Discussion Papers in Economics

Perform-Achieve-Trade Policy: A Case Study of Cement Industry for Energy Efficiency

Hena Oak and Sangeeta Bansal

Discussion Paper 17

Centre for International Trade and Development

School of International Studies

Jawaharlal Nehru University

India

Perform-Achieve-Trade Policy: A Case Study of Cement Industry for Energy Efficiency

Hena Oak* and Sangeeta Bansal**

Date: May 30, 2017

* Assistant Professor, Miranda House, University of Delhi and PhD Research Scholar, Centre for International Trade and Development, School of International Studies, Jawaharlal Nehru University, New Delhi-110067. Email: henaoak@gmail.com
**Professor of Economics, Centre for International Trade and Development, Jawaharlal Nehru University, New Delhi-110067. Email: sangeeta.bansal7@gmail.com

Abstract

India launched Perform-Achieve-Trade (PAT) scheme for selected high energy intensive industries in 2007 to induce efficient use of energy. The scheme identified most polluting firms within each industry (designated consumers) and set individual energy intensity reduction targets to be achieved during the PAT cycle 2012-2015. Firms that exceed the target will be given Energy Saving Certificates to be traded with those who under achieve. The objective of this paper is to use difference-in-differences method to analyse the effect of PAT for the Indian Cement industry. The sample period is 2005-2015. We find that EI is higher for the designated consumers than the non-designated consumers which implies that they were correctly identified. The average EI of designated consumers is found to be lower in the implementation phase of 2012-2015. The other control variables like capital intensity, size and age of the firm have expected signs. We further introduce leads and lags in the model to explore the dynamics between PAT and EI. We find that two years prior to the implementation of the policy the leads are close to zero and insignificant and thus the parallel trends assumption holds. Next we conduct two robustness checks by using different definitions of age of the firm and by using the data for non-designated consumers and size of the firm. The results are found to be robust.

JEL Classification: Q4, Q5

Key Words: Energy Intensity, India, Perform Achieve and Trade, Cement Industry

1. Introduction

Economic growth is imperative for developing and emerging economies like India. India, which is the seventh largest economy of the world (World Development Indicators, World Bank, updated in April 2017), is also the fastest growing economy, 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 (IMF 2017). It is also the second most populous country in the world with a population of 1.3 billion. The rapid economic growth combined with high growth in population results in growing energy demand. Sustained and unrestricted supply of energy is necessary to continuously move up the growth trajectory, as energy plays a vital role in the social and economic development of a country.

India is the world's third largest consumer of primary energy, after China and USA (BP Statistical Review, 2016). The demand for energy is unlikely to reduce in the coming years due to growing population, rapid urbanisation and economic growth.

India's energy basket comprises of both renewables and non-renewables. The share of non-renewable energy, which includes fossil fuels like coal, oil and natural gas, is dominant (75% in 2015 as per World Bank data). Fossil fuels are highly emission intensive and release greenhouse gases like carbon dioxide (CO_2).

Union Minister of Environment, Forest and Climate Change, Shri Prakash Javadekar, has 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. The challenge before India is how to achieve economic growth without adversely affecting the environment, i.e., move on the path of Sustainable Development. Can emissions be reduced along with keeping pace with modernisation and industrialization?

A long term possibility to reduce emissions is an increase in the share of renewables like wind and solar energy. But in the short term an alternative way to support economic growth while reducing the demand for dirty inputs is to use energy more efficiently. Thus efforts at efficient use of energy will help an emerging economy like India achieve its twin objectives of maintaining high growth rates while simultaneously cutting down emission levels. This paper aims to assess success of one of the schemes that India introduced to improve energy efficiency of its industrial sector, namely, Perform-Achieve-Trade (PAT). The first cycle of the scheme was during 2012 – 2015.

In the recently ratified COP21 Paris agreement on climate change India has pledged for domestic actions to reduce emission of greenhouse gases and creating clean energy and sustainable environment for its population. India has committed to reduce emission intensity of GDP by 33-35% by 2030 compared to 2005 level and increase its forest cover by 5 million hectares so as to achieve the targeted absorption of 2.5 - 3 tonnes of carbon from the atmosphere (The Indian Express).

The highest consumer of commercial energy in India is the industrial sector. In 2013-14, national energy consumption was 424,509 ktoe out of which the share of the industrial sector was 52.72% (Energy Statistics, Ministry of Statistics & Programme Implementation, GoI, 2015). It is followed by transport sector (6.85%).

The Government of India (GoI) has taken steps towards encouraging more efficient use of energy in the industrial sector. The first crucial step was the launch of the Energy Conservation Act, 2001. Bureau of Energy Efficiency (BEE) was created under this Act. Further in June 2008 the National Action Plan for Climate Change (NAPCC) was launched with eight National Missions that aimed at achieving key goals with respect to climate change. One of the missions of NAPCC is National Mission for Enhanced Energy Efficiency (NMEEE) and its objective is promoting energy efficiency through policies, regulation, financing mechanisms and business models. To enhance energy efficiency, NMEEE launched four initiatives. One of them, which is the focus of this paper, is the Perform-Achieve-Trade (PAT) scheme. Under PAT scheme, certain firms are identified and given individual targets for reduction in energy intensity. Those firms that over-meet their targets are given energy saving certificates, which can be traded in the market.

PAT is the first tradable permit scheme adopted by India. Through PAT, India has introduced a market based instrument in the economy as an environmental regulation measure for the first time. It has been relying on command and control instruments for environmental regulation. This scheme is unique even globally as countries implementing tradable permits have emission trading programmes with a target on emissions and trading in emission reduction certificates. PAT is *Cap & Trade in Energy Intensity*, which is different from Cap & Trade in Emissions adopted by the developed countries in two important respects. One, PAT sets targets in terms of energy intensity and not emissions, second, separate targets are set for each firm. The objective of PAT is to improve the energy efficiency of the high energy intensive industries through target setting and tradable energy saving certificates. 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 being used. The policy aims at reducing emissions by 26 million tonnes of carbon dioxide equivalent by 2015. That will play a crucial role in helping India to meet its commitment in the Copenhagen and Paris Agreement on Climate Change. Thus it is important to examine if the scheme has been successful in meeting its objective. It could also make way for the adoption of other market based instruments.

The objective of this paper is to assess the impact of the PAT scheme on energy intensity of firms of one of the BEE identified industries, viz., Cement Industry. For the purpose, we do firm level panel data analysis for the time period 2005–2015. We use difference-in-differences methodology to identify effects of the PAT scheme on energy intensity of firms that were identified as designated consumers. We also examine other factors affecting energy intensity of the cement industry. We find that energy intensity for the cement industry as a whole increased during the years PAT was implemented, but it did decrease for the designated consumers in the years of implementation. For the designated consumers CAGR for the period 2012-2015 declined as compared to 2007-2011 when the policy was first announced. This indicates success of the policy because the target group comprises of high energy intensive firms and controlling energy intensity for the same will take time, especially because India is new to cap and trade policy.

