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# Impact of Perform-Achieve-Trade Policy on the Energy Intensity of Cement and Iron and Steel Industries in India

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# IMPACT OF PERFORM-ACHIEVE-TRADE POLICY ON THE ENERGY INTENSITY OF CEMENT AND IRON AND STEEL INDUSTRIES IN INDIA

**Kaumudi Misra**∗

## Abstract

*The current paper attempts to evaluate the impact of Perform-Achieve-Trade (PAT) policy on the cement and iron and steel industries in India. A descriptive statistics analysis has been done separately for the cement and iron and steel industry, and the two are compared to understand the major differences between them. The paper uses panel data for a time period of nine years: 2007-2015. The difference-in-difference methodology is adopted for the analysis. The random effect two way error component model is used to analyse the impact of PAT policy on the industries. The study finds that in the case of the cement industry, the PAT policy is effective and helps the industry in transitioning to energy efficiency. The policy is found to be insignificant in the case of the iron and steel industry: The reasons for the same are discussed in the paper.*

**Keywords:** Perform-Achieve-Trade (PAT) policy, energy efficiency, cement and iron and steel industry.

## Introduction

Kyoto Protocol was the first international agreement on climate change. It came into force in 2005, binding its members to reduce green-house gas (GHG) emissions. The agreement targeted the industrialised nations, requiring them to reduce their emissions by 5 per cent from their 1990 levels. The member countries resorted to different methods to achieve the emission reduction targets. The most unique and successful practice was founded by the European Union. It introduced the Emissions Trading Scheme, a key tool to reduce its GHG emissions. European Union's Emissions Trading Scheme (EU-ETS) is a cap and trade system which sets a cap on the total amount of certain GHG that can be emitted by installations under the system. The cap is reduced overtime to drop the total emissions. Within the cap, companies buy and receive allowance which is tradable. After each year, a company must surrender enough allowances to cover its emissions; otherwise, heavy fines are levied.

In the case of emissions being reduced by the company, they are allowed to keep the allowances. The trading of allowances helps in ensuring that the emissions are cut where the costs are least. It's the world's first major carbon market (European Commission, 2018).

EU-ETS is currently in its third phase. Following are the features of the phases that the EU-ETS has been through. Phase 1: In the year 1997, Kyoto Protocol set legally binding emission reduction targets for 37 industrial countries. The European Union had also ratified the Kyoto Protocol being an industrialised nation. Policy instruments were required in order to meet these targets. In the year 2000, European Commission gave the first idea on the design of EU-ETS, which was later launched in 2005. The emissions fell by 5 per cent when compared to the beginning of 2013, and by 2020 this reduction is

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anticipated to fall by 21 percent. Set up in 2005, the EU-ETS is the world's first and biggest international emissions trading system accounting for over three-fourths of international carbon trading.

The paper is in the following order – the paper begins by listing the different carbon markets and steps taken across the globe to facilitate the same. Section 2 deals with the review of literature, followed by the data and methodology of the study. Section 4 presents a detailed descriptive statistics using the three-way tables for the cement and iron and steel industry.The $5^{th}$ section presents the panel analysis using the difference-in-difference analysis for two industries. The final section highlights the major findings and conclusion.

## International carbon markets

### Carbon emissions in the Paris agreement

The Paris agreement provided the basis for the international markets and also reinforced them to achieve their targets by assuring the transparency and accountability of parties. Article six of the agreement allow the parties to use international trading and emission allowances to help achieve the emission reduction targets. It helps in creating a market mechanism and establishes a framework for common robust accounting rules.

### Bilateral cooperation

In 2014, there came a project between China and the European Commission, to support the design and implementation of emission trading in China. The bilateral cooperation provides technical assistance for capacity building. It further supports seven regional pilot systems and also establishes a nation-wide emission trading system.

### Korea's emissions trading scheme

The emissions trading scheme of Korea was launched in 2015, covering 66 per cent of Korea's total greenhouse gases. It is the first non-Annex I country to adopt a mandatory emissions trading system. The scheme covers 599 of the largest emitters in the nation, including all the six Kyoto gases as well as the indirect emissions from electricity consumption. The scheme is mandatory in nature with the opt-in option for the firms that emit less (ICAP, 2018).

## Indian policies to combat climate change

Post-independence, a number of policies were introduced to help the manufacturing sector grow. Not until 2001 did any policy emphasise the importance of energy conservation. In 2001, the Energy Conservation Act was established that aimed at efficient usage of energy and its conservation. Some of the other initiatives taken up by the government to promote energy conservation and efficiency include the formation of the Prime Minister's National Action Plan on Climate Change in 2008 which aimed at mitigating and adapting to climate change. The NAPCC laid down eight national missions for combating climate change, the National Mission for Enhanced Energy Efficiency (NMEEE) being one of them. NMEEE laid down four initiatives to help India move towards energy efficiency, namely – Perform-

Achieve-Trade, Market Transformation for Energy Efficiency, Energy Efficiency Financing Platform and Framework for Energy Efficient Economic Development.

The current work focuses on Perform-Achieve-Trade (PAT), a cap and trade policy initiative that aims at transitioning the energy intensive industries to energy efficient industries. Perform-Achieve-Trade policy is different from the other emission trading policies listed above on the following grounds:

1. The policy aims at reducing the energy intake of the industries and doesn't directly cap the emissions per se. Therefore PAT indirectly helps in the reduction of emissions.
2. The policy is unique as it sets specific energy intake caps for each firm based on their energy intake in the pilot years. Further, since the cap is on the energy intake, the firms are encouraged to increase their outputs by investing in state of the art technology.
3. The other Emission Trading Schemes such as EU-ETS and Korea's Emissions Trading Scheme provide the industries with allowances which are majorly given free of cost. In the case of PAT, the Bureau of Energy Efficiency issues the Energy Saving Certificates (ESCerts) only if the designated consumers (firms under the PAT policy) comply with the energy reduction targets. These certificates are traded at the end of the phase.
4. BEE penalises the firms that fail to achieve the target by imposing huge penalties. The ESCerts are an economic incentive as the trading of ESCerts acts as an incentive for the firms to transition to energy efficiency.

The Bureau of Energy Efficiency has selected the major energy intensive industries.The energy intensive firms (designated consumers or DC) are then selected from these industries on the basis of their specific energy consumption. PAT sets targets for the designated consumers (each industrial unit) and if the target is surpassed, the DC is issued with an energy saving certificate. On the other hand, if an industry fails to comply with the target, it has to either pay a penalty or purchase the energy saving certificate from other industries. PAT not only aims at reducing the energy intake of the industries but also enable the energy intensive industries to introduce energy saving technologies and re-organisation among firms. This also results in energy use efficiency and emission abatements. PAT is divided into phases, the first phase is from 2012-2015, consisting of eight energy intensive industries namely – power plant, cement, iron and steel, paper and pulp, chlor-alkali, fertiliser, aluminium and textile. The current work focuses on the impact of Perform-Achieve-Trade (PAT) policy on the energy efficiency of the cement industry in the first phase: 2012-2015.

