Has Perform-Achieve-Trade Policy Improved Energy Efficiency of Indian Industries? Case of Cement, Fertilizer and Pulp & Paper Industries

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Abstract: India adopted a Cap and Trade in energy intensity via a scheme called Perform-Achieve-Trade (PAT) with the objective to improve energy efficiency of the high energy intensive industries through target setting and tradable energy saving certificates. The scheme was announced in 2007 and the first cycle runs from April 2012-March 2015. This is the first market based instrument adopted in India to achieve environmental protection. Under this scheme, the Bureau of Energy Efficiency identified eight most energy intensive industries, and within each of these industries it identified the most energy intensive plants and assigned them Energy Intensity (EI) targets. Firms exceeding their targets were given ESCerts which could be traded in Indian Energy Exchange and Power Exchange of India. This paper aims to examine effectiveness of the PAT scheme on inducing firms to reduce energy intensity of Cement, Fertilizer, and Pulp and Paper Industries. We use panel data for firms in the three industries with a difference-in-difference model to estimate the average treatment effect of the PAT scheme on firms that were assigned targets. We find that the PAT scheme was effective in improving energy intensity of firms in the cement and fertilizer industry, but not in the pulp & paper industry. Further, the scheme resulted in a decrease of power & fuel expenditure in the two industries, which in turn amounts to reduction of 13.17 million tC and 1.37 million tC for the cement and fertilizer industries respectively.

Key Words: Carbon emissions, Cement, Energy Intensity, Fertilizer, India, Market based instruments, Perform-Achieve-Trade, Pulp and Paper

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1. Introduction

Concerns about climate change and sustainability have generated global awareness and initiatives towards using cleaner energy and also reducing its use. Developing countries, however, find it difficult to reduce their energy consumption as it plays a vital role in the social and economic development of their countries. A challenge before developing countries is to achieve twin objectives of economic growth and environmental protection. Long term solutions include moving to renewable energy or cleaner energy. But in the short run, one way to reduce environmental deterioration associated with economic growth is to use energy more efficiently. Improving energy efficiency is also one of the goals of United Nations Sustainable Development Goals.

India, one of the largest and fastest growing economies of the world, with an average growth rate of approximately 7% in the last two decades is also the world's third largest consumer of primary energy after China and USA (BP Statistical Review, 2016). The country's energy basket is dominated by fossil fuels like coal, oil and natural gas (75% in 2015 as per World Bank data), which are highly emission intensive. The share of renewable energy like wind, solar power, etc. is only 2% and nuclear power is only 1% (Energy Statistics, Government of India, 2013).

Globally, various policy measures have been used to reduce emissions. While the developed countries have used market based instruments such as emission trading programmes, the developing countries have largely depended on command and control mechanisms to reduce emissions. The command and control environmental regulations are inflexible and costly. Further, most of the adopted policy measures target reduction in emissions and do not focus on increasing the efficiency in energy use.

India has introduced a unique program called Perform-Achieve-Trade (PAT) that aims at improving energy efficiency of its industrial sector. PAT is also the first market based instrument in India to achieve environmental protection. This program is a *Cap & Trade in Energy Intensity* with the objective to improve energy efficiency of the high energy intensive industrial units through target setting and tradable energy saving certificates. The scheme was announced in 2007 and the compliance period for the first phase was from April 2012-March 2015. The government plans to implement more phases of the PAT scheme in future[1]. For the

[1]The second phase has already been announced and the period of implementation is from 2016-17 to 2018-19.

first phase of the scheme, the Ministry of Power, and Bureau of Energy Efficiency have 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). The DCs are industrial units with energy consumption higher than a threshold level (varying across industries). PAT scheme set a mandatory Energy Intensity (EI) target for each DC. If the reduction in EI achieved by a designated consumer by the end of the compliance period surpasses its target, it will be issued energy saving certificates or ESCerts. DCs that are unable to meet their targets will have to buy the ESCerts. 1 ESCert equals 1 toe worth of energy consumption. These certificates can be traded in the Indian Energy Exchange and Power Exchange of India. The focus of the PAT scheme on the industrial sector is important as the industrial sector is the highest consumer of commercial energy in India and contributes significantly to GDP, around 26%. In 2015-16 national energy consumption in India was 519,286 ktoe out of which the share of the industrial sector was 57% (Energy Statistics, Government of India, 2017).

The PAT scheme would also contribute towards meeting India's commitment in international negotiations. India has pledged for domestic actions to reduce emission of greenhouse gases and creating clean energy and sustainable environment for its population in the recently ratified COP21 Paris agreement on climate change in the year 2016. It has committed to reduce emission intensity of GDP by 33-35% by 2030 compared to 2005 level.

This paper aims to examine the additional energy efficiency gain that has been achieved by the first phase of the PAT scheme in three of the highly energy intensive industries identified under it, namely, Cement industry, Fertilizer industry, and Pulp and Paper industry over the compliance period April 2012 - March 2015. The PAT scheme provides a natural experiment to examine the effects of being classified as Designated Consumers on energy efficiency of firms in years 2012 – 2015 relative to their energy intensity prior to the PAT scheme and relative to firms that are not classified as Designated Consumers. We examine the average treatment effect of PAT scheme on energy intensity of firms.

In the past India had attempted to improve energy efficiency of the industrial sector through various voluntary measures, for instance, The Fuel Policy Committee, 1970, recommended substitution of oil by coal and electricity; The Petroleum Conservation Research Association, 1978, promoted R&D in fuel efficient technologies; Energy Management Centre, 1989, was set up to strengthen energy saving initiatives; Energy Conservation Award, 1991 encouraged industries to adopt energy efficient measures. All these measures were voluntary in nature and not legally binding. The Energy Conservation Act was formulated in 2001 to devise government policies for energy conservation that would include penalties for non-compliance. The Act listed fifteen energy intensive industries as designated consumers. These are Aluminium, Fertilizers, Iron and Steel, Cement, Pulp and paper, ChlorAkali, Sugar, Textile, Chemicals, Railways, Port Trust, Transport Sector (industries and services), Petrochemicals, Gas Crackers, Naphtha Crackers and Petroleum Refineries, Thermal Power Stations, hydel power stations, electricity transmission companies and distribution companies, Commercial buildings or establishments (The Gazette of India, Ministry of Law, Justice and Company Affairs, 2001). Bureau of Energy Efficiency (BEE) was set up under this act to reduce energy intensity of the economy through market based instruments. BEE launched the PAT scheme, which requires firms to mandatorily meet the energy intensity reduction targets. The first phase of the scheme is implemented for eight out of the fifteen industries identified under the Energy Conservation Act. Our paper, therefore, also contributes to the literature that compares voluntary versus mandatory regulation in the context of environmental protection.

A large number of countries have used Cap and Trade in emission permits to reduce carbon emissions. A number of studies have assessed success of these programs. Some of the well known Cap and Trade in emissions programs include the Acid Rain Program in the US under the Clean Air Act 1990, European Union's Emission Trading Scheme started in the year 2005, New Zealand's Emission Trading Scheme launched in 2008, South Korea started its cap and trade in emissions permit program in 2015, etc. (Emission Trading Worldwide, ICAP, 2015). Brannlund et al. (1998) develop theoretical models with and without potential emissions trading for Swedish Pulp and Paper Industry. The paper compares industry profits with and without tradable permit system and apply the models to data for 41 pulp mills for the period 1989-90. It finds that the industry would have obtained 6% higher profits in 1989 and 1% higher profits in 1990 if emission trading had been allowed between firms. Globally, the largest example of permit trading is that of EU's Emission Trading Scheme that is already into its third phase. Many papers critically examine the strengths and weaknesses of the previous two phases (Bohringer, 2002; Sijm et al., 2005 and Sijm et al., 2006). Besides EU, Japan has also implemented the emission trading programme. Tokyo Metropolitan Government's emission trading scheme was implemented in 2010 to reduce emissions by 25% below 2000 level by 2020 (World Bank Report, 2010). The programme was implemented in phases and was successful mainly because it focussed on selected facilities. Although the PAT scheme is a Cap and Trade scheme, it differs from the Cap and Trade in emissions in an important way - it targets energy intensity and allows for trade in energy saving certificates.

