Factors Influencing Energy Intensity of Indian Cement Industry

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***Abstract*—India launched the Perform-Achieve-Trade (PAT) scheme for firms in the eight most energy intensive industries in 2007, Cement industry being one of the industries. The purpose was to induce efficient use of energy through trade in Energy Saving Certificates (ESCerts). The scheme identified the most polluting firms from each of these industries and set individual energy intensity reduction targets. The first PAT cycle runs from 2012-2015 and targets have to be met within this period. This is the first time India has adopted tradable permit scheme for dealing with an environmental problem. It will help India achieve its objective of sustainable development along with economic growth. The objective of this paper is to determine the factors that influence the energy intensity of firms of the Cement Industry and quantify the PAT effect. We use panel data fixed effects model and difference-in-differences estimate. The method of Propensity Score matching is used as a robustness check of the results. The results show that the Cement industry as a whole did not become more energy efficient after the scheme was launched. The firms that were identified have higher energy intensity than the other firms, which suggest that they were correctly identified by the government.**

***Index Terms*—Energy intensity, India, perform achieve and trade, tradable permits.**

I. Introduction

Economic growth is imperative for developing and emerging economies like India. This rapid growth requires sustained and unrestricted supply of energy to continuously move up the growth trajectory. India is the world's third largest consumer of primary energy which includes fossil fuels like coal, oil, etc [1]. Most of the demand comes from the industrial sector, whose share in national energy consumption was approximately 52.72% in 2013-14 [2]. However this form of energy is extremely emission intensive and hence there is an urgent need to reduce this dependence and move on the path of sustainable development. India has committed to reduce emission intensity both in the Copenhagen Summit and the recently ratified Paris Agreement. One of the important ways to achieve the same is efficient use of energy that will help India achieve its twin objectives of maintaining high growth rates while simultaneously cutting down emission levels.

Energy Intensity (EI) defined as the amount of energy consumed to generate one unit of GDP, is the closest indicator of how efficiently energy is used. Fortunately even though energy consumption has been rising for the country as a whole, EI has recorded a declining trend since early 2000. The cumulative annual growth rate for energy consumption and EI in 2005-2013 was 5.28% and -1.3% respectively [2]. This declining trend in EI has been corroborated by a few India based studies that have found that EI in the manufacturing sector fell by almost 60% in the period 1992-2008 and 25% in 2000-2008 respectively ([3], [4]).

One of the reasons for this decline is that the Government of India (GoI) has taken some noteworthy steps in controlling the EI of 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, with the objective to reduce the EI of the economy. Further in June 2008 the National Action Plan for Climate Change was launched with eight National Missions that aimed at achieving key goals with respect to climate change. One of the national missions is the National Mission for Enhanced Energy Efficiency (NMEEE) created with the objective of promoting energy efficiency through policies, regulation, financing mechanisms and business models. Perform-Achieve-Trade (PAT) scheme is an initiative of NMEEE and it pertains specifically to the industrial sector.

PAT is an ambitious scheme in the Indian context because for the first time India has introduced market based instruments to solve an environmental problem. The objective is to improve energy efficiency of the high energy intensive industries through target setting and tradable energy saving certificates. The Ministry of Power and BEE have first identified eight most energy intensive industries viz. Thermal Power Plants, Fertilizer, Cement, Pulp and Paper, Textiles, Chlor-Alkali, Iron & Steel and Aluminium. Our paper does a firm level analysis for the Cement industry.

Within each of these industries the most energy intensive plants were identified and called Designated Consumers (DCs). BEE set specific energy consumption target or SEC (defined as the ratio of net energy input in the DC's boundary to total output exported from the DC's boundary) for each designated consumer such that sum of the targets for all designated consumers within an industry equals the industry's target. These individual targets will take care of the heterogeneity that exists in each industry with respect to output, energy consumption trends, energy saving potential, age of the plant, etc. Each designated consumer is required to reduce its SEC by a certain value, based on its reference year's SEC. Reference year is defined as the average SEC from April 2007 to March 2010.

The target year for the first PAT cycle runs from April 2012-March 2015. At the end of the period if the designated consumer surpasses its target then it will be issued tradable energy saving certificates or ESCerts. 1 ESCert equals 1 toe worth of energy consumption. For the first PAT cycle 478 designated consumers were identified, spread across these 8 industries. These designated consumers currently account for

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25% of national GDP and almost 45% of commercial energy use in India [5]. Under this scheme BEE targets to achieve energy saving of 6.686 Mtoe. Fig. 1 shows the sector wise distribution of energy saving that BEE aims to achieve.

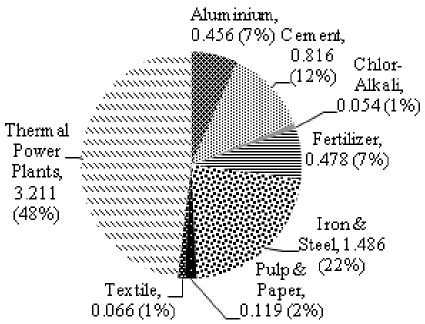


Fig. 1. Sector wise Energy Saving Targets under PAT Cycle-1 (2012-15).