The BEE conducted sector-specific studies in order to understand the situation better. The baseline period based on which the targets are set for the industries is 2007-2010. The studies suggest that the bandwidth of the specific energy consumption within each industrial sector is huge, thereby promising greater energy saving prospects. The specific energy consumption is calculated by dividing the net energy input into the DC's boundary by the total quantity of output exported from the DC's boundary. It is expressed in terms of the metric ton of oil equivalent (toe)/per unit of product. It is said that for higher energy efficient units, the energy saving potential is bleak. On the other hand, the units that are highly energy intensive have the greatest capacity towards energy saving. The highest number of industrial units selected are from the thermal sector – 144, followed by the textile industry having 90 designated consumers, cement and iron and steel with 85 and 67 DCs respectively.

The table 1 shows the minimum energy intake of industries to be classified as a designated consumers and the energy saving target set by PAT for each of the selected industries, this target is set based on the specific energy consumption of these industries and their designated consumers. The designated consumers are selected on the basis of the SEC. The SEC is measured in tonnes of oil equivalent. For the firms under cement, fertilizer, iron and steel, paper and pulp and thermal the minimum energy consumption for being selected as a designated consumer is 30000 toe. For firms of chlor-alkali the minimum energy consumption is 12000 toe, for aluminium it is 7500 toe followed by textile 3000 toe. Based on the above selection criteria of the designated consumer the thermal sector has 144 DCs, followed by textile 90, cement 82, iron and steel 67. The paper and pulp, fertilizer, chlor-alkali and aluminium industries have 31, 29, 22 and 10 DCs respectively.

**Table 1: Energy saving target: industry-wise**

| S.No | Sector | Minimum energy consumption for DC (tons of oil equivalent) | No. of DCs | Energy saving target (million toe) and % of saving |
|---|---|---|---|---|
| 1 | Aluminium | 7500 | 10 | 0.456 (7%) |
| 2 | Cement | 30000 | 85 | 0.816 (12%) |
| 3 | Chlor-alkali | 12000 | 22 | 0.054 (1%) |
| 4 | Fertiliser | 30000 | 29 | 0.478 (7%) |
| 5 | Iron and steel | 30000 | 67 | 1.486 (22%) |
| 6 | Paper and pulp | 30000 | 31 | 0.119 (2%) |
| 7 | Textile | 3000 | 90 | 0.066 (1%) |
| 8 | Thermal | 30000 | 144 | 3.211 (48%) |
| | Total | | 478 | 6.686 |

*Source*: PAT booklet, 2012

It is the thermal sector that is expected to have the largest share in the energy saving under PAT with 48 per cent of the saving coming from the sector. The iron and steel sector saves 22 per cent followed by the cement industry which saves 12 per cent of the total energy saved under PAT. Put together, these three industries save nearly 82 per cent of the total energy saved under PAT.

## Review of literature

The review of literature is divided into two:

### Literature on Perform-Achieve-Trade policy

Perform-Achieve-Trade policy has been less studied and therefore the literature is limited (Roy, 2010 and Oak & Bansal, 2017). Both the papers differ significantly as Roy 2010 is a briefing paper prior to the implementation of the policy and Oak & Bansal attempt to analyse the impact of PAT on the cement industry. Roy 2010 makes a strong recommendation of focusing primarily on the iron and steel industry as it is the highest energy consuming industry and emits 28 per cent of the total industrial carbon emissions.

Oak & Bansal 2017, on the other hand, analyse the impact of PAT on the cement industry. The paper uses the time period between 2005 and 2015, dividing it into pre- and post policy. The variables used for the analysis are energy intensity, capital intensity, size (gross fixed capital), and age. The paper used power and fuel expenditure as the proxy for energy and summed up the sales and stock of finished goods to get the output. The energy intensity was calculated by dividing the energy by the output. Further, the paper used dummy variables for the policy. The paper used the difference in methodology to understand the impact of PAT on the energy intensity of the cement industry. In the above equation, EI is the energy intensity, K is the capital intensity and size is represented by the gross fixed capital. The paper found that the older firms are more energy efficient as compared to the new ones, and reasoned out this by stating that the older and larger firms are more resource abundant, and thereby can invest in clean technology. It is important to highlight that the coefficients of the dummy variable are highly insignificant, yet the paper makes generalisations regarding PAT having a negative impact on the energy intensity of the Indian cement industry, thereby helping it move towards energy efficiency.

## Literature on energy intensity

The energy intensity of the Indian manufacturing industry has been studies at large.

A firm-level analysis of the determinants of energy intensity for the Indian manufacturing sector was done by Sahu and Narayan, 2010. The paper plots the annual growth rate of energy consumption and output, output and energy intensity to see whether the changes in productivity of the firms has any relationship with the changes in energy consumption of the firms. It is found that energy consumption explains the output better, whereas energy intensity is a better explanation for firm characteristics. The paper uses a large number of variables to understand their relationship with energy intensity – energy intensity, labour intensity, capital intensity, technology import intensity, research intensity, profit margin, repair intensity, size, size square, age, age square, firm dummy and industry dummy. The firm dummy categorises the firms into high energy intensive, moderate energy intensive and low energy intensive. The industry dummy categorises the firms into two – foreign owned and domestic firms. The paper used a multiple regression model technique to analyse the data. The paper found a negative insignificant relationship between labour intensity and energy intensity, while it found a positive and highly significant relationship between capital intensity and energy intensity. Age is also found to be positive and significant, $age^2$ is found to be negatively significant making their relationship an inverted U – the firms with a moderate age are more energy efficient. The result of R&D intensity differ from that of theory, it has a positive relationship with energy intensity. By this we understand that more of R&D leads to increase in energy intensity. The coefficients of technological intensity is negative and significant as per the theory – technology imports lead to an increase in the energy efficiency. The firm dummy is found to have a positive relationship with energy intensity – firms that consume more energy are more energy intensive. It is also found that the foreign owned firms are less energy intensive.

A similar study was conducted by Mukherjee in 2008 where the paper analyses the energy use efficiency of the Indian manufacturing industry. The paper conceptualises a single output four input production technology – labour, capital, energy and materials. Further energy is categorised into four – electricity, petroleum, coal and others. The paper also finds that a high quality labour results in higher energy efficiency. Energy intensity of India is found to be increasing from 1998-2000 and decreases thereafter. The paper does three energy efficiency tests – the radial measure of technical efficiency, slacks efficiency and cost efficiency. Based on the radial measure of technical efficiency, it is found that there exists a possibility of reducing the inputs proportionally by 6.76 percent. The slack efficiency reveals that the average energy efficiency of the states under the study was .92, making it possible for the energy input to be reduced by 8 percent. The cost efficiency reveals that the annual average energy efficiency across states is 85.38 percent. The paper does an interstate analysis which found that Goa, Haryana, Maharashtra, are energy efficient states, whereas Andhra Pradesh, Madhya Pradesh, Odisha and Rajasthan are inefficient in terms of energy usage. The paper concludes that the major factor causing the differences in energy efficiency across states is the industry mix.

