STATISTICS IN TRANSITION new series, June 2019
Vol. 20, No. 2, pp. 107–119, DOI 10.21307/stattrans-2019-017

ESTIMATION OF ENERGY INTENSITY IN INDIAN IRON AND STEEL SECTOR: A PANEL DATA ANALYSIS

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ABSTRACT

India holds the third position in the world as energy consumer of fossil fuels (BP SRWE, 2016). The total primary energy consumption in India in 2015 was 107 mtoe (The Economics Times, January 27, 2017). The industrial sector in India consumed about 30 percent (185 Mtoe) of aggregate final energy consumption of around 527 Mtoe in 2013. (India Energy Outlook, IEA, 2015). One of the most energy-intensive sectors is the Iron and Steel sector which consumes 25 percent of the total energy consumption. The energy consumption in Indian Iron and Steel sector is on the declining trend. It has declined from 10 GCal / tcs in 1990 to 6.9 GCal / tcs in 2010-11. About 20-40 percent of the total production in steel industry is energy cost. Therefore, energy cost share is important in deciding price of steel. Energy Conservation Act, 2001 (ECA) and formulation of Bureau of Energy Efficiency is an important initiative taken up by government in order to reduce energy consumption by various sectors in the Indian economy. Another important initiative is launching of first of its kind market-based mechanism, Perform, Achieve and Trade (PAT) mechanism in 2010 particularly targeting the energy consumption by industrial sector of the economy. Phase-I for PAT ran from 2012-2015 including eight most energy-intensive sectors under Indian Industrial sector of which Iron and Steel sector being a prominent sector. The objective of this paper is to empirically estimate the energy intensity of Indian Iron and Steel sector, also accounting for impact of ECA and PAT Phase-I in dummy variable form. The results indicate that the decline in energy consumption till 2011 by this sector can also be attributed to Energy Conservation Act implemented in the year 2001 along with other factors. This is empirically confirmed by our results that ECA has a significant impact over reduction of energy intensity of the steel firms. PAT doesn't seem to have much impact over energy intensity alone but the years where both PAT and ECA are prevalent, i.e., from 2012 to 2015 there seems to be a significant impact of around 0.050 reduction in energy intensity as accounted by different models in this paper. There is one more observation from the empirical results, that profit margin intensity was indirectly related to energy intensity implying more profitable firms invest more in energy efficiency.

Key words: energy intensity, Indian Iron and Steel sector, Energy Conservation Act, Perform-Achieve-Trade Mechanism, panel data.

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1. Introduction

Energy is the most important constituent that is necessary for all development in the economy. In fact the relation between the two is a prominent one, for a country to develop energy is required. Energy consumption in India has been steadily increasing. According to BP Energy Outlook 2017, India's energy consumption growth rate is 4.2 percent a year which is faster than all major countries in the world and will overtake China. Among Asian countries, India is the second largest energy consumer since 2008, surpassing Japan as the world's third largest oil consumer behind US and China.

India holds the third position in the world as primary energy consumer which includes fossil fuels like coal, oil, etc. (BP SRWE, 2016). Total primary energy consumption in India in 2015 was 107 mtoe (The Economics Times, January 27, 2017). The industrial sector in India consumed about 30 percent (185 Mtoe) of the total final energy consumption of around 527 Mtoe in 2013. (India Energy Outlook, IEA, 2015). In the list of GHG emitters in the world, India holds third rank after China and U.S. in 2016, with its greenhouse gas emissions increasing at a high rate of 4.7 percent in comparison to the last year (Netherlands Environmental Assessment Agency, September 29, 2017). Industries contribute approximately one fourth of India's total GHG emissions (Gupta et al. 2017). One of the most energy-intensive sectors is the Iron and Steel sector which consumes 25% of the total energy consumption (IEA, 2012). Energy consumption in Indian steel plants is high in comparison to world average as well mainly due to obsolete technology but it is gradually improving (Ministry of Steel, 2017). The Indian Iron and Steel sector contributed to about 28 percent of the emissions by the industrial sector in 2007. (Krishnan et al., 2013)

As per Worldsteel Association, in 2016, India ranked third in terms of steel production after China and Japan. The steel sector contribution to India's GDP is approximately 2 percent in 2015-16 (Ministry of Steel, GoI, 2016).