Various studies have analysed factors influencing EI of firms in India as well as other countries. None of the studies, however, has examined the effect of government's PAT initiative on EI. This is one of the few papers that assess success of the PAT scheme. Roy (2010) briefly explains the PAT scheme and also makes some recommendations especially with respect to its coverage. The paper focuses on the Iron & steel Industry as it is one of the sectors identified by the BEE. Roy recommends that the policy should be implemented in a single sector initially viz. the iron & steel sector. But our focus is different as it looks at the effect on EI post implementation and controls for other independent variables.

Bhattacharya et al (2001) apply the additive form of decomposition analysis to study the importance of structural and technological changes on energy consumption and EI of India. Goldar (2010) and Sahu et al (2011) examine factors that influence EI in the Indian industries. Both papers find smaller sized firms and domestically owned firms to be less efficient than large firms and foreign owned firms. Goldar (2010) also finds significant amount of energy efficiency spillover from foreign to domestic firms. Goldar (2012) concludes that a downward trend in EI from 1992 onwards could have been due to greater substitution towards non energy inputs and greater use of capital intensive energy saving technology due to rising energy prices. In other emerging economies like China one of the reasons for declining EI has been a structural shift in the economy. Fisher-Vanden et al (2004) consider a move towards less energy intensive products as one of the possible reasons for China's declining EI.

The firm level studies for India (Goldar 2010 & 2012; Sahu et al, 2011) examining energy efficiency analyse manufacturing firms as a whole and do not analyse industries specified under PAT scheme individually.

The rest of the paper is organised as follows. Section 2 provides a detailed description of PAT scheme and also gives a brief background of the Cement Industry in India. Section 3 describes the variables used in the study, data sources and econometric methodology. The empirical results are described in Section 4 and Section 5 summarizes the paper's conclusion.

2. Background Of Indian Cement Industry

Indian cement industry is the second largest in the world after China. It is essentially the "glue" that sticks the economy together. It is omnipresent in every sector and is quite literally the building block on which the economy stands. It is an indigenously developed industry. Cement demand is essentially derived demand and very closely linked to the performance of the economy. If the markets are buoyant, then there will be greater demand for housing, infrastructural investment like building of new roads, bridges, canals, etc., which will lead to greater demand for cement. For example during the global recession of 2008-09, India also witnessed a slowdown due to which growth of cement industry was not as high as the previous years. But with the Common Wealth games in 2010 and various stimulus packages announced by the government to help real estate and infrastructure, cement industry grew at an impressive rate of 12.7% from 8% in 2008-09. This year also witnessed an unforeseen capacity expansion of 37 million tonnes (highest in a single year) that led to latest modernisation of kilns, mills and grinding units (CMA Annual Report 2009-10). This helped in better utilisation of energy inputs as well. But the Euro zone crisis of 2011-12 slowed down GDP growth to 6.5%. The accompanying adverse effect on housing, infrastructural development, etc., led to a sharp fall in capacity utilisation of the cement industry. This reduced availability of resources for modernisation and technological upgradation. The period of economic gloom continued in fiscal years 2012-13 and 2013-14 culminating into a mismatch between demand and supply of cement. Currently the industry uses only 72% of its total capacity mainly due to poor investments in infrastructure like roads, housing, airports, ports, etc. (CMA Annual Report 2012-13). However initiatives by the new government such as construction of cement concrete roads, housing for all, smart cities, Make in India, etc., is expected to revive the cement industry.

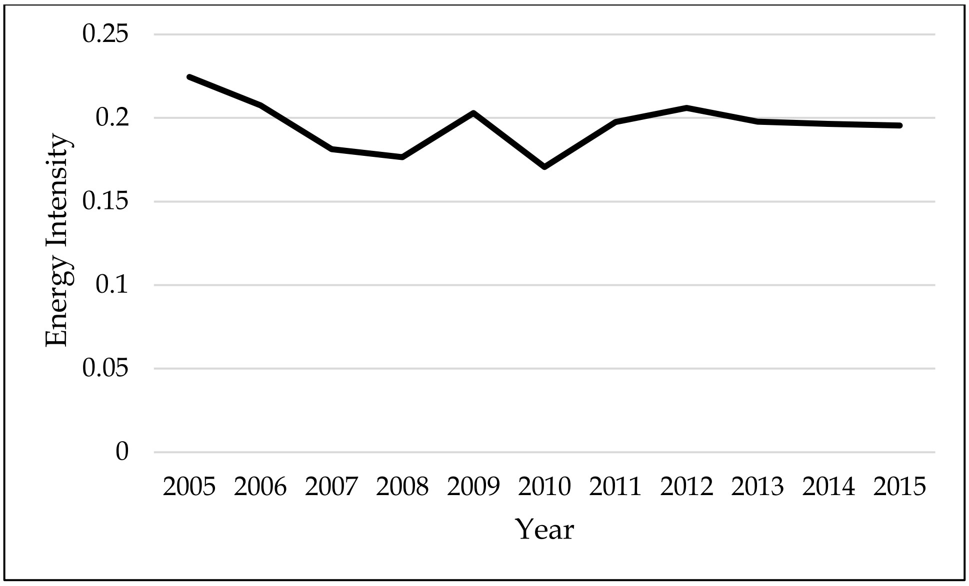
Since the development of this industry is pivotal for most of the other sectors, the government has allowed for 100% FDI in this sector. Lafarge was the first foreign investor to enter the Indian market in 1999. But this sector still does not figure in the top ten FDI attracting sectors of India. As per the data, between January 2000 – May 2015 this sector was at number 21 (SIA Newsletter June 2015, Department of Industrial Policy and Promotion, GoI). However there is a huge potential for foreign investment in this sector. This is mainly because even though globally India is the second largest producer of cement, its own per capita consumption is very low. Then there are major government projects underway like the National Highway Development Project including the Golden Quadrilateral and the North-South East-West Corridor. Hence huge gains can be made due to economies of scale in production.

The major costs incurred by cement firms are Energy, Transportation and Limestone. Within energy inputs, coal and electricity are its principal energy inputs and this makes the industry highly energy intensive. Therefore improving the energy intensity will go a long way in providing energy security to the industry.

Fortunately, the Indian cement industry is one of the most efficient in the world today in terms of technology used. In fact performance of the best cement plant (electrical energy consumption of 66kwh/ton of cement and thermal energy of 667kcal/kg of clinker) is closely comparable to the best cement plants in Japan (electrical energy consumption of 65kwh/ton of cement and thermal energy of 660 kcal/kg of clinker) (CMA Annual Report 2013-14). And the government is striving to achieve even higher targets. One of the core focus areas of the 12th Five Year Plan is technological improvement in the cement industry.