A study by Goldar (2011) stands out as it uses energy prices and technological progress in determining the energy intensity of the Indian manufacturing industries. The paper assesses the effect of energy price and technological progress on energy use in industries by estimating a energy demand function for the Indian manufacturing. The paper also does an analysis of the inter-firm variations in energy intensity, assessing the effect of technology and other firm characteristics such as firm size, vintage and foreign equity. The study uses data for a single year 2003-04 to check the energy intensities of all manufacturing units and the Indian manufacturing sector remained stable within a range, but post 1992witnessed a decrease in energy intensity. The reduction in energy intensity has been accompanied by an acceleration in energy prices in the same period. The paper uses four different models – they differ by the variations made in the explanatory variables. The paper does an inter-plant and inter-state analysis for the energy intensity to understand the major determinants of energy intensity. The analysis is done for 22 industries using the random effect model. The paper is superior to other papers as it uses two important explanatory variables in the model, namely foreign ownership: which reduces energy intensity as a result of technology spill-overs, and real prices of energy: which has a negative impact on energy intensity. The paper attributes the inter-plant variation to the energy use efficiency adopted by the less energy intensive firms. The variations in the energy intensity across states has been attributed to the different energy prices paid by the plants in different states.

The following two studies discuss the energy intensity of the manufacturing industries in China. The study by Teng 2012 is unique as it attempts to analyse the relationship between indigenous R&D technology, technology imports and energy consumption intensity in China. The usage of R&D to understand the energy efficiency is rare in the literature. The paper used the following variables - energy intensity, R&D expenditure into three: independent, foreign and domestic technology and human capital. The paper used a panel data for 31 industrial sectors. The paper divided the 31 sectors into energy intensive and less energy intensive industries for better analysis. The fixed effect panel model was used. The paper found that independent R&D has a significant negative impact both in the 31 industrial sector and the high energy consumption intensity sector. Foreign technology has a negative effect only on the aggregate industrial sector. Human capital is found to have a negative effect on all groups of industries. The interaction of independent R&D and foreign technology in the aggregate industrial dataset is significantly negative, but is insignificant for the categories of high and low energy industrial groups. The paper also finds that increasing the purchase of the domestic technology will not help in decreasing the energy intensities in the categories. The interaction between independent R&D and purchase of domestic technology is significantly negative for the 31 industrial sectors but not for the categories. He *et al* in 2012 analysed the relationship between energy consumption, economic growth and foreign direct investment in Shanghai. The paper used GDP, FDI and energy consumption. The VAR model is used for analysing the relationship between the variables. The paper found that an increase in economic growth and energy consumption causes FDI. The generalised impulse responses reveal that the initial impact of energy use on output not only is slightly higher, but it also lasts longer than FDI.

## Theoretical framework

There are various mechanisms adopted across the world to reduce pollution and environmental degradation. These can be largely categorised into – institutional, command and control and economic mechanisms. The three major instruments that fall under the domain of institutional mechanisms are bargaining, principle of liability and social responsibility. The command and control mechanism includes input controls, technology controls, output quotas and emission licences. The current work moves in depth with the economic instruments with regard to PAT. The major economic instruments are taxes, subsidies and marketable emission permits. PAT falls under the purview of the marketable emissions permit. It is a cap and trade policy. The trading doesn't alter the quantity of the permits, rather it redistributes the same between the firms. The current work attempts to understand how the policy initiative of PAT impacts the energy intensity of the cement industry.

Another theory that is applicable to PAT is the principal-agent theory. Here the principal is the government or BEE and the agents are the designated consumers. The principal aims at reducing the energy intake of the industries and provides them the incentive of energy saving certificates for the same. On the other hand it is for the firms – agents, to adopt different mechanisms to maximise their gains keeping in mind the reduction of energy intake. The principal agent problem revolves around how best to get the agents to act according to the principal, in our case how best can BEE make the designated consumers reduce their energy intake. It is also important to understand if the compensation provided to the DCs in the form of Energy Saving Certificates is sufficient or not. This aspect will be better understood after the trading of the first phase takes place.

## Data and methodology

The current paper attempts to evaluate the impact of PAT on the cement and iron and steel industries in India. For this purpose, the data has been collected from the PROWESS database of CMIE. The data has been collected for a period of nine years, 2007-2015. The time period from 2007-2011 is taken as the pre-policy period and that of 2012-2015 is the policy period. This categorisation is based on the year PAT policy was introduced - 2012. In the current analysis, the designated consumers are used as the treatment group and the non-designated consumers are used as the control group. The analysis is divided into two: a descriptive and panel analysis. They have been done separately for the two industries and the comparisons are made thereafter.

## Variable selection

### Cement industry

For the cement industry, data has been collected for 45 firms. Of the 45 firms, 27 firms are designated consumers (covering nearly 85 per cent of the cement firms under PAT) falling under the PAT policy, and the remaining 18 belong to the category of non-designated consumers (have no obligation to reduce their specific energy consumption). The study selects the variables on the basis of their contribution to the output produced and the literature reviewed. The variables selected are: capital, age, sales (taken as proxy for the size of the firm), output (sales summed up with stock of finished goods) and fuel and power (taken as the proxy for energy).

**Table 2: Variables and their unit of measurement**

| S.No | Variable | Unit of measurement | Proxy | Deflator |
|---|---|---|---|---|
| 1 | Year of incorporation | Years | Age of the firm | - |
| 2 | Total capital | Rupees | Capital | Perpetual inventory method<br>WPI: Machinery and machine tools |
| 3 | Expenditure on power and fuel | Rupees | Energy | WPI: Power and fuel |
| 4 | Sales | Rupees | Size of the firm: dummy variable – small, medium and large firms | WPI: Cement and lime |
| 5 | Sales | Rupees | Sales and change in stock of finished goods is added to get output. | WPI: Cement and lime |
| 6 | Change in stock of finished goods | Rupees | | |
| 7 | PAT firm | Dummy variable, representing DCs and NDCs | | |
| 8 | PAT year | Dummy variable, representing pre PAT and PAT period | | |
| 9 | PAT firm*PAT year | Interaction dummy, representing DCs behaviour in PAT period | | |

*Source*: Author's construct

## Variables

All the variables except the dummy variables have been extracted from the PROWESS database, for the time period 2007-2015.

## Dependent variable

Energy intensity: In the current work, energy intensity is the dependent variable which has been calculated by dividing energy by the output. The expenses on power and fuel is taken as a proxy for energy and output is calculated by adding the sales and the stock of finished goods. Both the energy and output are deflated using their corresponding WPI index and then are divided to get the energy intensity. Since the policy initiative of Perform Achieve Trade aims at reducing the energy intake of the energy intensive industry, it is most likely to have the energy intensity as the dependent variable.

$$\boldsymbol{Energy\ intensity = Energy/Output}$$

## Explanatory variables

Capital intensity: Capital has been taken as an important explanatory variable. The perpetual inventory method is used to adjust the capital. This is done as capital cannot be simply deflated by a corresponding WPI index. As capital is accrued along the years and are recorded in the prices of the year it is bought in, it is incorrect to adjust the same to its corresponding WPI index. The values available as capital are based on the book value; therefore, capital cannot be treated as other variables. The benchmark is selected on the basis of two criteria: an early year and for that year maximum number of firms must have the data. The two main assumptions of the perpetual inventory method are: price of capital changes at a constant rate and investment every year grows at a constant rate. The average annual growth rate of the WPI index is used as the growth in the price of capital and the average annual growth rate in the GFCF across the years is taken as the growth in the investment. The capital is then adjusted using the ratio of the replacement cost and the historical cost. This gives us the multiplier used to adjust the capital. Further, in the current analysis, depreciation is considered to be '0'. This is so because in the Indian context, the machines are regularly maintained and repaired. As this cost has already been taken into account, considering depreciation will lead to the problem of double counting. Once the capital is adjusted with the perpetual inventory method (using the multiplier), it is then adjusted using the WPI index of machinery and machine tools.