If PAT is successful then increased energy efficiency will reduce emissions by 26 million tonnes of carbon dioxide equivalent by 2015. That will play an extremely crucial role in helping to reduce carbon emission by 20-25% by 2020 as compared with the 2005 level.

The objective of this paper is twofold. First objective is to do a firm level analysis of one of the BEE identified industries viz. Cement industry. We will empirically test for the factors that can improve the EI of the firms belonging to the Cement industry for the sample period March 2000-March 2015 (financial year) using a Fixed Effects regression model. In the literature a number of studies have been undertaken to assess the factors influencing EI of various countries. The effect of energy consumption, GDP and FDI on CO_2 emissions in BRIC countries is estimated in [6] and the paper tests for Granger Causality between these variables for the period 1980-2007. A multivariate VAR model is used to test for granger causality between energy consumption, economic growth and FDI in Shanghai, China from 1985 to 2010 [7]. The case on Indonesian manufacturing is taken up in [8] to explore if FDI diffuses energy saving technology into the host country. They use firm level panel data for 1993-2009. The effect of indigenous R&D on the energy intensity of Chinese industries is analyzed in [9]. In the Indian case [10] 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.

The second objective is to use the difference-in-difference technique to quantify the effect of PAT for the Cement industry. We will also compare the EI of designated consumers and non- designated consumers.

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

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

II. Description of the Data, Variables and Hypothesis

The first objective of the study is to look at the factors that influence the EI of cement firms in India. Coal and electricity are the principal energy inputs used by this industry and this makes it highly energy intensive. The minimum annual energy consumption by the designated consumers in this sector is almost 30000 toe. BEE aims to achieve energy saving target of 0.816 million toe under the first PAT cycle. Currently it has listed 85 plants as designated consumers in this sector. These plants are identified from 43 cement firms i.e. one or more plants from a set of 43 firms is identified as a designated consumer. Ultratech Cement Ltd. has the highest number of designated consumers with 12 plants. It is followed by ACC Ltd. (11 plants), India Cement Ltd. (7 plants), Ambuja Cement Ltd. (6 plants) and Penna Cement Industries Ltd (3 plants). The rest of the firms have one or two plants as designated consumers.

This study takes a sample of 49 firms, out of which 26 firms have plants that have been listed as designated consumers and 23 firms are non-designated consumers Table I gives the list of designated consumers included in the study.

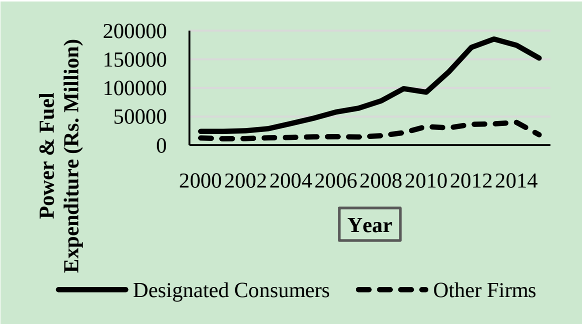
TABLE I: List of Firms Included in the Study

Firm	No. of Designated Consumers	Firm	No. of Designated Consumers
Ultratech Cement Ltd.	12	JK Lakshmi Cement	1
ACC Ltd	11	Zuari Cement Ltd.	1
India Cements Ltd	7	Mangalam Cement Ltd.	1
Ambuja Cement Ltd.	6	Malabar Cement Ltd.	1
Penna Cement Industries Ltd.	3	Panyam Cements & Minerals Indus. Ltd.	1
Lafarge India Pvt. Ltd	2	K C P Ltd.	1
Chettinad Cement Corporation	2	Binani Cement Ltd.	1
Shree Cement	2	Shree Digvijay Cement Co. Ltd.	1
Birla Cement	2	Gujarat Sidhee Cement Ltd.	1
JK Cement	2	Rain cement	1
Heidelberg Cement India Ltd.	2	Saurashtra Cement Ltd.	1
Prism Cement Works	1	Sanghi Industries Ltd.	1
Kalyanpur Cement Ltd.	1	OCL India Ltd.	1

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

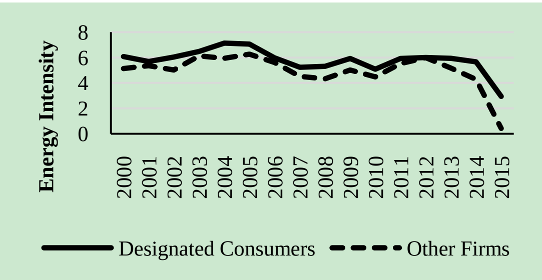
The firms were selected on the basis of data availability. Since plant level data is not available, we use firm level data to evaluate the impact of the PAT scheme. Out of the 43 firms that own these 85 high energy intensive plants, we have data on 26 firms that account for 66 designated consumers.

Therefore almost 78% of the designated firms have been included in this study. The remaining 17 firms that own 19 designated consumer plants could not be included due to unavailability of data. The data has been taken from Prowess Dataset, which provides firm level data of the Indian industries [11]. Prowess is a product of Centre for Monitoring Indian Economy (CMIE) that provides economic databases for India. The Ministry of Power, GoI's Perform-Achieve-Trade document published in July 2012 is used to identify the names of designated consumers of the cement industry.