In order to reduce nation's energy intensity and emission intensity, Energy efficiency and low carbon growth have become apparent pathways.

In order to reduce energy consumption and promote energy efficiency in the country, Ministry of Power introduced the Energy Conservation Act in 2001. The Act proposed adherence energy norms for energy consumption for heavy consumers, developed Energy Conservation Building Code for new buildings, standards for performance in energy efficiency and also display of labels on appliances indicating their energy consumption. Under this Act, Bureau of Energy Efficiency (BEE) was formulated to implement provisions defined by the Act. The strengthening and amendments in Act was done in 2010 (Tata Strategic, 2014).

In addition to this, National Action Plan on Climate Change (NAPCC) was launched in 2008. Under this, National Mission for Enhanced Energy Efficiency (NMEEE) came into picture.

One of the important initiatives promulgated under NMEEE is Perform Achieve and Trade scheme, under which most energy intensive units such as Thermal power plants, Steel, Cement, Aluminium, Chlor Alkali, Textiles, Pulp & Paper, Fertilizers (known as Designated Consumers) has been assigned energy efficiency improvement targets. This created Tradable Energy Savings Certificates (ESCerts) under PAT scheme. Companies not able to meet their target buy tradable energy saving certificates from those over achieving the target, creating an Energy Savings market in India.

PAT is a cost-effective mix of regulation in terms of mandatory energy saving targets along with formation of market for trading of these energy saving white certificates.

Total 67 plants of iron and steel are assigned energy reduction targets. For Iron and steel sector the threshold limit of energy consumption per annum is 30000 TOE (BEE, 2017). By the end of PAT Cycle-I, energy savings equivalent of 2.10 Million tonne of oil equivalent annually has been achieved, which is around 41% higher than the savings targets from 67 number of notified DCs. (Oak, 2017).

2. Literature review

Kumar (2003) and Sahu and Narayan (2009) has conducted a study to find out the factors affecting energy intensity of manufacturing industries. They used multiple regression technique to carry out their analysis. Kumar used eight years data for 1342 firms for their analysis whereas 2350 firms data for the year 2008 for their analysis. In 2017, Oak published a paper on factors affecting energy intensity of firms in Indian cement industry and also quantifying the effect of Perform, Achieve and Trade effect using panel data fixed effect model and difference-in-difference technique. The source of data for all these studies is CMIE Prowess database. Most of the explanatory variables used in these studies are similar such as firm size, age of the firm, technology import intensity, ownership. According to the authors, ownership (foreign or domestic), firm size, age are the important determinants of energy intensity in Indian manufacturing industry. Oak (2017) found cement firms having higher energy intensity to be covered under PAT Cycle-I (2012-15) are correctly identified by Government of India though cement industry remains highly energy intensive sector.

Bhandari and Shrimali (2017) studied the effectiveness of PAT by carrying out semi-structured interviews of designated consumers, BEE and EESL and also used PAT booklet as secondary source of information. According to them, the set targets of PAT are not strict enough to cause any energy savings more than business-as-usual, may not causing any long-term investment in energy efficiency and PAT market may not form, it’s too early to assess transaction costs. Amendment needs to cater these issues to make PAT more effective.

Teng (2012) carried out the similar analysis taking into account indigenous Research and Development to study the effect on energy intensity of Chinese industries. Mukherjee (2008) accounted for inter-state heterogeneity and carried out the similar analysis for the period of 1998-2003 using Data Envelopment Analysis for Indian industries.

3. Methodology

Our objective is to determine various factors affecting energy intensity of Indian Iron and Steel industries. Coal, Electricity and Natural Gas are the principal energy inputs used by Indian Iron and Steel sector and this makes it highly energy intensive. The minimum energy consumption by the DCs for this sector is

30,000 toe. By the end of first PAT Phase-I, energy savings equivalent of 2.10 Million tonne of oil equivalent annually has been achieved, which is around 41% higher than the saving targets from 67 Nos. of notified DCs. Since we want to determine the impact of PAT Phase-I as well on energy intensity of this industry we have particularly chosen those 18 firms which are included under PAT Phase-I for reducing their specific energy consumption and 7 other firms which are not included in PAT but belongs to size decile 1 category of Indian Steel sector as per CMIE ProwessIQ.