In the current case, the year 2000 is selected as the benchmark year. This is because most of the firms have their data available for that year. The formula for the perpetual inventory method is given below:

$$\{[(1+g)^{\gamma}+\mathbf{1}]-\mathbf{1}\}(\mathbf{1}+\boldsymbol{\Pi})^{\gamma}/\{\boldsymbol{g}[(\mathbf{1}+\boldsymbol{g})(\mathbf{1}+\boldsymbol{\Pi})]^{\gamma}+\mathbf{1}\}-\mathbf{1}$$

Where 'g' is the annual average growth rate of GFCF, '$\Pi$' is the annual average growth rate of the WPI index and '$\boldsymbol{\gamma}$' is the 'current year – the bench mark year'. In the current case we take the benchmark year as 2000, and our current year is 2015, therefore $\boldsymbol{\gamma}$ takes the value 15.

**Sales:** Sales is used as a proxy of the size of the firm. The sales is deflated using the WPI index of cement. The moving average of the first three years of the study period (2007-2009) is used to rank the firms for their categorisation into small, medium and large. Dummy variables are used for the size of the firm.

**Age:** Age is yet another explanatory variable which is of significance. Age is calculated using the data on the year of incorporation. The year of incorporation is subtracted from the survey year to get the age of the firm. In the current case, the survey year is 2007-2015. The age plays a vital role as it is suggested by the literature that the older firms tend to be more energy intensive as they would have to incur huge repair and replacement cost in order to bring in clean technology / technology that consumes less energy. The current analysis will help in accepting or rejecting this hypothesis.

**PAT firm:** PAT firm is a dummy variable used to represent the category of the firm: designated consumer or a non-designated consumer. In the current analysis, the dummy variable takes the value 1 if the firm is a designated consumer and 0 otherwise.

**PAT year:** PAT year is also a dummy variable which represents the PAT period and the pre-PAT period. The variable takes the value 1 in the PAT period (2012-2015) and 0 otherwise (2007-2011).

**PAT Interaction dummy:** The current study uses the difference in difference methodology to do the impact evaluation of PAT policy. The interaction dummy of PAT firm and PAT year has been used for the same purpose. The coefficient of this interaction dummy represents the difference in difference estimator. This interaction dummy represents the impact of the designated consumers on the energy intensity in the PAT period (2012-2015).

## Iron and steel industry

The iron and steel industry is one of the eight energy intensive industries under the PAT policy. Under the iron and steel industry, 67 firms have been selected under the PAT policy to reduce their specific energy consumption. The PROWESS database is used to collect the data for analysing the working of PAT for the iron and steel industry in India. A total of 51 firms are selected for the analysis, of which 30 firms fall under the purview of PAT (treatment group) and the remaining 21 firms do not fall under the PAT policy (control group).

**Table 3: Variables and unit of measurement**

| S.No | Variable | Unit of measurement | Proxy | Deflator |
|---|---|---|---|---|
| 1 | Year of incorporation | Years | Age of the firm | - |
| 2 | Total capital | Rupees | Capital | Perpetual inventory method WPI: Machinery and machine tools |
| 3 | Expenditure on raw materials | Rupees | Raw materials | WPI – Average of non- food items and minerals |
| 3 | Expenditure on power and fuel | Rupees | Energy | WPI: Power and fuel |
| 4 | Sales | Rupees | Size of the firm: dummy variable – small, medium and large firms | WPI: Average of steel and sponge iron |
| 5 | Sales | Rupees | Sales and change in stock of finished goods is added to get output. | WPI: Average of steel and sponge iron |
| 6 | Change in stock of finished goods | Rupees | | |
| 7 | PAT firm | Dummy variable, representing DCs and NDCs | | |
| 8 | PAT year | Dummy variable, representing pre PAT and PAT period | | |
| 9 | PAT firm*PAT year | Interaction dummy, representing DCs behaviour in PAT period | | |

*Source*: Author's construct

The selection of variables for the analysis of the iron and steel industry is similar to that of the cement industry. An addition has been made to the explanatory variable for the iron and steel industry

– raw material. The expenses on raw materials is used as a proxy for raw materials. The variable is in the unit of rupees and is deflated using the average of non-food articles and minerals from the WPI.

## Descriptive statistics

The descriptive analysis has been done separately for the two industries. Three-way tables have been used for the analysis, attempting to see the variables performance categorised into designated consumers (DCs) and non-designated consumers (NDCs) in both the time periods - pre and post policy initiative. The pre policy period is of five years: 2007-2011, and the post policy period comprises four years: 2012-2015. The first section of the descriptive statistics analysis deals with the case of the cement industry followed by the iron and steel industry.

## Descriptive analysis of cement industry

The variables used for the descriptive analysis of the cement industry are – age, capital intensity, energy intensity, output and raw material intensity.

**Table 4: Descriptive statistics of age**

| Age | | | | | | |
|---|---|---|---|---|---|---|
| | **No. of Obs** | **Mean** | **S.D** | **Min** | **Max** | |
| Before policy | 135 | 40.4074 | 24.4511 | 4 | 92 | DCs |
| After policy | 108 | 44.9074 | 24.4585 | 9 | 96 | |
| Before policy | 90 | 27.6667 | 18.9144 | 5 | 92 | NDCs |
| After policy | 72 | 32.1667 | 18.9201 | 10 | 96 | |

*Source*: Author's estimation

Table 4 shows the descriptive analysis of age for the cement industry. It is important here to note that while the minimum and maximum age of the DCs and NDCs are similar, the mean age shows that the DC firms are much older than the NDC firms. Two branches of literature exist for age – one group of studies states for the older firms it is difficult to adopt clean technology as they would have to incur huge replacement costs. Contrary to this, the other branch opines that it is the older firms which have sufficient resources to invest in low carbon technologies.

**Table 5: Descriptive statistics of capital intensity**

| Capital intensity | | | | | | |
|---|---|---|---|---|---|---|
| | **No. of Obs** | **Mean** | **S.D** | **Min** | **Max** | |
| Before policy | 135 | .0028 | .0034 | .0001 | .0217 | DCs |
| After policy | 106 | .0021 | .0023 | .0001 | .0137 | |
| Before policy | 88 | .0088 | .0152 | .0001 | .0596 | NDCs |
| After policy | 69 | .0078 | .0156 | 0 | .0689 | |

*Source*: Author's estimation

The descriptive analysis of capital intensity is presented in table 5. In the case of capital intensity, we can see that the mean capital intensity of the NDCs is much higher than the DCs and both the categories experience a downfall in the capital intensity in the post-policy period. It is also important to note that the maximum values of capital intensity for the DCs is lower than the NDCs and is also falling in the post-policy period. In the case of the NDCs, the maximum value of capital intensity is seen to have increased marginally. This can be seen as a spill-over effect of PAT which is helping the DCs firms in using their capital more efficiently.

