Effect of Perform-Achieve-Trade Policy on Energy Efficiency of Indian Industries: Evidence from Fertilizer Industry

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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. Energy plays a vital role in the social and economic development of a country. In fact the Ministry of Statistics and Programme Implementation, Government of India, calls it a "strategic commodity". 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 (BP Statistical Review, 2016). This demand is unlikely to reduce in the coming years because of growing population, rapid urbanisation and economic growth. India's energy basket mainly comprises of non-renewable energy resources, which includes fossil fuels like coal, oil and natural gas, is dominant (75% in 2015 as per World Bank data). Increased consumption of energy results in environmental deterioration due to emissions associated with it. Therefore a challenge before developing countries like India is to achieve twin objectives of economic growth and environmental protection. One of the ways is to use the energy resources more efficiently.

Countries across the world have used various policy measures 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. However, most of these policy measures targeted reduction in emissions and none of them focussed on increasing the efficiency in energy use. India has introduced a unique program that targets improvements in energy efficiency of its industrial sector. This program is called Perform-Achieve-Trade (PAT). This is also the first market based instrument in India to achieve environmental protection. The scheme was introduced for the industrial sector because this sector is the highest consumer of commercial energy. In 2015-16 national energy consumption was 519,286 ktoe out of which the share of the industrial sector was 56.91% (Energy Statistics, Government of India, 2017).

There are several ways to measure energy efficiency. Freeman et al. (1997) state in their paper, energy intensity is a “single, simple, easy-to-compute, summary measure of the efficiency with which energy is utilized”. The United Nations Sustainable Development Goals considers energy intensity to be a proxy for energy efficiency. Energy intensity is defined as as energy supplied to the economy per unit value of economic output. The Office of Energy Efficiency and Renewable Energy, U.S. Department of Energy defines energy intensity as the amount of energy used in producing a given level of output or activity. In the Indian case, the Energy Statistics, Ministry of Statistics & Programme Implementation, Government of India defines energy intensity as the amount of energy consumed for generating one unit of Gross Domestic Product (at constant prices). The objective of this study is to access the PAT scheme and various other factors influencing the energy intensity of one of the highly energy intensive industries, viz., Fertilizer Industry.

The Government of India has taken numerous steps to promote energy efficiency in India. The Energy Conservation Act was passed in 2001. In order to implement various regulations of the Act, the Bureau of Energy Efficiency (BEE) was created in 2002, with an objective to reduce the energy intensity of the economy. 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, financing mechanisms and business models. One of the important missions of NMEEE, which pertains to the industrial sector, is the 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.

2. Perform-Achieve-Trade

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 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. 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, were set for each DC such that sum of the targets for all DCs within an industry equals the industry's target. Therefore SEC is similar to energy intensity. BEE defines SEC in the target year as the percentage reduction in SEC from the baseline year, where SEC in the baseline year is the average of SEC figures in the years 2007-08, 2008-09 and 2009-10. At the end of the target period if the efficiency gains achieved by the designated consumer surpassed its target then it would be issued energy saving certificates or ESCerts. 1 ESCert equals 1 toe worth of energy consumption. The non-complying designated consumers would have to buy the ESCerts to meet their energy saving targets. These certificates can be traded in the Indian Energy Exchange and Power Exchange of India.

The objective of this paper is to quantify the PAT effect and to assess the impact of the PAT scheme on the energy intensity of one of the BEE identified industries viz. Fertilizer Industry. This paper will attempt to see if energy intensity of the designated consumers is any different in the years PAT was announced and implemented as compared with the other years. We use firm level panel data over the years 2004-05 to 2014-15. We use difference-in-differences approach in a fixed effects model to identify the effect of the PAT scheme on the designated consumers. We also examine other factors affecting energy intensity of firms from these industries. Finally we assess if a market exists for ESCerts for trade to take place.

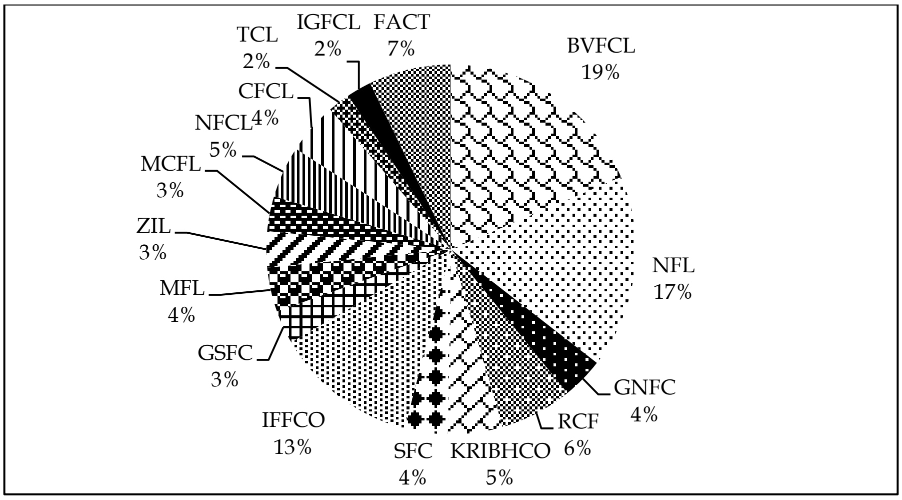
In the literature a number of studies have been undertaken to assess the factors influencing energy intensity at an international level. Pao et al (2011) estimate the effect of energy consumption, GDP and FDI on CO_2 emissions in BRIC countries and test for Granger Causality between these variables for 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. Mukherjee (2008) conduct Data Envelopment Analysis for India 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. There are India centric papers that analyse effect of various factors on the energy intensity of Indian manufacturing industries (Goldar, 2010; Sahu and Narayanan, 2011). In general, large sized firms were found to be less energy intensive than small sized firms. Older firms were less energy efficient than the new ones. Use of better imported technology by a firm helped in improving its energy efficiency. Also significant amount of energy efficiency spillover was found from foreign to domestic firms.

