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

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ABSTRACT

India is the world's third largest consumer of primary energy, which includes fossil fuels like coal, oil, etc. The total primary energy consumption in India in 2015 was 107 Mtoe. India's total final energy consumption was estimated at 527 Mtoe of which the industrial sectors consumed about 30% (185 Mtoe) in 2013. The Iron and Steel sector is one of the most energy-intensive industries, consuming about 25% of the total industrial energy consumption. The energy consumption in Indian Iron and Steel sector is on the declining trend. It declined from 10 GCal/tcs in 1990 to 6.9 GCal/tcs in 2010–11. On average, iron & steel plants spend about 20-40% of the total manufacturing cost to meet their energy demands. In fact, energy cost is considered as a major factor in pricing of the steel. Energy Conservation Act, 2001 (ECA), and the formulation of Bureau of Energy Efficiency are important initiatives 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 the industrial sector of the economy. Phase-I for PAT ran from 2012–015 including eight most energy-intensive sectors under Indian Industrial sector, with 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 the impact of ECA and PAT Phase-I in dummy variable form. The results indicate that the decline in energy consumption in this sector until 2011 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 on reduction of energy intensity of the steel firms. PAT does not seem to have a considerable impact on energy intensity alone but in 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 found to be negatively 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

The industrial sector drives the process of growth in all sectors of the economy. It consumes a large amount of energy, accounting for more than 50 percent of the total commercial energy consumed in India and among these the industries like iron and steel, aluminium, cement, pulp and paper, chlor-alkali, fertilizer, iron & steel, pulp & paper, textiles, thermal power plant account for more than 60 percent of total energy consumption by the industrial sector in India.

India is the world's third largest consumer of primary energy which includes fossil fuels like coal, oil, etc. (BP Statistical Review of World Energy, 2016). The total primary energy consumption in India in 2015 was 107 Mtoe (The Economics Times, January 27, 2017). India's total final energy consumption was estimated at 527 Mtoe of which the industrial sectors consumed about 30% (185 Mtoe) in 2013 (India Energy Outlook, IEA, 2015). The Iron and Steel sector is one of the most energy-intensive industries, consuming about 25% of the total industrial energy consumption (IEA, 2012). Energy consumption in most of the integrated steel plants in India is generally high at 6-6.5 Giga Calorie per tonne of crude steel as compared to 4.5-5.0 in steel plants abroad. The higher rate of energy consumption is mainly due to obsolete technologies including problems in retrofitting modern technologies in old plants, old shop floor & operating practices, poor quality of raw material viz. high ash coal/coke, high alumina iron ore, etc. The energy consumption in steel plants is, however, gradually reducing because of technological upgradation, utilization of waste heats, use of better quality inputs, etc. (Ministry of Steel, 2017). India ranks third in the list of GHG emitters in the world after China and U.S. India's greenhouse gas emissions rose by an alarming 4.7% in 2016, compared to the previous year (Netherlands Environmental Assessment Agency, September 29, 2017). Industries contribute approximately one fourth of India's total GHG emissions. (Gupta et al. 2017). The Indian Iron and Steel sector contributed to about 117.32 MtCO2 (28.4% of the industrial sector) in 2007 (Krishnan et al., 2013).

According to the Ministry of Steel, Government of India, the steel sector contributed nearly 2% to the Gross Domestic Product (GDP) during 2015-16. Also, in 2016, India is the third largest producer of steel in the world with steel production of 95.6 million tonnes after China (808.4 million tonnes) and Japan (104.8 million tonnes) as per Worldsteel Association.

Energy efficiency and low carbon growth have emerged as key pathways to reduce the nation's energy intensity and emissions intensity.

