ECONOMIC ANNALS, Volume LXIII, No. 219 / October – December 2018
UDC: 3.33 ISSN: 0013-3264

https://doi.org/10.2298/EKA1819007M

*Sanjay Kumar Mangla**

TRADE LIBERALIZATION AND FIRM-LEVEL PRODUCTIVITY: A PANEL DATA ANALYSIS OF THE INDIAN IRON–STEEL INDUSTRY

ABSTRACT: *The iron–steel industry in India contributes about 3% of gross domestic product and provides employment for more than half a million people. However, although steel production in India has increased at a trend growth rate of 7.83% during the post-reform period between 1991–1992 and 2012–2013, this does not necessarily indicate efficient utilization of production factors, as it can also result from a higher level of inputs. Therefore, it is important to record productivity growth and identify its determinants. This study estimates total factor productivity (from firm-level data) in the Indian iron–steel industry and examines the impact of trade liberalization (measured as decline in input tariffs, output tariffs, and effective protection rate) on productivity during the abovementioned period.*

KEY WORDS: *iron–steel, panel data, productivity, trade liberalization, India*

JEL CLASSIFICATION: D24, O24, O53

* Fellow, Centre for International Trade, Economics and Environment, CUTS International, Jaipur (Rajasthan) India, Email: sam211285@gmail.com

1. INTRODUCTION

The iron–steel industry occupies a prominent place in the development process, as it not only provides key inputs to all sectors from primary to tertiary, but also determines the development of a nation's physical infrastructure and industrial base. In addition, the level of per capita steel consumption is an important indicator of a country's standard of living and socioeconomic development.

India is presently experiencing a growing stage of the economic development process and the iron–steel industry is one of the sectors that is determining its speed. The industry accounts for 6.684% weightage in the country's total industrial sector at Base Year 2004–2005:100. It contributes about 3% to the gross domestic product (GDP) and provides employment for more than 0.5 million people (Annual Report 2013–2014, Ministry of Steel, Government of India). During the post-reform period from 1991–1992 to 2012–2013, steel production in India proliferated at a semi-log trend rate of growth (S-LTRG) of 7.82% and compound annual growth rate (CAGR) of 19.80%.

India's Industrial Policy Resolution (1956) reserved the iron–steel industry for the public sector, but allowed existing steel units in the private sector to continue and expand. The huge steel demand–supply gap, created especially by the re-rolling and engineering industries in the 1960s and 1970s, forced the Indian government to liberalize its steel policy in 1982, a process that was gradually extended. The real expansion of the industry began with the government's new set of regulation guidelines on June 6, 1990, which were followed by the New Industrial Policy and economic liberalization measures of July 1991. The government took various initiatives to encourage entry, participation, and growth of private investment, which resulted in its integration with the global steel industry. Price and distribution controls on various iron–steel products, manufactured by integrated steel plants, were abolished with effect from January 1992, ensuring prioritisation of the requirements of small-scale industries, exporters of engineering goods, and the North-Eastern Region, instead of strategic sectors such as defence and the railways.

Post-1991, tariff rates on inputs and various iron–steel products were rationalized and considerably reduced as part of the Indian trade liberalization programme. In the iron–steel industry, input tariffs, output tariffs, and effective rate of protection (ERP) declined from 49.12%, 94.05%, and 144.09% in 1991–1992, to 3.37%, 7.86%, and 14.39% in 2012–2013, respectively (Figure 1 in the Appendix).

Within this context, the aim of this study is to estimate the firm-level productivity of the Indian iron–steel industry during the post-reform period (from 1991–1992 to 2012–2013). It also examines the impact of trade liberalization (tariff liberalization) on productivity. The two hypotheses of the study are, first, that the productivity of the Indian iron–steel industry has not changed during the post-reform period, and, second, that trade liberalization has had no impact on productivity.

The rest of the paper consists of six sections. Section 2 elaborates the existing literature on the productivity of the iron–steel industry, the application of panel data econometric techniques in identifying its determinants, and the research gap in these areas. Section 3 develops the objectives of the study. Section 4 provides details of the methodology adopted to construct the input–output variables and econometric models applied to estimate productivity and examine the impact of trade liberalization. Section 5 presents the estimation results for productivity. Section 6 consists of estimation results for the relationship between trade liberalization and productivity. Section 7 concludes the study and provides policy recommendations.

2. LITERATURE REVIEW

There is plenty of literature on industrial productivity in India and other countries. Due to the scope of this study, this section only reviews research pertaining to productivity estimation in the Indian iron–steel industry. In addition, literature is briefly presented that deals with the application of panel data econometric techniques for identifying determinants of productivity.

2.1 Studies on productivity estimation in the Indian iron–steel industry.

An overview of existing literature on productivity in the Indian iron–steel industry finds very few studies that use firm-level data: two exceptions are

Topalova and Khandelwal (2011) and Sahu and Narayanan (2011). Most studies estimate industry-level productivity.

Mehta (1980) estimates productivity for a few energy-intensive industries in India, including the iron–steel industry, during the period 1953–1954 to 1964–1965, using the Solow Index in a Cobb-Douglas production function framework. According to his estimates, during this period the total factor productivity growth rate (TFPG) of the iron–steel industry was –5.2% per annum (semi-log trend). The Central Statistical Office (CSO 1981) and Goldar (1986) apply the Kendrick Arithmetic Index to estimate total factor productivity (TFP) in the Indian iron–steel industry. According to CSO estimates, TFPG was 0.07% per annum (CAGR) during the period 1960–1977, while Goldar's (1986) estimates show a negative TFPG (–1.66% per annum during 1960–1970).

The Translog Index method to estimate TFP has been applied in many studies, such as Ahluwalia (1991), Kumari (1993), Pradhan and Barik (1998), Ray and Pal (2010), Ray (2012), and Ray (2012a). These studies report mix results on the TFPG of the Indian iron–steel industry. The estimates of Ahluwalia (1991), Kumari (1993), and Pradhan and Barik (1998) reveal a negative TFPG, i.e., –1.60% per annum during the period 1959–1960 to 1984–1985; –1.2% per annum (semi-log trend) during 1971–1987; and –2.09% per annum (semi-log trend) during 1963 to 1992, respectively. However, the estimates of Ray and Pal (2010) and Ray (2012a) show a positive TFPG. According to the estimates of Ray and Pal (2010), TFPG was 0.565% per annum during 1979–1980 to 1991–1992 and 0.476% per annum during 1991–1992 to 2003–2004. According to Ray (2012a), TFPG was 1.44% per annum during 1979–1980 to 1991–1992 and 1.013% during 1991–1992 to 2003–2004.