A number of studies have examined factors influencing energy intensity of firms in the context of developed countries. Factors such as technological development, indigenous R&D expenditure and technological spillovers through FDI may reduce energy intensity. Erdem (2012) estimates the effect of FDI on technology determined energy efficiency using a macro level fixed effects model for 13 European Union countries for the years 1997-2007. Hubler and Keller (2009) also use macro level data to study the impact of FDI on the energy intensities of developing countries. They have taken a panel data sample of 60 developing countries for a period 1975-2004. But the overall results were found to be ambiguous across nations. The above papers do not find any evidence of transfer of energy saving technology via FDI. Yang et al (2012) examine if FDI diffuses energy saving technology into the host country taking micro level panel data of Indonesian manufacturing firms for years 1993-2009. The paper finds that only clean FDI (i.e., foreign firms with more energy saving than the industry average) will contribute towards improving energy intensity of domestic firms. Kepplinger et al (2013) estimate a mixed effects model to identify the factors that influence the energy intensity in the manufacturing sector for a set of countries for the year 2009. Both GDP and population were found to have a negative relationship with energy intensity. R&D that specifically focuses on developing energy saving technology may reduce energy intensity. Sultan (2012) finds that firms that spend more on R&D have a higher energy intensity. This could be because R&D in these firms focuses on product development rather than energy saving technology. Teng (2012) analyses the effect of indigenous R&D on the energy intensity of Chinese industries. The study is based on a panel analysis of 31 industrial sectors for the period 1998-2006. The estimation results from a fixed effects model shows that indigenous R&D significantly improves the energy intensity of the 31 sectors as a whole and high energy consuming sectors, but has no effect on the low energy consuming sectors. For China, there is evidence that FDI led to a fall in energy consumption through the technology effect (Lei et al, 2012; He et al, 2012).

Evidence from the Indian manufacturing sector suggests that large sized firms and newer firms were more energy efficient than small sized firms and older firms, respectively. A rise in foreign exchange expenditure on royalty and technical fees per unit sales helped in improving energy efficiency of firms (Goldar, 2010). Also significant amount of energy efficiency spillover was found from foreign to domestic firms (Goldar, 2010; Sahu and Narayanan, 2011).

Soni et al (2017) examine how outsourcing affects energy intensity of Indian manufacturing industries for the years 2005-2015. They find a positive relationship between outsourcing intensity and energy intensity for the cement industry, a negative relationship for the fertilizer industry and no effect on the pulp & paper industry.

Dasgupta and Roy (2017) analyse trends in energy intensity for seven out of the eight industries identified under the PAT scheme in the pre-PAT period (1973-74 to 2011-12) and find energy intensity to decline for all seven industries and the rate of decline was the highest for fertilizers and the lowest for pulp and paper.

The above studies have examined the factors influencing energy intensity of firms and industries in India, but none of them have analysed the impact of the PAT scheme on energy intensity of Indian industries. This is the first paper that estimates the causal effect of the PAT scheme on energy intensity of firms in the Indian industries. The analysis has been done for three industries: cement, fertilizer, and pulp and paper industries. India has introduced market based instruments for environmental protection for the first time through PAT scheme. Thus the study not only contributes to the energy efficiency literature but also to the literature on market based policy instruments for environmental protection in the context of developing countries. Since BEE plans to implement more phases of the PAT scheme in coming years, the results from our study would be useful in guiding implementation of future phases of the PAT scheme.

For the analysis, we use a panel data for the firms in cement, fertilizer, and paper and pulp industries for the period 2004-5 to 2014 -15[2]. Within the Indian industrial sector, cement is the third largest consumer of energy and second largest emitter of carbon dioxide (IEA 2011). Fertilizer industry is important for the economy as it is directly integrated with the agricultural sector. Pulp and paper industry is one of the fastest growing sectors in India, with very high energy consumption as per global standards.

We have 86 unique firms in the cement industry (giving us 946 observations), 60 unique firms from the fertilizer industry (giving us 660 observations) and 210 unique firms from the pulp and paper industry (giving us 2310 observations). The data has been sourced from the ProwessIQ database.

[2]Although the PAT scheme has been implemented on eight industries, due to data availability we have been able to do empirical analysis for only three industries, viz., cement, fertilizers, and pulp & paper.

We apply a difference-in-difference approach to estimate the average treatment effect of being categorized as being DC to comply with the PAT Scheme after 2011. From the estimated coefficients, we compute reduction in carbon emissions due to the PAT scheme. The key finding of our analysis is that the PAT scheme resulted in reducing energy intensity of the designated consumers in both cement and fertilizer industries, but not for the firms in the pulp & paper industry. We find that carbon emissions fell by approximately 13.17 million tonnes of carbon (tC) by the end of the compliance period of the PAT scheme for the cement industry and by 1.37 million tC for the fertilizer industry.

The rest of the paper is organized as follows. The next section provides a background to the PAT scheme. It is followed by a section on empirical methodology and description of variables used in the model. Section 4 describes the sample data and the summary statistics, and presents the empirical results. The last section summarizes the broad findings of the paper.

2. Background on the Perform-Achieve-Trade Scheme, and the Considered Industries

PAT is the first tradable permit scheme implemented in India. The scheme is *Cap & Trade in Energy Intensity* with an objective to improve the energy efficiency of the high energy intensive industries through target setting and tradable energy saving certificates. The scheme was announced in 2007 and the first cycle of compliance runs from April 2012-March 2015. Under this scheme, the Ministry of Power and BEE identified eight most energy intensive industries, viz., Thermal Power Plants, Fertilizer, Cement, Pulp and Paper, Textiles, Chlor-Alkali, Iron & Steel and Aluminium. It aimed at achieving an energy saving target of 6.686 million tonnes of oil equivalent (Mtoe) by the end of the compliance period. This target was divided between the eight identified industries. Within each of these industries highly energy intensive plants were identified and called Designated Consumers (DCs). Specific Energy Consumption (SEC) targets, defined as the ratio of net energy input into the DCs boundary to total output exported from the DCs boundary measured in tonnes of oil equivalent per unit of output, were set for each DC. BEE set up a technical committee that calculated SEC in the baseline and target years covering different forms of energy input used by the designated consumers in the production process and normalising it by taking into account capacity utilisation, mix of grid and captive electricity, and any other factor which affects energy consumption (PAT, Ministry of Power, Government of India, 2012). SEC in the baseline year is the average of SEC figures in the years 2007-08, 2008-09 and 2009-10. The calorific value of all forms of energy were converted to tonnes of oil equivalent (toe) using the conversion formula specified by the Ministry of Power, Government of India. The technical committee submitted its report to the BEE, which then submitted it to the central government with its final recommendations. The central government established the energy consumption norms and standards for each designated consumer.

At the end of the compliance period, accredited energy auditors verified if the designated consumers complied with the energy consumption standards. For enforcement, designated consumers were required to submit Form A or the Performance Assessment Document. The accredited energy auditor would then verify Form A and submit a certificate of verification through Form B to BEE. The energy auditor would determine if the designated consumer is required to buy ESCerts or receive ESCerts to sell. 1 ESCert equals 1 toe worth of energy consumption. These certificates would be traded in the Indian Energy Exchange.

