Measuring Perform-Achieve-Trade: Analysis of Indian Cement and Pulp & Paper Industries

Hena Oak

***Abstract*—India launched the Perform-Achieve-Trade (PAT) scheme for firms in the eight most energy intensive industries in 2007. The purpose was to induce efficient use of energy through trade in Energy Saving Certificates. The scheme identified the most polluting firms from each of these industries and set individual energy intensity reduction targets. The first PAT cycle runs from 2012-2015 and targets have to be met within this period. This is the first time India has adopted tradable permit scheme for dealing with an environmental problem. The objective of this paper is to quantify the PAT effect for two out of the eight identified industries viz. Cement and Pulp & Paper industries. The paper uses difference-in-differences to estimate the energy intensity of firms in the implementation years. The technique of difference-in- difference-in-differences is used to get even more robust results. Finally an OLS model is estimated to include other factors that influence the energy intensity of firms from these two industries. The paper finds PAT did not have a significant impact on the average energy intensity, but the coefficient of triple interaction term is significantly negative. All other explanatory variable shave the expected signs.**

***Index Terms*—Cement industry, energy intensity, India, perform achieve and trade, pulp & paper industry, tradable permits.**

I. Introduction

India is one of the fastest growing economies of the world with an average growth rate of approximately 7% in the last two decades. It is projected to be the sixth largest economy in the year 2017 [1]. It is also the second most populous country with a population of 1.3 billion [2]. The rapid economic growth along with high growth in population results in growing energy demand. For a developing country like India sustained and unrestricted supply of energy is necessary to continuously move up the growth trajectory.

India is the world's third largest consumer of primary energy, after China and USA [3]. The country's energy basket comprises primarily of non-renewable fossil fuels like coal, oil, natural gas, etc. The share was 75% in 2015 as per the World Bank data. Fossil fuels like coal are highly emission intensive and release greenhouse gases when burnt, which is primarily responsible for global warming. Given India's commitment both in the Copenhagen and Paris summits to making the planet green again, it is important that we reduce our dependence on fossil fuels. One of the important ways to achieve the same is efficient use of energy that will help India achieve its twin objectives of maintaining high growth rates while simultaneously cutting down emission levels.

Manuscript received July 4, 2017; revised November 14, 2017.

Hena Oak is with the Department of Economics, Miranda House, University of Delhi, India (e-mail: henaoak@gmail.com).

Energy Intensity (EI) defined as the amount of energy consumed to generate one unit of GDP, is the closest indicator of how efficiently energy is used. Fortunately even though energy consumption has been rising for the country as a whole, EI has recorded a declining trend since early 2000. The cumulative annual growth rate for energy consumption and EI in 2005-2013 was 5.28% and -1.3% respectively [4]. This declining trend in EI has been corroborated by a few India based studies that have found that EI in the manufacturing sector fell by almost 60% in the period 1992-2008 and 25% in 2000-2008 respectively [5], [6].

Besides private technological initiatives taken at the industry level to control EI, the Government of India (GoI) has also taken some noteworthy steps. The first crucial step was the launch of the Energy Conservation Act, 2001. Bureau of Energy Efficiency (BEE) was created under this Act, with the objective to reduce the EI of the economy. Further in June 2008 the National Action Plan for Climate Change was launched with eight National Missions that aimed at achieving key goals with respect to climate change. One of the national missions is the National Mission for Enhanced Energy Efficiency (NMEEE) created with the objective of promoting energy efficiency through policies, regulation, financing mechanisms and business models. Perform-Achieve-Trade (PAT) scheme is an initiative of NMEEE and it pertains specifically to the industrial sector.

PAT is the first scheme through which India has adopted a tradable market based instrument as an environmental regulation measure. It is different from the traditional emission trading scheme because, one, it sets targets in terms of energy intensity and not emissions and second, it sets separate targets for each firm. The objective is to improve energy efficiency of the highest energy intensive industries of the country through target setting and tradable energy saving certificates. The Ministry of Power and BEE have first identified eight most energy intensive industries viz. Thermal Power Plants, Fertilizer, Cement, Pulp and Paper, Textiles, Chlor-Alkali, Iron & Steel and Aluminium. Our paper does a firm level analysis for the Cement and Pulp and Paper industries.