Thus, the limited number of studies on productivity in the Indian iron–steel industry have mainly used three methods; viz. the Solow Index, the Kendrick Arithmetic Index, and the Translog Index. Furthermore, the results of most of the studies are contradictory, some showing an increase in productivity growth and others a decline.

2.2 Studies that apply panel data econometric methods to identify determinants of productivity.

The application of panel data econometric methods to identify determinants of productivity in the Indian context is new. They have mainly been applied to firm-level studies of the post-reform period. Some such studies are Balakrishnan, Pushpangadan and Babu (2000), Topalova and Khandelwal (2011), and Mangla (2017). In addition, some non-Indian studies (Gebrehiwot 2008; Loko and Diouf 2009, etc.) have applied panel data estimation methods in this area.

Balakrishnan et al. (2000) investigate productivity growth trends in Indian manufacturing and the impact of trade liberalization for a sample of 2,300 firms during 1988–1989 to 1997–1998 using panel data models. The study does not find any significant improvement in productivity growth due to trade liberalization. Topalova and Khandelwal (2011) apply an Arellano-Bond estimator to analyse the impact of trade liberalization on the productivity of 4,100 manufacturing companies in India in a dynamic unbalanced panel dataset for 1987–2001. They find that trade liberalization has a significant impact (decline in input tariffs, output tariffs, and ERP) on productivity growth. Mangla (2017) estimates firm-level productivity (15 companies in a balanced panel and 44 companies in an unbalanced panel) of the Indian cement industry during 1991–1992 to 2012–2013. He also applies fixed effect, random effect, and pooled OLS in the case of the balanced panel and an Arellano-Bond estimator in the case of the unbalanced panel to examine the impact of trade liberalization on productivity. The author found trade liberalization to have a significant impact on the productivity of Indian cement companies.

Thus, the above-mentioned studies indicate that the application of fixed effect, random effect, and pooled models and the Arellano-Bond estimator are the preferred methods for identifying the determinants of firm-level productivity.

2.3 Research gap.

In the existing literature on the Indian iron–steel industry the various studies have reached different results with regard to productivity growth and the impact of trade liberalization on productivity. This may be due to differences in time period, dataset, and methodology. Some of the prominent features of the estimation of Indian iron-steel industry productivity, and the subsequent research gaps, are as follows:

- Various studies have covered different time periods during the pre-reform (1947–1991) and post-reform (after 1991) eras. Few studies have compared productivity growth in pre-reform and post-reform periods.
- Almost all the studies have estimated industry-level productivity, and few studies are dedicated to firm-level productivity of only the iron–steel industry. Therefore, the present study estimates firm-level productivity.
- Various researchers have applied different input frameworks, such as two inputs (capital and labour) and three inputs (capital, labour, and intermediate inputs). However, the latest research on productivity uses a five-input model (labour, capital, materials, energy, and services). The present study also applies the five-input framework.
- Most of the studies have deflated output and input series at 1981–1982 prices, while the present study considers the latest 2004–2005 base year (recently the Indian government adopted 2011–2012 as the base year but complete data is not available).
- Most studies only cover the time period up to 2003–2004 (2012a). This study covers up to 2012–2013.

3. OBJECTIVES

Considering the importance of the iron–steel industry to the Indian economy and the decline in key tariff rates on its various products/raw materials, the following are the objectives of the study:

1. To estimate firm-level productivity in the Indian iron–steel industry during the post-reform period from 1991–1992 to 2012–2013.
2. To examine the impact of trade liberalization on firm-level productivity in the iron–steel industry in India during the post-reform period from 1991–1992 to 2012–2013.

4. DATA MEASUREMENT AND METHODOLOGY SPECIFICATIONS

4.1 The sample.

The study time period, i.e., 1991–1992 to 2012–2013, contains annual data covering 22 years. The period of the study is further divided into two sub-periods: 1991–1992 to 2001–2002 (the first decade of trade liberalization) and 2002–2003 to 2012–2013 (the second decade of trade liberalization). The sample companies/firms belong to NIC-2008 Code 2410, the manufacture of basic iron and steel. There were a total of 568 companies available on the CMIE-Prowess database in May 2015 with this NIC code. Companies with the following characteristics are not included in the sample:

- Companies having non-reported or zero values (Srivastava 1996).
- Companies reporting inconsistent time series data.
- Companies and/or years reporting negative values in capital and/or service inputs.

Furthermore, only companies reporting values on all parameters for all 22 years (1991–1992 to 2012–2013) have been considered in the final sample, as they present a substantial picture of the Indian iron–steel industry (almost half of the total output in the base year 2004–2005) and represent firms that have been operating since before the trade reforms (1991–1992) up until 2012–2013. Thus, the final sample consists of 25 companies with 550 observations and takes the form of a balanced panel.

4.2 Construction of Input–Output Variables

This study estimates the production function in a five-input framework, viz. labour, capital, energy, raw materials, and services (LKERMS). The following is a description of how the input and output variables are constructed.

Output. Output is measured as gross output. Since CMIE-Prowess does not provide direct data on gross output, it has been calculated as *Output = Sales of Industrial goods + Change in Stock.* Output value has been deflated with the wholesale price index (WPI) of ferrous metals at base year 2004–2005.

Labour: Labour represents the number of people working directly or indirectly in any industry or firm. It is measured as total emoluments paid to total persons engaged, as reported in CMIE-Prowess. In order to make the labour input comparable with the output series and other inputs, total emoluments representing expenses on account of labour input have been deflated with the labour price index (Base 2004–2005=100). The price of labour is calculated as total emoluments divided by total persons engaged (Hashim, Kumar & Virmani 2009).

Capital. Stock of capital, rather than service of capital, is taken as a measure of capital input. Here, net fixed capital stock (NFCS) at a constant price (Base 2004–2005) has been constructed as a proxy for capital input, applying the methodology specified in Srivastava (1996) and Balakrishnan et al. (2000).