BEE has identified 85 plants from 42 cement firms, 29 plants from 17 fertilizer firms, and 31 plants from 26 pulp and paper firms as designated consumers. For all the three industries, any plant that has energy consumption greater than 30000 toe, is specified as designated consumer.

Within the Indian industrial sector, cement is the third largest consumer of energy and second largest emitter of carbon dioxide (IEA 2011). Cement industry is highly dependent on fossil fuels as coal and thermal electricity are the principal energy inputs. The share of energy in total cost is as high as 40% in some cement plants, while the share of coal is 15% to 20% of the total cost (CSTEP 2012). Of the total energy saving target for the eight industries, 12.2% of the target has to be met by the cement industry, which implies an energy saving target of 0.816 Mtoe under PAT cycle I. An analysis of the data from the PAT booklet (PAT, Ministry of Power, Government of India, 2012) shows that for the cement industry the average SEC in the baseline year is 0.188 toe/ton of cement and the target year is 0.174 toe/ton of cement. The percentage reduction in SEC from the baseline year to the target year is approximately 5%.

The fertilizer industry is one of the most energy intensive sectors in the country, with the cost of feedstock and fuel accounting for 55% - 80% of the total cost of production. Energy is consumed in the form of natural gas, naphtha, fuel oil, low sulphur heavy stock and coal. The energy consumption and energy intensity is the highest for urea, where the cost of energy varies between 65% - 87% of production cost. Fertilizer industry has to meet 7.15% of the energy saving target under PAT Cycle-I, which means energy saving of 0.478 Mtoe.

For the pulp and paper industry, energy costs account for nearly 25% of paper manufacturing cost due to its dependence on conventional technologies of production. The main source of energy is coal, with a share of more than 50% of the total energy consumed, followed by electricity. The other energy inputs used in this industry are low sulphur heavy stock, furnace oil, light diesel oil, and high-speed diesel oil are used for steam generation and captive power generation. For this industry, the energy saving target is 0.119 Mtoe under the first PAT cycle, which is 1.8%of the energy saving target of the BEE.

3. Econometric Methodology and Model Specification

We have used difference-in-differences methodology to evaluate the impact of the PAT scheme on the energy intensity of firms. First we estimate a model that includes all the firms in the data set and has dummy variables for the three industries. We then estimate the effect of the PAT scheme on each of the three industries, separately. In both set of regression models, designated consumers, i.e., the firms that have been identified by BEE for the implementation of the PAT scheme, comprise the treatment group, and all the remaining firms in the industry constitute the control group, termed as non-DCs. We estimate the differential impact of the PAT scheme on DCs relative to their energy intensity before the implementation of the scheme, and relative to non-DCs in each industry. We estimate a fixed effects model to control for time invariant effects that differ across firms but remain constant overtime to take care of any omitted variable bias. We also control for time variant year fixed effects. Our model specification is

$$EI_{i,t} = \alpha_i + \lambda_t + \beta_0 + \beta_1 PATyear + \beta_2 (PATyear * PATfirm) + \beta_3 X_{i,t} + \epsilon_{i,t}$$

where $EI_{i,t}$ is the energy intensity of firm i in the year $t = 2004 - 05, \ldots\ldots, 2014 - 15$. $X_{i,t}$is the vector of time varying individual characteristics for firm i at time t such as per unit capital investment, per unit R&D expenditure, per unit imports, etc., that affect its energy intensity. α_i and $\lambda_t$are the time invariant firm, and year fixed effects, respectively. $\epsilon_{i,t}$ is the random error term. *PATyear* is a dummy variable that takes value 1 for years 2012 and 0 otherwise, *PATfirm* is a dummy variable that takes value 1 for the DCs and 0 otherwise. The parameter $\beta_2$is the average treatment effect of the PAT scheme on DCs over the period 2012 – 2015, the implementation period of the scheme.

The key assumption in the difference-in-differences methodology is the parallel trends assumption. The assumption requires the energy intensity of the treatment and control groups to follow the same time trend in the pre-treatment period. We estimate a model with leads to analyse pre-treatment trends.

$$EI_{i,t} = \alpha_i + \lambda_t + \beta_0 + \beta_1 PATyear + \sum_{j=-m}^{0} \beta_j (PATyear * PATfirm)_{t+j} + \beta X_{i,t} + \epsilon_{i,t}$$

where there are m leads (leading to the policy). β_j is the coefficient of the j^{th}lead. A formal test of the difference-in-differences assumption is $\beta_j = 0 \; \forall \; j < 0$,i.e., the coefficients of all leads should be equal to 0. Leads very close to 0 would imply no evidence of anticipatory effects, which means the difference-in-differences estimator is not significantly different between the treatment and control groups in the pre-treatment period. This supports the parallel trends assumption. Autor (2003) includes both leads and lags in a difference-in-differences model to analyse the effect of increased employment protection on the firm's use of temporary help workers.

Dependent and Independent Variables

We now define variables used in our regressions.

Energy intensity is a measure of efficiency with which energy is utilized and thus can be treated as a proxy for energy efficiency (United Nations Sustainable Development Goals, 2018). Energy intensity is defined as energy supplied to the economy per unit value of economic output (Freeman et al., 1997; Energy Statistics, Government of India, 2017; Office of Energy Efficiency and Renewable Energy, U.S. Department of Energy).

BEE has defined SEC in physical units measuring it in metric tonne of oil equivalent. Due to lack of availability of data in physical units, we use the ratio of power &fuel expenditure to total sales (in monetary units) as an indicator of SEC. We term it as energy intensity (EI) and it is the dependent variable in our regression model. This definition is used in a number of studies on India (Dasgupta et al., 2012; Dasgupta and Roy, 2017; Sahu and Narayanan, 2011). The advantage of defining energy intensity this way is that it can be used for any aggregate industry group producing a range of outputs (Dasgupta and Roy, 2017). Therefore we define our dependent variable energy intensity as follows:

$$EI = \frac{Power \,\&\, Fuel\ expenditure\ (Rs.Million)}{Total\ Sales\ (Rs.Million)}$$

Both Power & Fuel expenditure and Total Sales are converted in constant prices by using appropriate whole sale price indices (with 2004-05 as the base year) published by the Office of the Economic Advisor, Government of India.

Power and Fuel expenditure is defined as the cost of consumption of energy for carrying out the business of a company (ProwessIQ Database Dictionary). This includes the cost of consumption of coal, electricity, petroleum products such as diesel, naphtha, etc., and other sources of energy. Total Sales is defined as regular income generated by companies from clearly identifiable sale of goods and from non-financial services, where regular income excludes income of prior periods and income from extra-ordinary transactions.

PATyear is a year dummy that takes value 1 for the compliance years of the PAT scheme, i.e., 2012-13 to 2014-15 and takes value 0 for the other years i.e., 2004-05 to 2011-12.

PATfirm is firm level dummy that takes value 1 if the firm is a designated consumer and equals0 if the firm is a non-designated consumer.

The primary explanatory variable of interest is the interaction between *PATyear* and *PATfirm* i.e., (*PATyear***PATfirm*). The coefficient of the interaction term (*PATyear***PATfirm*) is the difference-in-differences estimator or the average treatment effect. A negative value for the coefficient implies that the energy intensity of the designated consumers is lower than the energy intensity that would have been in the absence of government intervention through the PAT scheme. The other firm level characteristics that influence energy intensity of the firms from the three industries included in the paper have been described as follows.

Per unit capital investment-This variable indicates pace of new investment, and is measured as a change in gross fixed assets between periods t and $t-1$ as a proportion of total sales.
If the new investment is undertaken in more energy efficient technologies, the faster the pace of new investment the quicker would be a decline in energy intensity. Thus we hypothesize that EI is declining in per unit capital investment.