Within each of these industries the most energy intensive plants were identified and called Designated Consumers (DCs). BEE set specific energy consumption target or SEC (defined as the ratio of net energy input in the DC's boundary to total output exported from the DC's boundary) for each designated consumer such that sum of the targets for all designated consumers within an industry equals the industry's target. These individual targets will take care of the heterogeneity that exists in each industry with respect to output, energy consumption trends, energy saving potential, age of the plant, etc. Each designated consumer is required to reduce its SEC by a certain value, based on its reference

doi: 10.18178/ijesd.2017.8.12.1062

year's SEC. Reference year is defined as the average SEC from April 2007 to March 2010.

The target year for the first PAT cycle runs from April 2012-March 2015. At the end of the period if the designated consumer surpasses its target then it will be issued tradable energy saving certificates or ESCerts. 1 ESCert equals 1 toe worth of energy consumption. For the first PAT cycle 478 designated consumers were identified, spread across these 8 industries. These designated consumers currently account for 25% of national GDP and almost 45% of commercial energy use in India. Under this scheme BEE targets to achieve energy saving of 6.686 Mtoe. If PAT is successful then increased energy efficiency will reduce emissions by 26 million tonnes of carbon dioxide equivalent by 2015 [7]. That will play an extremely crucial role in helping to reduce carbon emission by 20-25% by 2020 as compared with the 2005 level.

The objective of this paper is to do a firm level analysis of two of the BEE identified industries viz. Cement industry and Pulp & Paper industry. We will quantify the PAT effect and assess the impact of the PAT scheme on the EI of the firms belonging to these two industries. We use difference-in-differences approach to identify the effect of the PAT scheme on firms that were identified as designated consumers. We also estimate a difference-in-difference-in-differences model to get the effect of PAT on EI of large-sized designated consumers. Finally we will empirically test for other factors that can improve the EI of the firms by estimating an ordinary least square model with firm and year fixed effects. The sample period is from March 2005-March 2015 (financial year).

Both the cement and pulp & paper industries are highly energy intensive because coal and electricity are the principal energy inputs used. The Indian cement industry is the second largest in the world after China. It is essentially the "glue" that sticks the economy together. It is an indigenously developed industry and the demand for cement is essentially derived demand and very closely linked to the performance of the economy. Currently the industry uses only 72% of its total capacity mainly due to poor investments in infrastructure like roads, housing, airports, ports, etc [8]. However initiatives by the new government such as construction of cement concrete roads, housing for all, Make in India, etc., is expected to revive the cement industry. The minimum annual energy consumption for the designated consumers in this industry is almost 30000 toe. BEE has listed 85 cement plants as designated consumers. By imposing EI targets on them it aims to achieve energy saving target of 0.816 million toe under the first PAT cycle.

The pulp & paper industry is one of India's fastest growing sectors today. Its growth is in sync with GDP growth, something similar to the cement industry. Pulp & Paper industry has got an expanding demand base due to multiple factors like the government's emphasis on education leading to rising literacy rates which increases demand for books, newspapers, etc and helps in accelerating the growth of print industry. At the same time it's also one of the most energy intensive sectors of the economy, with huge potential to bridge the technology gap. The energy consumption is drastically high as compared to global standards. Another drawback is that it's dominated by small and medium scale mills with a capacity of less than 50,000 tons per annum. Technological obsolescence is a major problem here since most of the small mills were established using second hand imported machinery. Pollution control becomes more difficult in these units [9]. BEE has listed 31 pulp & paper plants as designated consumers. The minimum annual energy consumption for the designated consumers in this industry is almost 30000 toe. By imposing EI targets on them it aims to achieve energy saving target of 0.119 million toe under the first PAT cycle.