Srivastava (1996) and Balakrishnan et al. (2000) argue, "Straightforward application of the perpetual inventory method (PIM) is not possible, as balance sheet figures for capital are at historic cost, which has to be converted into asset value at replacement cost". The value of capital in the benchmark year is converted at replacement cost using the revaluation factor (Balakrishnan et al. 2000).

Using Balakrishnan et al. (2000), the revaluation factor is calculated according to the following assumptions:

1. A benchmark year is decided based on the maximum number of observations. The life of capital is assumed to be 20 years, as noted in the Report of the Census of Machine Tools 1986 of the Central Machine Tools Institute, Bangalore. (National Accounts Statistics: Sources and Methods, Central Statistical Organization, New Delhi, 1989). Here, the benchmark year is 2005–2006, as all the sampled companies report the value of net fixed assets (NFA) in this year. Thus, the earliest vintage of capital for iron–steel companies dates from 1985–1986, or from the year of their incorporation if it is after 1985–1986.
2. The price of capital (P) changes at constant rate $\pi = \frac{P_t - P_{t-1}}{P_{t-1}}$ from 1985–1986 or year of incorporation up to the benchmark year. The value of π is

calculated from a series of price deflators. The price deflators are calculated from gross fixed capital formation (GFCF) at 2004–2005=100 prices. GFCF in the iron–steel industry is measured as its share (calculated from the Annual Survey of Industries (ASI) data) in GFCF in registered manufacturing, as reported by National Accounts Statistics (NAS).

3. Similar to the price of capital, investment is also assumed to be changing at a constant rate $g = \frac{I_t - I_{t-1}}{I_{t-1}}$ from 1985–1986 or year of incorporation up to the benchmark year. Here, investment means GFCF in the iron–steel industry, as measured above.

Based on the values of π and g, the revaluation factor (R^G) is calculated as:

$$R^G = \frac{\left[(1+g)^{\tau+1} - 1\right]\left[(1+\pi)^{\tau}\right]\left[(1+g)(1+\pi) - 1\right]}{g\left[\{(1+g)(1+\pi)\}^{\tau+1} - 1\right]}$$

Here, τ is the length of the life of capital goods, assumed to be 20 years. The value of τ =20 for firms whose incorporation year is 1985–1986 or before; for all other firms τ is calculated as the difference between the benchmark year and the year of incorporation.

The benchmark year capital stock, NFA, is converted into capital at replacement cost at the current price by multiplying capital in the benchmark year by R^G. Then the value of capital at replacement cost in the benchmark year is deflated to arrive at a measure of capital stock in real terms for the benchmark year using the WPI of capital (Base Year 2004–2005). The series of NFCS at constant price (2004–2005) is obtained by adding the subsequent years' real investment to the capital stock existing at every time period using the following PIM equation:

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

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 i represents the firm in industry j.

The investment (I) values are obtained as $GFA_{ijt} - GFA_{ijt-1}$ and real investment is obtained by deflating the WPI of capital input. Rate of depreciation (δ) has been taken as a constant 5%, as (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).

Energy. Energy input loses its identity during the production process. Power & fuel expenses as reported in CMIE-Prowess have been taken as a measure of energy input. Power and fuel includes coal, petroleum products, and electricity. In order to make the energy input series comparable to other inputs, it has been deflated with weighted WPI (Base year 2004–2005) of energy input where weights have been obtained from the Input-Output Transaction Matrix (I-O-TM) of India for 2004–2005.

Raw Materials. Raw materials also lose their identity during the production process. They have been measured as 'raw materials consumed', as reported in CMIE-Prowess. In order to make the raw materials series comparable to other inputs, it has been deflated with the weighted WPI (base year 2004–2005) of raw materials input where weights have been obtained from the I-O-TM of India for 2004–2005.

Services. CMIE-Prowess does not provide separate data on services as an input used in production; rather it provides a data series on total inputs. Banga and Goldar (2004) and Hashim et al. (2009) suggest an alternative measure to obtain a services input series, subtracting materials and fuels consumed from total input. Thus, following them, services input has been obtained by subtracting the expenses of power & fuel and raw materials consumed from total expenses, as reported in CMIE-Prowess.

In order to make the services input comparable with other inputs, it has been deflated with the price index (base year 2004–2005) of service inputs where weights have been obtained from the I-O-TM 2004–2005 of India. WPI series for services are not available in India; therefore, price deflators for services cannot be constructed. In order to resolve this problem, implicit price deflators for major service items are constructed using service sector GDP series at the factor cost constant price (base Year: 2004–2005) and current price, obtained from CSO, Government of India, as:

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

4.3 Research Model for Estimating Productivity

TFP has been estimated using Levinshon and Petrin's (2003) approach. Resolving the problem of simultaneity is one of the biggest concerns when estimating firm-level TFP. This problem arises when there is contemporaneous correlation between the vector of inputs and part of the error term. In the recent literature, there are two important methods of estimating firm-level TFP to resolve this problem; viz. Olley and Pakes (1996) and Levinshon and Petrin (2003). Olley and Pakes (1996) use investment as a proxy for unobservable productivity shocks, which Levinsohn and Petrin (2003) criticize on the following grounds:

- it is valid only for plants reporting non-zero investment, and
- Olley and Pakes consider investment as a function of state variables, which are costly to adjust by definition; therefore, investment as a proxy involves substantial adjustment costs and can create further problems.

Levinsohn and Petrin (2003) correct the simultaneity problem by using intermediate inputs (typically subtracted out in a value-added production function) as a proxy for unobservable productivity shocks. Their approach has the following advantages:

- It avoids the problem of truncation of zero-investment observations arising from intermittent investment by firms reporting zero-investment, because most of the firms report positive use of intermediate inputs such as raw materials and energy (fuel and electricity).
- Intermediate inputs develop a simple link between estimation strategy and economic theory, as primarily they are not a state variable, which means that an estimation strategy of production function using intermediate inputs as a proxy for unobservable productivity shocks is consistent with economic theory.

- This approach does not involve any additional cost in terms of data or computation, as intermediate inputs are used beyond subtracting them from the gross output to get value added.