There are some significant steps the Government of India (GoI) has taken in controlling the energy intensity of the industrial sector. The first key initiative was the launch of the Energy Conservation Act, 2001. Bureau of Energy Efficiency (BEE) was formulated under this Act, with the aim to promote energy efficiency in the Indian economy. Further, in June 2008 the National Action Plan for Climate Change was launched with eight National Missions that aimed at achieving key goals with respect to climate change. One of the national missions is the National Mission for Enhanced Energy Efficiency (NMEEE) created with the objective of promoting energy efficiency through policies, regulation, financing mechanisms and business models. Perform-Achieve-Trade (PAT) scheme is an initiative of NMEEE and it pertains specifically to the industrial sector. PAT is an ambitious scheme in the Indian context because for the first time India has introduced market-based instruments to solve an environmental problem. The objective is to improve energy efficiency of the high energy-intensive industries through target setting and tradable energy saving certificates. The Ministry of Power and BEE first identified eight most energy-intensive industries viz. Thermal Power Plants, Fertilizer, Cement, Pulp and Paper, Textiles, Chlor-Alkali, Iron & Steel and Aluminium. Within each of these industries the most energy-intensive plants were identified and called Designated Consumers (DCs). BEE set specific energy consumption target or SEC (defined as the ratio of net energy input in the DC's boundary to total output exported from the DC's boundary) for each designated consumer such that the sum of the targets for all designated consumers within an industry equals the industry's target. These individual targets will take care of the heterogeneity that exists in each industry with respect to output, energy consumption trends, energy saving potential, age of the plant, etc. Each designated consumer is required to reduce its SEC by a certain value, based on its reference year's SEC. The reference year is defined as the average SEC from April 2007 to March 2010. The target year for the first PAT cycle runs from April 2012-March 2015. At the end of the period, if the designated consumer surpasses its target then it will be issued tradable energy saving certificates or ESCerts. 1 ESCert equals 1 toe worth of energy consumption. Perform, Achieve and Trade in its first cycle was designated to reduce the specific energy consumption (SEC) in energy-intensive sectors under which 478 DCs from 8 sectors viz. Aluminium, Cement, Chlor-Alkali, Fertilizer, Iron & Steel, Pulp & Paper, Thermal Power Plants and Textiles were included. These designated consumers currently account for 25% of national GDP and almost 45% of commercial energy use in India. PAT Cycle I achieved an energy saving of 8.67 Mtoe against the targeted energy saving of 6.68 Mtoe, which is above 30 percent over achievement and is equivalent to monetary savings of approx. Rs. 9500 crore. PAT is a multi-cycle scheme aimed to cover most of the energy-intensive sectors of the economy. Under Iron and Steel sector, a total of 67 plants are identified as DCs and assigned mandatory energy reduction targets. The notified threshold limit is 30000 TOE of energy consumption per annum for the Iron and Steel sector. By the end of PAT Cycle-I, energy savings equivalent of 2.10 million tonne of oil equivalent annually was achieved, which is around 41% higher than the savings targets from 67 of the notified DCs (Oak, 2017).