The papers on India look at the industrial sector as an aggregate and do not segregate them into different industrial groups. To the best of our knowledge none of the papers estimate the effect of the PAT scheme on the identified industries.

3. PAT and the Indian Fertilizer Industry

BEE has identified 29 designated consumers from the fertilizer sector (PAT, Ministry of Power, Government of India, 2012). These plants have been identified from 17 fertilizer firms, i.e., one or more plants from a set of 17 firms are identified as a designated consumer. All these 29 units are producers of ammonia and urea. For calculation of specific energy consumption, BEE has defined “Product” for each industry that it has identified. For the fertilizer industry “product” is defined as Urea (in tonnes) since it is the main fertilizer produced indigenously (PAT Consultation Document, 2011). The range of specific energy consumption for this industry is 5.86 to 9.11Gcal/T of Urea. The minimum annual energy consumption by the designated consumers in this sector is 30000 toe. BEE aims to achieve energy saving target of 0.478 million toe under the first PAT cycle (PAT, Ministry of Power, Government of India, 2012).

Within the set of firms that own the designated consumers, National Fertilizers Ltd. (NFL) and Indian Farmers Fertilizer Co-op Ltd. (IFFCO) have the highest number of designated consumers with 5 plants each. They are followed by Brahmaputra Valley Fertilizers Corporation Ltd. (BVFCL), Rashtriya Chemicals & Fertilizers Ltd. (RCF), Krishak Bharati Cooperative Ltd (KRIBHCO), Nagarjuna Fertilizers & Chemicals Ltd (NFCL) and Chambal Fertilizers and Chemicals Ltd. (CFCL) with 2 plants each. The rest of the firms have one plant each. However the distribution of target to be met by individual plants is skewed (Figure 1).

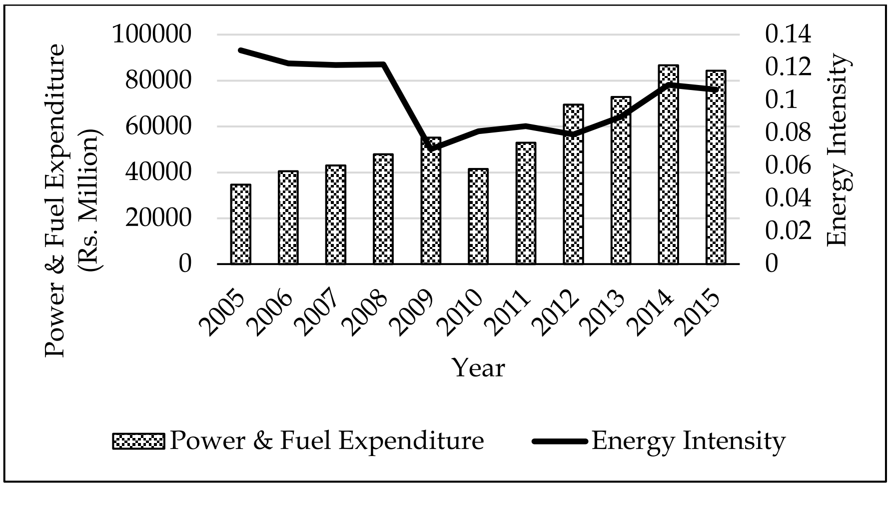


Source: BEE and Ministry of Power, GoI PAT Document, July 2012 & Own Calculations

Figure 1: Total Specific Energy Consumption to be achieved in target year by designated consumers of Fertilizer Industry

Our analysis shows that more than 50% of the burden reducing the energy intensity by end of the target year lies with four firms, viz. BVFCL, NFL, IFFCO and FACT, with the first three firms accounting for 49% of the SEC burden. This implies that to a large extent the success of PAT is dependent on the performance of these producers.

Our sample comprises of 60 fertilizer firms. If Power & Fuel expenditure is taken as a proxy for energy consumption, then data for the period 2004-2005 to 2014-2015 for the 60 firms shows energy intensity remained high before PAT was announced (Figure 2). After the policy was announced in 2007, there was a sharp decline in energy intensity. Though it did increase post 2009 and again declined in 2011-2012, the rise was not as rapid as before the policy was announced.



Source: CMIE Prowess Data & Own calculations.

Figure 2: Power & Fuel Expenditure (Rs. Million) and Energy Intensity of Indian Fertilizer Industry 2005-2015

The rise in energy intensity is less rapid due to advances in process technology and catalysts, better stream sizes of urea plants and increased capacity utilisation. Capacity utilisation is important because losses and waste heat are about the same magnitude irrespective of production in the plant at a point in time (Schumacher et al 1999). The relatively new fertilizer plants use state-of-the-art technology and are more energy efficient than the older plants. The government has also taken steps to facilitate research and development activities. For example the Department of Fertilizers has sponsored R&D projects undertaken by academic institutions like Indian Institutes of Technology, Delhi and Kharagpur. The firms are now in the position to absorb and assimilate the latest technological developments, incorporating environmental friendly process technologies, and are in a position to operate the plants at their optimum levels without any foreign assistance and on international standards in terms of capacity utilization, specific energy consumption & pollution standards.