The Levinsohn-Petrin productivity index has been constructed according to the gross revenue approach, since output has been measured as the value of total output. The Levinsohn and Petrin (2003) approach is based on the assumptions that the prices of inputs and output are assumed common across firms, and there is no error in the input demand function. Hence, this study assumes the same wage rate across all firms. Levinsohn and Petrin (2003) estimate TFP in two stages.

The Levinsohn and Petrin (2003) method is written in the Cobb-Douglas production function specification. Therefore, the present study also takes the following Cobb-Douglas production function specification of firm i at time t :

$$y_{it} = \beta_0 + \beta_l l_{it} + \beta_k k_{it} + \beta_e e_{it} + \beta_{rm} rm_{it} + \beta_s s_{it} + \omega_{it} + \eta_{it} \quad (1)$$

Here, output is a function of the above-mentioned five inputs and productivity shocks (error terms). In equation (1), y = output, l = labour, k = capital, e = energy, rm = raw materials, s = services, ω and η = error terms (productivity shocks, where the former is a state variable and known as observable productivity shock, while the latter is unobservable productivity shock).[1] Output and all five inputs are taken in natural log, thus equation (1) becomes:

$$\ln y_{it} = \beta_0 + \beta_l \ln l_{it} + \beta_k \ln k_{it} + \beta_e \ln e_{it} + \beta_{rm} \ln rm_{it} + \beta_s \ln s_{it} + \omega_{it} + \eta_{it} \quad (2)$$

Here, the five inputs are divided into two categories: (1) freely variable inputs consisting of labour, energy, raw materials, and services, and (2) a state variable, i.e., capital. However, this model may suffer from the problem of simultaneity when unobservable productivity shock is correlated with variable inputs. As specified by Levinsohn and Petrin (2003), the problem of simultaneity can be avoided by taking intermediate inputs – raw materials in the present study – as a valid proxy, given that the demand function for intermediate inputs is

[1] This study has not taken into account the issue of non-stationary panels, as the number of years is smaller than the number of units/companies.

monotonic in the firm's productivity for all relevant levels of capital. The first-stage estimation provides coefficients of the variable inputs, except raw materials, using no-intercept OLS. The coefficient of these variable inputs also indicates their marginal productivities.

The second stage provides coefficient estimates of capital, which are the firm/plant-level measure of TFP, and/or an estimate of returns to scale. Two moment conditions are used to identify β_{rm} and β_k. The first moment condition identifies β_k, assuming that capital does not respond to innovation in productivity. The second moment condition identifies β_{rm}, assuming that the last period's raw materials choice is uncorrelated with productivity innovation in this period.

The Levinsohn and Petrin (2003) method provides the TFP level of all firms and in each year. Since productivity is a relative measure, in order to make the TFP of all firms comparable the total factor productivity index (TFPI) at base year 2004–2005 has been calculated as:

$$TFPI_{it} = \frac{TFP_{it}}{\text{Mean } TFP \text{ in 2004-05}} \times 100 \quad (3)$$

Mean TFP has been calculated taking the arithmetic mean of the TFP of all firms in the respective year.

4.4 Trade Liberalization and Productivity

This study also examines the impact of trade liberalization (decline in input tariffs, output tariffs, and ERP) of the Indian iron–steel industry on its firm-level productivity. Further, two other variables, i.e., trade openness and real effective exchange rate (REER), have also been considered as regressors of productivity, as they have an impact on export–import, and thus influence demand for a firm's inputs and supply of output.

Prior to economic liberalization, India maintained very high tariff rates on both inputs and outputs of the iron–steel industry, which afterwards were considerably reduced in a phased manner. A weighted (trade-based) effectively applied tariff (EAT) has been used as a measure of trade liberalization. EAT is defined as the lowest available tariff. If a preferential tariff exists, it is used as the effectively applied tariff. Otherwise, the Most Favoured Nation (MFN) applied tariff is used. The dataset on tariff rates is generated from the World Integrated Trade Solution (WITS)-TRAINS database.

India's weighted tariff rate on important intermediate inputs in the global iron–steel industry (trade-based weighted effectively applied tariff) was prepared as a measure of input tariffs. The intermediate inputs include raw materials and energy, and their items and weights were derived from the I-O-TM of India for 2004–2005. The simple average of trade-based weighted EAT of the main iron–steel industry output products was taken as a measure of output tariffs. ERP captures the net effect of lowering tariffs on output and intermediate inputs. It is calculated, following Corden (1966), as:

$$ERP_t = \frac{OUTPUTTARIFFS_t - INPUTTARIFFS_t}{1 - \sum_s \alpha_s}$$

Here, α_s is the share of input s in total inputs.

Trade openness is calculated as the ratio of non-oil exports plus imports to GDP at factor cost (Constant Price 2004–2005=100). REER is an index based on thirty-six country bilateral trade weights. The REER data series (Base 2004–2005=100) was taken from the Handbook of Statistics on the Indian Economy (HBSIE), 2013–2014. The REER indices are based on wholesale prices.

The following function has been estimated to examine the impact of the above-mentioned trade liberalization indicators on productivity:

$$TFPI_{it} = f(x_t, \mu_{it}; \beta) \tag{4}$$

The specified equation is as follows:

$$TFPI_{it} = \beta_0 + \beta x_t + \mu_{it} \tag{5}$$

Here, $TFPI_{it}$ is the firm-level Levinsohn and Petrin (LP) TFPI of firm i in year t, x_t is the vector of trade liberalization indicators along with trade openness and

REER for firm i in year t, β is the vector of parameters to be estimated, and μ_{it} is the error term of firm i in year t. It is noted that the value of x for all firms i remains identical in the same t and these regressors are in fact individual invariant. Equation (5) was estimated for the following three models:

Model 1: $TFPI_{it} = \beta_0 + \beta_1 inputtariffs_t + \beta_2 outputtariffs_t + \beta_3 ERP_t + \mu_{it}$

Model 2: $TFPI_{it} = \beta_0 + \beta_1 inputtariffs_t + \beta_2 outputtariffs_t + \beta_3 ERP_t + \beta_4 trdopenness_t + \mu_{it}$

Model 3: $TFPI_{it} = \beta_0 + \beta_1 inputtariffs_t + \beta_2 outputtariffs_t + \beta_3 ERP_t + \beta_4 trdopenness_t + \beta_5 REER_t + \mu_{it}$

5. PRODUCTIVITY TRENDS

TFPG was estimated for three periods; viz. Period 1 (1991–1992 to 2001–2002), Period 2 (2002–2003 to 2012–2013), and Period 3 (1991–1992 to 2012–2013).