BEE can play an important role in helping the government achieve the same. It has identified 85 designated consumers from this sector (energy intensive plants). These plants have been selected from 43 cement firms, i.e., one or more plants from a set of 43 firms are identified as a designated consumer (own analysis). 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. The minimum annual energy consumption by the designated consumers in this sector is almost 30000 tons of oil equivalent. BEE aims to achieve energy saving target of 0.816 million toe under the first PAT cycle (BEE and Ministry of Power, GoI PAT Document, July 2012).

Prowess database has data on 194 cement firms. But due to the problem of missing observations, we have included a sample of 87 firms. Out of these 87 firms, 32 firms have plants that have been listed as designated consumers. If Power and Fuel expenditure is taken as a proxy for energy consumption, then we can see from Figure 1 that energy intensity of the cement industry has been rising since 2010. During the implementation phase of PAT policy it declined slightly and then remained steady till 2015.



Source: Own Calculations

Figure 1: Energy Intensity of Indian Cement Industry 2005-2015

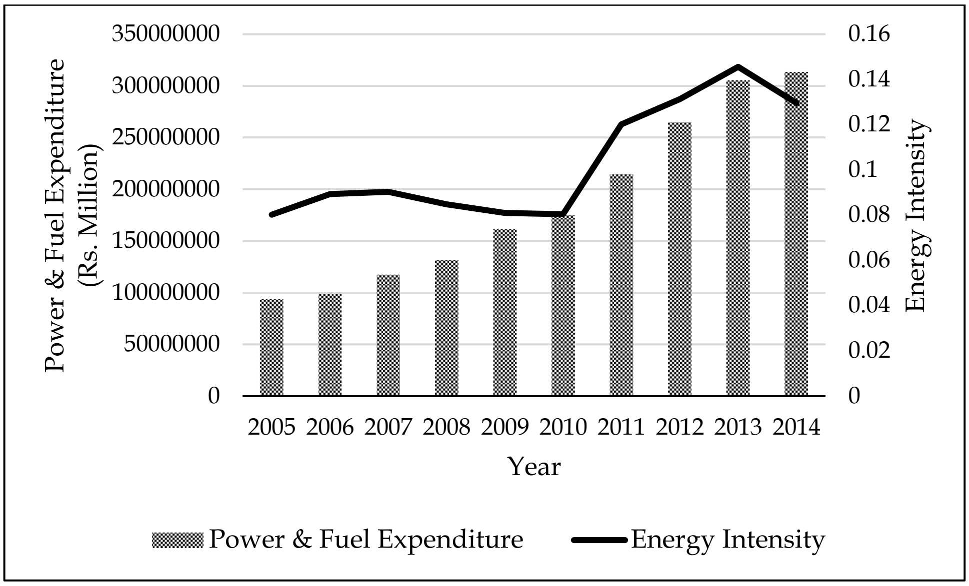
We do a graphical analysis for each designated consumer and non-designated consumer (Figure 2 and 3 in Appendix) and we find that for most designated consumers EI declined during the implementation phase. While for the non-designated consumers the trend remained almost steady for the sample period (except Barak Industries which experienced a sharp decline in EI).

Mandal (2010) does a state level analysis of the cement industry to measure its environmental efficiency with respect to carbon dioxide for the years 2000 - 2005. The paper finds that average environmental efficiency measure declined in 2004 - 2005 compared with 2000 - 2001. This was a period of increase in energy consumption, as evident from Figure 2. Overtime the industry achieved operational and energy efficiency in the new plants. A number of firms collaborated with Central and State Pollution Control Boards and technological institutions like

GTZ German Technology Corporation to better the cement kilns. Recently the cement industry has also made substantial investments in setting up Waste Heat Recovery Plants to get more energy from the existing energy resources.

In general EI has registered a declining trend for the entire industry, with brief periods of increase. During the PAT implementation phase energy intensity declined for both set of firms, even though it remained more for the designated consumers than the other firms. Overall graphical results suggest that the Cement industry is becoming more energy efficient with time.

We did a graphical analysis for the Cement industry using 761 firms from the Annual Survey of Industries database (various years) for the sample period 2005 - 2014 (Figure 4).



Source: Annual Survey of Industries & Own Calculations.

Figure 4: Power & Fuel Expenditure (Rs. Million) and Energy Intensity of Indian Cement Industry 2005-2014

The results show the trend to be similar to our analysis using the Prowess database. Hence cement industry in general was becoming more efficient after year 2012.

3. Data, Variables And Econometric Methodology

3.1. Data Sources and Variables

In the literature a number of studies have been undertaken to assess the factors influencing EI at an international level. Pao et al (2011) estimate the effect of energy consumption, GDP and FDI on CO_2 emissions in BRIC countries and test for Granger Causality between these variables for the period 1980-2007. Erdem (2012) explains the relationship between FDI and technology determined energy efficiency using a Fixed Effects model for 13 EU countries. Both papers find that foreign technology plays a positive role in reducing emissions in the recipient country. He et al (2012) use a multivariate VAR model to test for granger causality between energy consumption, economic growth and FDI in Shanghai, China from 1985 to 2010. Yang et al (2012) take up the case on Indonesian manufacturing to explore if FDI diffuses energy saving technology into the host country. They use firm level panel data for 1993-2009. 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. Zheng et al (2011) analyse the relation between exports and EI in their study of Chinese industries because in 1999-2007 China achieved a sustained increase in exports, along with declining industrial EI. In the Indian case Mukherjee (2008) 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.

For empirical estimation of Energy intensity (EI) we need data on energy consumed and output produced. However in the absence of data on total energy consumed and production in physical units, we define it in monetary terms as follows:

$$EI = \frac{Power\ \&\ Fuel\ expenditure\ (Rs\ million)}{Total\ Production\ (Rs\ million)}$$

Power & Fuel expenditure (Rs Million) is used as a proxy variable for energy consumed. Total Production is defined as the sum of Sales (Rs. Million) and change in stock of finished goods (Rs. Million). All the independent variables included in the study (except the dummy variables) have been divided by Total Production (Rs. Million) in order to normalize them to neutralize the effect of inflation. Data on the dependent variable and all independent variables, except the dummy variables, has been taken from Prowess Dataset. This dataset 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. Annual Reports of firms have also been consulted to fill the missing data as much as possible and depending on availability of the reports.

i. PAT year (*PATyear*) - This is a year dummy included to capture the effect of BEE's PAT scheme on the industry, after PAT was implemented. Variable *PAT year* = 1 for the years 2012-2015 and 0 otherwise.