4. Econometric Methodology, Data and Variables

In the PAT scheme, designated consumers are defined to be plants that have been assigned energy intensity reduction targets. But plant level data is not available. Therefore we use firm level data as a proxy variable. In our study, designated consumer is defined to be a fertilizer firm that owns either single or multiple plants identified by BEE for energy intensity reduction. Our sample comprises of 60 firms. Out of these 60 firms, 10 firms have plants that have been listed as designated consumers. The 10 designated firms in our dataset own 21 plants that have been targeted by BEE. Out of the 29 designated plants, 21 are included in our study. Therefore almost 73% of designated consumers have been covered, which includes the top firms with 5 plants each i.e. NFL and IFFCO.

Difference-in-differences methodology is used to evaluate the impact of the PAT scheme on the energy intensity of the fertilizer firms. Designated consumers are the treatment group since they have been identified by BEE for the implementation of PAT scheme. Non-designated consumers are all the other remaining firms in the fertilizer industry who have not been identified by BEE and hence they are the control group. We also control for other variables and various firm and year specific effects that might influence the dependent variable, energy intensity. We estimate the following fixed effects model:

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

Where i represents individual fertilizer firm and t represents year. α_i and λ_t are the time invariant firm and year fixed effects respectively. $EI_{i,t}$ is the dependent variable defined as follows:

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

For empirical estimation of energy intensity we need data on energy consumed and output produced in physical units. However in the absence of data in physical units, we define it in monetary terms. In this study *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). This definition is used in a number of India centric papers. Dasgupta et al. (2012) and Dasgupta and Roy (2017) define energy intensity as the ratio of fuel expenditure to value of output (both in constant prices). Sahu and Narayanan (2011) construct the energy intensity indicator as the ratio of power and fuel expenditure to net sales. According to Dasgupta and Roy (2017) "energy intensity defined this way has the advantage that it can be used for any aggregate industry group producing a range of outputs".

Our primary independent variable of interest is the interaction between *PATyear* and *PATfirm* i.e., (*PATyear***PATfirm*). *PATyear* is a year dummy included to capture the effect of BEE's PAT scheme on the industry. *PATyear* takes value 1 for years PAT scheme was implemented, i.e., 2012-13 to 2014-15 and takes value 0 for the other years i.e., 2004-05 to 2011-12. We define dummy variable *PATfirm* to take value 1 if the firm is a designated consumer and take value 0 if the firm is a non-designated consumer. The interaction term estimates the energy intensity of the designated consumers in the years 2012-13 to 2014-15 when PAT scheme was implemented. The coefficient of the interaction term, β_2 is the difference-in-differences estimator or the average treatment effect. A negative value for β_2 implies that the actual energy intensity of the designated consumers is lower than the energy intensity that would have been with parallel trends had there been no government intervention through the PAT 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. But this assumption is difficult to verify through a formal test. Therefore 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. 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.

$X_{i,t}$ are a set of firm level characteristics that will influence energy intensity of the firms. We use the following control variables to take care of any omitted variable bias.

Change in gross fixed assets as a proportion of total production ($Technology_{i,t}$) – Gross fixed assets includes fixed assets like land, buildings, plant & machinery, etc. Change in gross fixed assets between periods t and t-1 as a proportion of total production will indicate whether share of fixed assets in total production is rising. This can be taken as a substitute for technology because a higher share of fixed assets indicates greater capitalisation of the production process.

Research & Development intensity ($RD_{i,t-1}$) – This is defined as the ratio of R&D expenditure (Rs. million) to Total Production (Rs. million). We lag the variable by one period because R&D expenditure undertaken in period t is expected to influence energy intensity only after a lag. In the Indian case Goldar (2010) finds that R&D helps to improve energy intensity of all the firms, but it does not make a statistically significant contribution in case of energy intensive firms. Teng (2012) finds a positive contribution of domestic R&D in the case of China's energy intensity. Aixiang (2011) reached a similar conclusion based on data on scientific personnel, number of college students and R&D grants for China.

Size of the firm ($Size_{i,t}$) – 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 proxy for size variable. Goldar (2010) uses log of sales to represent size of the firm and the paper finds a significant negative relationship between size and energy intensity for all firms in general but not specifically for energy intensive firms.

Ownership dummy (*Owner*) – This dummy variable is defined as *Owner* = 1 if the firm is a private limited 0 otherwise (this includes firms belonging to Central government, State government, Co-operative sector). This is to see if organisation type has any relationship with energy intensity. *Owner* was introduced because this sector comprises of Public sector, Co-operatives and Private sector companies.

Import intensity ($Imp_{i,t}$) - This is defined as the ratio of Imports (Rs million) to Total Production (Rs million). Imports include imports of raw materials, capital goods and foreign exchange spending on royalty and technical know-how. Since trade plays a vital role in improving the energy intensity of the recipient country through technological spillovers, $Imp_{i,t}$ should have a positive influence on energy intensity. In the paper the years for which data on imports is unavailable, the variable is taken to be 0. The assumption is that firms are not making any imports that year.

Outsourcing intensity ($Outsource_{i,t}$) - 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 Production (Rs million). This only includes the expenses incurred by a firm for getting their manufacturing requirements done by other enterprises. Greater the outsourcing of manufactured jobs, lower will be energy intensity due to reduced production by the firm. Soni et al (2017) look at factors that can influence energy intensity of Indian manufacturing industries. They find a positive relationship between outsourcing intensity and energy intensity for the cement industry and a negative relationship between outsourcing intensity and energy intensity for the fertilizer industry.