Per unit imports - This is defined as the ratio of Imports (Rs million) to Total Sales (Rs million). Imports include imports of raw materials, capital goods and foreign exchange spending on royalty and technical know-how. Trade may contribute to improving energy intensity of the recipient country through technological spillovers, thus, we hypothesise that per unit imports may have a positive impact on improving energy intensity. Missing observations on imports are taken to be 0, i.e., the firm is not making any imports that year.

Research & Development (R&D) intensity– This is defined as the ratio of R&D expenditure (Rs. million) to Total Sales (Rs. million). R&D intensity is an indicator of the innovativeness of the firm. We hypothesize that firms that are more innovative would bring about a greater reduction in energy intensity of their production process. We lag the variable by one period because R&D expenditure undertaken in period $t$is likely to influence energy intensity only after a lag.

Size of the firm– Larger sized firms have more resources to invest in better technology and to modernize their units and can also collaborate with foreign firms. We use log of gross fixed assets as a proxy for size variable. Goldar (2010) uses log of sales to represent size of the firm. Sahu and Narayanan (2009) define size as log of energy consumed. Since we use both energy consumption and sales to define our dependent variable, we cannot use either of them to define the size of the firm.

Ownership of the firm– This is a dummy variable that takes value if the firm is a private enterprise and 0 if it is a government enterprise (this includes firms belonging to Central government, State government, Co-operative sector). This is to examine if organisation type has any relationship with energy intensity.

Per unit outsourcing - Outsourcing is the practice of transferring a part of the job to other enterprises instead of doing it internally. This variable is defined as the ratio of outsourced manufacturing jobs (Rs. million) to Total Sales (Rs. million). This only includes the expenses incurred by a firm for getting their manufacturing requirements done by other enterprises. To comply with the mandatory reduction in energy intensity, a firm may outsource their manufacturing to other firms. The hypothesis is that energy intensity is declining in outsourcing intensity.

Foreign Direct Investment (*FDI*) – Firms with a higher FDI are likely to be technologically superior, especially if the foreign investment is flowing in from a country which is more developed than the recipient country. As per the OECD and IMF definitions, the acquisition of at least 10% of the ordinary shares or voting power in a public or private enterprise by non-resident investors makes it eligible to be categorized as FDI. In the Budget of 2013-14, the then finance minister of India announced to follow the internationally accepted definition of FDI. We have taken percentage of equity shares held by foreign promoters of the company as a proxy variable for FDI because of lack of data on firm level foreign capital inflows. The percentage of shares held by foreign promoters is considered as FDI only if this percentage is more than 10%.

4. Data and Summary Statistics

The data has been taken from Prowess IQ database. The Prowess IQ is the largest available firm-level time series data set on financial variables of Indian firms. This database is a product of the Centre for Monitoring Indian Economy Pvt Ltd (CMIE). It includes all companies traded on the National Stock Exchange and the Bombay Stock Exchange, thousands of unlisted public limited companies and hundreds of private limited companies. The database is built from Annual Reports, quarterly financial statements, Stock Exchange feeds and other reliable sources. [3]

We have considered all firms from the cement, fertilizer and pulp & paper industries for which data on Power & Fuel Expenditure was available from the Prowess dataset. Our sample comprises of 86 firms from cement industry, 60 firms from fertilizer industry, and 210 firms from pulp and paper industry.

Tables 1-3 provide summary statistics of firms in the cement, fertilizer and paper and pulp industries, respectively.

Table 1: Summary statistics for the cement industry

	Designated Consumers					Non-Designated Consumers				
Variable	Obs	Mean	Std. Dev.	Min	Max	Obs	Mean	Std. Dev.	Min	Max
*Energy Intensity**	318	0.223	0.076	0.001	0.446	406	0.216	0.151	0.0003	1.23
*Gross fixed assets**	327	25360	41109	2.4	318741	452	2188	7497	0.3	72005
Capital-Sales ratio	301	0.024	653.07	-7646	8310	364	-0.633	17.9	-183.4	162.9
*R&D Exp-Sales ratio**	298	0.0004	0.001	0	0.019	400	0.0002	0.001	0	0.011
Imports-Sales ratio	324	0.156	1.571	0	20.8	423	0.69	13.8	0	284.5
Outsource-Sales ratio	352	0.002	0.007	0	0.042	594	0.001	0.011	0	0.16
FDI	81	30.8	19.07	0.01	75.14	2	0.05	0	0.05	0.05

*Note: 1. * indicates variables are statistically significant.*
2. The unit of measurement for FDI is percentage. All the other variables, except the dummy variables, are expressed as a ratio of value of the variable (Rs. million) to total sales (Rs. million).
3. Capital-Sales ratio is defined as the ratio of change in gross fixed assets to total sales.

[3] Annual Survey of Industries (ASI) data set could not be used for the analysis as ASI data set does not disclose firm names, and therefore, DCs and non-DCS cannot be identified.

Table 2: Summary statistics for the fertilizer industry

	Designated Consumers					Non-Designated Consumers				
Variable	Obs	Mean	Std. Dev.	Min	Max	Obs	Mean	Std. Dev.	Min	Max
*Energy Intensity**	101	0.193	0.12	0.029	0.58	387	0.04	0.053	0.001	0.5
*Gross fixed assets**	101	27505	254778	4772	108883	399	1503	4440.0	1.4	27621
Capital-Sales ratio	95	-0.106	1.32	-10.4	3.70	347	0.23	5.265	-16.92	92.30
*R&D Exp-Sales ratio**	92	0.0002	0.001	0	0.003	386	0.0002	0.001	0	0.01
*Imports-Sales ratio**	101	0.167	0.16	0	0.63	405	0.096	0.190	0	1.72
Outsource-Sales ratio	110	0.00004	0.0003	0	0.00	550	0.003	0.017	0	0.29
Ownership of firm	110	0.3	0.46	0	1	550	0.96	0.19	0	1

*Note: 1. * indicates variables are statistically significant.*
2. All the variables, except the dummy variables, are expressed as a ratio of value of the variable (Rs. million) to total sales (Rs. million).
3. Capital-Sales ratio is defined as the ratio of change in gross fixed assets to total sales.

Table 3: Summary statistics for the pulp and paper industry

	Designated Consumers					Non-Designated Consumers				
Variable	Obs	Mean	Std. Dev.	Min	Max	Obs	Mean	Std. Dev.	Min	Max
*Energy intensity**	222	0.158	0.06	0.05	0.31	1476	0.13	0.11	0.00	1.69
*Gross fixed assets**	226	8204.6	9896.3	0	56398.6	1545	596.8	1117.6	0	12568.9
Capital-Sales ratio	206	0.05	0.49	-1.9	4.31	1310	-25.5	824.2	-29642	1126.9
*R&D Exp-Sales ratio**	242	0.001	0.00	0	0.01	2068	0.00	0.00	0	0.02
*Imports-Sales ratio**	223	0.11	0.12	0	0.55	1513	0.08	0.17	0	4.5
Outsource-Sales ratio	242	0.002	0.01	0	0.05	2068	0.01	0.11	0	2.46

*Note: 1. * indicates variables are statistically significant.*
2. All the variables, except the dummy variables, are expressed as a ratio of value of the variable (Rs. million) to total sales (Rs. million).
3. Capital-Sales ratio is defined as the ratio of change in gross fixed assets to total sales.

For the cement industry out of the 86 firms, 32 firms have plants that have been listed as designated consumers. These 32 firms own 74 plants out of the 85 plants identified by BEE as designated consumers. Out of the 60 firms in our data for the fertilizer industry, 10 firms have plants that have been listed as designated consumers. Out of 210 firms in our data from the paper and pulp industry, 22 firms own plants that are DCs. Our sample data covers 87% of the total DCs in the cement industry, 73% of the DCs in the fertilizer industry and 81% of DCs in the pulp and paper industry.