ii. PAT firm (*PATfirm*) – This is a policy dummy variable. It will capture the difference in the EI of the designated consumers and non-designated consumers as a result of the former being identified by BEE and expected to meet given targets. *PAT firm* = 1 for Designated Consumers and 0 otherwise.

iii. Interaction dummy variable (*PATyear* PATfirm*) – This variable is defined as the product of *PAT year* and *PAT firm*. It will capture the average effect of PAT policy on the average EI of the designated consumers in the years 2012-2015. It is also the difference-in-differences estimator.

iv. Capital Intensity (*k*) – To proxy for technological development, capital per unit of output used. Greater the capital intensity, greater is the possibility of better technology being used that will help to improve EI. In the absence of data we use capital employed per unit production as a proxy for capital intensity.

v. Size of the firm (*Size*) – 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 gross fixed assets as a measure of size variable.

vi. Age dummy (*Agedum*) – This is a dummy variable defined as *Age* = 1 if the firm is 40 years or older and 0 otherwise. For older firms higher operating expenses and obsolete technology makes it more difficult to improve energy efficiency.

vii. Age dummy (*Agedum1*) – This is a dummy variable defined as *Age* = 1 if the firm is 24 years or older and 0 otherwise.

viii. Age (*Age*) – This is taken as the difference between the current year and the year of incorporation.

ix. Age1 (*Age1*) – We take the difference between the year of incorporation and year 2010 and the difference between the two is taken to be the age of the firm for the time period 2005-2015.

The different definitions of age of the firm (*Agedum1, Age* and *Age1*) have been used for robustness check to see if the results change when the definition of age of the firm is changed.

BEE uses plant level data for specifying targets, i.e., production plants that are highly energy intensive have been identified and termed as designated consumers. A firm can either have a single plant or multiple plants identified by BEE, depending on their energy consumption trends. Therefore the designated consumers are actually plants belonging to a particular firm.

However due to unavailability of plant level data, we use firm level data to evaluate the effect of PAT and term any firm that has a plant identified by BEE as “designated consumer”. Hence in our paper designated consumer is defined to include firms that have a plant identified by BEE for PAT scheme.

BEE has identified 85 plants as designated consumers and these plants belong to 43 different cement firms. In our dataset we have 87 cement firms of which 32 firms are designated consumers and 55 firms are non-designated consumers.

We have considered all the firms for which the data was available in the Prowess dataset. For the other cement industry firms that are not in the Prowess data set, we tried to locate annual report of the firms and incorporate that data. Many, annual reports, however, were not available. The 32 designated firms in our dataset own 74 plants that have been targeted by BEE. A firm from the sub-set of 32 firms can either own a single energy intensive plant or multiple plants. For example Ultratech Cement Ltd. has the maximum number of identified plants at 12 plants, followed by ACC Ltd. at 11 plants (a complete list of these 32 firms with the number of high energy intensive plants that they individually own is given in Appendix Table 8). Out of the 85 designated plants, 74 are included in our study. Therefore almost 87% of designated consumers have been covered.

The Ministry of Power, Government of India’s Perform-Achieve-Trade document published in July 2012 is used to identify the names of designated consumers of the cement industry. The dummy variable *PAT firm* is created using the names from the document.

3.2. Econometric Methodology

We will use difference-in-differences methodology to measure the effectiveness of the Perform-Achieve-Trade policy in the Indian Cement industry. This method is used to measure the differential effect of a policy on the treatment group (which is exposed to the policy) versus the control group (which is not affected by the policy). PAT is the policy whose effect is to be analysed. Designated consumers are the treatment group as they participate in the policy. Non-designated consumers are the control group as the policy is not implemented on them. The reference category against which all comparisons are made, is when both dummy variables take value 0, i.e., non-designated consumers in the years 2005-2011.

An ordinary least square model with firm and year fixed effects is estimated to include other control variables that affect the EI of cement firms. The model specification is given as follows:

$$EI_{i,t} = \alpha_i + \lambda_t + \beta_0 + \beta_1 PATyear + \beta_2 PATfirm + \beta_3 (PATyear * PATfirm) + \beta_4 k_{i,t}$$

$$+\beta_5 \left(k_{i,t}\right)^2 + \beta_6 Size_{i,t} + \beta_7 Agedum + u_{i,t} \quad (1)$$

Where α_i and λ_t are the firm and year fixed effects respectively. We correct for standard errors by clustering at the firm level.

In the above equation, β_1 is the difference in the average EI of the control group (non-designated consumers) in the post-treatment period (2012-2015) and average EI of the control group in the pre- treatment period (2005-2011). β_2 gives the difference in the average EI of the treatment group (designated consumers) in the pre-treatment period (2005-2011) and average EI of the control group in the pre- treatment period (2005-2011). If β_2 is positive, then it implies that EI of designated consumers is higher than non-designated consumers before PAT was implemented.

β_3 is the difference-in-differences estimator. It is the differential effect of being a designated consumer in the years 2012-2015. It is also called the average treatment effect i.e., the effect of the treatment PAT on the EI of designated consumers.

The key assumption in the difference-in-differences methodology is the Parallel Trends assumption. The assumption requires the EI of the treatment and control groups to follow the same time trend in the pre-treatment period. But this assumption is difficult to verify through a formal test. Therefore we can use pre-treatment data to check graphically if trends are similar. We can also introduce leads in the model to analyse pre-treatment trends (Waldinger lectures). 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.

Difference-in-differences calculates the "normal" difference in EI between the two groups i.e., the difference that would still exist if neither group experienced the treatment. The treatment effect given by β_3 is the difference between the actual observed EI and the "normal" EI. If the treatment effect β_3 is negative, then it means that the actual EI is lower than the EI that would have been with parallel trends had there been no government intervention through PAT.

Equation (1) can be used to facilitate comparisons between the two set of firms and between two time periods as shown in Table 2.

TABLE 2: ANALYSIS OF THE PAT POLICY

Year	2005-2011 (Before PAT)	2012-2015 (After PAT)	Difference (After PAT-Before PAT)
Non-Designated Consumer	β_0	$\beta_0 + \beta_1$	β_1
Designated Consumer	$\beta_0 + \beta_2$	$\beta_0 + \beta_1 + \beta_2 + \beta_3$	$\beta_1 + \beta_3$
Difference (Designated-Non Designated Consumer)	β_2	$\beta_2 + \beta_3$	β_3

As mentioned above, the model can have leads to give support to the parallel trends assumption. We can also add lags to the model given in (1) to check if the effect of PAT increases or decreases overtime as the firms go further into the implementation phase. 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. Similarly, in order to study about the dynamics between the government policy PAT and EI, we estimate the following model with leads and lag:

$$EI_{i,t} = \alpha_i + \lambda_t + \beta_0 + \beta_1 PATyear + \beta_2 PATfirm + \sum_{j=-m}^{q} \beta_j (PATyear * PATfirm)_{t+j} + \beta X_{i,t} + u_{i,t}$$

where there are m leads (leading to the policy) and q lags (after the policy). β_j is the coefficient of the jth lead or lag. $X_{i,t}$ are all other covariates. A formal test of the difference-in-differences assumption is $\beta_j = 0 \ \forall \ j < 0$ i.e. coefficients of all leads should be equal to 0. For $j \geq 0$ the coefficient β_j need not be identical because the effect of the policy would change overtime (for example the policy might become more effective overtime).