In the literature a number of studies have been undertaken to assess the factors influencing EI of various countries. The effect of energy consumption, GDP and FDI on CO_2 emissions in BRIC countries is estimated in [10] and the paper tests for Granger Causality between these variables for the period 1980-2007. A multivariate VAR model is used to test for granger causality between energy consumption, economic growth and FDI in Shanghai, China from 1985 to 2010 [11]. The case on Indonesian manufacturing is taken up in [12] to explore if FDI diffuses energy saving technology into the host country. They use firm level panel data for 1993-2009. The effect of indigenous R&D on the energy intensity of Chinese industries is analyzed in [13]. In the Indian case [14] uses the method of Data Envelopment Analysis for the period 1998-2003 to study inter-state heterogeneity in energy efficiency because of variation in the composition of manufacturing output, differences in relative energy prices, labour quality, capital investment and environmental regulation.

This study is different from the other India based papers because none of the other papers have done a firm level econometric analysis to look at the influence of the government's PAT initiative on EI. PAT is the first tradable permit scheme adopted by India as in the past India has been relying on command and control instruments for environmental protection. This scheme is unique even globally, as most countries have emission trading programmes with a target on emissions and not on energy.

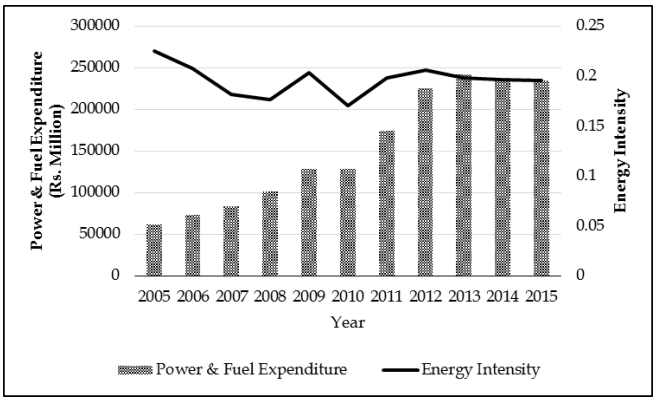
The rest of the paper is organized as follows. Section II describes the data and variables used in the study, followed by an outline of the econometric methodology in Section III. Section IV gives the empirical results and Section V summarizes the paper's conclusion.

II. Description of the Data, Variables and Hypothesis

The objective of the study is to empirically test the success of the PAT scheme and look at the factors that influence the EI of cement firms and pulp & paper firms in India. Cement industry has 85 designated consumers. These plants have been identified from 43 cement firms i.e. one or more plants from a set of 43 firms is identified as a designated consumer. Ultratech Cement Ltd. has the highest number of designated consumers with 12 plants. It is followed by ACC Ltd. (11 plants), India Cement Ltd. (7 plants), Ambuja Cement Ltd. (6 plants) and Penna Cement Industries Ltd (3 plants). The rest of the firms have one or two plants as designated consumers.

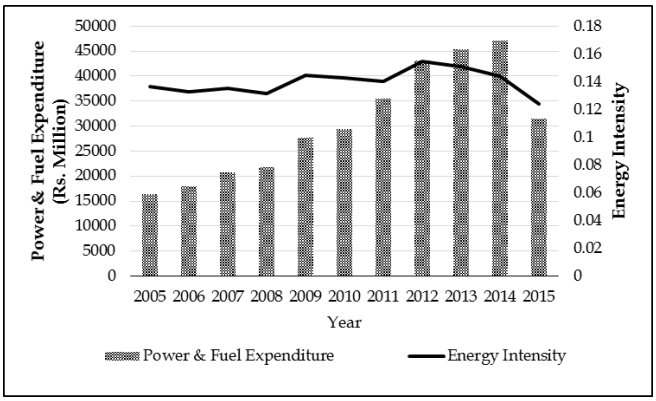
Pulp & Paper industry has 31 designated consumers. These plants have been identified from 26 pulp & paper firms. ITC Ltd. has the highest number of designated consumers with 3

plants. It is followed by Ballarpur Industries Ltd., BILT Graphic Paper Products Ltd and JK Paper Ltd with 2 plants each. The remaining firms have one plant as designated consumer.