New Pricing Scheme dummy (*NPS-III*) – Government of India started the New Pricing Scheme (NPS) for Urea in April 2003. The objective of this scheme was to provide subsidies to urea manufacturers based on feedstock used and the age of the plant. The plants were assigned pre-set energy consumption norms. The NPS scheme was implemented in three stages: NPS-I from April 2003 to March 2004 (it is not within our sample period), NPS-II from April 2004 to September 2006, NPS-III from October 2006 to March 2014 and Modified NPS-III from April 2014 to March 2015. Since we have annual data in terms of financial year, it is not possible to define a dummy variable to begin from the middle of the year. Therefore we assume that NPS-II continued till 31st March 2007 and NPS-III began from 1st April 2007. We define a dummy variable *NPS-III* to be equal to 1 for the years 2007-08 to 2014-15 (this includes both NPS-III and Modified NPS-III) and 0 for the years 2004-05 to 2006-07 (period of NPS-II). This is to control for any other policy that is likely to have an impact on energy intensity of fertilizer firms.

In our sample we have considered all firms from the fertilizer industry for which data on Power & Fuel Expenditure was available from the Prowess dataset. Prowess is a product of Centre for Monitoring Indian Economy that provides economic databases for India. It contains financial performance data of over 40,000 Indian companies. It is built from company annual reports, quarterly financial statements and stock exchange feeds. For the other 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 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 both the industries. The dummy variable *PAT firm* is created using the names from the document.

This paper will also assess if there exists a market for ESCerts. The objective of the PAT scheme is to induce efficient use of energy in Indian industries through trade in ESCerts. Since this market based instrument has to be traded, there have to be firms that can sell ESCerts and firms that will buy ESCerts. BEE defines specific energy consumption in the target year as the percentage reduction in specific energy consumption from the baseline year, where the baseline year is the average of the years 2007-08, 2008-09 and 2009-10[1]. We calculate energy intensity in the baseline year (EI_{Base}) as the average of energy intensity in the years 2007-08, 2008-09 and 2009-10, i.e.,

$$EI_{Base} = \frac{1}{3}(EI_{2007-08} + EI_{2008-09} + EI_{2009-10})$$

The target year is 2014-15. Energy intensity in the target year ($EI_{Actual\ target\ achieved}$) is energy intensity as estimated in the year 2014-15, i.e.,

$$EI_{Actual\ target\ achieved} = \frac{(Power\ \&\ Fuel\ Expenditure)_{2014-15}}{(Total\ Production)_{2014-15}} = EI_{2014-15}$$

1. Note: BEE Documents on PAT term energy intensity as Specific Energy Consumption (SEC). We use the term Energy Intensity (EI). The basic definition of both the terms is identical i.e. the amount of energy consumed per unit of output produced.

Using the plant level data on specific energy consumption given in the baseline and target years (PAT, Ministry of Power, Government of India, July 2012), we calculate by what percentage (*x*) energy intensity has to be reduced in the baseline year to be met in the target year:

$$x = \left[1 - \frac{SEC_{Target\ to\ be\ achieved}}{SEC_{Base}}\right] * 100$$

Using the value of *x*, we reduce EI_{Base} in our sample to estimate the target that the firms are expected to achieve by the end of PAT Cycle I in 2014-15. This is the $EI_{Target\ to\ be\ achieved}$:

$$EI_{Target\ to\ be\ achieved} = EI_{Base}\left(1 - \frac{x}{100}\right)$$

Trade will exist if there are firms who meet the target and some firms who are unable to meet targets and will need to buy ESCerts to continue production, i.e., there has to be a gap between the energy intensity that had to be achieved by the year 2014-15 as per the PAT scheme and the energy intensity actually achieved. The potential demand for ESCerts is defined as:

$$Potential\ Demand\ for\ ESCerts = EI_{Target\ to\ be\ achieved} - EI_{Actual\ target\ achieved}$$

A positive value for *Potential Demand for ESCerts* implies that the firm has surpassed its target and will be a seller of ESCerts, while a negative value implies that the firm has been unable to meet its target and will have to buy ESCerts.

5. Empirical Analysis

The objective of this section is to analyse the effect of the PAT scheme on the fertilizer industry. Table I gives the summary statistics of the dataset.

Table I: Summary Statistics

	Designated Consumers					Non-Designated Consumers				
Variable	Obs	Mean	Std. Dev.	Min	Max	Obs	Mean	Std. Dev.	Min	Max
EI_{it}	101	0.193	0.12	0.02976	0.58	387	0.04	0.053	0.001	0.5
$Size_{it}$	101	27505.4	25477.8	4771.9	108882.5	399	1502.6	4440.0	1.4	27620.9
$Tech_{it}$	95	-0.106	1.32	-10.4008	3.70	347	0.23	5.265	-16.92	92.30
RD_{it-1}	92	0.0002	0.0005	0	0.003	386	0.0002	0.001	0	0.01
Imp_{it}	101	0.167	0.16	0	0.63	405	0.096	0.190	0	1.72
$Outsource_{it}$	110	0.00004	0.0003	0	0.00	550	0.003	0.017	0	0.29

We do a two group mean comparison test to test the null hypothesis that average energy intensity of non-designated consumers is greater than or equal to average energy intensity of designated consumers against the alternative hypothesis that average energy intensity of non-designated consumers is less than the average energy intensity of designated consumers. The null hypothesis is rejected at 5% level of significance. Therefore average energy intensity of the designated consumers is greater than that of non-designated consumers for the sample.

A similar two group mean comparison test is done for the other variables. We find that average size of the designated consumers is significantly larger than the non-designated consumers. Designated consumers also have higher import intensity than the non-designated consumers. However there is no significant difference between the two groups with respect to the average change in gross fixed assets as a proportion of total production, average R&D expenditure intensity and average outsourcing intensity. But designated consumers have higher capital intensity than non-designated consumers.

Table II does a formal analysis to see the impact of PAT and other control variables on the energy intensity of the fertilizer firms.