The econometric results are illustrated in the next section on Empirical Results.

4. Empirical Results

The objectives of this study is to analyse the effect of the PAT on the Cement industry. Table 3 below gives the descriptive statistics for average energy intensity of designated consumers and non-designated consumers both before and after the policy was implemented. This will give a brief idea of whether or not the Cement industry has been positively responsive towards PAT.

TABLE 3: AVERAGE EI BEFORE AND AFTER PAT SCHEME

Year	Designated Consumer	Non-Designated Consumer
2005-2011	0.207	0.161
2012-2015	0.212	0.154

This preliminary analysis shows that both before and after PAT was implemented, EI of designated consumers was greater than the non-designated consumers. EI of the designated consumers increased in the years PAT was implemented while for the non-designated consumers EI declined in the years 2012-2015. Designated consumers were identified because the government requires them to reduce their EI. But high energy intensive firms will take time before they can control and reduce EI to the target level. PAT was announced in the year 2007. We calculated CAGR for the years 2007-2011 and 2012-2015 and found it to be 5.1% and 0.4% respectively. Therefore PAT is having an effect on the designated consumers, though it is gradual.

Table 4 does a more formal analysis to see the impact of PAT and other control variables on the EI of the cement firms.

Model 1 is the basic difference-in-differences model. The results show that EI of the non-designated consumers is 14%[1] higher in 2012 - 2015 than 2005 - 2011. EI of designated consumers is higher than the non-designated consumers before the policy was implemented. The difference-in-differences estimator is negative, implying that designated consumers have lower average EI in the years 2012-2015. However the variables *PATfirm* and the difference-in-differences coefficient (*PATyear*PATfirm)* are insignificant in the model.

1. *Consider a linear regression* $y_{it} = a + bx_{it}$ *Differentiating we get* $\frac{dy}{dx} = b$.

To get in terms of percentage we do the following transformation: $\frac{\frac{dy}{y}}{\frac{dx}{x}} = b\left(\frac{x}{y}\right)$

where $\left(\frac{x}{y}\right)$ *is calculated at the mean values of* x & y

TABLE 4: EMPIRICAL ANALYSIS OF PAT

Variable	Model 1	Model 2	Model 3	Model 4
PAT year	0.033* (0.02)	-0.003 (0.036)	0.006 (0.032)	0.006 (0.045)
PAT firm	0.004 (0.02)	0.078*** (0.005)	0.16* (0.085)	0.16*** (0.005)
$[(PATyear)(PATfirm)]_{t0}$	-0.015 (0.03)	-0.037 (0.036)	-0.055** (0.026)	-0.055 (0.051)
$k_{i,t}$			0.005*** (0.001)	0.005 (0.005)
$(k_{i,t})^2$			-4.92e-06*** (5.78e-07)	-4.92e-06 (5.39e-06)
$Size_{i,t}$			-1.08e-08 (3.71e-07)	-1.08e-08 (2.18e-07)
Agedum			-0.072 (0.067)	-0.072*** (0.012)
Constant	0.219*** (0.01)	0.133*** (0.013)	0.124* (0.072)	0.124*** (0.018)
R^2	0.005	0.38	0.36	0.45
No. of Obs	730	730	680	680
Firm Fixed Effects	No	Yes	Yes	Yes
Year Fixed Effects	No	Yes	Yes	Yes

, and ***: Null hypothesis rejected at 10%, 5% & 1%; levels of significance respectively.*
Cluster Robust Standard Errors in parenthesis except in Models 1 & 3.
$[(PATyear)(PATfirm)]_{t0}$ is the year of implementation of the policy.

In Model 2 we add firm and year fixed effects to Model 1 and estimate clustered standard errors. *PATfirm* is significantly positive, but the other two variables are insignificant.

Model 3, which includes control variables like capital intensity, size of the firm, age of the firm, firm fixed effects and year fixed effects, does not report robust standard errors.

In Model 4, with the use of robust standard errors clustered at the firm level to control for serial correlation within a firm, there is a change in level of significance as well. Model 4 is our preferred model. 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.

The coefficient of the difference-in-differences term (*PATyear*PATfirm)* is negative and weakly significant at approximately 28% 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 target group.

All the other explanatory variables in Model 4 have expected signs, but the standard errors are different between Models 3 and 4. Capital intensity ($k_{i,t}$) that captures the technology of production, is positive but significant only at 37% level of significance in Model 4. One may expect that firms that are more capital intensive firms use superior technology that makes production more efficient. But technological improvement may be directed towards other factors of production and not towards improving the energy efficiency of firms. In fact as per the report by National Council for Cement and Building Materials, most cement manufacturers do not invest in environment efficient technology or waste utilization technology because they do not give good returns (95th GoI Report on performance of Cement Industry. $(k_{i,t})^2$ is negative and significant only at approximately 37%. This implies that as capital used per unit of production grows beyond a certain threshold level, it has helps in reducing EI, though the evidence is not strong. Most papers that include domestic R&D as an indicator for technology find that it contributes towards improving EI. In the Indian case Goldar (2010) finds that R&D helps to improve EI of all the firms, but it does not make a statistically significant contribution in case on energy intensive firms. Teng (2012) finds a positive contribution of domestic R&D in the case of China's EI. Aixiang (2011) reached a similar conclusion based on data on scientific personnel, number of college students and R&D grants for China.

A negative but statistically insignificant relationship is found between EI and *Size* implying that size of the firm has no role to play in determining the EI of firms. This result differs partially from that of Goldar (2010). Log of sales is used to represent size of the firm and the paper finds a significant negative relationship between size and EI for all firms in general but not specifically for energy intensive firms. Sahu et al (2009) find an inverted U-shaped relation between size and EI of Indian firms, where size is defined as log of energy consumed.

The dummy variable *Agedum* shows that older firms have lower EI than the new firms (EI of older firms is about 31% lower than the new firms). This is in contrast to what the literature finds where older firms are expected to use obsolete technology, while the new firms enter the market with more modern techniques of production. However older firms will also have more resources at their disposal to make investments to improve production technology. In our sample most of the large sized firms are 40 years or older (almost 49% of the large sized firms were established in or before 1975). Large sized older firms have other factors in their favour like assets, higher sales, etc., that can help them in improving production techniques.