Source: CMIE prowess data & own calculations
Fig. 1. Power & fuel expenditure and energy intensity of cement industry.

For the pulp & paper industry, EI rises in general and then after PAT comes into effect; it falls from 2012 onwards as evident from Fig. 2.



Source: CMIE prowess data & own calculations
Fig. 2. Power & Fuel Expenditure and Energy Intensity of pulp & paper industry.

The sample of firms for this paper was selected on the basis of data availability. Since plant level data is not available, we use firm level data to evaluate the impact of the PAT scheme. We take a sample of 87 cement firms, out of which 32 firms have plants that have been listed as designated consumers and 55 firms are non-designated consumers. The sample for pulp & paper firms is 137, out of which 22 firms have plants listed as designated consumers and 115 firms have plants listed as non-designated consumers. The data has been taken from Prowess Dataset [15], which provides firm level data of the Indian industries. Prowess is a product of Centre for Monitoring Indian Economy (CMIE) that provides economic databases for India. The Ministry of Power, GoI's Perform-Achieve-Trade document published in July 2012 is used to identify the names of designated consumers of the cement industry.

If Power & Fuel expenditure is taken as a proxy for energy consumption, then data for the period 2005-2015 shows it to be rising steadily for both the industries (Fig. 1 & Fig. 2 below). For the cement industry, EI decreases in general and then increases between 2010 - 2012 (Fig. 1). It declines marginally post 2012 and then remains steady.

For empirical estimation EI is taken to be the dependent variable. It is defined as follows:

$$EI = \frac{Power\ and\ Fuel\ Expenditute\ (Rs.Million)}{Total\ Production\ (Rs.Million)}$$

Power & Fuel Expenditure is taken as a substitute for energy consumption in physical units. It includes the cost of consumption of electricity, petroleum products such as diesel, naphtha, etc, coal and other sources of energy. Total production is taken as a substitute for total output. It is defined as the sum of total sales and change in stock. All variables are in Rupees Million (Rs. Million).

The primary independent variables are policy dummy variables that are used to capture the effect of BEE's Perform-Achieve-Trade scheme. The dummy variables and other control variables that influence EI are summarized as follows:

- PAT year (*PATyear*) - This is a year dummy variable which will capture the effect of BEE's PAT scheme during the first PAT cycle. It is defined as *PAT year* = 1 for the years 2012-2015 when PAT was implemented and 0 otherwise.
- PAT firm (*PATfirm*) – This is a policy dummy variable. It is defined as *PATfirm* = 1 if firm is a designated consumer and 0 if firm is a non-designated consumer.
- Interaction dummy variable (*PATyear*PATfirm*) – This variable is defined as the product of *PATyear* and *PATfirm*. It is the difference-in-differences estimator and it will capture the average EI of the designated consumers in the years 2012-2015.
- Capital Intensity (*k*) – Capital employed per unit of output is an indicator of technology of the firm. Greater the capital intensity, greater is the possibility of better technology being used that will help to improve EI.
- k^2 – This variable is included to introduce non-linearity in the model and to check for any threshold effect i.e. to test if the impact of *k* is any different on EI when capital per unit of output crosses a certain quantitative limit.
- Size of the firm (*Size*) – Size of the firm is defined by its sales and assets in the last three years (CMIE Prowess database). CMIE has classified firms into different size groups ranging from decile 1 to decile 10 in descending order of size. We define this dummy variable as *Size* = 1if firm belongs to decile 1 to 3 and can be characterized as a large sized firm and 0 otherwise. Larger sized firms have more resources to invest in better technology and to modernize their units and can also collaborate with foreign firms.
- Interaction between PAT year, PAT firm & Size (*PATyear*PATfirm*Size*) – This is a three way interaction and we use difference-in-difference-in-differences to estimate the EI of large sized designated consumers in the years this policy was implemented.
- Age of the firm (*Age*) – This is a dummy variable defined as *Age* = 1 if the firm's year of incorporation is 1975 or before and 0 if it is after 1975. For older firms higher operating expenses and obsolete technology makes it more difficult to improve energy efficiency.
- Industry dummy (*Indus*) – This is defined as *Indus* = 1 if firm belongs to pulp & paper industry and 0 if the firm belongs to cement industry.