The two group mean comparison shows that DCs are significantly more energy intensive and larger in terms of gross fixed assets than non-DCs in all the three industries. Further DCs also have significantly higher per unit R&D expenditure in the fertilizer and paper and pulp industry.

We use leads of the interaction term *(PATyear*PATfirm)* to test the parallel trends assumption, i.e., average energy intensity of designated and non-designated consumers follows the same trend in the pre-treatment period. We add the indicator variables for three years before the adoption of the policy. $(PATyear*PATfirm)_{t0}$ is the year the policy was implemented i.e., year 2012. $(PATyear*PATfirm)_{t+j}$ are the years prior to adoption of policy, i.e., it leads to the year PAT was implemented for j=1, 2 (Appendix Tables A1, A2 and A3 for the cement, fertilizer and pulp and paper industries respectively). For all the three industries the coefficients of the leads are close to zero and are insignificant confirming the parallel trends assumption.

5. Empirical Results

The results on the effect of the PAT scheme on energy intensity of firms are reported in Tables 4 – 7. While Table 4 reports results when all the firms in the data set are included, Tables 5 to 7 report results from the three industries individually. Hausman test shows that fixed effect model is more appropriate for our data. All models in Tables 4 –7 report results from fixed effects models using the difference-in-differences (DID) methodology, include year fixed effects, and report standard errors clustered at the firm level.

In Table 4, we estimate four models that differ in the covariates included.

Model 1 is the basic difference-in-differences model that includes the interaction term *PATyear*PATfirm* to measure differential effect of listed as DCs in the compliance period of the PAT scheme. Model 2 introduces industry dummy variables to estimate differential impact of the PAT scheme on different industries. Model 3 includes other control variables such as per unit capital investment, per unit R&D expenditure, per unit imports and per unit outsourcing. Model 4 additionally includes log of gross fixed assets as an indicator for size of the firm.

Table 4: Effect of PAT and other factors on energy intensity of firms in cement, fertilizer and, pulp and paper industries for the years 2004-05 to 2014-15

Variables	(1) EI	(2) EI	(3) EI	(4) EI
$PATyear_t$	-0.043*** (0.008)	-0.045*** (0.008)	-0.041*** (0.011)	-0.037** (0.015)
DID $(PATyear_t)*(PATfirm_{i,t})$	-0.016** (0.008)	0.006 (0.009)	0.003 (0.009)	0.002 (0.009)
$(Cement)*(PATyear_t)$		0.008 (0.014)	0.012 (0.014)	0.013 (0.014)
$(Fertilizer)*(PATyear_t)$		0.001 (0.005)	-0.001 (0.00530)	-0.002 (0.005)
$(Cement)*(PATyear_t)*(PATfirm_{i,t})$		-0.0257 (0.0186)	-0.027 (0.0181)	-0.026 (0.018)
$(Fertilizer)*(PATyear_t)*(PATfirm_{i,t})$		-0.068*** (0.017)	-0.065*** (0.018)	-0.066*** (0.018)
Capital Investment- Sales Ratio			0.0002 (0.0001)	0.0002 (0.0001)
Ln(Gross fixed assets)				-0.006 (0.01)
R&D Expenditure-Sales Ratio			-2.163** (0.877)	-2.172** (0.863)
Imports – Sales Ratio			0.002 (0.028)	0.002 (0.028)
Outsourcing-Sales Ratio			0.038*** (0.012)	0.039*** (0.012)
Constant	0.170*** (0.005)	0.170*** (0.005)	0.169*** (0.009)	0.203*** (0.058)
Observations	2,909	2,909	2,566	2,566
R-squared	0.034	0.040	0.043	0.044
Number of id	356	356	354	354
Year FE	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes

, and ***: Null hypothesis rejected at 10%, 5% & 1%; levels of significance respectively.*

Robust Standard Errors in parenthesis.

EI is the dependent variable in all the specifications. EI is the ratio of power & fuel expenditure (Rs. million) to total sales (Rs. million). Both the numerator and denominator are in constant prices (year 2004-05=100).

Cement and Fertilizer are the dummy variables for firms from those two industries. Pulp and Paper industry is the reference category.

The coefficient of *PATyear* is negative and statistically significant in all the model specifications. This implies that on average, energy intensity was lower in the years of implementation of the PAT scheme as compared to the other years. The coefficient of the interaction term (*PATyear*PATfirm*) in model 1 is negative and statistically significant implying that the PAT scheme resulted in reducing the energy intensity of the designated consumers. On average, energy intensity of DCs reduced by 1.6% during the implementation period. In models 2 and 3, the coefficient of the interaction term is negative and statistically significant for the fertilizer industry, and weakly significant for the cement industry. The energy intensity of DCs in the cement and fertilizer industries reduced by 2.6% and 2.7% respectively. However, the effect of most of the control variables is statistically insignificant.

We next estimate the effect of the PAT scheme on the three industries individually as the industries can be very different from each-other in terms of various firm level characteristics such as energy intensity, R&D expenditures, market share, size, etc. On an average, cement and fertilizer firms are larger in size, more energy intensive than the pulp and paper firms. Per unit R&D expenditure is almost similar in the three industries (refer to the summary tables 1, 2 and 3). The individual regression analysis will also capture the effect of the variables that are specific to a particular industry such as ownership dummy variable for the fertilizer industry.

Cement Industry

The results for the cement industry are presented in Table 5. We estimate four models that differ in covariates, Model 1 is the basic difference-in-differences model, Model 2 includes controls such as technology, per unit R&D expenditure and per unit imports. Models 3 and 4 additionally include size of the firm, and FDI and per unit outsourcing, respectively. We get consistent results across these specifications.

The difference-in-differences estimator given by the interaction term (*PATyear*PATfirm*) is negative and statistically significant in all the specifications providing robust evidence that firms identified as DCs reduced their energy intensity due to the PAT scheme. The estimate of the additional energy efficiency gain, on average, that has been achieved by DCs due to the PAT scheme is 2.9%.

The effect of other firm level control variables is also consistent across the models. The coefficient for the pace of new investment (proxied by per unit change in gross fixed assets) and the coefficient of Imports-Production ratio is negative and statistically significant in all the models.

The effect of per unit R&D expenditure is also negative and statistically significant in all the three models. Using model 2 we find that a1 unit increase in the R&D expenditure-Production ratio reduces energy intensity by 2.26 units. The result confirms similar findings in the literature that show indigenous R&D expenditure helps to reduce energy intensity of industries (Goldar, 2010 for Indian industries and Aixiang, 2011; and Teng, 2012 for Chinese industries).

Table 5: Effect of PAT Scheme and other factors on energy intensity of firms in cement industry for the years 2004-05 to 2014-15

Variables	(1) EI	(2) EI	(3) EI	(4) EI
$PATyear_t$	-0.042** (0.017)	-0.028 (0.023)	-0.035 (0.028)	-0.029 (0.023)
DID ($PATyear_t$)($PATfirm_{i,t}$)*	-0.023** (0.011)	-0.029*** (0.011)	-0.030*** (0.011)	-0.029*** (0.011)
Capital Investment- Production Ratio		-001** (0.0003)	-0.001** (0.0003)	-0.001** (0.0003)
Ln(Gross Fixed Assets)			0.007 (0.010)	
R&D Expenditure- Production Ratio		-2.256** (0.930)	-2.143** (0.958)	-2.951*** (0.945)
Imports – Production Ratio		-0.245*** (0.062)	-0.244*** (0.062)	-0.244*** (0.062)
Outsourcing- Production Ratio				0.665 (1.208)
FDI_t				0.001* (0.0003)
Constant	0.248*** (0.01)	0.243*** (0.018)	0.197*** (0.073)	0.241*** (0.018)
Observations	721	649	649	649
R-squared	0.68	0.729	0.73	0.731
Year FE	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes

, and ***: Null hypothesis rejected at 10%, 5% & 1%; levels of significance respectively. Robust Standard Errors in parenthesis.*

EI is the dependent variable in all the specifications. EI is the ratio of power & fuel expenditure (Rs. million) to total sales (Rs. million). Both the numerator and denominator are in constant prices (year 2004-05=100).