TABLE 5: EMPIRICAL ANALYSIS OF PAT

Variable	Model 5
PAT year	0.054** (0.024)
PAT firm	0.151*** (0.011)
$[(PATyear)(PATfirm)]_{t+2}$	0.012 (0.036)
$[(PATyear)(PATfirm)]_{t+1}$	0.033 (0.073)
$[(PATyear)(PATfirm)]_{t0}$	-0.078 (0.087)
$[(PATyear)(PATfirm)]_{t-1}$	-0.01 (0.025)
$k_{i,t}$	0.005 (0.006)
$(k_{i,t})^2$	-5.36e-06 (5.89e-06)
Size	-1.36e-07 (3.39e-07)
Agedum	-0.065 (0.021)
Constant	0.088*** (0.013)
R^2	0.42
No. of Obs	525
Firm Fixed Effects	Yes
Year Fixed Effects	Yes

, and ***: Null hypothesis rejected at 10%, 5% & 1%; levels of significance respectively.*
Cluster Robust Standard Errors in parenthesis except in Model 2.
$[(PATyear)(PATfirm)]_{t0}$ is the year of implementation of the policy. t+m are the leads and t-q is the lag.

In the next model, Model 5 (Table 5 above), we introduce leads and lags of the interaction term *(PATyear*PATfirm)* in order to explore the dynamics between the government policy PAT and EI. We add the indicator variables for 1 and 2 years before the adoption of the policy. $(PATyear*PATfirm)_{t0}$ is the year the policy was implemented i.e., year 2012. $(PATyear*PATfirm)_{t-1}$ is one year after adoption of the policy. This is to test if the impact of PAT increases or reduces the EI of designated consumers after the year of implementation.

Before the adoption of PAT, the coefficients of the two leads are close to 0 and insignificant. This implies that there is no evidence of the policy having any effect before the implementation period and the parallel trends assumption holds. The year PAT was implemented the EI drops by 0.078 points, but the treatment effect is insignificant. A year after the implementation it drops by 0.01 points, but the effect continues to be insignificant. All the other variables have the expected signs as before.

We conduct two more robustness checks of our result. In Table 6 in the appendix we re-estimate Model 4 by replacing *Agedum* with *Age*, *Age1* and *Agedum1* (Models 6, 7 and 8 respectively). Most of the results do not change in Models 7 and 8, except for the level of significance. The difference-in-differences coefficient (*PATyear*PATfirm)* continues to be negative and weakly significant. In Model 6 the signs of most of the variables are not as expected (*PATyear* and *Age*).

The second robustness check is done by taking the sample of non-designated consumers and dividing it into two groups on the basis of its size. This is done to test if size of the non-designated consumers plays any role in influencing the EI (Table 7 Appendix). However the interaction variable ($PATyear*Size_{i,t}$) is close to 0 and insignificant. This means that size did not play any role in influencing the EI of non-designated consumers before and after PAT was implemented. And our results are robust.

5. Conclusion

In this study we analyse the impact of a new cap and trade government policy (PAT), aimed at improving the energy intensity of a set of high energy consuming firms from the Cement industry. PAT was implemented from 2012 to 2015 and this is considered to be its trial phase. The success of this initial phase will determine if cap and trade policy in energy intensity can work in India. If yes, then PAT can be extended to include more firms from the set of non-designated firms belonging to the eight industries already identified by BEE. The policy can similarly be widened to incorporate more industries like automobiles, etc.

Graphical results show that energy intensity of cement industry decreases slightly during the PAT cycle (2012 - 2015) and remains steady. Even though energy intensity remains higher for designated consumers than non-designated consumers in the PAT implementation years, the CAGR for designated consumers decreases during 2012 – 2015. A more formal econometric analysis using the difference-in-differences approach shows that the average energy intensity of designated consumers is lower in the implementation phase. This is important because the policy was targeted to reduce energy intensity of the treatment group and it has been successful in doing so. We also find that the average EI of designated consumers is higher than the non-designated consumers before PAT was implemented. This implies that the identification of firms by BEE is correct. Most of the other explanatory variables have expected signs. Capital intensity, an indicator of technology of production, does not assist in improving EI even after certain threshold is reached. Firm Size does not play a role in influencing the EI. But older firms are found to be less energy intensive than the new firms. Since older firms have been in operation for a longer time, they have more resources available for investment in modern techniques of production.

As per our knowledge this is the first paper that does an empirical analysis to gauge the success of PAT scheme. The success of this policy will play a big role in helping India achieve its intended nationally determined contributions as ratified in the Paris agreement. That is crucial for us because India has to maintain high economic growth and energy is critical to sustain growth. Therefore 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.

REFERENCES

Aixiang (2011), "Research on Relationship between Energy Consumption Quality and Education, Science and Technology based on Grey Relation Theory", *Energy Procedia,* 5: 1718-1721.

Autor, D. (2003). Outsourcing at Will: The Contribution of Unjust Dismissal Doctrine to the Growth of Employment Outsourcing. *Journal of Labor Economics*, 21 (1), 1-42.

BP Statistical Review of World Energy. (2016).

Bhattacharya, R., & Paul, S. (2001). Sectoral Changes in Consumption and Intensity of Energy in India. *Indian Economic Review*, 36 (2), 381-392.

Energy Statistics (2015), Central Statistics Office, National Statistical Organisation, Ministry of Statistics and Programme Implementation, Government of India.

Erdem, D., (2012). Foreign direct investments, energy efficiency, and innovation dynamics. *Mineral Economics*, 24, 119–133.

Fisher-Vanden, K., Jefferson, G H., Liu, H., & Quan Tao, Q. (2004). What is driving China's decline in energy intensity?. *Resource and Energy Economics*, 26, 77–97.

Goldar, B. (2010). Energy Intensity of Indian Manufacturing Firms: Effect of Energy Prices, Technology and Firm Characteristics. *Science, Technology & Society*, 16(3), 351-372.

Goldar, B. (2012). Input Substitution and Technical Change in Indian Manufacturing, 1973-2007. *The Journal of Industrial Statistics*, 1 (2), 169 – 181.

He, W., Gao, G., & Wang, Y. (2012). The relationship of energy consumption, economic growth and foreign direct investment in Shanghai**.** *Advances in Applied Economics and Finance (AAEF) 507*, 3(1).

"India Population (2016) - Worldometers"

International Monetary Fund (2017), *World Economic Outlook 2017*, April.

