from 1991-92 to 2012-13

	N	Min	Max	Mean	Std. Deviation
INPUTTARIFFS (iron-steel industry)	22	3.21	49.12	15.33	10.46
OUTPUTTARIFFS (iron-steel industry)	22	6.33	94.05	29.42	20.23
ERP (iron-steel industry)	22	5.89	144.09	45.19	32.24
INPUTTARIFFS (cement industry)	22	3.61	26.96	12.05	6.07
OUTPUTTARIFFS (cement industry)	22	6.37	77.00	29.12	19.63
ERP (cement industry)	22	3.10	141.74	48.36	45.99
TRDOPENNESS	22	0.06	0.56	0.23	0.15
REER	22	92.63	108.54	99.57	3.97
IR	22	8.88	19.00	13.00	2.50
INFL	22	1.83	12.30	5.55	3.11
CSGR	22	0.57	16.34	7.05	4.16

Source: Author’s calculation

Trade liberalization and industry level productivity in iron-steel industry: The decline in input-tariffs, output-tariffs and ERP significantly leads to increase in productivity when measured separately. However, the magnitude of their impact is different. The increase in trade openness has significant positive impact on productivity in all the models. Any significant impact of REER on productivity has not been found.

The decline in IR and INFL and increase in CSGR significantly leads to increase in productivity when measured separately, but there is no significant impact when measured along with other determinants.

Trade liberalization and industry level productivity in cement industry: The decline in input-tariffs significantly leads to increase in productivity estimated in all the models. There is no significant impact of output-tariffs and REER on productivity. The decline in ERP significantly leads to increase in productivity when estimated separately and with other indicators of trade liberalization; however, its impact is not significant when estimated with all other variables together. There is no significant impact of trade openness on productivity except Model (9). The decline in IR and INFL significantly leads to increase in productivity when measured separately but there is no significant impact when measured along with other variables. The increase in CSGR significantly leads to increase in productivity when measured separately and with all the determinants together.

Trade liberalization and industry level productivity in iron-steel and cement industries (pooled cross sectional time series data): The decline in input-tariffs and ERP leads to increase in productivity in all the models except when measured with trade openness. The decline in output-tariffs leads to increase in productivity only when measured separately. The increase in trade openness leads to increase in productivity in all the models except when measured with output-tariffs. There is no significant impact of REER on productivity. The decline in IR leads to increase in productivity when measured separately. The decline in INFL and increase in CSGR significantly lead to increase in productivity when measured separately and with all the determinants together.

There are two important studies (Mangla, 2017 and Mangla, 2018) in literature pertaining to trade-liberalization and productivity in iron-steel and cement industries in India during the post-reform period which also used the same measures of trade-liberalization and reached on the same conclusion as shown in this study. However, the basic difference between the above-mentioned two studies and the present study is that the earlier ones estimated productivity at firm-level data using Levinshon Petrin method while the present study estimates productivity at industry level data using Malmquist Productivity Index method. The results of all the three studies in terms of impact of trade liberalization on productivity of these two industries are almost similar which further shows that results are robust.

Table 11: Trade Liberalization and Industry Level Productivity in Iron-Steel Industry in India during the Post-Reform Period from 1991-92 to 2012-13

Estimation Model	(1)*	(2)*	(3)*	(4)*	(6)*	(7)***	(8)***	(9)*	(10)*	(11)*	(12)*	(13)*
Estimation Method: OLS	*No. of Obs.: 22*											
CONSTANT	100.215* (1160.70)	100.201* (1228.31)	100.170* (1098.01)	99.522* (1321.54)	100.858* (346.01)	100.080* (830.15)	99.698* (818.61)	99.686* (511.81)	99.624* (501.69)	99.552* (525.24)	99.651* (513.08)	98.270* (85.35)
INPUTTARIFFS	-0.021* (-4.42)							-0.006 (-0.91)			-0.019 (-1.53)	-0.012 (-0.64)
OUTPUTTARIFFS		-0.010* (-4.11)							-0.002 (-0.56)		Dropped	Dropped
ERP			-0.006* (-3.64)							-0.0004 (-0.17)	0.005 (1.23)	0.004 (0.79)
TRDOPENNESS				1.637* (5.92)				1.317* (2.94)	1.435* (3.13)	1.578* (3.53)	1.398* (3.13)	1.547** (2.80)
REER												0.013 (1.07)
IR					-0.074* (-3.35)							0.003 (0.11)
INFL						-0.033*** (-1.78)						-0.018 (-0.98)
CSGR							0.028*** (1.90)					0.009 (0.72)
F/Wald-Statistics	19.51	16.92	13.27	35.04	11.24	3.16	3.59	17.79	17.07	16.69	12.69	5.85
Adj. R-Squared	0.4685	0.4312	0.3688	0.6185	0.3278	0.0651	0.1035	0.6152	0.6049	0.5990	0.6254	0.6180
Standard Error	Default	Default	Default	Default	Default	Bootstrap	Bootstrap	Default	Default	Default	Default	Default