In PAT Phase-I (2012-2015), there are 67 DCs (plants) which are included, out of which we have selected 18 firms for our analysis as listed below:

Table 3.1. List of PAT Phase-I firms included in the study

S.No.	Firm
1	Bhushan Steel Ltd
2	ESSAR Steel
3	Rashtriya Ispat Nigam Ltd.
4	Steel Authority Of India Ltd.
5	Tata Sponge Iron Ltd.
6	Tata Steel Ltd.
7	Welspun Corp Ltd.
8	Aarti Steels Ltd.
9	Balasore Alloys Ltd.
10	Hira Ferro Alloys Ltd.
11	J S W Ispat Steel Ltd. [Merged]
12	Monnet Ispat & Energy Ltd.
13	Orissa Sponge Iron & Steel Ltd.
14	Sunflag Iron & Steel Co. Ltd.
15	Usha Martin Ltd.
16	Bhilai Engineering Corpn. Ltd.
17	Mukand Ltd.
18	Sharda Ispat Ltd.

Table 3.2. List of Non-PAT Phase-I firms included in the study

S.No.	Firm
1	Kalyani Steels Ltd.
2	Modern Steels Ltd.
3	Vardhman Industries Ltd.
4	Mahindra Ugine Steel Co. Ltd.(Merged)
5	Pennar Industries Ltd.
6	Tulsyan NEC Ltd.
7	Uttam Value Steels Ltd.

The data source for the study is CMIE ProwessIQ Version 1.80. The time period for the study has been taken from 1995-2015. Since we want to study the impact of both Energy Conservation Act, 2001 and Perform, Achieve and Trade (Phase-I), 2012-15 we have particularly taken the time span of 20 years. The names of the designated consumer of Iron and Steel industry have been taken from The Ministry of Power report published in July 2012.

In this study, dependent variable is Energy Intensity (EI) which is defined as the ratio of Power and Fuel expenses (in Billion) to Sales (in Billion). Due to data unavailability on energy consumption & output in physical units we have taken Power and Fuel Expenses (Rs. Billion) and Sales (Rs. Billion) to define Energy Intensity.

Table 3.3. The variables are defined as follows

Variable	Defined as (all values in Rs. Million)	Expected Relationship
Energy Intensity	Power and Fuel Expenses to Sales	
Profit Margin Intensity (PMI)	Profit After Tax to Sales	positive
Labor intensity	Salaries and Wages to Sales	negative
Capital intensity	Ratio of Net Fixed Assets to Sales	negative
Firm Size	Sales and Assets in three years (current year plus last two years)	negative

Table 3.3. The variables are defined as follows (cont.)

Variable	Defined as (all values in Rs. Million)	Expected Relationship
Technology Import intensity	Ratio of the sum (of the foreign exchange spending on the capital goods, raw materials and the foreign exchange spending on royalties, technical knowhow paid by the firm to foreign collaborations) to Sales	negative
Repairs Intensity	Ratio of total expenses on repairs of plants and Machineries to Sales	positive
Age	Current year minus year of incorporation	positive/negative
PAT dummy (pat)	This is a dummy variable capturing the effect of PAT Phase-I on energy intensity of firms defined as pat = 1 for the years 2012-15 and 0 otherwise.	negative
ECA dummy (eca)	This is a dummy variable capturing the effect of Energy Conservation Act, 2001 on energy intensity of firms defined as eca = 1 for the years 2001-2015 and 0 otherwise	negative
_Ipat_eca_1	This is a dummy variable capturing the effect of Energy Conservation Act, 2001 on energy intensity of firms defined as _Ipat_eca_1 = 1 for the years 2001-2015 and 0 otherwise	negative
_Ipat_eca_2	This is a dummy variable capturing the impact of both PAT and ECA simultaneously on energy intensity of firms defined as _Ipat_eca_2 = 1 for the years 2012-2015 and 0 otherwise	negative

All the variables are first corrected for inflation using Index numbers and then converted into natural log form. In this paper we have used Fixed Effect Model to estimate the impact of above factors on Energy Intensity of Steel firms.