**Table 6: Descriptive statistics of energy intensity**

| **Energy intensity** | | | | | | |
|---|---|---|---|---|---|---|
| | **No. of Obs** | **Mean** | **S.D** | **Min** | **Max** | |
| Before policy | 135 | .2655 | .0950 | 0 | .51 | DCs |
| After policy | 106 | .2471 | .0879 | .02 | .51 | |
| Before policy | 88 | .2120 | .1336 | .01 | .57 | NDCs |
| After policy | 69 | .20 | .1352 | 0 | .53 | |

Source: Author's estimation

Energy intensity is the most important variable in the analysis of PAT policy. The descriptive analysis results of energy intensity are shown in table 6. Here it is important to highlight that the mean energy intensity of the DCs is higher than the energy intensity of the NDCs. Also it is important to highlight that even after the NDCs having a fewer number of observations, they tend to have a higher standard deviation and maximum energy intensity values in comparison to the DCs.

The higher mean values of energy intensity of the DCs when compared to the NDCs justifies the notion that the BEE has selected the energy intensive units under the PAT policy. Both the DCs and NDCs have experienced a downfall in their energy intensities in the post-policy period. The reasons for this decrease in energy intensity will be zeroed upon after an in-depth analysis of the PAT policy.

**Table 7: Descriptive statistics of output**

| **Output** | | | | | | |
|---|---|---|---|---|---|---|
| | **No. of Obs** | **Mean** | **S.D** | **Min** | **Max** | |
| Before policy | 135 | 2.57e+10 | 3.23e +10 | 1.74e+09 | 1.66e+11 | DCs |
| After policy | 106 | 3.97e+10 | 5.40e+10 | 6.26e+08 | 2.60e+11 | |
| Before policy | 88 | 6.59e+09 | 1.35e+10 | 1.08e+08 | 6.63e+10 | NDCs |
| After policy | 69 | 8.35e+09 | 1.61e+10 | 1.44e+08 | 6.71e+10 | |

*Source*: Author's estimation

Output is an important variable in the current analysis. The PAT policy aims at reducing the energy intensity of the firms that fall under its purview. Even though the PAT policy aims to reduce the energy intake of the firms, this reduction has a direct implication on the output of the firms. In the case of the cement industry, the output can be seen increasing for both the DCs and the NDCs in both the time periods (pre- and post policy).

**Table 8: Descriptive stats of raw material intensity**

| Raw material intensity | | | | | | |
|---|---|---|---|---|---|---|
| | **No. of Obs** | **Mean** | **S.D** | **Min** | **Max** | |
| Before policy | 135 | .1528 | .1389 | .0038 | 1.0934 | DCs |
| After policy | 106 | .1142 | .0468 | .0364 | .2943 | |
| Before policy | 88 | .9246 | 2.6035 | .0126 | 17.7223 | NDCs |
| After policy | 69 | .4489 | 1.0658 | .0102 | 7.5746 | |

*Source*: Author's estimation

Table 8 of the descriptive analysis presents the results of the raw materials for the cement industry. It can be seen here that though in the post-policy period both the DCs and NDCs experience a fall in their raw material intensity, the raw material intensity of the NDCs is much higher than that of the DCs. By this, we understand that the firms under the NDCs, on an average, use more of raw materials as compared to the DC firms.

## Descriptive statistics of iron and steel industry

The variables used for the descriptive analysis of the iron and steel industry are – age, capital intensity, energy intensity, raw material intensity and sales.

**Table 9: Descriptive statistics of age**

| Age | | | | | | |
|---|---|---|---|---|---|---|
| | **No. of Obs** | **Mean** | **S.D** | **Min** | **Max** | |
| Before policy | 150 | 24.4333 | 19.2121 | 2 | 104 | DCs |
| After policy | 120 | 28.9333 | 19.2086 | 7 | 108 | |
| Before policy | 105 | 24.6191 | 12.5364 | 1 | 51 | NDCs |
| After policy | 84 | 29.1191 | 12.5212 | 6 | 55 | |

*Source*: Author's estimation

Table 9 represents the descriptive statistics of age for the iron and steel industry in India. It can be seen that on an average, both the DC and NDC firms are of the same age – 24. Yet it is important to note that the maximum age of the DC firms is double that of the NDC firms. This also reflects in the higher standard deviation of the DC firms in comparison to the NDC firms.

**Table 10: Descriptive statistics of capital intensity**

| Capital intensity | | | | | | |
|---|---|---|---|---|---|---|
| | **No. of Obs** | **Mean** | **S.D** | **Min** | **Max** | |
| Before policy | 150 | .1241 | .2706 | .0058 | 2.8967 | DCs |
| After policy | 120 | .3078 | 1.3245 | .0039 | 10.2217 | |
| Before policy | 105 | .0671 | .0667 | .0041 | .2743 | NDCs |
| After policy | 84 | .0737 | .1098 | .0041 | .7859 | |

*Source*: Author's estimation

The descriptive statistics of the capital intensity for the iron and steel industry is presented in table ten. The capital intensity of the DC firms is found to be much higher than that of the NDC firms. The same trends can be seen in the standard deviation and the minimum and maximum values of the DC and NDC firms. It is important to highlight that on an average, the capital intensity for both the DC firms and the NDC firms can been seen to be on the rise in the post-policy period. This can be justified as the PAT policy puts a cap on the energy intake and not on the capital usage.

**Table 11: Descriptive statistics of energy intensity**

| Energy intensity | | | | | | |
|---|---|---|---|---|---|---|
| | **No. of Obs** | **Mean** | **S.D** | **Min** | **Max** | |
| Before policy | 150 | .0752 | .1525 | .00006 | 1.7683 | DCs |
| After policy | 120 | .0651 | .0792 | .0006 | .5953 | |
| Before policy | 105 | .05171 | .0369 | .0003 | .1984 | NDCs |
| After policy | 84 | .0471 | .0374 | .0007 | .1650 | |

*Source*: Author's estimation

The descriptive statistics of energy intensity for the iron and steel industry is analysed in table 11. Firstly, it is important to note that on an average, the energy intensity of the DC firms is higher than that of the NDC firms. There is definitely a drop in the energy intensity for both the DC and NDC firms: however, the fall is marginal. The same is true in the case of the standard deviation and the maximum values respectively.

**Table 12: Descriptive statistics of output**

| Output | | | | | | |
|---|---|---|---|---|---|---|
| | **No. of Obs** | **Mean** | **S.D** | **Min** | **Max** | |
| Before policy | 150 | 5.43e+10 | 1.03e+11 | 8.75e+07 | 5.95e+11 | DCs |
| After policy | 120 | 7.64e+10 | 1.29e+11 | 3.43e+07 | 5.19e+11 | |
| Before policy | 105 | 1.53e+10 | 1.72e+10 | 1.01e+09 | 7.08e+10 | NDCs |
| After policy | 84 | 2.43e+10 | 3.01e+10 | 3.93e+10 | 1.19e+11 | |

*Source*: Author's estimation

It is evident from table 12 that the output of both the DC and NDC firms is increasing on an average. Also, the descriptive analysis finds that the output of the DC firms is much higher than that of the NDC firms. The same is true in the case of the standard deviation and the maximum values of output respectively. It is also important to highlight that that the minimum values for the DC firms can be seen to fall in the post-policy period: this is not true in the case of the NDC firms. Also, the minimum values of DC firms in both the time periods (pre- and post policy) is much less than that of the NDC firms.