Note: Figures in parentheses are t or z ratios.

Results of Model-5 have not been shown as this model is found insignificant.

*Significance: *1 percent, **5 percent and ***10 percent*

Source: Author's own estimates

Table 12: Trade Liberalization and Industry Level Productivity in Cement Industry in India during the Post-Reform Period from 1991-92 to 2012-13

Estimation Model	(1)**	(3)**	(6)***	(7)**	(8)*	(9)*	(11)**	(12)*	(13)*
Estimation Method: OLS	*No. of Obs.: 22*								
CONSTANT	99.783*	99.909*	100.071*	99.942*	99.768*	99.533*	100.034*	99.722*	99.510*
	(2667.97)	(3505.16)	(924.36)	(2460.78)	(2375.13)	(1269.24)	(1382.84)	(1064.81)	(260.69)
INPUTTARIFFS	-0.006**					-0.016*		-0.014*	-0.014*
	(2.34)					(4.24)		(4.07)	(4.03)
OUTPUTTARIFFS								Dropped	Dropped
ERP		-0.001**					-0.002*	-0.001*	0.0003
		(-2.33)					(-3.01)	(-2.87)	(0.22)
TRDOPENNESS						0.562*	-0.357***	0.166	0.433
						(3.59)	(-1.86)	(0.87)	(1.48)
REER									0.0000
									(0.01)
IR			-0.016***						-0.003
			(-1.98)						(-0.38)
INFL				-0.015**					-0.009
				(-2.28)					(-0.87)
CSGR					0.013*				0.010***
					(3.03)				(1.76)
F/Wald-Statistics	5.50	5.41	3.93	5.22	9.20	9.29	4.76	11.29	5.48
Adj. R-Squared	0.1100	0.1737	0.1223	0.1673	0.2988	0.4413	0.2639	0.5951	0.5989
Standard Error	Bootstrap	Default	Default	Default	Robust	Default	Default	Default	Default

Note: Figures in parentheses are t or z ratios.

Results of Models-2, 4, 5 and 10 have not been shown as these models are found insignificant.

*Significance: *1 percent, **5 percent and ***10 percent*

Source: Author's own estimates

Table 13: Trade Liberalization and Industry Level Productivity in Iron-Steel and Cement Industries in India [Pooled Cross-Sectional Time Series data] during the Post-Reform Period from 1991-92 to 2012-13

Estimation Model	(1)*	(2)*	(3)*	(4)*	(6)*	(7)***	(8)**	(9)*	(10)*	(11)*	(12)*	(13)*
Estimation Method	P-OLS	P-OLS	P-OLS	P-OLS	P-OLS	P-OLS	P-OLS	P-OLS	P-OLS	P-OLS	FE	FE
No. of Obs.: 44	No. of Groups: 02											
CONSTANT	100.110*	100.073*	100.018*	99.700*	100.483*	100.030*	99.752*	99.850*	99.807*	99.745*	99.693*	99.018*
	(1322.01)	(1618.29)	(1538.45)	(1638.28)	(599.92)	(1307.52)	(1376.46)	(581.39)	(647.11)	(793.71)	(667.10)	(155.93)
INPUTTARIFFS	-0.014*							-0.006			-0.146*	-0.164*
	(-4.51)							(-0.99)			(-3.09)	(-3.99)
OUTPUTTARIFFS		-0.006*							-0.002		0.155*	0.178*
		(-3.88)							(-0.75)		(2.99)	(3.91)
ERP			-0.003*							-0.0005	-0.054*	-0.059*
			(0.001)							(-0.45)	(-2.99)	(-3.74)
TRDOPENNESS				0.860*				0.609***	-0.647***	0.763**	0.804**	1.299*
				(4.37)				(1.83)	(1.87)	(2.20)	(2.47)	(3.65)
REER												0.005
												(0.72)
IR					-0.045*							-0.007
					(-3.62)							(-0.47)
INFL						-0.024**						-0.026**
						(-2.18)						(-2.24)
CSGR							0.021**					0.018**
							(2.60)					(2.52)
F/Wald-Statistics	20.94	7.72	11.16	9.76	6.73	2.53	3.55	21.84	6.63	21.77	8.31	7.74
Adj. R-Squared	0.2372	0.2382	0.1804	0.2896	0.2105	0.0665	0.1062	0.2963	0.2820	0.2751	0.2152	0.3169
Time fixed effect	No	No	No	No	No	No	No	No	No	No	No	No
Industry fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No
Error	Bootstrap	Default	Bootstrap	Default	Default	Default	Default	Bootstrap	Default	Bootstrap	Default	Default