Following is the suggestive Fixed Effect equation for the model:

$$lnEI_{it} = \beta_0 + \beta_1 lnA_{it} + \beta_2 lnPMI_{it} + \beta_3 lnLI_{it} + \beta_4 lnRI_{it} + \beta_5 lnSI_{it} + \beta_6 lnCI_{it} + \beta_7 lnTMI_{it} + \beta_8 ECA + \beta_9 PAT + \beta_{10}(\_Ipat\_eca\_1) + \beta_{11}(\_Ipat\_eca\_2) + \varepsilon_{it}$$

Where, the variables are described in the following table:

Table 3.4.

Model	**Dependent Variable**	**Independent Variable**
Model-1	Energy Intensity (EI)	Age of the firm (A) Profit Margin Intensity (PMI) Labour intensity (LI) Repairs Intensity (RI) Size of the Firm (SI) Capital intensity (CI) Technology Import Intensity (TMI) PAT {1 = 2012 to 2015, 0 = otherwise} ECA {1 = 2001 to 2015, 0 = otherwise}
Model-II (with PAT)	Energy Intensity (EI)	Age of the firm (A) Profit Margin Intensity (PMI) Labour intensity (LI) Repairs Intensity (RI) Size of the Firm (SI) Capital intensity (CI) Technology Import Intensity (TMI) PAT {1 = 2012 to 2015, 0 = otherwise}
Model-III (with ECA)	Energy Intensity (EI)	Age of the firm (A) Profit Margin Intensity (PMI) Labour intensity (LI) Repairs Intensity (RI) Size of the Firm (SI) Capital intensity (CI) Technology Import Intensity (TMI) ECA {1 = 2001 to 2015, 0 = otherwise}
Model-IV (with PAT and ECA)	Energy Intensity (EI)	Age of the firm (A) Profit Margin Intensity (PMI) Labour intensity (LI) Repairs Intensity (RI) Size of the Firm (SI) Capital intensity (CI) Technology Import Intensity (TMI) _Ipat_eca_1{1 = 2001 to 2015, 0 = otherwise} _Ipat_eca_2{1 = 2012 to 2015, 0 = otherwise}
Model-V (Tobit Regression with PAT and ECA)	Energy Intensity (EI)	Age of the firm (A) Profit Margin Intensity (PMI) Labour intensity (LI) Repairs Intensity (RI) Size of the Firm (SI) Capital intensity (CI) Technology Import Intensity (TMI) _Ipat_eca_1{1 = 2001 to 2015, 0 = otherwise} _Ipat_eca_2 {1 = 2012 to 2015, 0 = otherwise

4. Analysis

Table 4.1. Panel unit root tests

	LLC (Levin-Lin-Chu) Test		Breitung Test		HT (Harris-Tzavalis) Test	
Variables	**Level (Adjusted t*)**	**First Difference (Adjusted t*)**	**Level (lambda)**	**First Difference (lambda)**	**Level (rho)**	**First Difference (rho)**
Include Trend (Panel Means and Time Trend included)						
lnA	-29.4846***	-33.6975***	8.6887	7.0427(1.0000)	0.6874	0.6655(0.5606)
lnPMI	1.6640	-6.5752***	0.8454	-2.2194**	0.6026	0.1340***
lnEI	-1.3215	-7.2656***	-0.7045	-4.7738***	0.5801**	-0.0569***
lnLI	-6.0000***	-9.5107***	-2.3595***	-4.8624***	0.4971***	-0.1074***
lnRI	-3.2267***	-8.2206***	0.0501	-3.1826***	0.4553***	-0.1456***
lnSI	-23.2976***	-57.5117***	0.1171	-0.1638(0.4349)	0.6285	0.0782***
lnCI	0.1428	-7.9140***	1.8007	-4.4809***	0.5948**	-0.1465***
lnTMI	-1.8461**	-5.3417***	-1.7593**	-5.9932***	0.3406***	-0.3071***