Table II: Effect of PAT and Other Factors on Energy Intensity of Fertilizer Firms

Variables	Model 1	Model 2	Model 3	Model 4
PAT year	0.00274 (0.00796)	-0.00145 (0.00562)	-0.00167 (0.00561)	-0.00207 (0.00614)
(PATyear)(PATfirm)*	-0.00360 (0.00819)	-0.0119* (0.00706)	-0.0146** (0.00623)	-0.00503 (0.00830)
$Technology_{i,t}$		0.00328*** (0.00113)	0.00328*** (0.00113)	0.00325*** (0.00112)
$Size_{i,t}$		9.99e-07 (7.29e-07)	-4.62e-06* (2.49e-06)	3.51e-07 (1.05e-06)
*(PATfirm)** $(Size_{i,t})$			5.68e-06** (2.59e-06)	
$RD_{i,t-1}$		-6.284** (2.760)	-6.331** (2.825)	-12.54** (4.986)
$Imp_{i,t}$		-0.00287 (0.00922)	-0.00101 (0.00888)	0.00688 (0.0106)
$Outsource_{i,t}$		-0.138 (0.0902)	-0.139 (0.0906)	-0.169 (0.126)
*(PATfirm)** $(Outsource_{i,t})$				-4.089 (5.971)
*(Owner)** $(Size_{i,t})$		-5.79e-06** (2.47e-06)		
Constant	0.0728*** (0.00486)	0.0858*** (0.00804)	0.0817*** (0.00743)	0.0792*** (0.00816)
R-squared	0.016	0.195	0.191	0.159

Observations	488	405	405	405
Year Fixed Effects	Yes	Yes	Yes	Yes

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

Model 1 is the basic difference-in-differences model. The results show that energy intensity of fertilizer firms is higher in 2012-13 to 2014-15 than 2004-05 to 2011-12, but the effect is insignificant. The difference-in-differences estimator is negative, implying that designated consumers have lower average energy intensity in the years 2012-13 to 2014-15 but the coefficient (*PATyear*PATfirm)* is insignificant.

Model 2 controls for variables like technology intensity, size of the firm, R&D expenditure intensity, import intensity and outsourcing intensity by fertilizer firms and an interaction between ownership and size of the firm. The coefficient of the interaction term (*PATyear* PATfirm*) is negative and significant. This implies the average energy intensity of designated consumers in the years 2012-13 to 2014-15 is lower with the implementation of this policy than without. Therefore PAT policy has had the desired effect on the fertilizer industry. The government introduced the New Pricing Scheme in April 2003 to encourage investments to improve energy efficiency in fertilizer industry. Now PAT scheme has also contributed to strengthen this trend (Table III below uses a dummy variable to capture the effect of NPS-III on fertilizer firms).

Most of the other explanatory variables in Model 2 have expected signs. However $Technology_{i,t}$ has a positive and significant effect on energy intensity. A 1% rise in fixed assets increases energy intensity by 0.007%[2] approximately. 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. Therefore the Working Group recommended setting up of a fertilizer research institute to carry out R&D activities related to the same. This is especially true for phosphate and potash based fertilizers where almost the entire raw material requirement has to be imported. The working group suggested that the Department of Fertilizers can look into production of

2. In a linear model $y = \alpha + \beta x$ elasticity is calculated as follows [Gujarati (2004)]:
   $\frac{dy}{dx} = \beta$ which implies $\frac{dy}{dx}\frac{x}{y} = \beta\left(\frac{x}{y}\right)$
   The elasticity is calculated at the mean values of x & y.

potash from gluconite, recovery of potash from sea water and use of indigenous rock phosphate. In fact $RD_{i,t-1}$ has a significantly negative relation with energy intensity. A 1% increase in R&D expenditure intensity in period t-1 reduces energy intensity by 0.015%.

$Size_{i,t}$ has a positive but statistically insignificant effect on energy intensity. In Model 3, we test if the relationship between size of the firm, $Size_{i,t}$, and energy intensity depends on whether the firm is a designated consumer or non-designated consumer. There is a positive and statistically significant relationship between energy intensity and $Size_{i,t.}$ A rise in $Size_{i,t}$ increases energy intensity of designated consumers. While for the non-designated consumers, there is a negative and significant relationship between $Size_{i,t}$ and energy intensity. This could be because out of the 50 non-designated consumers in our sample, 72% of them are small and medium sized firms and 28% are large sized firms. Therefore the advantages from economies of large scale production can be obtained by the non-designated consumers.

Fertilizer industry has both private sector firms and public sector firms and co-operatives. We include an interaction term $(Owner)*(Size_{i,t})$ to see if the effect of size on energy intensity varies with ownership of the firm. We find that a rise in the firm size significantly reduces energy intensity if the firm is privately owned. But the effect of firm size on energy intensity is insignificant in case of public sector firms and co-operatives.

$Imp_{i,t}$ has a negative but insignificant effect on energy intensity. In case of the fertilizer industry the share of imports is quite high, but imports are mainly in the form of raw materials required for the production of urea, phosphate and potash. For example natural gas and LNG used for the production of Urea is imported. Therefore the possibility of technological spillovers is limited.

Finally $Outsource_{i,t}$ has a negative but statistically insignificant effect on energy intensity. The result is similar to Soni et al (2017). But unlike Soni et al (2017) who find that outsourcing intensity is more significant for firms that are less energy intensive, we find that with respect to the effect of outsourcing on energy intensity, there is no significant difference between designated and non-designated consumers (Table II Model 4).