Note: Statistical Test Results for the choice of regression model are given in Annexure 1

- *Significance: *1 percent, **5 percent and ***10 percent*
- *The problem of serial autocorrelation is detected (heteroskedasticity is not present) in column (12) using Breusch-Pagan LM test which is solved using STATA command [xtregar].*
- *Figures in parentheses are t or z ratios.*
- *The standard tests have been used to decide the estimation method.*
- *Results of Models-5 have not been shown as this model is found insignificant.*

Source: Author's own estimates.

7. CONCLUSION

The results indicate two contrasts in industry level productivity growth viz., positive productivity growth rate of iron-steel industry and negative productivity growth rate of cement industry. However, the sub-period analysis indicates that productivity growth of iron-steel industry has declined in the second decade of trade liberalization and became negative while productivity growth of cement industry has shown signs of improvements, although still negative, during the second decade of trade reforms.

The industry level TFP growth in iron-steel and cement industries has been 1.40 percent and -0.70 percent per annum respectively during the period from 1991-92 to 2012-13. Thus, the industry level TFP growth in iron-steel industry has been higher than that of the cement industry.

The empirical analysis has shown that trade liberalization introduced in India has significant impact on industry as well as firm level TFP in both iron-steel and cement industries India during the post-reform period. The input-tariffs, output-tariffs and ERP has considerably declined from 1991-92 to 2012-13. This reduction in tariff rates has significant impact on productivity in Indian iron-steel and cement industries. The decline in tariff rates leads to a significant increase in productivity of both industries. The foreign trade sector in India has been opened up at a fast rate during this period. The trade openness also has positive significant impact on productivity. Thus, trade liberalization has significant impact on productivity of these two industries.

The study has also examined the effect of other determinants viz.; REER, IR, INFL and CSGR on industry as well as firm level productivity in both iron-steel and cement industries. The empirical analysis shows that REER does not have significant impact on productivity except of few cases i.e., firm level productivity in iron-steel industry (both balanced and unbalanced panel) and firm level productivity in cement industry in balanced panel dataset. The IR and INFL have significant impact on productivity and decline in these two macroeconomic variables significantly increases productivity of both the industries. The iron-steel and cement products are highly used in construction activities and the analysis shows that CSGR has significant positive impact on productivity as increase in CSGR leads to increase in productivity of both the industries.

The present study presents the empirical analysis of productivity growth in iron-steel and cement industries in India over two decades of post-reform period i.e., from 1991-92 to 2012-13. The study also shows the impact of trade liberalization measures i.e., decline in tariff rates and trade openness along with exchange rate, interest rate, inflation rate and growth of construction sector on productivity of the two industries during the same period.

The results indicate two contrasts in industry level productivity growth viz.; positive productivity growth rate of iron-steel industry and negative productivity growth rate of cement industry. However, the sub-period analysis indicates that productivity growth of iron-steel industry has declined in second decade of trade liberalization and became negative, while productivity growth of cement industry has shown signs of improvements, although still negative, during the second decade of trade reforms. The performance of iron-steel industry in term of IIP and production has also shown declining trends during the Period-2 (from 2002-03 to 2012-13), while cement industry has shown improvement trends in Period-2. Thus, it is a cause of concern that both performance and productivity of iron- steel industry has slowed/declined in the second decade of policy reforms.