III. Econometric Methodology

We use an ordinary least square (OLS) model with firm and year fixed effects to estimate the effect of factors that influence EI of firms belonging to cement industry and pulp & paper industry. The sample period is from March 2005-March 2015 (financial year). The estimated OLS regression is:

$$EI_{it} = \alpha_i + \lambda_t + \beta_0 + \beta_1 (PATyear) + \beta_2 (PATfirm) + \beta_3 (PATyear*PATfirm) + \gamma_i (X_{it}) + \mu_{it} \quad (1)$$

where α_i and λ_t are the firm and year fixed effects respectively and X_{it} represents all other control variables viz. capital intensity, size of the firm, age of the firm and industry dummy variable.

We then use difference-in-differences methodology to quantify the PAT effect. This statistical technique is used when some exogenous event, like a change in government policy, changes the environment in which entities operate [16]. It is an example of a natural experiment. A natural experiment always has a treatment group which is affected by the policy change and a control group which remains unaffected by the policy change. In our paper designated consumers are the treatment group as they participate in the PAT policy. Non-designated consumers are the control group as the policy is not implemented on them. The difference-in-differences estimate ($\hat{\beta}_3$) is the differential effect of being a designated consumer in the years 2012-2015. It is obtained by subtracting the change in the average EI of non-designated consumers between the two time periods from the change in the average EI of designated consumers between the two time periods:

$$\hat{\beta}_3 = (\overline{EI}_{DC,2} - \overline{EI}_{DC,1}) - (\overline{EI}_{NDC,2} - \overline{EI}_{NDC,1})$$

where *DC* is designated consumer and *NDC* is non-designated consumer. 1 represents pre-PAT years 2005-2011 and 2 represents PAT implementation years 2012-2015. Table I gives the effect of PAT on the two set of firms and the difference in EI before and after the scheme was introduced.

TABLE I: Analysis of PAT Scheme

	Before PAT	After PAT	Difference (After-Before)
NDC	β_0	$\beta_0 + \beta_1$	β_1
DC	$\beta_0 + \beta_2$	$\beta_0 + \beta_1 + \beta_2 + \beta_3$	$\beta_1 + \beta_3$
Difference (DC-NDC)	β_2	$\beta_2 + \beta_3$	β_3

The coefficient of (*PATyer*PATfirm)* i.e. β_3 is the difference-in-differences estimate. It is also called the average treatment effect i.e. the effect of the treatment PAT on the EI of designated consumers.

One problem with this analysis is that there may be other factors like size of the firm, age of the firm, etc. that can affect the EI of the designated consumers relative to the non-designated consumers. Then a more robust analysis will be difference-in-difference-in-differences. There is considerable heterogeneity across firms with respect to size. Size of the firm plays an important role in determining the energy consumption of firms and subsequently in identification by BEE. Most of the firms in the cement and pulp & paper industries are large sized firms belonging to size decile 1 to 3. Hence equation 1 is extended to include the triple difference term:

$$EI_{it} = \alpha_i + \lambda_t + \beta_0 + \beta_1 (PATyear) + \beta_2 (PATfirm) + \beta_3 (PATyear*PATfirm) + \beta_4 (Size) + \beta_5 (PATyear*Size) + \beta_6 (PATfirm*Size) + \beta_7 (PATyear*PATfirm*Size) + \gamma_i (X_{it}) + + \mu_{it} \quad (2)$$

The difference-in-difference-in-differences estimate ($\hat{\beta}_7$) estimates the EI of large sized designated consumers in the years 2012-2015:

$$\hat{\beta}_7 = (\overline{EI}_{DC,LS,2} - \overline{EI}_{DC,LS,1}) - (\overline{EI}_{NDC,LS,2} - \overline{EI}_{NDC,LS,1}) - (\overline{EI}_{DC,SS,2} - \overline{EI}_{DC,SS,1})$$

where *LS* is large-sized firms and *SS* are small and medium-sized firms. It controls for the change in the average EI of large sized firms that are non-designated consumers and are not affected by the policy and change in the average EI of small and medium sized firms that are designated consumers.