Note - Level of Significance 5% - **, 10% - *, 1% - ***

4.1 Panel unit root tests

When we have a panel dataset our first step is to test for stationarity of all variables included in the study. For this, panel unit root test is conducted for all variables individually. A number of tests exists to test the stationarity of unit root. We have selected the two out of these namely, Levin–Lin–Chu (LLC) test, Breitung Test and Harris-Tzavalis (HT) test to enhance the robustness of the results. There is a problem of serial correlation with LLC test which cannot be completed removed therefore it has low power when we have small sample to test but it accounts for heterogeneity in various sections. The null hypothesis and alternate hypothesis of these unit root tests are there exist unit root implying that the variables are non-stationary and the alternative hypothesis is that there is no unit root implying that the variables are stationary. Table 4.1 shows the results of each variable for panel unit root tests. It can be seen from Table 4.1 that the variables lnA, lnLI, lnRI, lnSI and lnTMI in level form are statistically significant under the LLC test and the variables lnEI, lnLI, lnRI, lnCI and lnTMI in level form are statistically significant under HT test. Also, the variables lnLI and lnTMI at level are statistically significant under Breitung Test. The level of lnPMI is statistically insignificant under all three panel unit root tests. However, after first-order differencing, it is found that all the variables become stationary. Therefore, we may conclude that each variable is integrated of order one, i.e. I(1).

Table 4.2. Panel Data Analysis

	Model-I	**Model-II**	**Model-III**	**Model-IV**	**Model-V**
	Fixed Effect (d.lnei)	**Fixed Effect (d.lnei) with PAT**	**Fixed Effect (d.lnei) with ECA**	**Regression (d.lnei) with PAT and ECA**	**Random Effects Tobit Regression (d.lnei) with PAT and ECA**
d.lna	.0430493 (.0236734)	.0420724 (.0236985)	.020151 (.0262972)	.0117013 (.0231499)	-.0251003 (.0519315)
d.lnpmi	-.029305** (.0126731)	-.0294189** (.0126285)	-.0277864** (.0124823)	-.0264096*** (.0082738)	.0102759 (.0144196)
d.lnli	.1217567 (.064475)	.1215724 (.0647464)	.0925055 (.0565193)	.0918982 (.0780218)	.0242819 (.1357845)
d.lnri	.1674165 (.1140994)	.1688265 (.1173236)	.1533531 (.1156504)	.157753 (.1717628)	-.1073084 (.2978768)
d.lnsi	-.0022371 (.0014945)	-.0022522 (.0014738)	-.0022353 (.0013608)	-.0021529 (.0019842)	-.0039505 (.003526)
d.lnci	.017824 (.0111022)	.0179308 (.0111871)	.0171829 (.0113085)	.0165042** (.0082753)	.0064548 (.0144504)
d.lntmi	-.0254261 (.0161362)	-.0256924 (.0161611)	-.0240584 (.0163596)	-.0236041 (.0184868)	.0198583 (.0322479)
d.lnei					
_cons	-.0038066*** (.0010709)	-.0036542*** (.0011662)	.0021938 (.0029389)	.0028769 (.0030286)	.1159452*** (.0132042)
eca			-.0065094** (.002748)		
pat		-.0005471 (.0015633)			
_Ipat_eca_1				-.0072334** (.0031461)	-.0318942*** (.0055608)
_Ipat_eca_2				-.0059626 (.0038211)	-.0496313*** (.0067687)
Number of obs.	500	500	500	500	500
Number of groups	25	25	25		25
F	F(7,24)=2.51	F(8,24)= 2.25	F(8,24)=3.40	F(9, 490) = 4.14	Wald chi2(9) = 65.42
Prob > F	0.0440	0.0595	0.0095	0.0000	Prob > chi2 = 0.0000

Our objective is to empirically estimate energy intensity of the Iron and Steel industry using various factors affecting it and also evaluating the impact of Energy Conservation Act, 2001 (ECA) and PAT Cycle-I on the Energy intensity of Iron and Steel Sector in India by accounting for these two in dummy variable form.

The results Table 4.2, (similar to Sahu and Narayan (2009)) indicate a positive relation of age with energy intensity in Model I, II, III and IV. Model V indicates a negative relation of age with energy intensity.