**Table 13: Descriptive statistics of raw material intensity**

| Raw material intensity | | | | | | |
|---|---|---|---|---|---|---|
| | No. of Obs | Mean | S.D | Min | Max | |
| Before policy | 150 | .6208 | .1804 | .1840 | 1.1135 | DCs |
| After policy | 120 | .6270 | .7943 | .1905 | 6.6137 | |
| Before policy | 105 | .7157 | .2459 | .0566 | 1.2939 | NDCs |
| After policy | 84 | .5556 | .2734 | .0445 | 2.3384 | |

Source: Author's estimation

It is interesting to note that initially, the raw material intensity of the NDC firms is higher than that of the DC firms, but in the post-policy period, the NDC firms witness a decrease in their raw material intensity. On the other hand, the DC firms can be seen to show a marginal increase in their raw material intensity.

## A comparison between the cement and the iron and steel industry

Some of the major findings of the descriptive analysis of the cement and the iron and steel industry are discussed below:

1. The most important variable under the PAT policy is energy intensity. In the above analysis, it is found that the cement industry is found to be more energy intensive when compared to the iron and steel industry. On an average, a cement firm under the PAT policy has an energy intensity of .26, this being much higher than that of the iron and steel industry at .07. This finding suggests that on an average, the cement industry uses nearly four times the energy used by the iron and steel industry.
2. In terms of both raw material intensity and capital intensity, the iron and steel industry is way ahead of the cement industry. In the case of raw material intensity, the iron and steel industry uses .62 units of energy to produce an unit of output, while the cement industry uses a mere .11 units of raw material for an unit of output. The iron and steel industry is found to be a capital intensive one when compared to the cement industry – the capital intensity of the iron and steel industry is found to be .12 and that of the cement industry is a meagre .003. Therefore, the iron and steel firm uses approximately five times the raw material that a cement firm uses and 40 times its capital.
3. It is also found that the average age of the firms in the cement industry is 40 and that of those in the iron and steel industry is around 25. By this we understand that the cement industry is much older when compared to the iron and steel industry in India.
4. The descriptive analysis concludes by stating that the cement industry is energy intensive and older than the iron and steel industry. The iron and steel industry is more raw material and capital intensive in India.

## Selection of methodology

The methodology for evaluating the PAT policy is based on the suggestions from the literature and the applicability of the method in the current case. The difference-in-difference (DD) method is used to analyse the impact of a policy on the treatment group when compared to the control group. A paper by Oak and Bansal (2017) used the difference in difference methodology for evaluating the working of PAT for the cement industry in India. The DD method compares the changes between the control group and the treatment group in the first stage It then compares the changes that occurred in the treatment group before and after the intervention. In the DD technique, it is important to have the data for both the prior to the intervention and post it periods for the control and treatment group, while in the current case the data is collected for the period 2007 – 2015 (this time period covers both the pre- and post policy period). The applicability of DD technique is best suited for the current analysis.

# Panel Regression

## Cement industry

Panel regression is used to analyse the impact of PAT policy on the cement industry in India.

**Null hypothesis:** The Perform-Achieve-Trade policy has no impact on the energy intensity of the cement industry in India.

**Alternative hypothesis:** The Perform-Achieve-Trade policy has an impact on the energy intensity of the cement industry in India.

The model that is estimated is as follows:

$$EI\ it = \alpha 0 + \beta 1\ KI\ it + \beta 2\ Age\ it + \beta 3\ D1\ it + \beta 4\ D2\ it + \beta 5\ P.Y\ it + \beta 6\ P.F\ it + \beta 7\ P.Y * P.F\ it + U\ it, RE$$

*EI – energy intensity; KI – capital intensity; D1 – size dummy for medium firms; D2 – size dummy for large firms; P.Y – dummy variable for PAT year; P.F – dummy variable for PAT firm, P.Y*P.F – Interaction dummy (represents PAT firms in the policy period).*

The Hausman test helps in selecting between the Fixed effect and the Random effect (RE) model. In the current analysis, the results of the Hausman test is Prob>Chi$^2$ = .93. In the cases where the value of Prob>Chi$^2$ is lesser than .05, the fixed effect model is selected. Since .93 >.05, the random effect model is selected for the current analysis.

**Table 14: Random effect results**

| Variable | Co-efficient | Std. Error | t value | P value |
|---|---|---|---|---|
| Capital intensity | 1.8344 | 0.7424 | 2.47 | 0.013 |
| Age | 0.0011 | 0.0006 | 2.03 | 0.043 |
| Medium firms | -0.0346 | 0.0311 | -1.11 | 0.266 |
| Large firms | -0.0784 | 0.0357 | -2.19 | 0.028 |
| PAT firm | 0.0860 | 0.0333 | 2.58 | 0.010 |
| PAT year | -0.0197 | 0.0092 | -2.15 | 0.031 |
| PAT interaction dummy | -0.0032 | 0.0113 | -0.29 | 0.775 |
| Constant | 0.1788 | 0.0284 | 6.31 | 0.000 |
| Within $R^2$ - 0.05, B/w $R^2$ - 0.21<br>Overall $R^2$ - 0.18 | | Rho - 0.72 | | |

*Source*: Author's construct

Table 14 presents the results of the random effect model. A random effect two way error component model has been used to understand the impact of PAT policy on the cement industry in India. The two way error component model is used as both the time dummy (PAT year) and the cross section dummy (PAT firm) are found to be significant in the analysis. The variables capital intensity, age and PAT firm have a positive impact on energy intensity. On the other hand, the large firms and PAT year are found to have a negative impact on the energy intensity of the cement industries. The variables medium firms and the PAT interaction dummy are found to be insignificant.

It is found that a unit change in capital intensity leads to a 1.83 unit increase in capital intensity. This finding goes with the findings of Oak and Bansal (2017). In theory, capital intensive firms are supposed to be more energy efficient. This theory holds true in the cases where investments are made in environmental friendly technology. In the current case, it is hard to justify that the capital intensive firms are pro clean technology. The firms which are considered as large have the probability to become more energy intensive as compared to the smaller firms to the tune of .078. This can be justified as it is difficult for the large firms to replace their existing machinery with energy efficient ones. Age is also found to have a positive impact on the energy intensity. This suggests that as the age of a firm increases, they tend to become more energy intensive. This finding of age having a positive impact on energy intensity is contrary to that of Oak and Bansal (2017). Our findings support the theory that states that the older firms are more energy intensive when compared to the young ones. The young firms tend to invest more in environmental technologies while on the other hand the older firms would have to incur heavy replacement costs for the same.

The PAT firm is found to have a significant positive impact on the energy intensity of the cement industry. This is due to the selection of the study time period. The study period consists of nine years, from 2007-2015. PAT firm constitutes the data for the entire study period though PAT was introduced in the year 2012. Prior to 2012, the firms had no obligation to reduce their energy intakes. The period of 2007-2011 tends to dominate the behaviour of the designated consumers when compared to the policy period. The years 2007-2011 have a greater impact on the energy intake of the firms as compared to the PAT years.

PAT year is a dummy variable which takes the value 1 for the period 2012-2015 and 0 otherwise. In the case of the PAT year, there is a significant negative impact on the energy intensity. This suggests that PAT has a negative impact on the energy intensity of the cement industry, thereby helping the firms in becoming energy efficient.

The PAT interaction dummy captures the behaviour of the firms under PAT during the PAT period. The PAT interaction has a negative sign, but is insignificant. This is because the data available on PAT is restricted to three years (2012-2015), and this may not be able to capture the impact of PAT on the cement industry. This finding is similar to that of Oak and Bansal, where the interaction dummy is insignificant.