2. Literature review

The factors affecting energy intensity of industrial firms in India have been examined earlier by Kumar (2003) and Sahu and Narayana (2009). Both the studies used multiple regression analysis to examine the important factors influencing energy intensity in industrial firms. Data for 1342 firms for a period of eight years (panel data) from CMIE Prowess database was used by Kumar for this study. The independent variables considered include firm size, age of the firm, wages, R&D intensity, technology import intensity, profit margin, capital intensity, repair intensity, degree of vertical integration, and the pattern of ownership (particularly foreign ownership of the firm). Kumar found a negative relationship between firm size and energy intensity, which can be accredited to economies of scale. Energy intensity was found to be positively related to repair intensity (ratio of expenditure incurred on repairs of plant and machinery to sales). Also, a positive relationship was found between energy intensity and technology import intensity (defined as the expenditure in foreign exchange incurred on imports of capital goods, raw materials, royalty, and purchase of technical know-how as a ratio to sales), which is contrary to the expected relationship. It also indicated that the type of ownership has an important influence on energy intensity. Foreign ownership was found to be associated with lower energy intensity, while state ownership was found to be associated with higher energy intensity. Sahu and Narayanan used the data for 2350 firms for the year 2008 for their analysis, extracted from *Prowess*. The independent variables considered include firm size (logarithm of sales), labour intensity, capital intensity, repair intensity and age of the firm. Other variables considered include R&D intensity (ratio of R&D expenditure to sales), technology import intensity (definition similar to that adopted by Kumar), foreign ownership (dummy variable for foreign-owned firms), export intensity (exports to sales ratio) and profit margin. Thus, many of the explanatory variables considered by Sahu and Narayanan are the same as those used by Kumar in his analysis. Sahu and Narayanan included both firm size and square of size as explanatory variables. The advantage of including the squared term as suggested by Sahu and Narayan was that the relationship between firm size and energy intensity need not be monotonically increasing or decreasing. Certainly, the coefficient of size was found to be positive and that of the squared term negative. Consequently, Sahu and Narayanan deduced an inverted-U shaped relationship between energy intensity and firm size. A negative relationship was found between energy intensity and export intensity (implying that export-oriented firms are more efficient in the use of energy) and also between energy intensity and profit margin. A positive relationship of energy intensity was found with capital intensity and repair intensity, which was same as the findings of Kumar (2003). The results suggested that foreign firms were more energy efficient, which is again same as the findings of Kumar. Another similarity between the findings of the two studies was that both found a significant positive relationship between energy intensity and technology import intensity. This was contrary to expectations. Sahu and Narayanan found a positive relationship between energy intensity and the age of the firm. This kind of a relationship was expected because older firms will be having plant and machinery of older vintage, which were likely to be less energy efficient as compared with the plant and machinery of more recent vintage. Pertaining to this, the results of Kumar are contrary to that of Sahu and Narayanan. Kumar found a negative insignificant coefficient of the age variable. For this study, an analysis of firm level variation in energy intensity has been undertaken, which is similar to the analysis undertaken by Kumar (2003) and Sahu and Narayanan (2009).

The effect of indigenous R&D on the energy intensity of Chinese industries is analysed by Teng (2012). In the Indian case, Mukherjee (2008) used the method of Data Envelopment Analysis for the period 1998-2003 to examine inter-state heterogeneity in energy intensity because of the varying composition of manufacturing output, differences in relative energy prices, labour quality, capital investment and environmental regulation.

2.1 Brief history of energy-efficiency certificate schemes

Market-based instruments for energy efficiency are identified as an important tool in the policy portfolio for climate change mitigation. These instruments are generally called Tradable White Certificates (TWC) within the European Union (European Commission, 2006), and have gained importance in recent years in France, Italy, Great Britain and Australia (Hamrin et al., 2007). For the first time in 2002, United Kingdom introduced the concept of enhancement of energy efficiency by considering both bilateral and over-the-counter trading, but without a provision for the trading of certificates (Langniss and Praetorius, 2006; Hamrin et al., 2007; Vine and Hamrin, 2008). The first of its kind energy-efficiency trading system was introduced in New South Wales, Australia in 2003 under Greenhouse Gas Abatement Scheme. This scheme allowed the specific greenhouse abatement projects which abate emissions beyond the benchmark emissions to generate National Greenhouse Gas Abatement Certificates that are tradable (Hamrin et al., 2007; Crossley, 2008). France established its tradable ESC scheme in 2005 with an energy saving target of 54 TWh between July 2006 – June 2009 (Hamrin et al., 2007). The Italian White Certificate scheme, which took effect in 2005, established a goal of reducing its energy intensity by 2% per year until 2015 and up to 2.5% per year until 2030 (Hamrin et al., 2007; Pavan 2008). India introduced a similar market-based scheme for efficiency improvement, Perform, Achieve and Trade (PAT), in 2012 with a target saving of about 6.5 – 10.0 Mtoe of energy during 2012 – 2015 (GoI, 2012; CII, 2011b; Kumar and Agarwala, 2013).