The study has shown a positive impact of trade liberalization measures i.e., decline in tariff rates and increase in opening of foreign trade on productivity of iron-steel and cement industries. Therefore, the study seems to suggest the need for more measures to liberalize trade and further decline in quantitative restriction on foreign trade. The study has also shown a positive impact of reduction in interest rate and inflation rate on productivity of these two industries. Therefore, government should provide loans at cheaper rate to the industrial units and steps should be taken to control inflationary pressure in the economy. Further, the study has revealed a positive impact of higher growth rate of construction sector on productivity of the two industries, therefore, construction sector should be strengthened, and steps should be taken for the growth of construction sector.

References

Ahluwalia, I. J. (1991). Productivity and growth in Indian manufacturing. Delhi: Oxford University Press.

Arora, N. (2013). Does catching-up or innovation drive total factor productivity growth in Indian sugar industry? A non-parametric analysis. *Indian Economic Review*, *XLVIII* (2), 351-379.

Arya, I. C. (1981). On measuring technological change in cement industry in India. *Arthavijnana*, *23*(2), 167-179.

Banga, R., & Goldar, B. (2004). Contribution of services to output growth and productivity in Indian manufacturing: Pre and post reforms. (*ICRIER Working Paper* No. 139) . New Delhi: Indian Council for Research on International Economic Relations.

Caves, D. W., Christensen, L. R., & Diewert, W. E. (1982). The Economic Theory of Index Numbers and the Measurement of Input, Output, and Productivity. *Econometrica, 50*(6), 1393-1414. https://doi.org/10.2307/1913388

Central Statistical Office, Ministry of Statistics and Programme Implementation, Government of India. (1981). *Wages and productivity in selected industries: 1960 to 1977*. Government of India (GOI).

Chawla, I. (2012). A note on the methodology for measuring labour input from company databases. *Economic and Political Weekly*, *47*(3), 69-75.

Coelli, T. J. (1996). A guide to DEAP version 2.1: A data envelopment analysis (computer) program. *CEAP Working Paper* No. 8/96. Armidale, Australia: Centre for Efficiency and Productivity Analysis.

Cooper, W. W., Seiford, L. M., & Tone, K. (2007). Data envelopment analysis: A comprehensive text with models, applications, references and DEA- solver software. Boston: Kluwer Academic Publishers.

Corden, M. (1966). The structure of a tariff system and the effective protective rate. *Journal of Political Economy*, *74*(3), 221-237.

Dougherty, C. (2012). Introduction to Econometrics. New Delhi: Oxford University Press.

Fare, R., Grosskopf, S., & Lovell, C. A. K. (1994). Production Frontiers. Cambridge: Cambridge University Press.

Farrell, M. J. (1957). The measurement of productive efficiency. *Journal of the Royal Statistical Society*, *Series A*(120), 253-290.

Goldar, B. & Kumari, A. (2003). Import liberalization and productivity growth in Indian manufacturing industries in the 1990s. *The Developing Economies*, *XLI*(4), 436-60.

Goldar, B. N. (1986). Productivity growth in Indian industry. Delhi: Allied Publishers.

Goldar, B., Pradhan, B. K., & Sharma, A. K. (2013). Elasticity of substitution between capital and labour inputs in manufacturing industries of the Indian economy. *The Journal of Industrial Statistics*, *2*(2), 169-194.

Gupta, G. S. (1973). Production function and factor productivity in Indian cement industry. *Indian Journal of Industrial Relations*, *8*(3), 359-386.

Reserve Bank of India. (2022). *Handbook of Statistics on Indian Economy, 2001-22*. https://rbi.org.in/Scripts/AnnualPublications.aspx?head=Handbook+of+Statistics+on+Indian+Economy

Hashim, A. H., Kumar, A., & Virmani, A. (2009). Impact of major liberalization on productivity: The J curve hypothesis. (*Department of Economic Affairs Working Paper* No. 5/2009-DEA). New Delhi: Department of Economic Affairs, Ministry of Finance, Government of India.

Datanet India Pvt. Ltd. (2004). *Input-Output Transaction Matrix- 2003-04*. https://www.indiastat.com/data/economy/input-output-transactions-2003-2004

Jajri, I. (2007). Determinants of total factor productivity growth in Malaysia. *Journal of Economic Cooperation*, *28*(3), 41-58.

Krugman, P. (1994). The myth of Asia's miracle. *Foreign Affairs*, *73*, 62-78.

Kumari, A. (1993). Productivity in public sector. *Economic and Political Weekly*, *28*(48), M145 – M162.