5.1 LP Productivity Estimators.

LP productivity estimators of all inputs for the production function specified in Equation 2 are given in Table 1.

Table 1: LP Firm-Level Productivity Estimators: Indian Iron–Steel Industry, 1991–1992 to 2012–2013

Dependent variable represents revenue (gross output)				Number of Obs.	= 550	
				Number of groups:	= 25	
Group variable (*i*): company/firm				Obs. per group: Min.	= 22	
Time variable (t): year				Avg.	= 22.0	
				Max.	= 22	
lnoutput	**Coef.**	**Std. Err.**	**Z**	**P>|Z|**	**[95% Conf.**	**Interval]**
lnlabour	0.1304	0.0373	3.50	0.000	0.0574	0.2034
lncapital	0.3000	0.0957	3.14	0.002	0.1125	0.4876
lnenergy	0.0555	0.0219	2.54	0.011	0.0127	0.0984
lnrm	0.3000	0.1755	1.71	0.087	-0.0440	0.6440
lnservices	0.1832	0.1013	1.81	0.071	-0.0154	0.3817
Wald test of constant returns to scale:		Chi2	= 0.21 (P = 0.6474).			

Source: *Author's own estimates*

The LP productivity estimators of all inputs are significant at either 1% or 10%. The coefficients of all inputs are positive (labour: 0.1304, capital: 0.30, energy: 0.0555, raw materials: 0.30, services: 0.1832), which signifies a positive relationship between inputs and total output produced. It means that an increase in quantity of input/s employed leads to an increase in production, and vice-versa. The capital and raw material inputs have the highest coefficient values, indicating that these two inputs constitute the highest proportion in production, followed by services, labour, and energy inputs.

5.2 Categories-wise Productivity Trends.

The firm-level TFP and its growth rate were estimated in four categories: (1) at aggregate level, (2) according to size of firm, (3) according to industry group/product, and (4) according to ownership. The TFPG according to these categories is given in Table 2.

TFPG at Aggregate Level

Table 2 shows negative TFPG in Period 1 and Period 2, but a positive growth rate in Period 3. A possible reason is that the productivity index seems to decline in Period 1 and Period 2 but shows a small increasing trend in Period 3.

TFPG according to Size of Firm

The firms have been categorized as large-scale, medium-scale, and small-scale, following the methodology of Topalova and Khandelwal (2011). A firm belongs to the large-, medium-, or small-scale category if its average industrial sales during the entire period of the study are more than or equal to the 99^{th} percentile, more than or equal to the median, and less than the median of the distribution, respectively.

The TFPG according to the size of the firm reports mixed results in different periods. The TFPG of large- and small-scale firms is negative, while medium-scale firms are positive in all three periods. Further, the TFPG of medium-scale firms is much higher than that of large- and small-scale firms.

Table 2: Period-wise Firm-Level TFPG (% per annum) in Indian Iron–Steel Industry, 1991–1992 to 2012–2013

TFPG	Period 1 1991–1992 to 2001–2002	Period 2 2002–2003 to 2012–2013	Period 3 1991–1992 to 2012–2013
Aggregate Level *No. of Firms: 25 No. of Obs.: 550*			
S-LTRG	0.17	0.36	0.20
CAGR	---	---	0.50
According to Size of Firm			
Large-Scale *No. of Firms: 1 No. of Obs.: 22*			
S-LTRG	4.15	0.51	0.63
CAGR	---	---	---
Medium-Scale *No. of Firms: 12 No. of Obs.: 264*			
S-LTRG	1.75	0.21	1.13
CAGR	4.10	0.50	2.70
Small-Scale *No. of Firms: 12 No. of Obs.: 264*			
S-LTRG	1.63	1.01	0.68
CAGR	---	---	---
According to Industry Group/Product			
Ferro alloys *No. of Firms: 3 No. of Obs.: 66*			
S-LTRG	0.04	1.73	2.16
CAGR	---	4.10	5.10
Metal products *No. of Firms: 3 No. of Obs.: 66*			
S-LTRG	0.36	1.38	0.60
CAGR	0.80	3.20	1.40
Sponge iron *No. of Firms: 3 No. of Obs.: 66*			
S-LTRG	0.58	1.41	1.19
CAGR	1.40	3.30	2.80
Steel *No. of Firms: 16 No. of Obs.: 352*			
S-LTRG	0.41	1.42	0.38
CAGR	---	---	---
According to Ownership			
Government *No. of Firms: 1 No. of Obs.: 22*			
S-LTRG	4.15	0.51	0.63
CAGR	---	---	---
Joint Venture *No. of Firms: 1 No. of Obs.: 22*			
S-LTRG	1.17	10.42	3.55
CAGR	---	---	---
Private *No. of Firms: 23 No. of Obs.: 506*			
S-LTRG	0.06	0.10	0.34
CAGR	0.10	---	0.80

Source: *Author's own estimates*

TFPG according to Industry Group

The main products of the iron–steel industry are ferro alloys, metal products, pig iron, sponge iron, and steel. The classification of firms according to these industry groups is obtained from the CMIE-Prowess database.

The TFPG according to industry group provides important observations on the productivity growth of various iron–steel products. The TFPG of firms producing ferro alloys, metal products, and sponge iron is positive in all three periods, except ferro alloys in Period 1. Here, firm-level TFPG increased in Period 2 compared to Period 1 for all these products. The TFPG of firms producing steel is negative in all three periods and declined in Period 2 compared to Period 1. Thus, the productivity growth of firms producing ferro alloys, metal products, and sponge iron is satisfactory, but for steel companies it is very discouraging.

TFPG according to Ownership

The main ownership categories are government-owned firms, joint ventures, and privately managed firms. The classification of firms according to ownership is also obtained from the CMIE-Prowess database.

The TFPG according to ownership provides important observations on the productivity growth of companies under various ownership types. The TFPG of government-owned firms and joint ventures is negative in all three periods, and for privately owned firms it is positive in Period 1 and Period 3 but negative in Period 2. The TFPG of joint venture and privately owned firms declined in Period 2 compared to Period 1. Further, the productivity growth of privately owned firms is higher than that of joint venture and government-owned firms; however, it declined in Period 2 compared to Period 1.