In the next model we estimate the effect of other factors on the energy intensity of fertilizer firms. We also introduce a dummy variable to capture the effect of the New Pricing Scheme on the energy intensity of fertilizer firms. NPS was implemented in three stages. NPS-I (April 2003-March 2004) does not lie within the sample period. The dummy variable NPS-III is 1 for the years NPS-III and Modified NPS-III was implemented (April 2006-march 2014 and April 2014- march 2015 respectively) and 0 otherwise (period of NPS-II)

Table III: Effect Other Factors on Energy Intensity of Fertilizer Firms

Variables	Model 5	Model 6
PAT year		0.00483 (0.00507)
(PATyear)(PATfirm)*		-0.0119* (0.00706)
NPS-III	-0.00606 (0.00444)	-0.00628 (0.00443)
$Technology_{i,t}$	0.00327*** (0.00112)	0.00328*** (0.00113)
$Size_{i,t}$	6.87e-07 (6.80e-07)	9.99e-07 (7.29e-07)
$RD_{i,t-1}$	-6.745** (2.807)	-6.284** (2.760)
$Imp_{i,t}$	-0.00201 (0.00866)	-0.00287 (0.00922)
$Outsource_{i,t}$	-0.143 (0.0903)	-0.138 (0.0902)
(Owner) ($Size_{i,t}$)*	-5.48e-06** (2.58e-06)	-5.79e-06** (2.47e-06)
Constant	0.0871*** (0.00786)	0.0858*** (0.00804)
R-squared	0.191	0.195
Observations	405	405
Year Fixed Effects	Yes	Yes

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

In Model 5, we do not include the PAT scheme and estimate the effect of other factors. The dummy variable *NPS-III* is insignificant and does not have an effect on energy intensity. The signs of the other variables remain the same as in Model 2.

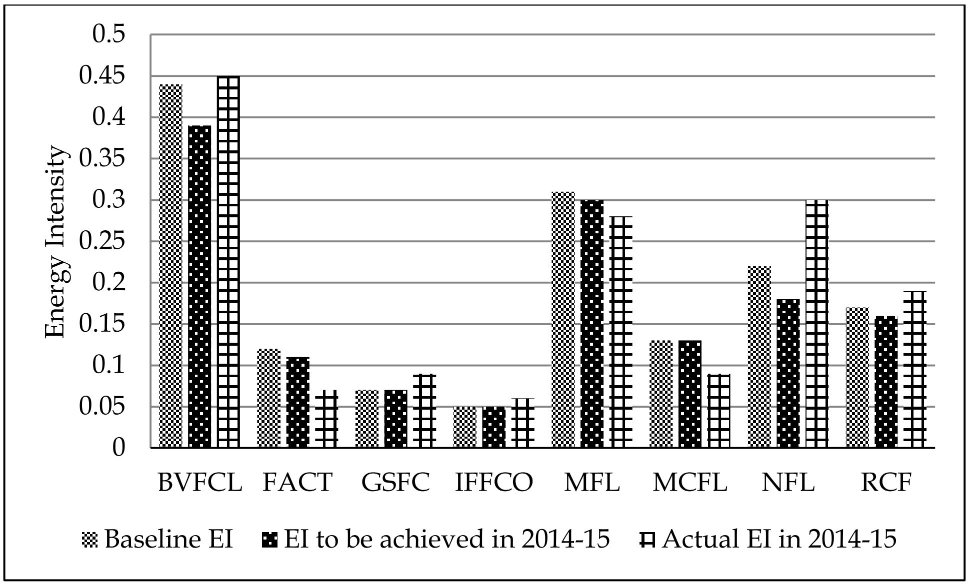
In Model 6, we include the interaction term to capture the PAT scheme to differentiate between the two policies because both of them influence energy intensity – PAT scheme does it directly, while NPS does it indirectly by setting pre-set energy consumption norms for the urea plants. The coefficient of the interaction term *(PATyear)*(PATfirm)* is negative and statistically significant at 10% level of significance. The coefficient of the dummy variable *NPS-III* is insignificant. This implies that out of the two policies, only PAT scheme has helped in reducing the energy intensity of designated consumers in the fertilize industry. The other explanatory variables have the same signs as before.

In Model 7 (Appendix Table A1) we include leads of the interaction term in order to test for the parallel trends assumption. The coefficients of $[(PATyear)(PATfirm)]_{t+j}$ leads are close to zero and insignificant. The year PAT is implemented the coefficient of the interaction term drops by 0.0335 points and becomes significant. Therefore the parallel trends assumption holds.

6. Market for ESCerts

In this section we examine if a market exists for ESCerts in the fertilizer industry. Appendix Table A2 gives the energy intensity in the baseline year, the percentage reduction in energy intensity from the baseline year to be achieved in the target year and the target that the firms are expected to achieve by the end of PAT Cycle I. We then estimate the potential demand for ESCerts. A positive value implies that the firm has surpassed its target and will be a potential seller of ESCerts, while a negative value implies that the firm has been unable to meet its target and will have to buy ESCerts (Appendix Table A3).

We find that for National Fertilizers Ltd., Indian Farmers Fertiliser Co-Op. Ltd., Rashtriya Chemicals & Fertilizers Ltd., Gujarat State Fertilizers & Chemicals Ltd. and Brahmaputra Valley Fertilizers Corporation Ltd. the gap is negative (Appendix Table A3) and so they will demand ESCerts. This gap is maximum for National Fertilizers Ltd., followed by Brahmaputra Valley Fertilizers Corporation Ltd (Figure 3 below).