2.2 Perform, Achieve and Trade (PAT), Phase-I (2012-15)

Oak (2017) determined the factors influencing energy intensity of firms in Cement Industry and quantified the PAT effect using panel data fixed effects model and difference-in-differences estimates. The robustness of results was checked using the method of Propensity Score matching. The data were taken from Prowess Dataset, which provides firm level data of the Indian industries. Prowess is a product of Centre for Monitoring Indian Economy (CMIE) that provides economic databases for India. The Ministry of Power, GoI's Perform-Achieve-Trade document published in July 2012 was used to identify the names of designated consumers of the cement industry.

The results showed that the Indian Cement industry as a whole did not become more energy efficient after the scheme was launched but the firms that were identified have higher energy intensity than the other firms in Cement industry, which suggests that they were correctly identified by the government.

Bhandari and Shrimali (2017) analysed the effectiveness of PAT so far and in the future using Primary Research through semi-structured interviews of designated consumers, BEE and EESL between the months of May-July 2013. The primary secondary source of information was the PAT Booklet published by the Ministry of Power. They conclude the following: the targets are not strict enough to add energy efficiency activities beyond business-as-usual; long-term investment in energy efficiency may not happen; the PAT market may not form; many equity issues remain unaddressed; and, it is too early to assess transaction costs. Based on best practices, the policy implications according to Bhandari and

Shrimali (2017) are: set additional targets that account for rising energy costs; promote long-term investments via clear and consistent goals; create a functioning PAT market platform to ensure cost-effectiveness; reduce equity concerns via normalized targets and standardized auditing; and, keep transaction costs low.

The objective of this paper is to empirically estimate the energy intensity of one of the BEE identified industry under PAT Phase-I, i.e. the Iron and Steel industry using various factors affecting it. The sample period for the study is selected to be 1995-2015. We will also be evaluating the impact of Energy Conservation Act, 2001 (ECA) and PAT Phase-I on the Energy intensity of Iron and Steel Sector in India by accounting for these two in dummy variable form.

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 the first PAT Phase-I, energy savings equivalent of 2.10 million tonne of oil equivalent annually was achieved, which is around 41% higher than the saving targets from 67 of the notified DCs. Since we want to determine the impact of PAT Phase-I also 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.

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

S.No.	Firm
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 was 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 Ministry of Power, Government of India's Perform-Achieve-Trade document published in July 2012 has been used to identify the names of the designated consumers of Iron and Steel industry.

In this paper, Energy Intensity (EI) is taken to be a dependent variable and is defined as the ratio of Power and Fuel expenses (Rs. Billion) to Sales (Rs. Billion). Due to absence of data on energy consumption and 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
Labour intensity	Ratio of Wages and Salaries to Sales	negative
Capital intensity	Net Fixed Assets as a proportion of Sales	negative
Firm Size	Sales and Assets in three years (current year plus last two years)	negative
Technology Import intensity	Ratio of the sum (of the forex spending on the capital goods, raw materials and the forex spending on royalties, technical know-how 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	Calculated by deducting the year of incorporation from the current year	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 the above factors on Energy Intensity of Steel firms.

The following is the suggestive Fixed Effect equation for the model:

$$\ln EI_{it} = \beta_0 + \beta_1 \ln A_{it} + \beta_2 \ln PMI_{it} + \beta_3 \ln LI_{it} + \beta_4 \ln RI_{it} + \beta_5 \ln SI_{it} + \beta_6 \ln CI_{it} + \beta_7 \ln TMI_{it} + \beta_8 ECA + \beta_9 PAT + \beta_{10}(\_Ipat\_eca\_1) + \beta_{11}(\_Ipat\_eca\_2) + \varepsilon_{it}$$