Lambert, D. K., & Parker, E. (1998). Productivity in Chinese provincial agriculture. *Journal of Agriculture Economics*, *49*(3), 378-392.

Mahopatra, B. K. (1970). The rate of technical change in Indian cement industry: 1949-64. *Asian Economic Review*, *12*(3), 297-309.

Malmquist, S. (1953). Index numbers and indifference surfaces. *Trabajos de Estatistica*, *4*, 209-242.

Mandal, S. K., & Madheswaran, S. (2009). Technical progress, scale effect and total factor productivity growth in Indian cement industry: Panel estimation of stochastic production frontier. (*ISEC Working Paper* No.216). Bangalore: The Institute for Social and Economic Change.

Mangla, S. K. (2017). Trade liberalization and firm level productivity in Indian cement industry: Evidences from post-reform period. *Artha Vijnana: Journal of The Gokhale Institute of Politics and Economics*, *59*(3), 211-237.

Mangla, S. K. (2018). Trade liberalization and firm-level productivity: A panel data analysis of the Indian iron-steel industry. *Economic Annals*, *63*(219), 7-32.

Manjappa, D. H., & Mahesha, M. (2008). Measurement of productivity growth, efficiency change and technical progress of selected capital-intensive and labour intensive industries during reform period inIndia. *Indian Journal of Economics and Business*, *5*(4), 57-65.

Mehta, S. S. (1980). Productivity, production function and technical change. Delhi: Concept Publishing Co.

Ministry of Statistics and Programme Implementation (MOSPI), Government of India. (2019). *Annual Survey of Industries 1982-83 to 2012-13, Vol. 1*, Government of India (GOI). http://microdata.gov.in/nada43/index.php/catalog/ASI

Central Statistical Organization, MOSPI, Government of India. (1970). *National Industrial Classification Manuals*. Government of India, New Delhi. https://mospi.gov.in/web/mospi/national-industrial-classification

Central Statistical Organization, MOSPI, Government of India. (1987). *National Industrial Classification Manuals*. Government of India, New Delhi. https://mospi.gov.in/web/mospi/national-industrial-classification

Central Statistical Organization, MOSPI, Government of India. (1998). *National Industrial Classification Manuals*. Government of India, New Delhi. https://mospi.gov.in/web/mospi/national-industrial-classification

Central Statistical Organization, MOSPI, Government of India. (2004). *National Industrial Classification Manuals*. Government of India, New Delhi. https://mospi.gov.in/web/mospi/national-industrial-classification

Central Statistical Organization, MOSPI, Government of India. (2008). *National Industrial Classification Manuals*. Government of India, New Delhi. https://mospi.gov.in/web/mospi/national-industrial-classification

Pradhan, G., & Barik, K. (1998). Fluctuating total factor productivity in India: Evidence from selected polluting industries. *Economic and Political Weekly*, *33*(9), M25-M30.

Ray, S. (2012). Determinants of total factor productivity growth in selected manufacturing industries in India. *Research and Social Practices in Social Sciences*, *7*(2), 25-43.

Ray, S. (2012a). Productivity growth in some energy intensive manufacturing industries in India: An analytical assessment. *International Journal of Economics and Financial Issues*, *2*(1), 54-70.

Ray, S. (2012b). Measuring and decomposing sources of productivity performance in India's paper and pulp industry under liberalized regime: A Nonparametric approach. *International Journal of Economic Sciences and Applied Research*, *5*(1), 147-171.

Ray, S. C. (1997). Regional variation in productivity growth in Indian manufacturing: A nonparametric analysis. *Journal of Quantitative Economics*, *13*(1), 73-94.

Ray, S., & Pal, M. K. (2010). Trend in total factor productivity growth in Indian iron and steel industries under a liberalized trade regime: An empirical analysis with adjustment for capacity utilization. *Journal of Applied Business and Economics*, *11*(3), 55–74.

Sawhney, P. K. (1967). Productivity trends in Indian cement industry. *Asian Economic Review*, *9*(3), 255-272.

Schumacher, K., & Sathaye, J. (1999). India's cement industry: Productivity, energy efficiency and carbon emissions. (*LBNL Working Paper* No. 41842). Berkeley, California: Lawrence Berkeley National Laboratory.