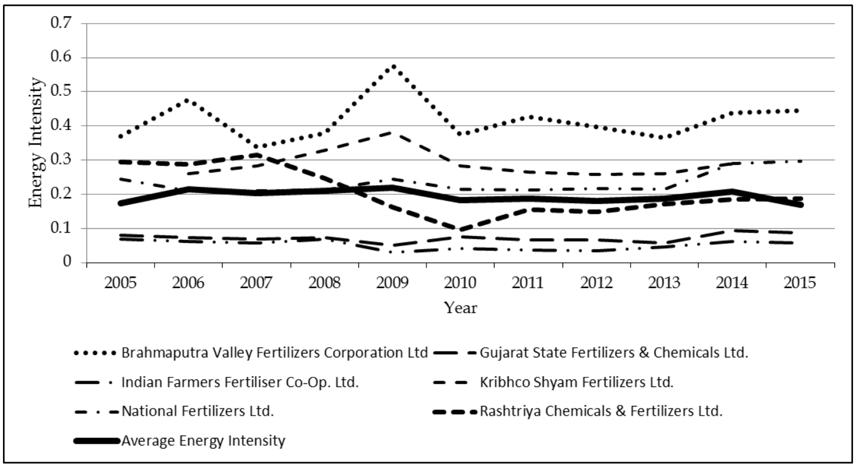


Source: Own Calculations

Figure 3: Comparison of EI between baseline & target years

In the case of National Fertilizers Ltd., three of the five plants identified by BEE, had baseline energy intensities that were very close to the range of specific energy consumption specified for the designated consumers (range is 5.86 to 9.11 Gcal/T of Urea and for the plants in Nangal, Bhatinda and Panipat specific energy consumption is 7.04, 7.14 and 7.58 Gcal/MT Urea respectively) (PAT Fertilizer Sector, 2015). Therefore the fall in energy intensity is not likely to be immediate. The difference is second highest in case of Brahmaputra Valley Fertilizers Corporation Ltd. BVFCL has two plants (Namrup-II and Namrup-III) that have been identified by BEE. But the energy consumption is very high at 16.89 and 11.54 Gcal/T Urea respectively. Moreover they have utilised just 70% of their total capacity due to inherent technological and location problems (PAT Fertilizer Sector, 2015). Hence the target has not been met.

Another feature of the potential buyers of ESCerts is that their energy intensity continues to rise even in the implementation period. In Figure 4 below we compare the energy intensity of the buyer firms with the average energy intensity of all the designated consumers.



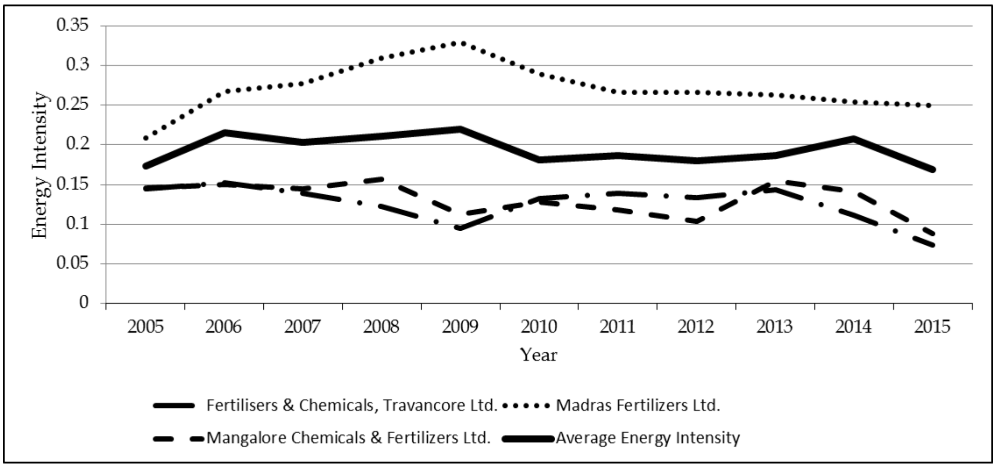
Source: Own Calculations

Figure 4: Energy Intensity of Potential Buyers of ESCerts

We find that Brahmaputra Valley Fertilizers Corporation Ltd., Kribhco Shyam Fertilizers Ltd. and National Fertilizers Ltd. have energy intensities higher than the average energy intensity of the designated consumers. The energy intensity of Rashtriya Chemicals & Fertilizers Ltd. declines till year 2010 and then again rises to be at par with the average energy intensity. A common feature of these firms is that they are relatively new with the year of incorporation being after year 1975, except for National Fertilizers Ltd. Energy intensity of Gujarat State Fertilizers & Chemicals Ltd. and Indian Farmers Fertiliser Co-Op.

Ltd. lies below the average energy intensity. These two firms are old firms, with age being forty years or more.

The second group comprises of firms who have surpassed their targets. Madras Fertilizers Ltd., Fertilisers & Chemicals, Travancore Ltd., and Mangalore Chemicals & Fertilizers Ltd. will receive ESCerts that can be sold because their energy intensity in 2014-15 is lower than what they had to achieve in the target year. As seen in Figure 5 below, energy intensity of Fertilisers & Chemicals Travancore Ltd. and Mangalore Chemicals & Fertilizers Ltd. lies below the average energy intensity of designated consumers, while Madras Fertilizers Ltd. lies above it. We also find that all the three potential sellers of ESCerts are old firms that are forty years or older, with the year of incorporation being 1975 or before.



Source: Own Calculations

Figure 5: Energy Intensity of potential sellers of ESCerts

Another feature that is common for Madras Fertilizers Ltd. and Mangalore Chemicals & Fertilizers Ltd. is that both of them are pre-92 naphtha based plants. Though many plants have converted to natural gas or are in the process of converting, Madras Fertilizers Ltd. and Mangalore Chemicals & Fertilizers Ltd. are yet to convert due to unavailability of natural gas. Capacity utilisation for both firms fluctuates and lies below 100%. In fact in 2014-15, the capacity utilisation for both firms is below 70%. All the other firms who are buyers of ESCerts in our analysis are either gas based firms or mixed feedstock based firms. The gas based firms, specially the firms that were set up after 1992 when technological development in urea production was maximum, have lower energy consumption. This could have resulted in greater consumption of energy to produce more output, thereby causing them to buy ESCerts (this result is similar to the result of our theoretical model in which the firm with better technology is found to buy ESCerts and the firm with lower technology is found to sell ESCerts). But existence of firms who have surpassed their targets and firms who have not met their targets shows that a market for ESCerts exists for the fertilizer sector and trade is feasible.