Lei, Rihui, Zhang, Y. and Wei, S. (2012). International Technology Spillover, Energy Consumption and CO2 Emissions in China. *Low Carbon Economy*, 3 (3): 49-53.

Mandal, S.K., and Madheswaran, S, (2010). Environmental efficiency of the Indian cement industry: An interstate analysis. *Energy Policy*, 38, 1108-1118.

Martinez, Clara Ines Pardo. (2010). Investments and Energy Efficiency in Columbian Manufacturing Industries. *Energy and Environment*, 21 (6), 545-562.

Mukherjee, K. (2008). Energy use efficiency in the Indian manufacturing sector: An interstate analysis. *Energy Policy*, 36, 662–672.

Pao, H., & Tsai, Chung-Ming. (2011). 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*, 36, 685-693.

Perform Achieve and Trade, July 2012, Ministry of Power, Government of India.

Parliament of India, Rajya Sabha, 95th Report on Performance of Cement Industry. Presented to the Rajya Sabha on 24th February 2011.

Prowess Database (CD accessed from JNU Library).

Roy, J. (2010), Iron and steel Sectoral Approaches to the Mitigation of Climate Change, Perform, achieve and Trade (PAT in India), Briefing paper in Climate Strategies on 6th December 2010.

Sahu, S.K., & Narayanan, K. (2009). Determinants of Energy Intensity: A Preliminary Investigation of Indian Manufacturing, Indian Institute of Technology, Mumbai, MPRA Paper no. 16606.

Sahu, S.K., & Narayanan, K. (2011). Determinants of Energy Intensity in Indian Manufacturing Industries A Firm Level Analysis. *Eurasian Journal of Business and Economics*. 4 (8), 13-30.

Teng. (2012). Indigenous R&D, Technology Imports and Energy Consumption Intensity: Evidence from Industrial Sectors in China. *Energy Procedia*. 16, 2019-2026.

The Indian Express, India to ratify Paris agreement on climate change: Here is everything you need to know, article written by Express Web Desk, September 26, 2016.

The World Bank: Data, URL: http://data.worldbank.org/

The World Bank: Data, URL: http://data.worldbank.org/data-catalog/world-development-indicators#

The World Factbook – India, CIA.

Waldinger, F., London school of Economics, URL: https://www.fabianwaldinger.com/applied-econometrics

Yang, Y., & Todo, Y. (2012). *Diffusion of Energy Saving Technologies through Foreign Direct Investment Empirical Evidence from Indonesian Manufacturing*. Paper presented in 12th IAEE European Energy Conference.

Zheng, Y., Qi, J., & Chen, X. (2011). The effect of increasing exports on industrial energy intensity in China. *Energy Policy*, 39 (5), 2688 - 2698.