Sehgal, Sh., & Sharma, S. K. (2011). Total factor productivity of manufacturing sector in India: A regional analysis for the state of Haryana. *International Journal of Management Business Research*, *1*(4), 241-256.

Sharma, S. (2007). Liberalization and productivity growth: A case of Indian cement industry. *International Journal of Productivity and Quality Management*, *2*(3), 307 -321.

Shephard, R. W. (1970). Theory of cost and production functions. Princeton: Princeton University Press.

Sinha, J. N., & Sawhney, P. K. (1970). Wages and productivity in selected. *Indian Journal of Industrial Relations,vol 6*, No. 1, pp. 88-90

Topalova, P., & Khandelwal, A. (2011). Trade liberalization and firm productivity: The case of India. *The Review of Economics and Statistics*, *93*(3), 995-1009.

Unel, B. (2003). Productivity trends in India's manufacturing sectors in the last two decades. (*IMF Working Paper* No. WP/03/22). Washington, D.C.: International Monetary Fund.

The World Bank. (2022). *UNCTAD - Trade Analysis Information System (TRAINS) year 1991 to 2013*. https://databank.worldbank.org/source/unctad-%5E-trade-analysis-information-system-(trains)

Young, A. (1995). The tyranny of numbers: confronting the statistical realities of the East Asian growth experience. *Quarterly Journal of Economics*, *110*(3), 641-680.

Annex

Statistical Test Results for the choice of regression model for examining the impact of trade liberalization on industry level productivity in iron-steel and cement industries (pooled cross-sectional time series data)

Followings are the statistical test results for deciding among Fixed Effect (FE), Random Effect (RE) and Pooled-Ordinary Least Square (P-OLS) methods for estimating effect of trade liberalization and other determinants on industry level total factor productivity in iron-steel and cement industries (cross-sectional pooled data) in India.

Total No. of Groups: 02
Total No. of Observations: 44

Model/ Column	Choice FE VS RE Hausman test (Chi^2)	Choice RE VS P-OLS BP-LM test (Chi^2)	Suggested Estimation Method	Time fixed effect (F Value) *	
(1)	3.82	0.01	P-OLS	1.37	No
	(0.0506)	(0.9270)		(0.2432)	
(2)	0.00	0.63	P-OLS	0.80	No
	(0.9661)	(0.4280)		(0.6967)	
(3)	0.02	0.82	P-OLS	1.37	No
	(0.8945)	(0.3647)		(24.32)	
(4)	0.00	0.64	P-OLS	1.48	No
	(1.0000)	(0.4250)		(0.1887)	
(5)	0.00	0.75	P-OLS	1.47	No
	(1.0000)	(0.3876)		(0.1951)	
(6)	0.00	0.67	P-OLS	0.92	No
	(1.0000)	(0.4121)		(0.5699)	
(7)	0.00	0.72	P-OLS	1.28	No
	(1.0000)	(0.3946)		(0.2878)	
(8)	0.00	0.71	P-OLS	1.18	No
	(1.0000)	(0.3988)		(0.3519)	
(9)	0.88	0.32	P-OLS	1.37	No
	(0.6444)	(0.5722)		(0.2432)	
(10)	0.01	0.62	P-OLS	0.80	No
	(0.9973)	(0.4309)		(0.6967)	
(11)	0.08	0.67	P-OLS	1.16	No
	(0.9632)	(0.4141)		(0.3710)	
(12)	10.03	---	FE	2.32	Yes*
	(0.0399)			(0.0383)	
(13)	18.39	---	FE	2.06	No
	(0.0185)			(0.0684)	

Figures in parentheses are Prob. Values.

*However, the test indicates the presence to time fixed effect, but using time fixed effect, trade-openness explanatory variable is dropped, therefore time fixed effect has not been considered.

Time fixed effect test [*testparm*]:
H_0: coefficients for all years are jointly equal to zero
If Prob. (F) > 0.05, accept the H_0 meaning no time fixed effect
Hausman test (Choice RE VS FE):
H_0: RE is consistent
If Prob. (Chi^2) > 0.05, accept H_0 meaning RE is consistent, otherwise FE is consistent
Breusch-Pagan Lagrange Multiplier (BP-LM) [Choice RE VS P-OLS, if RE consistent)
H_0: variances across entities is zero meaning no significant difference across units (i.e. no panel effect)
If Prob. (Chi^2) > 0.05, accept H_0 meaning OLS should be used, otherwise RE should be used