IV. Empirical Results

Table II summarizes the number of observations, mean value, standard deviation and maximum and minimum values of the dependent and independent variables used in the study. The maximum and minimum values of each variable will indicate whether there are extreme values or not in the data and the standard deviation indicates dispersion around the mean value. Comparing the number of observations across variables will indicate the number of missing observations in the data.

TABLE II: Summary Statistics

Variable	Obs.	Mean	Std. Dev	Min	Max
EI	2019	0.772	16.83	0.0003	533.3
Total Production	2052	5370	17253.6	0.0004	259878
PAT year	2464	0.364	0.481	0	1
PAT firm	2464	0.241	0.428	0	1
k	1936	519.9	15064	-87.4	510400
Size	2464	0.419	0.494	0	1
Age	2464	0.201	0.401	0	1
Indus	2464	0.612	0.487	0	1
Imp	1295	467.5	1181	0.06	11615

Next we analyse the effect of PAT policy and estimate the impact of various factors on the EI of cement and pulp & paper firms (see Table III).

Model 1 is the basic difference-in-differences model. The interaction term (*PATyear*PATfirm*)is weakly significant at 27% level of significance. The average EI of designated consumers in the years 2012-2015 is lower with the implementation of this policy than without. The result is encouraging as it shows that the policy is working for the designated consumers of both the industries. Graphically also Fig. 1 shows EI to decline and then remain steady for the cement industry and Fig. 2 shows EI to decline continuously for the pulp & paper industry.

Model 2, which includes control variables like capital

intensity, size of the firm, age of the firm and industry dummy, is our preferred model.

TABLE III: FACTORS INFLUENCING EI OF CEMENT & PULP & PAPER INDUSTRIES

Variable	Model 1	Model 2
PAT year	-1.14 (1.1)	0.008 (0.023)
PAT firm	0.575 (0.544)	0.345*** (0.011)
*PATyear*PATfirm*	1.576 (1.42)	-0.035 (0.035)
$k_{i,t}$		0.002*** (0.0002)
$(k_{i,t})^2$		-2.25e-09*** (3.22e-10)
Size		-0.153*** (0.028)
Age		0.326*** (0.027)
Indus		-0.144*** (0.029)
Constant		0.066*** (0.041)
R^2	0.26	0.99
No. of Obs.	2019	1903
Firm & Year Fixed Effects	Yes	Yes

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

The coefficient of *PATyear* is positive but insignificant. This implies that there is no significant difference in the EI of non-designated consumers before and after PAT was introduced. This is not surprising since non-designated consumers were not the target group of the policy. *PATfirm* is positive and significant. The average EI of designated consumers is higher than that of non-designated consumers in the years 2005-2011 before PAT was implemented. This implies designated consumers were correctly identified by BEE for both the industries. However the difference-in-differences estimator is negative but insignificant. This implies PAT does not have any effect on the EI of designated consumers in the implementation years.

Table IV does a more formal analysis to see the result of the PAT scheme.

TABLE IV: EMPIRICAL ANALYSIS OF PAT SCHEME

	Before PAT	After PAT	Difference (After-Before)
NDC	0.066	0.074	0.008
DC	0.411	0.384	-0.027
Difference (DC-NDC)	0.345	0.31	-0.035

The results suggest that EI of designated consumers is lower, while EI of non-designated consumers is higher after the implantation of PAT. Comparing between the two set of firms we find that EI of designated consumers is higher than non-designated consumers, both before and after PAT was implemented.