Size of the firm is defined as log of gross fixed assets. All the other independent variables, except the dummy variables, are expressed as proportion of total sales.

Although we have normalized our variables by sales to take care of size heterogeneity, in model 3 we explicitly include log of gross fixed assets as a proxy for size of the firm. Goldar (2010) use log of sales to represent size of the firm and find a significant negative relationship between size and energy intensity for all firms in general but not specifically for energy intensive firms. Sahu and Narayanan (2009) find that once energy consumption reaches a certain threshold, energy intensity declines with size, where size is defined as log of energy consumed. In our analysis we do not find a statistically significant relationship between firm size and its energy intensity.

In model 4 we estimate the effect of per unit outsourcing and FDI on energy intensity. The coefficient of Outsourcing-Sales ratio is statistically insignificant because it includes outsourced manufacturing jobs and cement industry's manufacturing is indigenous. The effect of FDI is positive and statistically significant. More FDI causes the scale of economic activity to rise and puts a greater strain on energy resources, (Pao and Tsai, 2011). It will help in improving efficacy in energy use only if it causes spillover of energy saving technology (Yang et.al., 2012 finds that only clean FDI will cause energy intensity to fall). But the Indian cement industry is not one of the top sectors that attract FDI.

Results show that the PAT scheme has helped to reduce energy intensity of designated consumers from cement industry. Based on the results of model 2, we estimate the decline in carbon emissions that results from a more efficient use of energy resources in this industry. A more efficient use of energy should cause a decline in the power & fuel expenditure. We estimate the total decline in the power & fuel expenditure of the cement industry due to the PAT scheme as the difference between predicted power & fuel expenditure in the year 2011-12, which is the year before the implementation of the PAT scheme, and 2014-15, which is the year by which the energy intensity targets had to be met by DCs:

$$Total\ decline\ in\ Power\ \&\ Fuel\ expenditure = (Average\ decline\ in\ EI\ of\ the\ DCs\ due\ to\ PAT\ scheme) * (Total\ sales\ of\ DCs\ in\ the\ implemenatation\ period\ of\ PAT\ scheme)$$

We find that on an average between the years 2011-12 and 2014-15, power & fuel expenditure decreases by Rs. 56151.28 million. Coal is the major energy input used in the production of cement, followed by electricity. Cement industry is the third largest consumer of coal in India (Technology Compendium on Energy Caving Opportunities, 2013) and uses non-coking coal due to its high ash content. Fall in power & fuel expenditure can be attributed to a fall in the consumption of non-coking coal and electricity. We estimate the average share of coal and electricity in the total power & fuel expenditure for the cement industry, using unit level data from the Annual Survey of Industries (ASI) for the years 2012-13 and 2013-14 (data for 2014-15 is not available). The share is calculated for these years because they are the years for which PAT scheme was implemented. ASI has data on the purchase value of coal, electricity purchased, petrol, diesel and oil, and other fuel consumed. The total expenditure on energy inputs is calculated as follows:

$$Total\ expenditure\ on\ energy\ inputs\ in\ year\ t =$$

$$= \sum[Purchase\ value\ of (coal + electricity\ purchased + other\ fuel\ consumed)]$$

where $t = 2012 - 13\ and\ 2013 - 14$

The share of the individual energy inputs is calculated as:

$$Share\ of\ i^{th} energy\ input\ in\ year\ t = \frac{Purchase\ value\ of\ i^{th} energy\ input\ in\ year\ t}{Total\ expenditure\ on\ energy\ inputs\ in\ year\ t} * 100$$

where $i = coal, electricity\ purchased\ and\ other\ fuel\ consumed$

$$Average\ share\ of\ energy\ input\ i = \frac{\sum_{t=2012-13}^{2014-15}(share\ of\ i^{th} energy\ input\ in\ year\ t)}{2}$$

Results show the share of non-coking coal and electricity to be 64% and 36% respectively (the share of other fuel consumed is negligible). Therefore power & fuel expenditure decreases by Rs. 35936.82 million due to a fall in the consumption of non-coking coal and Rs. 20214.46 million due to electricity.

We use data from IndiaStat, which is owned by Datanet India that provides socio-economic statistical information about India, to get prices of the energy inputs (current prices). Using appropriate wholesale price indices with 2004-05 as the base year, we deflate the current prices to get constant prices of energy inputs.

We then estimate the fall in the consumption of the energy input in physical units as follows:

$$Decline\ in\ consumption\ of\ i^{th} energy\ input = \frac{Decline\ in\ Power\ \&\ Fuel\ Expenditure\ caused\ by\ i^{th} energy\ input}{Price\ of\ i^{th} energy\ input\ (constant\ prices)}$$

We then use the India specific conversion factor for carbon emission factor to assess the decline in carbon emissions caused by a decline in the consumption of the i^{th} energy input (India, Second Biennial Update Report to the United Nations Framework Convention on Climate Change, Ministry of Environment, Forest and Climate Change, Government of India, 2018).

$$Total\ decline\ in\ carbon\ emissions\ (in\ tonnes\ of\ carbon)$$
$$= (Decline\ in\ the\ consumption\ of\ i^{th} energy\ input\ (in\ terajoules\ of\ energy))$$
$$* (India\ specific\ carbon\ emision\ factor\ (in\ tonnes\ of\ carbon\ per\ terajoule\ of\ energy))$$

There are several grades of coal sold in India, differentiated as per their gross calorific value (GCV). The cement industry uses grades of non-coking coal from grade G-4 to G-9 (Cement Manufacturer's Association). From 2012 onwards, price of non-coking coal is as per the GCV (Coal Directory of India, various years. We take the average price of the six grades of non-coking coal from G-4 to G-9 to estimate the decline in the quantity of non-coking coal (IndiaStat). The average price of non-coking coal is Rs. 1193.33[4]. A fall in the power & fuel expenditure by Rs. 35936.82 million causes consumption of non-coking coal to go down by 30.11 million tonnes of coal. This is equivalent to 486051.86 Terajoules of energy[5]. Therefore a fall in energy consumption of 486051.86 Terajoules will cause carbon emissions to fall by 12.77 million tonnes of carbon.

For price of electricity purchased by the cement industry, we use data on average power tariff for industrial sector in India (IndiaStat) for the years 2012-13 and 2013-14 (data is not available for 2014-15). The price of electricity purchased is found to be Rs. 4.79 per Kwh. Therefore a fall in the power & fuel expenditure by Rs. 20214.46 million causes consumption of electricity purchased to go down by 4220.14 million Kwh. This is equivalent to 15192.49 Terajoules of energy[6]. A fall in energy consumption of 15192.49 Terajoules will cause carbon emissions to fall by 0.399 million tonnes of carbon.

Hence the overall reduction in carbon emissions arising out of the decline in the consumption of non-coking coal and electricity purchased is 13.17 million tonnes of carbon.

Fertilizer industry

The empirical results for the fertilizer industry are presented in Table 6. Model 1 is the basic difference-in-differences model. Model 2 includes firm level characteristics like per unit capital investment, per unit R&D expenditure and per unit imports. Models 3 and 4 additionally include size of the firm and interaction between dummy variable ownership of the firm and

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[4] Data on gross calorific value of different grades of non-coking coal and the corresponding prices is taken from Coal Directory of India, various years. Wholesale price index with base year 2004-05 is used to get the values in constant prices. We calculate the average price for the three years 2012-13 to 2014-15.