6. IMPACT OF TRADE LIBERALIZATION

In order to estimate all three models examining the impact of trade liberalization on productivity as specified for Equation (5), the standard econometric procedure (Daugherty 2012) of estimating panel data was adopted. Problems of autocorrelation (using the Wooldridge test) and groupwise heteroskedasticity (using the Modified Wald test) were detected in all the models. As N (number of firms) is greater than number of years (T), cross-sectional dependence/contemporaneous correlation among residuals across entities was checked using Pesaran CD, Frees, and Friedman CSD tests, and was not found present.

To solve problems of autocorrelation and groupwise heteroskedasticity, the Prais-Winsten Regression Panel Corrected Standard Errors (PCSE) method controlling for AR1 and group-wise/panel-level heteroskedasticity was applied. Further, to check its robustness, the Feasible Generalized Least Square (FGLS) method was applied to estimate all three models: FGLS-1 where each group/panel is assumed to have errors that follow the same AR (1) process and FGLS-2 where each group/panel is assumed to have errors that follow a different AR (1) process.

The study uses the estimation results of FGLS-2 in Model 2 to determine the impact of trade liberalization on productivity.

The statistics on the impact of trade liberalization on the firm-level productivity of the Indian iron–steel industry are given in Table 3. Regression results show a statistically significant impact of key tariff rates and trade openness on productivity, while REER does not seem to have a significant relationship with productivity. The table revels that productivity has a positive association with input tariffs, ERP, and trade openness, and a negative association with output tariffs. Considering the trends in these variables, the results indicate that (1) a decline in input tariffs and ERP reduces productivity, and (2) a decline in output tariffs and increase in trade openness escalates productivity.

Theoretically, productivity should be negatively associated with input tariffs, but the results of this study give an opposite picture. The input tariffs variable used in this study captures the change in the intermediate inputs tariff rate used in the iron–steel industry. These inputs and their respective weights were calculated from the I-O-TM 2004–2005 of India. A possible reason for the positive impact of input tariffs on the productivity of the Indian iron-steel industry is that a substantial proportion of intermediate inputs (raw materials and energy) used in Indian iron–steel products is not imported but is produced domestically. According to I-O-TM 2004–2005, the major intermediate and energy inputs used in the Indian iron–steel industry are coal and lignite; non-ferrous basic metals; iron and steel casting & forging; electricity; miscellaneous metal products; petroleum products; iron-ore; natural gas; iron, steel & ferro alloys; coal tar products; and inorganic heavy chemicals. All of these inputs constitute more than 97% of the total intermediate inputs used in the iron–steel industry, and India produces a sufficient amount of all these inputs except petroleum products.

Like input tariffs, output tariffs are also associated negatively with productivity, as they reduce the final prices of Indian iron–steel product exports in importing countries. This further encourages production and may provide economies of scale to companies that produce on a large scale. The regression results on the relationship between output tariffs and productivity are in line with the theory. The highest impact of a decline in output tariffs on increasing productivity is observed when incorporated with trade openness along with liberalization of input tariffs and ERP. The results indicate an increase of 1.125% in productivity if output tariffs decline by 1%.

The trade openness ratio of the Indian economy increased by 0.51 points (900%) between 1991–1992 and 2012–2013 (author's estimates). Analysis shows that trade openness has significantly contributed to the productivity growth of the Indian iron-steel industry, as it helps companies to explore new markets outside India. The results suggest that an increase of 0.01 in the trade openness ratio may increase productivity by 0.105%.

7. CONCLUSION

The simplest way of increasing production is to increase input values. Another is to improve efficiency in using these inputs, known as 'acceleration in productivity'. Several authors (Kuznets 1966; Krugman 1992; Urata 1994) in economic literature have accepted productivity growth as an essential instrument of economic progress. Therefore, it is important to target productivity growth along with increased production. Of all the major industries the iron–steel industry is the largest heavy industry, contributing significantly to the Indian economy in terms of GDP (3%) and employment (more than 0.5 million people). This industry was heavily liberalized for foreign trade during India's economic liberalization programme, which started in 1991. Input tariffs, output tariffs, and ERP in this industry, respectively, have declined from 49.12%, 94.05% and 144.09% in 1991–1992 to 3.37%, 7.86% and 14.39% in 2012–2013.

Table 3: Trade Liberalization and Firm-Level Productivity in the Indian Iron–Steel Industry (Balanced Panel), 1991–1992 to 2012–2013

Dependent Variable: TFPI
Period: 1991–1992 to 2012–2013 *(No. of Obs. 550)*, **Groups:** *25*

Estimation Model	Model 1				Model 2				Model 3			
Estimation Method	FE	PCSE*	FGLS-1*	FGLS-2*	FE	PCSE*	FGLS-1*	FGLS-2*	FE	PCSE*	FGLS-1*	FGLS-2*
CONSTANT	5.050*	4.858*	4.798*	4.898*	4.814*	4.906*	4.839*	4.970*	3.756*	4.167*	3.597*	4.014*
	(24.80)	(33.61)	(42.80)	(35.42)	(24.16)	(33.86)	(43.62)	(35.89)	(2.34)	(4.33)	(6.16)	(4.48)
INPUT TARIFFS	0.305	0.428***	0.225	0.441**	0.721	0.571**	0.314**	0.651*	0.614	0.489***	0.175	0.546**
	(0.73)	(1.82)	(1.61)	(1.99)	(1.47)	(2.26)	(2.05)	(2.75)	(1.19)	(1.78)	(1.06)	(2.13)
OUTPUT TARIFFS	-0.600	-0.801***	-0.453***	-0.842**	-1.212	-0.990**	-0.577**	-1.125*	-1.056	-0.875***	-0.382	-0.977**
	(-0.79)	(-1.93)	(-1.84)	(-2.16)	(-1.44)	(-2.29)	(-2.21)	(-2.78)	(-1.21)	(-1.91)	(-1.39)	(-2.28)
ERP	0.265	0.352**	0.023***	0.369**	0.534	0.442**	0.259**	0.503*	0.470	0.390**	0.172	0.437**
	(0.81)	(2.01)	(1.95)	(2.24)	(1.47)	(2.40)	(2.32)	(2.90)	(1.25)	(1.99)	(1.46)	(2.38)
TRD OPENNESS					0.010	0.074	0.042	0.105**	0.079	0.055	0.008	0.082***
					(1.64)	(1.62)	(1.52)	(2.53)	(1.17)	(1.05)	(0.27)	(1.73)
REER									0.224	0.159	0.266**	0.206
									(0.66)	(0.78)	(2.16)	(1.08)
F/Wald-Statistics	0.70	218.61	220.83	170.80	0.70	81.95	277.32	190.41	1.05	228.77	235.46	192.74
R-Squared	0.0026	0.8203	--	--	0.0026	224.63	--	--	0.0065	0.8194	--	--
Time fixed effect	No	No	No	No	No	No	No	No	No	No	No	No
Firm fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
AR 1	Yes				Yes				Yes			
	(94.302)				(92.199)				(89.384)			
GroupWise Heteroskedasticity	Yes				Yes				Yes			
	(5620.40)				(5620.40)				(5620.40)			
Pesaran CD	0.910				0.458				0.052			
Frees stat	2.357				2.462				2.515			
Friedman CSD	37.094				32.429				29.274			