All the other explanatory variables in Model 2 have expected signs. Capital intensity ($k_{i,t}$) that captures the technology of production, is significantly positive and $(k_{i,t})^2$ is negative and significant. This implies that capital intensity is increasing at a decreasing rate. Rate at which EI increases with a rise in capital intensity decreases after capital used per unit of production grows beyond a certain threshold level.

Coefficient of *Size* is negative and significant. The average EI of large-sized firms is less than that of small and medium-sized firms. Coefficient of *Age* is significantly positive. Older firms are more energy inefficient than the new firms. This is similar to what most of the literature using age of the firm finds, because older firms are expected to use obsolete technology, while the new firms enter the market with more modern techniques of production. Finally the industry dummy variable *Indus* is negative and significant. Overall firms from the pulp & paper industry have lower EI than firms from cement industry. The cumulative rate of decrease of the pulp & paper industry in the years 2012-2015 is approximately 7.1%, while for the cement industry the cumulative rate of decrease is 1.7%.

In the next model we estimate the difference-in-difference-in-differences model. Model 3 in Table V below gives the empirical results for equation 2.

TABLE V: DIFFERENCE-IN- DIFFERENCE-IN-DIFFERENCES RESULT FOR CEMENT & PULP & PAPER INDUSTRIES

Variable	Model 3
PAT year	-0.008 (0.032)
PAT firm	0.025 (0.029)
Size	-0.164*** (.022)
*PATyear*PATfirm*Size*	-0.127* (0.074)
*PATyear*PATfirm*	0.059 (0.044)
*PATyear*Size*	0.041 (0.041)
*PATfirm*Size*	0.333*** (0.018)
Indus	0.146 (0.0003)
$k_{i,t}$	0.002*** (0.0002)
$(k_{i,t})^2$	-2.25e-09*** (3.22e-10)
Age	0.326*** (0.027)
Constant	0.066 (0.041)
R^2	0.99
No. of Obs.	1903
Firm & Year Fixed Effects	Yes

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

The coefficient of the triple interaction term (*PATyear*PATfirm*Size*) in Model 3 captures the variation in EI of large-sized firms (relative to medium and small sized firms) who are designated consumers (relative to non-designated consumers) in the years PAT policy was implemented (relative to the pre-PAT policy years). The negative coefficient implies an approximately 16.5% decline in the EI of large-sized designated consumers due to implementation of PAT in the years 2012-2015.

All the other variables have the same signs as before, except *Indus*. The coefficient of *Indus* is positive; implying the EI of cement firms is lower than the pulp & paper firms. However the effect is insignificant.

V. Conclusion

EI of Indian manufacturing sector has been declining. Government of India launched the Perform-Achieve-Trade scheme in 2007 to use market based instruments to reduce the EI of the industrial sector. Since the first phase of PAT is the trial phase, the government and BEE identified eight most energy intensive industries and within each industry the most energy intensive firms were identified. These firms, called designated consumers, were give EI targets that were to be met within the first PAT cycle from 2012-2015.

The objective of this paper is to quantify the effect of PAT for two of the eight identified industries viz. Cement and Pulp & Paper industries. We use the statistical technique of difference-in-differences to measure the effect of PAT on the average EI of designated consumers in the implementation years. We also estimate an OLS model with firm and year fixed effects to control for other independent variables.

Graphical results show the EI to be declining for both the Cement and Pulp & Paper industries after the implementation of PAT scheme. However the empirical results suggest that PAT has not played a significant role in reducing EI of designated consumers. One reason could be that the study uses firm level data to capture the PAT effect, while BEE has used plant level data. Use of plant level data will help in a more precise estimation of this policy. But due to non-availability of that data, firm level data is the closest proxy that can be used. The second reason could be that other factors have been responsible for the downward trend in EI. For example the industries may be becoming more energy efficient due to technological factors or better quality imports.

Regression results show that capital intensity, after crossing a threshold, helps in reducing EI of firms. Size of the firm is another variable that positively influences EI. Large sized firms are expected to have greater resources to invest in technological improvements in production. Large sized firms in both industries have lower EI than small and medium sized firms. Older firms (that are 40 years or older) are found to be more energy intensive that the new firms across both industries. And EI of pulp & paper firms declines more rapidly than that of cement firms.