[5] 1 million tonne of coal = 16.14 petajoules of energy
1 petajoule = 1000 Terajoule of energy

[6] 1 million Kwh of electricity = 0.0036 petajoules of energy
1 petajoule = 1000 Terajoule of energy
1 million Kwh of electricity = 3.6 Tj of energy

size and per unit outsourcing respectively. We get consistent results across all model specifications.

Table 6: Effect of PAT and other factors on energy intensity of firms in the fertilizer industry for the years 2004-05 to 2014-15

Variables	(1) EI	(2) EI	(3) EI	(4) EI
$PATyear_t$	-0.014*** (0.005)	-0.013* (0.008)	-0.018** (0.008)	-0.014* (0.008)
DID ($PATyear_t$)($PATfirm_{i,t}$)*	-0.016** (0.007)	-0.015** (0.007)	-0.020*** (0.008)	-0.014** (0.007)
Capital Investment- Production Ratio		0.002*** (0.0002)	0.003*** (0.0002)	0.002*** (0.0002)
ln(Gross Fixed Assets)			0.028 (0.019)	
*Ownership*ln(Gross Fixed Assets)*			-0.025 (0.019)	
R&D Expenditure- Production Ratio		-13.64*** (3.22)	-14.23*** (3.24)	-13.11*** (3.12)
Imports- Production Ratio		-0.001 (0.006)	-0.001 (0.007)	-0.002 (0.007)
Outsourcing- Production Ratio				-0.117 (0.078)
Constant	0.074*** (0.004)	0.076*** (0.007)	0.009 (0.040)	0.076*** (0.007)
Observations	489	425	425	425
R-squared	0.925	0.941	0.942	0.942
Year FE	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes

, and ***: Null hypothesis rejected at 10%, 5% & 1%; levels of significance respectively.*

Robust Standard Errors in parenthesis.

EI is the dependent variable in all the specifications. EI is the ratio of power & fuel expenditure (Rs. million) to total sales (Rs. million). Both the numerator and denominator are in constant prices (year 2004-05=100).

Size of the firm is defined as log of gross fixed assets. All the other independent variables, except the dummy variables, are expressed as proportion of total production.

The coefficient of the year dummy variable *PATyear* is negative and statistically significant in all the four models. This implies that the energy intensity of fertilizer firms has been lower in the years 2012-13 to 2014-15 than 2004-05 to 2011-12. The coefficient of the difference-in-differences estimator (*PATyear*PATfirm)* is also negative and statistically significant in all the specifications, which shows that PAT policy has had the desired effect on the fertilizer industry. This implies on an average DCs have been able to achieve additional energy efficiency gains of 1.5% under the PAT scheme.

The effect of new capital investment, given by the Capital-Production ratio, is positive and statistically significant. In model 2, we find that a 1 unit rise in per unit capital investment increases energy intensity by 0.002 units. This could be because this sector has reached a point of technological stagnation (Report of the Working Group on Fertilizer Industry for the 12th Plan). Most of the naphtha and fuel oil based plants have converted to natural gas, which is far more energy efficient. The scope for further reduction is limited.

The coefficient of per unit R&D expenditure is negative and statistically significant in all the three models. A 1 unit rise in the R&D Expenditure-Production ratio causes EI to fall by 14.23 units.

Per unit imports have a positive but statistically insignificant impact in all the three models. The possibility of any technological spillovers via imports is limited because imports are mainly in the form of raw materials and not capital goods. Also all the designated consumers from the fertilizer industry are producers of urea, which is dependent on only indigenous raw materials.

In model 3 we include log of gross fixed assets to estimate the effect of size of the firm. We also estimate the effect of the interaction between log of gross fixed assets and dummy variable ownership of the firm see if the effect of size on energy intensity varies with firm ownership. The dummy variable was included because the fertilizer industry comprises of public sector, co-operatives and private sector companies. The effect, however, is found to be statistically insignificant.

In model 4 the effect of per unit outsourcing is estimated, which is found to be negative and statistically insignificant. The result is different from Soni et al (2017) who find a statistically significant relation between outsourcing intensity and energy intensity for fertilizer industries. We had estimated Model 8 by adding an interaction term (PATfirm*Outsourcing-Production ratio) to see if there is any difference between designated and non-designated consumers (model not reported here). But the coefficient of the interaction term was insignificant. Therefore, unlike Soni et al (2017) who find that outsourcing intensity is more significant for firms that are less energy intensive, we do not find the effect to be different for designated and non-designated consumers.

Results show that the PAT scheme has helped to reduce energy intensity of designated consumers from fertilizer industry. Using model 2, we estimate the total decline in predicted power & fuel expenditure to be Rs. 17162.84 million that results from a more efficient use of energy resources. Energy input for the fertilizer industry comprises of natural gas, coal and electricity. Using the unit level data from ASI, the share of these three energy inputs is found to be 11%, 20% and 44% respectively. Of the total decline in power & fuel expenditure, Rs. 1887.91 million is due to natural gas, Rs. 3432.57 million is due to coal and Rs. 7551.64 million is due to electricity purchased. The prices of natural gas, non-coking coal and electricity purchased are Rs. 11 per cubic metre, Rs. 1193.33 per tonne of coal and Rs.4.79 per Kwh respectively. The corresponding decline in quantity are 171.67 million cubic metre of natural gas, 2.88 million tonnes of coal and 1576.54 million Kwh of electricity purchased. This is equivalent to decline in energy consumed of 51.92 terajoules for natural gas, 46426.08 terajoules for non-coking coal and 1576.54 terajoules for electricity purchased. The resultant decline in carbon emissions is 0.34 million tonnes of carbon[7], 1.22 million tonnes of carbon and 0.15 million tonnes of carbon for natural gas, non-coking coal and electricity purchased respectively. Therefore, the fertilizer industry will cause a total decline of 1.37 million tonnes of carbon due to the PAT scheme.

Pulp and Paper Industry

Table 7 presents the empirical results for the pulp and paper industry.

Model 1 is the basic difference-in-differences model. Model 2 includes firm level characteristics like per unit capital investment, per unit R&D expenditure and per unit imports. Models 3 and 4 additionally include size of the firm and per unit outsourcing respectively. We get consistent results across all model specifications.

The coefficient of *PATyear* is negative and statistically significant in all the models included in the specification, except in Model 3. This suggests that energy intensity of the pulp and paper& firms is higher in 2012-13 to 2014-15 than 2004-05 to 2011-12. The coefficient of the difference-in-differences estimator *(PATyear*PATfirm)* is positive and statistically insignificant in all the models. Therefore, the PAT scheme does not have any effect on the designated consumers of the pulp and paper industry.

[7] India specific carbon emission factor for natural gas is 0.002 tonne of carbon per cubic meter. this is equal to 51.92 tC/TJ (The Final Report of the Expert Group on Low Carbon Strategies for Inclusive Growth, Planning Commission Government of India, April 2014)

Table7: Effect of PAT and other factors on energy intensity of firms in the pulp and paper industry for the years 2004-05 to 2014-15

Variables	(1) EI	(2) EI	(3) EI	(4) EI
PATyear$_t$	-0.035*** (0.009)	-0.032*** (0.010)	-0.017 (0.012)	-0.032*** (0.010)
DID (PATyear$_t$)(PATfirm$_{i,t}$)*	0.005 (0.006)	0.003 (0.006)	0.002 (0.006)	0.003 (0.006)
Capital Investment- Production Ratio		9.67e-05 (0.0001)	9.95e-05 (0.0001)	9.66e-05 (0.0001)
ln(Gross Fixed Assets)			-0.015*** (0.005)	
R&D Expenditure- Production Ratio		-1.247 (1.153)	-1.149 (1.166)	-1.246 (1.154)
Imports- Production Ratio		0.039 (0.032)	0.036 (0.032)	0.038 (0.032)
Outsourcing- Production Ratio				0.038 (0.023)
Constant	0.155*** (0.004)	0.150*** (0.008)	0.229*** (0.025)	0.150*** (0.008)
Observations	1,698	1,491	1,491	1,491
R-squared	0.799	0.811	0.814	0.811
Firm Fixed Effects	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes

, and ***: Null hypothesis rejected at 10%, 5% & 1%; levels of significance respectively.*

Robust Standard Errors in parenthesis.