7. Conclusion

Energy intensity of the fertilizer industry has been declining since 2005. There has been a slight increase after 2009, but energy intensity is still lower than what it was in the beginning of the sample period. The Indian Fertilizer industry is one of the most efficient in the world in terms of energy consumption. In fact a number of fertilizer firms have won accolades at International fertilizer Association's Green Leaf Award. This award is given for outstanding performance in terms of safety, health and environment. Rashtriya Chemicals & Fertilizers Ltd has won the award in 2017. IFFCO was the second runner up in 2015. TATA Chemicals Ltd. was the first runner up in 2013 and IFFCO won the award in 2011. This further showcases the fertilizer industry's commitment towards protecting the environment.

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. Most of the other explanatory variables have expected signs.

Therefore the results suggest that PAT has worked for the fertilizer industry. Capacity utilisation has remained above 100%. But more can be done to reduce energy intensity further, since this industry is extremely critical due to its direct influence on the agricultural sector. The government can explore possible joint ventures with companies outside India. This will bring in more technological expertise in the country. More of the non-gas urea plants can be converted into gas based plants as it is both energy efficient and cheap. To fulfil the growing domestic demand for Urea, new plants can be based on natural gas as feedstock.

Finally we find that a market exists for ESCerts as there are set of firms who have positive estimated energy savings and those who have negative estimated energy savings. The former set of firms will receive ESCerts and can be potential suppliers and the latter set of firms will have to buy ESCerts to continue production and will be potential buyers of ESCerts. The intersection of demand and supply will determine the equilibrium price of ESCerts.

References

Aixiang, T. (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).

Dasgupta, S., Roy, J., Bera, A., Sharma, A. and Pandey, P. (2012), "Growth Accounting for Six Energy intensive Industries in India", *The Journal of Industrial Statistics,* 1: 1-15.

Dasgupta, S. and Roy, J. (2017), "Analysing energy intensity trends and decoupling of growth from energy use in Indian manufacturing industries during 1973–1974 to 2011–2012", *Energy Efficiency,* 10: 925–943.

Energy Statistics (2017), 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.

Freeman, S.L., Niefer, M.J. and Roop, J.M. (1997), "Measuring industrial energy intensity: practical issues and problems", *Energy Policy,* 25 (7-9): 703-714.

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

Gujarati, D.N. (2004), *Basic Econometrics*, New Delhi: Tata McGraw-Hill.

He, W., Gao, G. and 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).

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

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

Pao, H. and 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.

Prowess Database (CD accessed from Jawaharlal Nehru University Library).

Sahu, S.K. and 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.

Schumacher, K. and Sathaye, J. (1999), "India's Fertilizer Industry: Productivity and Energy Efficiency", *Ernest Orlando Lawrence Berkeley National Laboratory.* LBNL-41846.

Soni, A., Mittal, A. and Kapshe, M. (2017), "Energy Intensity analysis of Indian manufacturing industries", *Resource-Efficient Technologies*, 3: 353–357.

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

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

Yang, Y. and 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.

Appendix

Table A1: Empirical Analysis of PAT with Leads

Variables	Model 7
PAT year	0.00200 (0.00561)
$[(PATyear)*(PATfirm)]_{t+2}$	-0.00542 (0.00900)
$[(PATyear)*(PATfirm)]_{t+1}$	0.0119 (0.0102)
$[(PATyear)*(PATfirm)]_{t0}$	-0.0216** (0.00983)
$Technology_{i,t}$	0.00661* (0.00372)
$Size_{i,t}$	-5.36e-06* (2.74e-06)
$(PATfirm)*(Size_{i,t})$	6.58e-06** (2.78e-06)
$RD_{i,t-1}$	-5.172* (2.746)
$Imp_{i,t}$	0.00787 (0.0122)
$Outsource_{i,t}$	-0.0814 (0.108)
Constant	0.0753*** (0.00757)
R-squared	0.204
Observations	365
Year Fixed Effects	Yes

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

TABLE A2: BASELINE EI AND TARGET EI IN 2014-15

Designated Consumers	EI_{Base}	Percentage reduction in EI_{Base}	$EI_{Target\ to\ be\ achieved}$
BVFCL	0.44	12%	0.39
FACT	0.12	2%	0.11
GSFC	0.07	1%	0.07
IFFCO	0.05	1.1%	0.05
Kribhco	0.33	3%	0.32
MFL	0.31	2.3%	0.30
MCFL	0.13	2.4%	0.13
NFL	0.22	19%	0.18
RCF	0.17	4%	0.16
ZIL	NA	2.3%	NA

$EI_{Target\ to\ be\ Achieved}$ *refers to target to be achieved in 2014-15.*

TABLE A3: POTENTIAL DEMAND FOR ESCERTS BY DESIGNATED CONSUMERS

Designated Consumers	$EI_{Target\ to\ be\ achieved}$	$EI_{Target\ Achieved}$	Potential Demand for ESCerts
BVFCL	0.39	0.45	-0.06
FACT	0.11	0.07	0.04
GSFC	0.07	0.09	-0.02
IFFCO	0.05	0.06	-0.01
Kribhco	0.32	NA	NA
MFL	0.30	0.28	0.02
MCFL	0.13	0.09	0.04
NFL	0.18	0.30	-0.12
RCF	0.16	0.19	-0.03
ZIL	NA	0.07	NA