One drawback of the difference-in-differences methodology is that it does not capture the effect of other factors that may affect the EI of designated consumers relative to non-designated consumers. To capture the effect of one of the factors viz. *Size*, the paper uses difference-in-difference-in-differences methodology. The coefficient of the triple interaction term shows that EI of large-sized designated consumers is lower in the years PAT was implemented.

Therefore in general, an efficient use of energy will ensure that even with growing population and pressures of human activities energy consumption will be such that emissions do not reach catastrophic levels and greenhouse effect maintains the temperature of the Earth at a natural habitable level. Hence it is important to divert a part of the funds towards improving production techniques so that India is able to meet its commitment to reducing emissions and can also successfully emerge as the first nation that could control emissions by reducing energy used per unit of output.

References

[1] International Monetary Fund, *World Economic Outlook 2017*, April.
[2] *India Population 2016 – Worldometers*.
[3] *BP Statistical Review of World Energy*, 2016.
[4] Energy Statistics, Central Statistics Office, National Statistical Organisation, Ministry of Statistics and Programme Implementation, Government of India, 2015.
[5] B. Goldar, "Energy intensity of indian manufacturing firms: Effect of energy prices, technology and firm characteristics," *Science, Technology & Society*, vol. 16, no. 3, pp. 351-372, 2010.
[6] S. K. Sahu and K. Narayanan, "Determinants of energy intensity in indian manufacturing industries a firm level analysis," *Eurasian Journal of Business and Economics*, vol. 4, no. 8, pp. 13-30, 2011.
[7] Perform Achieve and Trade, Ministry of Power, Government of India, July 2012.
[8] Cement Manufacturers' Association, *Annual Report 2012-2013*.
[9] Indian Paper Manufacturers Association (IPMA). [Online]. Available: http://ipma.co.in/
[10] H. Pao and C.-M. Tsai, "Multivariate granger causality between CO2 emissions, energy consumption, FDI and GDP: Evidence from a panel of BRIC (Brazil, Russian Federation, India, and China) countries," *Energy*, vol. 36, pp. 685-693, 2011.
[11] W. He, G. Gao, and Y. Yang, "The relationship of energy consumption, economic growth and foreign direct investment in Shanghai," *Advances in Applied Economics and Finance (AAEF) 507*, vol. 3, no. 1, 2012.
[12] Y. Yang and Y. Todo, "Diffusion of energy saving technologies through foreign direct investment empirical evidence from Indonesian manufacturing," presented in 12th IAEE European Energy Conference, 2012.
[13] Teng, "Indigenous R&D, technology imports and energy consumption intensity: Evidence from industrial sectors in China," *Energy Procedia*, vol. 16, pp. 2019-2026, 2012.
[14] K. Mukherjee, "Energy use efficiency in the Indian manufacturing sector: An interstate analysis," *Energy Policy*, vol. 36, pp. 662–672, 2008.
[15] Prowess Database (CD accessed from JNU Library.
[16] B. Meyer, "Natural and quasi experiments in economics," *Journal of Business and Economics Statistics*, vol. 13, no. 2, 1995.

Hena Oak is with Delhi School of Economics, University of Delhi, India, 2004-2006. She got the MA (economics), Delhi School of Economics, University of Delhi, India, 2002-2004; the MA (economics), Vancouver School of Economics, University of British Columbia, Vancouver, Canada, 2011-2012.

She is working as assistant professor, Department of Economics, Miranda House College, Uni. of Delhi, India. She has taught courses on microeconomics, statistics and econometrics. Her research interests include environmental economics and international trade. She has presented papers on the problem of air pollution in the Indian context in numerous national and international conferences. Currently she is pursuing her PhD from Jawaharlal Nehru University, Delhi. Her PhD research focuses on energy intensity of Indian manufacturing firms, with special focus on a new government policy that attempts to introduce market based instruments to improve energy efficiency in the Indian industry.