The $R^2$ for the analysis is found to be .18, implying that 18 per cent of the variations in energy intensity is caused due to the explanatory variables in model and the remaining 78 per cent of the variations in the model are due to the unaccounted variables captured by the error term. Also the rho value is .72, implying that 72 per cent of the variance is due to the differences across the panels. The $R^2$ and the rho values suggest that the model is a good fit.

## Iron and steel industry

A panel regression has been done to evaluate the PAT policy for the iron and steel industry in India. This has been done for 51 firms across the time period 2007-2015. Of the 51 firms, 30 firms fall under the purview of PAT and the remaining 21 firms have no obligation of reducing their specific energy consumption. The PAT policy is evaluated by testing the following null hypothesis using the difference in difference method under panel regression. Two separate models are run to understand the impact of PAT on the iron and steel industry in India. In the first model, age is an explanatory variable with a continuous data. In the second model, the firms are divided into two: young and old (based on their age in the year 2015).

**Null hypothesis:** The Perform-Achieve-Trade policy has no impact on the energy intensity of the iron and steel industry in India.

**Alternative hypothesis:** The Perform-Achieve-Trade policy has an impact on the energy intensity of the iron and steel industry in India.

### Model 1: Analysis with age as a continuous variable

$$EI\ it = \alpha 0 + \beta 1\ KI\ it + \beta 2\ RI\ it + \beta 3\ Age\ it + \beta 4\ D1\ it + \beta 5\ D2\ it + \beta 6\ P.Y\ it + \beta 7\ P.F\ it + \beta 8\ P.Y * P.F\ it + U\ it, RE$$

*EI – energy intensity; KI – capital intensity; RI – raw material intensity; D1 – size dummy for small firms; D2 – size dummy for medium firms; P.Y – dummy variable for PAT year; P.F – dummy variable for PAT firm, P.Y*P.F – Interaction dummy (represents PAT firms in the policy period).*

In the above model, energy intensity is the dependent variable which depends on the capital intensity, age, raw material intensity, size of the firm (small and medium), PAT firm, PAT year and the PAT interaction dummy. Dummy variables are made use of for the size and PAT variables. The interaction dummy of PAT firm and PAT year is used as the difference in difference indicator. In the case of a PAT firm, the dummy takes the value 1 if the firm is a designated consumer and 0 otherwise. For PAT year, the dummy takes the value 1 for the period 2012-2015, 0 otherwise. The interaction dummy represents the behaviour of the designated consumers in the PAT period. The random effect model is selected on the basis of the Hausman test.

The Hausman test helps in selecting between the fixed effect and the random effect model. In the current analysis, the results of the Hausman test is Prob>Chi$^2$ = .98. In the cases where the value of Prob>Chi$^2$ is lesser than .05, the fixed effect model is selected. Since .98 >.05, the random effect model is selected for the current analysis.

Following are the results of the random effect model.

**Table 15: Random effect results**

| Variable | Co-efficient | Std. Error | t value | P value |
|---|---|---|---|---|
| Capital intensity | .0313 | .0021 | 14.94 | 0.000 |
| Raw material intensity | .0411 | .0007 | 56.36 | 0.000 |
| Age | .0005 | .0003 | 1.39 | 0.165 |
| Small firms | -.0338 | .0143 | -2.36 | 0.018 |
| Medium firms | -.3130 | .0145 | -2.15 | .031 |
| PAT year | -.00026 | .0041 | -.06 | .949 |
| PAT firm | 0.0050 | .0121 | 0.41 | .680 |
| PAT interaction dummy | -.0023 | .0050 | -0.46 | .654 |
| Constant | .03370 | .0163 | 2.06 | .040 |
| Within $R^2$ – 0.92, B/w $R^2$ - 0.32<br>Overall $R^2$ - 0.78 | | Rho - 0.71 | | |

Source: Author's construct

The results of the panel regression are presented in table 15. The variables capital intensity and raw material intensity are found to have a significant positive impact on the energy intensity, implying that a unit increase in capital intensity leads to an increase in energy intensity by .03 units. In the case of raw materials, a unit increase in the raw material leads to a .04 unit increase in the energy intensity. This finding of capital intensity having a positive relationship with energy intensity is similar to that of Oak and Bansal (2017). The variable age is found to be insignificant in the analysis. Therefore, no conclusion can be drawn from the findings on age. The insignificance of the age variable is justified as in the descriptive statistics the mean age of the DCs and the NDCs are not significantly different.

Further, it is found that the small and medium firms are more energy efficient when compared to the large firms. This can be justified as replacing the existing machinery with environment friendly technology is the main obstacle for the large firms. The most important finding of the analysis for iron and steel industry is that all the PAT policy variables are found to be highly insignificant. Though the variables PAT year and PAT interaction dummy variable have the required negative signs, no conclusion can be drawn from the same as the coefficients of the variables are found to be highly insignificant.

The $R^2$ is found to be .78, which implies that 78 per cent of the variations in energy intensity are caused due to the explanatory variables in model and the remaining 18 per cent of the variations in the model are due to the unaccounted variables captured by the error term. Also the rho value is .71, implying that 71 per cent of the variance is due to the differences across the panels. The $R^2$ and the rho value suggest that the model is a good fit.

### Model 2: Analysis with age dummies

An attempt is made at running another model that categorises the firms as young and old on the basis of their age. The age of the firm in 2015 is used to categorise the firms. The firms that fall above the mean age in 2015 are categorised as old and the ones that fall below the mean age are categorised as young firms. A dummy variable is used for this categorisation where all the firms that are young take the value 1 and the others take the value 0. The random effect model has been selected on the basis of the Hausman test. In the current analysis, the result of the Hausman test is Prob>Chi$^2$ = .93. In the cases where the value of Prob>Chi$^2$ is lesser than .05, the fixed effect model is selected. Since .93 >.05, the random effect model is selected for the current analysis.

The model is as follows:

$$EI\ it = \alpha 0 + \beta 1\ KI\ it + \beta 2\ RI\ it + \beta 3\ Y.F\ it + \beta 4\ D1\ it + \beta 5\ D2\ it + \beta 6\ P.Y\ it + \beta 7\ P.F + \beta 8\ P.Y * P.F\ it + U\ it, RE$$

*EI – energy intensity; KI – capital intensity; RI – raw material intensity; Y.F – dummy variable for young firms; D1 – size dummy for small firms; D2 – size dummy for medium firms; P.Y – dummy variable for PAT year; P.F – dummy variable for PAT firm, P.Y*P.F – Interaction dummy (represents PAT firms in the policy period).*

**Table 16: Panel regression results with age dummies**

| Variable | Co-efficient | Std. Error | t value | P value |
|---|---|---|---|---|
| Capital intensity | .0313 | .0021 | 14.94 | 0.000 |
| Raw material intensity | .0411 | .0007 | 56.36 | 0.000 |
| Young firms | -.0213 | .0115 | -1.86 | 0.062 |
| Small firms | -.0334 | .0139 | -2.46 | 0.014 |
| Medium firms | -.3132 | .0142 | -2.21 | .027 |
| PAT year | .0019 | .0038 | 0.47 | .638 |
| PAT firm | 0.0023 | .0112 | 0.19 | .849 |
| PAT interaction dummy | -.0023 | .0050 | -0.46 | .643 |
| Constant | .0563 | .0134 | 4.10 | 0.000 |
| Within $R^2$ – 0.92, B/w $R^2$ - 0.35<br>Overall $R^2$ - 0.80 | | Rho - 0.70 | | |

*Source*: Author's calculation

Table 15 presents the results of the second model with age dummies as explanatory variables. The average age of the firms in 2015 was found to be 30. The firms whose age is equal to or above 30 are termed old and the ones less than 30 are termed young. The results of the panel regressions are similar to that of model one except for the result of the age variable. In the current case where age is treated as a dummy variable, it is found that the younger firms have a negative relationship with energy intensity when compared to the older firms. This finding goes with the theory which states that the older firms tend to be less energy efficient. This finding is contrary to the findings of Oak and Bansal (2017), which found that the older firms are more energy efficient. Further, the PAT variables are found to be highly insignificant in model two also.