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

In panel data analysis, the panel unit root test must be taken first in order to identify the stationary properties of the relevant variables. There exist a number of methods for panel unit root tests. In this study, we choose the three panel unit root tests, namely Levin–Lin–Chu (LLC) test, Breitung Test and Harris-Tzavalis (HT) test to enhance the robustness of the results. The LLC test takes into account the heterogeneity of various sections, but it has low power in small samples because of the serial correlation, which cannot be completely eliminated. The null hypothesis of the above three unit root tests is that there exists a unit root (i.e. the variables are non-stationary), and the alternative hypothesis is that no unit root exists in the series (i.e. the variables are stationary). Table 4.1 shows the results of the panel unit root tests for each variable. 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 the energy intensity of the Iron and Steel industry using various factors affecting it and also evaluate 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 from Table 4.2 indicate a positive relation of age with energy intensity in Model I, II, III and IV. This is in agreement with the findings of Sahu and Narayan (2009) indicating a positive coefficient with this variable. 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 that 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 labour intensity was found to be insignificant, which means labour 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 the energy intensity implying as higher the labour intensive firms higher will be the energy intensity of the production process.

As reported by most of the models, there is a positive relationship between repairs intensity and energy intensity implying that as firms are spending more on repairs of plant and machinery their energy intensity is also high. Although the coefficient for this variable is not significant the positive relation is at par with the 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 to the findings of Sahu and Narayan (2009) stating an inverted U-shaped relation between firm size and energy intensity. The negative relation can be interpreted as that growth of industry will lead to more resources for investment in energy intensity and thereby reducing energy consumption means if the industry produces at large-scale its per unit energy consumption will decline.

As reported by all the regressions, capital intensity is found to be positively related with energy intensity implying that more capital-intensive firms are more energy-intensive. Although 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), who found a similar result for Hellenic and Indian manufacturing sector respectively.

Although the coefficient of technological import intensity is not found to be significant in any of the models, but there seems to be 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 on reducing the energy intensity of Steel Industry.

The dummy variable, PAT capturing the impact of Perform, Achieve and Trade Mechanism, Phase-I (2012-2015) does not seem to have any significant impact on reducing energy intensity of Steel industry as reported by the 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 seem to have impact on energy intensity of Steel industry thereby reducing energy consumption.

4. Conclusion

Eight industries in India have been identified as energy-intensive industries under PAT scheme: aluminium, cement, fertilizer, iron & steel (including sponge iron), pulp & paper, chlor-alkali, power plant & aluminium. They consume nearly 230 million metric tonnes of oil equivalent. Iron and Steel industry accounts for 15% of this total energy consumption.

The energy consumption in Indian Iron and Steel sector is on the declining trend. It declined from 10 GCal/tcs in 1990 to 6.9 GCal/tcs in 2010-11. It can be concluded that the decline in the energy intensity was in the range of 2.5 percent annually. The iron and steel industry, which primarily consumes coking coal and some high-grade non-coking coal, is the second largest consumer of domestic coal, although its consumption decreased from 20% of total consumption in the country in 1970 to about 5% in 2008 (CII, 2013).

On average, iron & steel plants spend about 20-40% of the total manufacturing cost to meet their energy demands. In fact, energy cost is considered as a major factor in pricing of the steel (Worldsteel Association, 2017).

Iron and Steel Industry in India is on an upswing because of the strong global and domestic demand. In 2015-16, India produced 90 MT of crude steel and attained the position of 3rd largest steel producer in the world, after China and Japan. Under Iron and Steel a total of 67 plants are identified and assigned mandatory energy reduction targets. The notified threshold limit is 30000 TOE of energy consumption per annum for the Iron and Steel Sector (BEE, 2017).

The decline in energy consumption in this sector until 2011 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 on reduction of energy intensity of the steel firms.

PAT does not seem to have a considerable impact on energy intensity alone (Model II) but in 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). However, by the end of first PAT cycle-I, energy savings equivalent of 2.10 million tonne of oil equivalent annually was achieved, which is around 41% higher than the saving targets from 67 of the notified DCs. PAT may seem not to have a considerable impact according to our empirical results, which 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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