Source: *Author's own estimates*

Notes:

- **Significance:** *1%, **5% and ***10%
- Wooldridge statistics are used to check autocorrelation in FE. (Values in parentheses for AR1 are corresponding Wooldridge statistics).
- Modified Wald test is used to check Groupwise heteroskedasticity in FE,. (Values in parentheses for Groupwise heteroskedasticity are corresponding Wald statistics).
- Pesaran CD, Frees, and Friedman CSD tests are used as N>T to check cross-sectional dependence/contemporaneous correlation among residuals across entities in FE. Their respective values for all the three models, as reported in the table, suggest the absence of cross-sectional dependence.
- Results of FGLS-2 in Model 2 were used for the final analysis.

In the context of the significance of productivity in economic growth and the importance of the iron-steel industry in the Indian economy in the wake of trade liberalization, this study measures firm-level productivity in this industry and examines the potential impact of trade liberalization.

The study found positive productivity growth during 1991–1992 to 2012–2013 but negative productivity growth during two sub-periods; i.e., 1991–1992 to 2001–2002 and 2002–2003 to 2012–2013. The disaggregated analysis of productivity growth according to firm size, industry group, and ownership provides the following insights:

(1) Productivity growth was only positive in medium-scale firms, (2) firms producing ferro alloys, metal products, and sponge iron registered positive productivity growth, while steel-producing firms registered negative productivity growth, and (3) the productivity of privately managed/owned firms increased, while the productivity of government-owned firms and joint ventures declined.

Examining the impact of trade liberalization on productivity in India found that a decline in output tariffs on iron–steel products and increase in trade openness significantly escalates productivity. On the other hand, the liberalization of input tariffs has a negative effect on productivity growth, which might be due to the fact that the majority of the intermediate inputs used in the Indian iron–steel industry are procured in the domestic market.

Thus, this study reveals that to accelerate the productivity of the Indian iron–steel industry the focus should be on improving the production efficiency of government-owned firms and joint ventures. Furthermore, the government should work to reduce tariffs on Indian iron–steel products in international markets. The Indian economy also needs to be further opened up to foreign trade, as openness of the economy has both direct and indirect positive effects on productivity.

REFERENCES

Ahluwalia, I. J. (1991). *Productivity and Growth in Indian Manufacturing.* Delhi, India: Oxford University Press.

Annual Report 2013–14. Ministry of Steel, Government of India.

Annual Report 2014–15. Department of Industrial Policy and Promotion (DIPP), Ministry of Commerce and Industry, India.

Annual Survey of Industries, Vol. 1, 1982–83 to 2012–13. Ministry of Statistics and Programme Implementation (MOSPI), Government of India.

Balakrishnan, P., Pushpangadan, K. & Babu, M. S. (October 7, 2000). Trade Liberalization and Productivity Growth in Manufacturing: Evidence from Firm-Level Panel Data. *Economic and Political Weekly,* 35(41), PP. 3679–3682.

Banga, R. & Goldar, B. (2004). *Contribution of Services to Output Growth and Productivity in Indian Manufacturing: Pre and Post Reforms.* (ICRIER Working Paper 139), New Delhi: Indian Council for Research on International Economic Relations.

Central Statistical Office, (October 1981). *Wages and Productivity in Selected Industries: 1960 to 1977.* Ministry of Planning, Government of India.

Corden, M. (1966). The Structure of a Tariff System and the Effective Protective Rate. *Journal of Political Economy,* 74(3), pp. 221–237.

Goldar, B. & Kumari, A. (2003). Import Liberalization and Productivity Growth in Indian Manufacturing Industries in the 1990s. *The Developing Economies,* XLI(4), pp. 436-60.

Goldar, B. N. (1986). *Productivity Growth in Indian Industry.* Delhi, India: Allied Publishers.

Handbook of Industrial Policy and Statistics. Various Issues, Office of the Economic Advisor, DIPP, Ministry of Commerce & Industry, Government of India.

Handbook of Statistics on Indian Economy. Various Issues, Reserve Bank of India, Mumbai, India.

Hashim, A. H., Kumar, A. & Virmani, A. (2009). *Impact of Major Liberalization on Productivity: The J Curve Hypothesis.* (DEA Working Paper 5/2009-DEA). New Delhi: Department of Economic Affairs, Ministry of Finance, Government of India.

Input-Output Transaction Matrix 2004–05. India Development Foundation, Gurgaon, India.

Krugman, P. (1992). *The Age of Diminished Expectations: US Economic Policy in the 1980s.* Cambridge, UK: MIT Press.

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

Kumari, A. (November 27, 1993). Productivity in Public Sector. *Economic and Political Weekly*, 28(48), pp. M145 – M162.

Kuznets, S. (1966). *Modern Economic Growth.* Yale, USA: Yale University Press.

Levinsohn, J. & Petrin, A. (2003). Estimating Production Functions using Inputs to Control for Unobservable. *Review of Economic Studies,* 70, pp. 317–341.

Mangla, S. K. (2017). Trade Liberalization and Firm Level Productivity in Indian Cement Industry: Evidences from Post-Reforms Period. *Artha Vijnana,* 59(3), pp. 211–237.