Profit margin intensity is found to be significant in almost all the regressions with a negative relation with energy intensity implying if profit margin intensity will increase energy intensity will decline. This may be interpreted as if profits are increased then industry will be able to invest more in energy efficiency thereby reducing energy consumption.

The coefficient of labor intensity was insignificant i.e. labor intensity does not seem to be affecting energy intensity of the firms in Steel sector. But as the results suggest there seems to be a positive relationship between energy intensity implying as higher the labor intensive firms higher will be the energy intensity of the production process.

As reported by most of the Models, there is a +ve relationship between repairs intensity and energy intensity implying as firms are spending more on repairs of plant and machinery their energy intensity is also high. Though the coefficient for this variable is not significant the positive relation is at par with findings of Sahu and Narayan (2009), an analysis of energy intensity of Indian Manufacturing.

As the size of industry increases, it will lead to decline in energy intensity as stated by the results of all the regressions. This is in line with the results of Kumar (2003) but in opposition of findings by Sahu and Narayan (2009) stating an inverted U-shaped relation between firm size and energy intensity. The negative relation can be interpreted as growth of industry will lead to more resources for investment in energy intensity and thereby reducing energy consumption means if the industry produce at large-scale its per unit energy consumption will decline.

As reported by all the regressions, capital intensity is +ve related with energy intensity implying more capital-intensive firms are more energy-intensive. Though this variable is found to be significant only in Model IV. This result is in line with Papadogonas et al. (2007) and Sahu and Narayan (2009), found similar result for Hellenic and Indian manufacturing sector respectively.

Though the coefficient of technological import intensity is not found to be significant in any of the Models, but there seems to a negative relation of this variable with energy intensity. This implies that as the firm spends more on technological imports from abroad it will lead to advancement and thereby reduce energy intensity of firms.

The ECA dummy capturing the impact of Energy Conservation Act, 2001 (ECA) on energy intensity of Steel companies has a significant and negative impact as depicted by Model III. The same result is also depicted by _Ipat_eca_1 dummy in Model IV and V. This implies ECA, 2001 has a significant impact in reducing the energy intensity of Steel Industry.

The dummy variable, PAT capturing the impact of Perform, Achieve and Trade Mechanism, Phase-I (2012-2015) doesn't seem to have any significant impact on reducing energy intensity of Steel industry as reported by results of Model II.

As reported by Model V, _Ipat_eca_2 dummy is significant implying PAT and ECA both simultaneously prevalent from 2012 to 2015 seems to have impact on energy intensity of Steel industry thereby reducing energy consumption.

4. Conclusion

Out of the eight sectors covered under PAT cycle-I (2012-15), one of the most energy-intensive sectors is the iron and steel sector contributing to 15 percent of total energy consumption out of these.

Though the energy consumption in these two sector is on declining trend but still it forms 20-40 percent of the total production cost of steel (Worldsteel Association, 2017).

Also, iron and steel sector is on a rising trend due to high global and domestic demand of crude steel in the market and attained third rank after China and Japan. Total 67 plants of iron and steel are assigned energy reduction targets. For Iron and steel sector the threshold limit of energy consumption per annum is 30000 TOE (BEE, 2017).

The decline in energy consumption till 2011 by this sector can also be attributed to Energy Conservation Act implemented in the year 2001 along with other factors. This is also confirmed by the empirical results in our results that ECA has a significant impact over reduction of energy intensity of the steel firms.

PAT doesn’t seem to have much impact over energy intensity alone (Model II) but the years where both PAT and ECA are prevalent, i.e., from 2012 to 2015 there seems to be a significant impact of around 0.050 reduction in energy intensity (Model V). Though, by the end of first PAT cycle-I, energy savings equivalent of 2.10 Million tonne of oil equivalent annually has been achieved, which is around 41% higher than the saving targets from 67 Nos. of notified DCs. PAT may not have seem to impact much by our empirical results might be because PAT has defined Designated consumers on the basis of plant level data and due to non-availability of data we are bound to take firm level data for our analysis.

There is one more observation from the empirical results, that profit margin intensity was found to be negatively related to energy intensity implying more profitable firms invest more in energy efficiency.

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