To further understand the cause of the insignificance of PAT variables, a simple 't' test has been performed.

A 't' test was done for the variable energy intensity in the PAT period, comparing the difference in mean of the DCs and the NDCs. The test has been done individually for the four-year period of the PAT policy (2012-2015). Following are the results of the same:

**Table 17: 't' test – energy intensity**

| Year | P. value | DCs mean | NDCs mean |
|---|---|---|---|
| 2012 | .2525 | .0529 | .0455 |
| 2013 | .0729 | .0512 | .0381 |
| 2014 | .0386 | .0942 | .9463 |
| 2015 | .4294 | .0621 | .0601 |

*Source*: Author's estimation

The 't' test reveals that there exists a significant difference in the means of energy intensity between DCs and NDCs only in 2013. There exists no significant difference between the DCs and NDCs in the other years of the PAT policy. This justifies the findings of the panel regression where the PAT variables are found to be highly insignificant. Therefore based on the results of the panel regression which is supported by the findings of the 't' test, it is found that the PAT policy has no significant impact on the iron and steel industry. The null hypothesis stating that the PAT policy has no significant impact on the energy intensity of the iron and steel industry is accepted.

## Reasons for PAT being ineffective in the case of iron and steel industry in India

In the current analysis, the cement industry is found to be more energy intensive whereas the iron and steel industry is found to be more raw material and capital intensive. In the case of the sponge iron industry, about 60 per cent of the production comes from the states of Chattisgarh, Orissa and West Bengal. The majority of plants here are smaller in capacity and are coal based. The PAT policy covers only the firms whose energy intake is above 30,000 MTOE –the larger plants. Further, the large iron plants use gas and contribute about 30 per cent in the production process (Maharashtra and Gujarat).

Table 18 represents the trend in energy consumption by the cement and the iron and steel industries in India. It is evident that the cement industry has been able to check its energy consumption well ahead of the introduction of the PAT policy. It has been successful in reducing both its heat consumption and power consumption since the 1950s.

**Table 18: Energy consumption by cement and iron and steel industry**

| Production of Sponge Iron (million tonnes) | | | | | | |
|---|---|---|---|---|---|---|
| **Year** | **2005-06** | **2006-07** | **2007-08** | **2008-09** | **2009-10** | **2010-11** |
| Coal based | 10.28 | 13.08 | 14.53 | 15.53 | 18.18 | 20.92 |
| Gas based | 4.54 | 5.26 | 5.84 | 5.52 | 6.15 | 5.19 |
| Total | 14.82 | 18.34 | 20.37 | 21.09 | 24.33 | 26.71 |
| **Cement industry** | | | | | | |
| **Parameter/Yr** | | **1950-60** | **1970's** | **1980's** | **1990's** | **Post 2000** |
| Heat consumption (Kcal/kg clinker) | | 1300-1600 | 900-1000 | 800-900 | 650-750 | 650-750 |
| Power consumption (KWh/T of cement) | | 115-130 | 110-125 | 105-115 | 95-105 | 80-100 |

Source: Shakti Sustainable Energy Foundation (SSEF) and CII, 2013

Contrary to this, the iron and steel industry uses coal for its energy source and this dependence has been increasing continuously. The usage of gas has witnessed only a marginal increase. Therefore, it is evident that the cement industry is successful in moving on the efficiency path when compared to the iron and steel industry.

# Findings and conclusion

## Findings

In the case of cement industry, the study finds a positive relationship between capital intensity, age and PAT firm with energy intensity of the cement industry. The positive relationship between capital and energy intensity is justified as it is known that capital (machinery) requires more energy. Therefore, any increase in capital would lead to an increase in the energy intensity. Age has a positive relationship with energy intensity in the cement industry. This is due to the fact that the older industries have to spend a lot on the repairing and replacing of the machinery with the new environment-friendly technology. This phenomenon often acts as a discouragement for the firms to move towards energy efficiency.

The large firms and PAT year are found to have a negative impact on the energy intensity of the cement industries. This finding is justified as it is the large firms which have enough resources to invest in new technology which helps them in becoming energy efficient. In the case of medium and small firms, they lack resources for the same. The case of the PAT year having a negative sign implies that PAT has a negative impact on the energy intensity of the cement industry. Therefore, the null hypothesis that the Perform-Achieve-Trade policy has no impact on the energy intensity of the cement industry in India is rejected.

The variable medium firms and the PAT interaction dummy are found to be insignificant. The PAT interaction dummy captures the behaviour of the firms under PAT during the PAT period. The PAT interaction has a negative sign, but is insignificant. This is because the data available on PAT is restricted to three years (2012-2015), and this may not be able to capture the impact of PAT on the cement industry. This finding is similar to that of Oak and Bansal, where the interaction dummy is insignificant. The $R^2$ for the analysis is found to be .18, implying that 18 per cent of the variations in energy intensity is caused due to the explanatory variables in the model and the remaining 78 per cent of the variations in the model are due to the unaccounted variables captured by the error term.

In the case of the iron and steel industry, the first model finds variables capital intensity and raw material intensity to have a positive relationship with the dependent variable – energy intensity. This implies that any increase in capital and raw material intensity leads to an increase in the energy intensity of the iron and steel industry. The variables medium and small firms are found to have a negative relationship with energy intensity when compared to the large firms. The PAT variables are found to be highly insignificant. Further, the rho value and $R^2$ prove the model to be a good fit. The 't' test supports the findings of the panel regression. The results suggest that the PAT policy has no significant impact on the energy intensity of the iron and steel industry in India.

The second model divides the firms into young and old based on the age. The analysis finds that the young firms are significantly more energy efficient than the older firms. This finding is justified - in theory the older firms are found to be more energy intensive as compared to the newer ones. The coefficients of the other variables are found to be similar to the first model.

## Conclusion

The paper attempts to analyse the working of PAT for the cement and iron and steel industries in India. In the case of the cement industry, the variables PAT firm and PAT year are found to be significant. The PAT year has a negative sign which suggests that PAT did have a positive impact on the energy efficiency of the firm – it helps in the reduction of energy intake. Contrary to this, in the case of the iron and steel industry, the PAT variables are highly insignificant. The findings of a 't' test for energy intensity comparing the DCs and NDCs suggest that there doesn't exist a significant difference in the means of energy intensity across the PAT years (2012-2015), except for the year 2013. The reasons for PAT being ineffective for the iron and steel industry will be probed in future work.

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