Mehta, S. S. (1980). *Productivity, Production Function and Technical Change.* Delhi, India: Concept Publishing Co.

National Accounts Statistics. Central Statistical Office, Ministry of Statistics and Programme Implementation, Government of India.

National Industrial Classification Manuals 1970, 1987, 1998, 2004 and 2008. Central Statistical Organization, Ministry of Statistics and Programme Implementation, Government of India.

Olley, S. & Pakes, A. (1996). The Dynamics of Productivity in the Telecommunications Equipment Industry. *Econometrica,* 64(6), pp. 1263–1297.

Pradhan, G. & Barik, K. (February 28, 1998). Fluctuating Total Factor Productivity in India: Evidence from Selected Polluting Industries. *Economic and Political Weekly*, 33(9), pp. 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), pp. 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), pp. 54–70.

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), pp. *55–74.*

Sinha, J. N. & Sawhney, P. K. (1970). *Wages and Productivity in Selected Indian Industries.* Delhi, India: Vikas Publications.

Srivastava, V. (1996). *Liberalization, Productivity and Competition: A Panel Study of Indian Manufacturing.* Delhi, India: Oxford University Press.

Topalova, P. & Khandelwal, A. (2011). Trade Liberalization and Firm Productivity: The Case of India. *The Review of Economics and Statistics,* 93(3), pp. 995–1009.

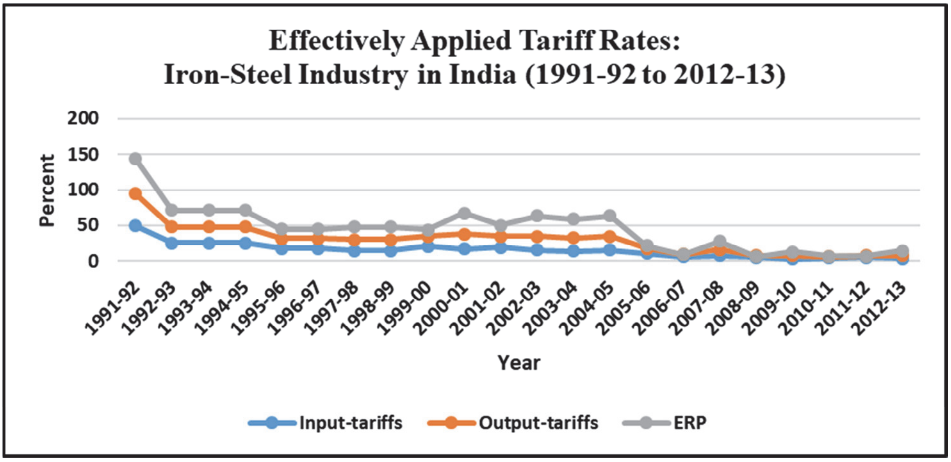
Urata, S. (1994). Trade Liberalization and Productivity Growth in Asia: Introduction and Major Findings. *The Developing Economies,* 32(4), pp. 363–372.

Received: August 17, 2017
Accepted: August 27, 2018

APPENDIX

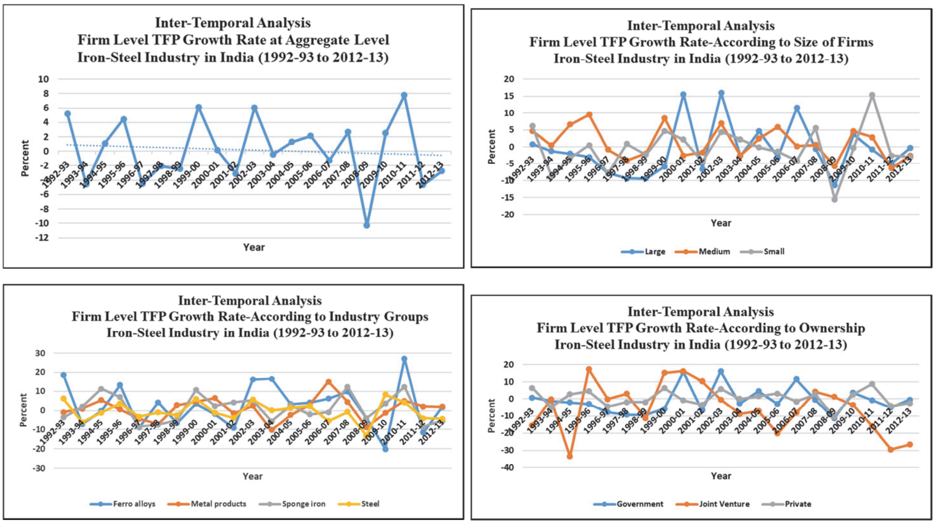
Key figures on trade liberalization and productivity in the Indian iron–steel industry

Figure 1: Trends in Key Tariff Rates: Indian Iron–Steel Industry, 1991–1992 to 2012–2013



Author's own estimates from WITS database

Figure 2: Trends in Firm-Level TFP Growth: Indian Iron–Steel Industry, 1991–1992 to 2012–2013



Author's own estimates

Annexure-2

List of Companies considered when estimating Firm-Level Productivity in the Iron–Steel Industry

S. No.	Company Name
1	Anil Special Steel Inds. Ltd.
2	Balasore Alloys Ltd.
3	Bihar Sponge Iron Ltd.
4	Essar Steel India Ltd.
5	Ferro Alloys Corpn. Ltd.
6	Gontermann-Peipers (India) Ltd.
7	India Steel Works Ltd.
8	Indian Metals & Ferro Alloys Ltd.
9	Kalyani Steels Ltd.
10	Mahindra Ugine Steel Co. Ltd.
11	Modern Steels Ltd.
12	Mukand Ltd.
13	Orissa Sponge Iron & Steel Ltd.
14	Panchmahal Steel Ltd.
15	Pennar Industries Ltd.
16	Prakash Industries Ltd.
17	Sarda Energy & Minerals Ltd.
18	Steel Authority Of India Ltd.
19	Sujana Metal Products Ltd.
20	Sunflag Iron & Steel Co. Ltd.
21	Surya Roshni Ltd.
22	Tata Sponge Iron Ltd.
23	Tata Steel Ltd.
24	Tube Investments Of India Ltd.
25	Uttam Galva Steels Ltd.