EI is the dependent variable in all the specifications. EI is the ratio of power & fuel expenditure (Rs. million) to total sales (Rs. million). Both the numerator and denominator are in constant prices (year 2004-05=100).

Size of the firm is defined as log of gross fixed assets. All the other independent variables, except the dummy variables, are expressed as proportion of total production.

The coefficients of Capital Invetsment-Production ratio, R&D expenditure- Production ratio and Imports- Production ratio are positive and statistically insignificant in all the specifications. The pulp and paper industry suffers from technological obsolescence. A huge investment in assets and research and development activities will be required to improve energy consumption per unit of output. Factors like absence of financial opportunities, lower economies of scales, etc. make it difficult for investments to flow in. Most of the imports include recycled/waste paper used in the production of pulp and paper and the impact on energy intensity will be quite limited, except for the recycled paper being of superior quality. Technological spillovers from developed countries will not have a major impact because Indian paper mills are mostly small in size, while the mills abroad are large in size and therefore technical know-how from developed countries will be difficult to replicate in India.

Size of the firm (given by log of gross fixed assets) has a negative and statistically significant effect on the energy intensity of this industry. As the firm size increases, there is a fall in the energy intensity. The Indian paper industry is dominated by small and medium sized firms which make pollution control extremely difficult. A rise in the firm size will mean more resources with them to make investments to modernize their mills and control pollution.

Outsourcing- Production ratio given in Model 4 has a statistically insignificant effect on energy intensity. This result is similar to Soni et al (2017) who find that outsourcing of manufactured jobs has no impact on energy intensity of pulp and paper industry.

6. Conclusion

India is an emerging economy, with energy having an important role to play in helping the country maintain its high rate of growth. India is the third largest consumer of energy and the share of fossil fuels in total energy has been growing rapidly. The repercussion comes in the form of increased emissions and rapid depletion of resources for the future. Therefore energy conservation is an important goal to be achieved by the economy. But at the same time, India cannot forgo its development priorities. Hence the country must strike a balance between its twin objectives of economic growth and environmental protection.

The Government of India through BEE has taken various steps at the national level to improve energy efficiency. One of the schemes launched by the BEE is the Perform-Achieved-Trade scheme, created as a part of National Mission for Enhanced Energy Efficiency. The PAT scheme has been designed for attaining energy efficiency in the industrial sector, since this sector has always been the highest consumer of energy. Through this scheme, the BEE and Government of India also introduced market based instruments for the first time to solve an environmental problem.

The objective of this paper is to estimate the effect of various factors on the energy intensity of cement, fertilizer, and pulp and paper firms, with a special focus on the PAT scheme. We do a panel data analysis and estimate a fixed effects model for a sample period of 2004-05 to 2014-15. We use the difference-in-differences methodology to evaluate the causal effect of the PAT scheme on the energy intensity of firms from these three industries. We also estimate the fall in power & fuel expenditure and the concomitant fall in carbon emissions as a result of the PAT scheme.

A formal econometric analysis shows that the PAT scheme led to a fall in the energy intensity of designated consumers for the cement and fertilizer industries. The policy was successful in meeting its objective. The key finding from the econometric analysis is that the fall in power & fuel expenditure would decrease carbon emissions by reduction of 13.17 million tC and 1.37 million tC for the cement and fertilizer industries respectively. Erstwhile Union Minister of Environment, Forest and Climate Change (2014-2016), Shri Prakash Javadekar, had stated that India is keen to attempt to work towards a low carbon emission pathway, while simultaneously endeavouring to meet all the developmental challenges that the country faces today. India has pledged for domestic actions to reduce emission of greenhouse gases and creating clean energy and sustainable environment for its population in the recently ratified COP21 Paris agreement on climate change in the year 2016. The success of the PAT scheme will help India in moving a step closer to fulfilling its commitment.

For future research an analysis of the PAT scheme in physical units will give more precise estimates. It would also lead to more accurate estimates of reduction in carbon emissions from a fall in energy consumption. We hope that if more data comes in on the actual trade in ESCerts, their price and the names of participating designated consumers, we will be able to extend this research to assess how well this tradable instrument has worked in improving efficiency in energy use.

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APPENDIX

Table A1: Empirical analysis of PAT with leads of interaction term for cement industry

Variables	Dependent Variable EI
PAT year	0.033 (0.021)
[(PATyear)(PATfirm)]$_{t+2}$	-0.002 (0.023)
[(PATyear)(PATfirm)]$_{t+1}$	0.013 (0.018)
[(PATyear)(PATfirm)]$_{t0}$	-0.043*** (0.014)
Capital Investment- Sales Ratio	-0.002* (0.002)
R&D Expenditure- Sales Ratio	-2.93*** (0.96)
Imports- Sales Ratio	-0.241*** (0.057)
Constant	0.188*** (0.009)
Observations	518
R-squared	0.807
Firm FE	Yes
Year FE	Yes

*,** and ***: Null hypothesis rejected at 10%, 5% & 1%; levels of significance respectively.
Cluster Robust Standard Errors in parenthesis.
[(PATyear)(PATfirm)]$_{t0}$ is the year of implementation of the policy. t+m are the leads.

Table A2: Empirical analysis of PAT with leads of interaction term for fertilizer industry

Variables	Dependent Variable EI
PAT year	-0.006 (0.005)
[(PATyear)(PATfirm)]$_{t+2}$	0.003 (0.011)
[(PATyear)(PATfirm)]$_{t+1}$	0.002 (0.009)
[(PATyear)(PATfirm)]$_{t0}$	-0.012* (0.008)
Capital Investment- Sales Ratio	0.003*** (0.0007)
R&D Expenditure- Sales Ratio	-15.36*** (3.37)
Imports- Sales Ratio	0.001 (0.007)
Constant	0.068*** (0.004)
Observations	365

R-squared	0.951
Firm FE	Yes
Year FE	Yes

, and ***: Null hypothesis rejected at 10%, 5% & 1%; levels of significance respectively.*
Cluster Robust Standard Errors in parenthesis.
[(PATyear)(PATfirm)]$_{t0}$ is the year of implementation of the policy. t+m are the leads.

Table A3: Empirical analysis of PAT with leads of interaction term for paper industry

Variables	Dependent Variable EI
PAT year	0.008 (0.013)
[(PATyear)(PATfirm)]$_{t+2}$	0.008 (0.015)
[(PATyear)(PATfirm)]$_{t+1}$	-0.006 (0.01)
[(PATyear)(PATfirm)]$_{t0}$	0.001 (0.008)
Capital Investment- Sales Ratio	0.0002 (0.0002)
R&D Expenditure- Sales Ratio	-1.247 (1.541)
Imports- Sales Ratio	0.029 (0.037)
Constant	0.248*** (0.042)
Observations	1,302
R-squared	0.689
Firm FE	Yes
Year FE	Yes

, and ***: Null hypothesis rejected at 10%, 5% & 1%; levels of significance respectively.*
Cluster Robust Standard Errors in parenthesis.
[(PATyear)(PATfirm)]$_{t0}$ is the year of implementation of the policy. t+m are the leads.