Appendix

Figure 2: Energy Intensity of Designated Consumers for the period 2005-2015

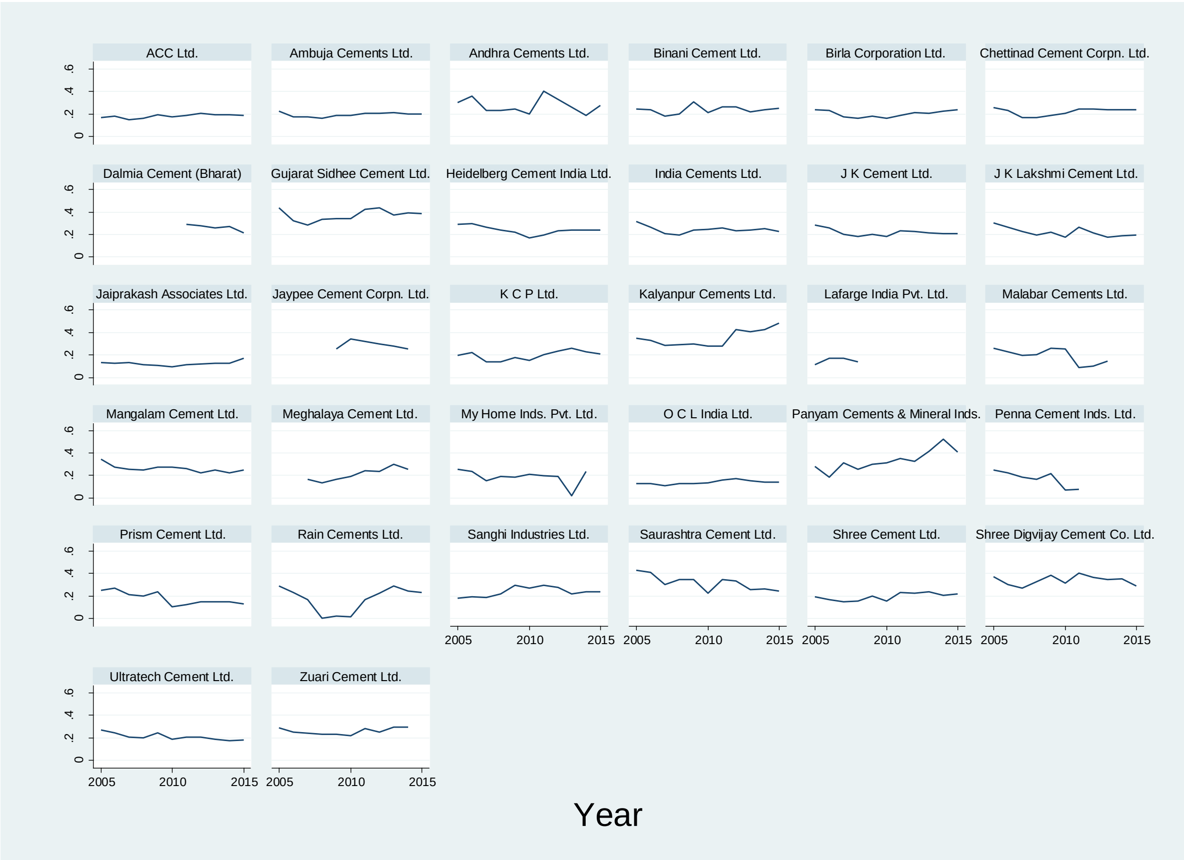


Figure 3: Energy Intensity of Non-Designated Consumers for the period 2005-2015

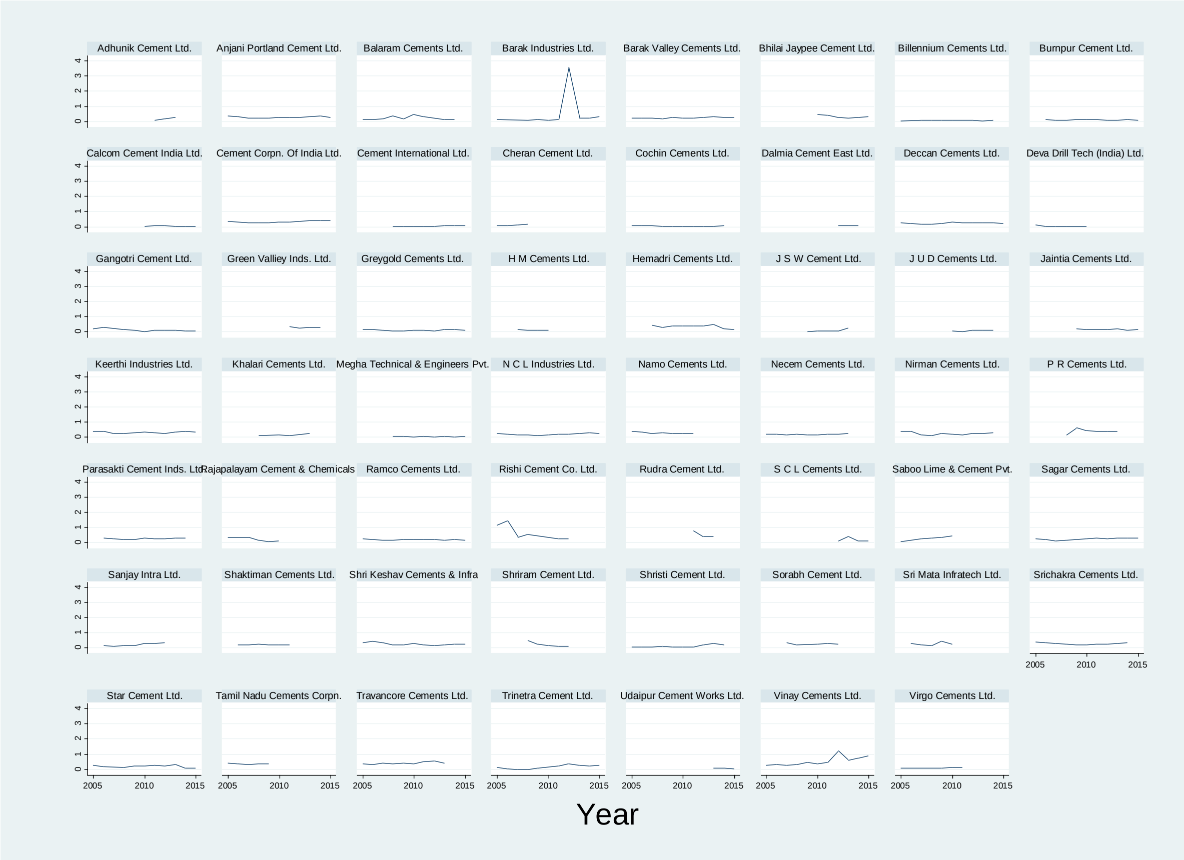


TABLE 1: SUMMARY STATISTICS

Variable	Observation	Mean	Std. Dev.	Min	Max
$EI_{i,t}$	730	0.2303924	0.1794381	0.000308	3.571429
$k_{i,t}$	748	12472.2	231551.6	0.1102078	4477067
Size	957	0.4942529	0.5002284	0	1
Agedum	957	0.183908	0.3876118	0	1
Agedum1	957	0.5517241	0.4975775	0	1
$Age_{i,t}$	949	27.62381	20.021	0	96
PAT year	957	0.3636364	0.4812972	0	1
PAT firm	957	0.3678161	0.4824631	0	1

TABLE 6: EMPIRICAL ANALYSIS OF PAT (ROBUSTNESS CHECK)

Variable	Model 6	Model 7	Model 8
PAT year	-0.004 (0.154)	0.006 (0.045)	0.006 (0.045)

PAT firm	0.041 (0.905)	0.144*** (0.005)	0.088*** (0.012)
(PATyear)(PATfirm)	-0.055 (0.051)	-0.055 (0.051)	-0.055 (0.051)
$k_{i,t}$	0.005 (0.005)	0.005 (0.005)	0.005 (0.005)
$(k_{i,t})^2$	-4.92e-06 (5.39e-06)	-4.92e-06 (5.39e-06)	-4.92e-06 (5.39e-06)
$Size_{i,t}$	-1.08e-08 (2.18e-07)	-1.08e-08 (2.18e-07)	-1.08e-08 (2.18e-07)
Age	0.001 (0.018)		
Age1		-0.001*** (0.00)	
Agedum1			-0.072*** (0.012)
Constant	0.105 (0.352)	0.15*** (0.018)	0.195*** (0.021)
R^2	0.45	0.45	0.45
No. of Obs	680	680	680
Firm Fixed Effects	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes

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

TABLE 7: ROBUSTNESS CHECK USING NON-DESIGNATED CONSUMERS

Variable	Non-Designated Consumers
PAT year	0.008 (0.055)
$Size_{i,t}$	2.69e-06 (3.24e-06)
$(PATyear*Size_{i,t})$	-2.11e-06 (1.52e-06)
$k_{i,t}$	0.006 (0.007)
$(k_{i,t})^2$	-6.23e-06 (6.97e-06)

Agedum	0.276*** (0.069)
Constant	0.136 (0.091)
R^2	0.46
No. of Obs	372
Firm Fixed Effects	Yes
Year Fixed Effects	Yes

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

Table 8: LIST OF FIRMS INCLUDED IN THE STUDY

Name of the Firm	No. of Plants	Name of the Firm	No. of Plants
Ultratech Cement Ltd.	12	Gujarat Sidhee Cement Ltd.	1
ACC Ltd.	11	J K Lakshmi Cement Ltd.	1
India Cements Ltd.	7	Jaiprakash Associates Ltd.	1
Ambuja Cements Ltd.	6	K C P Ltd.	1
Penna Cement Inds. Ltd.	3	Kalyanpur Cements Ltd.	1
Birla Corporation Ltd.	2	Malabar Cements Ltd.	1
Chettinad Cement Corpn. Ltd.	2	Mangalam Cement Ltd.	1
Heidelberg Cement India Ltd.	2	Meghalaya Cement Ltd.	1
J K Cement Ltd.	2	My Home Inds. Pvt. Ltd.	1
Jaypee Cement Corpn. Ltd.	2	O C L India Ltd.	1
Lafarge India Pvt. Ltd.	2	Panyam Cements	1
Rain Cements Ltd.	2	Prism Cement Ltd.	1
Shree Cement Ltd.	2	Sanghi Industries Ltd.	1
Andhra Cements Ltd.	1	Saurashtra Cement Ltd.	1
Binani Cement Ltd.	1	Shree Digvijay Cement Co. Ltd.	1
Dalmia Cement (Bharat) Ltd.	1	Zuari Cement Ltd.	1

Source: PAT Booklet, Ministry of Power, Govt. of India, July 2012.