Source: CMIE prowess data & own calculations

Fig. 2. Power & fuel expenditure of cement industry.



Source: Own calculations

Fig. 3. Energy intensity of cement industry.

If Power and Fuel expenditure is taken as a proxy for energy consumption, then data for the period 2000-2015 for the 49 firms in this sample shows that though both the designated consumers and non-designated consumers started with almost similar levels of power and fuel expenditure, overtime the gap between the two widened considerably.

The line graph in Fig. 2 shows the power and fuel expenditure for both set of firms. Both set of firms recorded an increase in energy consumption. But for the designated consumers the rise was faster and more pronounced than the non-designated consumers. It was only post 2012 that energy consumption began to decline, which may be due to BEE's PAT scheme, but the gap still remains quite wide. A state level analysis of the cement industry to measure its environmental efficiency w.r.t. carbon dioxide for the years 2000-2005 finds that average environmental efficiency measure declined in 2004-05 compared with 2000-01 ([12]). This was a period of increase in energy consumption, as evident from Fig. 2.

However if the rise in production is faster than that of energy consumption, then that indicates an efficient utilisation of energy resources. As can be seen from Fig. 3, EI for the Cement industry (defined as the ratio of Power & Fuel expenditure to Sales) is higher for the designated consumers than the other firms throughout the period 2000-2015.

In this paper for empirical estimation Energy Intensity (EI) is taken to be the dependent variable. It is defined as follows:

$$\boldsymbol{EI} = \frac{\boldsymbol{Power} \,\&\, Fuel\ Expenditure\ (Rs\ million)}{\boldsymbol{Sales}\ (\boldsymbol{Rs\ million})}$$

In the absence of data on output and energy consumption in physical units, we use Sales (Rs Million) and Power & Fuel expenditure (Rs Million) respectively as proxy variables to define EI. The independent variables that influence EI are summarized as follows:

- Domestic Inputs Intensity (*Dom*) - This is the ratio of Indigenous inputs consumed (Rs Million) to Sales (Rs Million). Indigenous inputs are defined to include indigenous raw materials, other material consumption and stores and spares. Since Cement is an indigenously developed industry, the contribution of *Dom* is expected to be significant in improving EI.
- Import Intensity (*Imp*) - This is defined as the ratio of Imports (Rs million) to Sales (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 EI of the recipient country through technological spillovers, *Imp* should have a positive influence on EI.
- Capital Intensity (k) - Capital per unit of output is an indicator of technology of the firm. Greater the capital intensity, greater is the possibility of better technology being used that will help to improve EI. In the absence of data we use gross fixed assets per unit sales as a proxy for capital intensity.
- k^2 – This variable is included to introduce non-linearity in the model and to check for any threshold effect i.e. to test if the impact of k is any different on EI when capital per unit of output crosses a certain quantitative limit.
- Size of the firm (*Size*) – Size of the firm is defined by its sales and assets in the last three years (Prowess database). Larger firms have more resources to invest in better technology and to modernize their units and can also collaborate with foreign firms.
- Age of the firm (*Age*) – This is a dummy variable defined as *Age* = 1 if the firm's year of incorporation is before 1991 and 0 if it is 1991 and after. For older firms higher operating expenses and obsolete technology makes it more difficult to improve energy efficiency.
- PAT year (*PAT year*) - This is a year dummy variable which will capture the effect of BEE's PAT scheme during the first PAT cycle. It is defined as *PAT year* = 1 for the years 2012-2015 and 0 otherwise.
- PAT firm (*PAT firm*) – 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. It is defined as *PAT firm* = 1 for the Designated Consumers and 0 otherwise.
- Interaction dummy variable (*PAT*) – This variable is defined as the product of *PAT year* and *PAT firm*. It will capture the average EI of the designated consumers in the years 2012-2015 when both *PAT year* and *PAT firm* will take value 1.

All the independent variables, except the dummy variables, are in logs. The model also has year fixed effects.

III. Econometric Methodology

The paper uses the Fixed Effects Least Square Dummy Variable Method (LSDV) to estimate the effect of factors that influence EI of cement firms. LSDV uses a dummy variable for N-1 entities, in this case entities being cement firms (D_n). The estimated Fixed Effects equation is

$$ln(EI_{it}) = \beta_0 + \beta_1 \, ln(Dom_{it}) + \beta_2 \, ln(Imp_{it}) + \beta_3 \, [ln(k_{it})]^2 + +\beta_4 \, ln(Size_{it}) + \beta_5 \, (Age_{it}) + \beta_6 \, (PATyear) + \beta_7 \, (PATfirm) + +\beta_8 \, (PAT) + \gamma_2 D_2 + \ldots\ldots + \gamma_{49} D_{49} + \mu_{it}$$

The second objective is to quantify the PAT effect. For that we use the difference-in-differences methodology. PAT is the policy whose effect is to be analysed. Designated consumers (DC) are the treatment group as they participate in the policy. Non-designated consumers (NDC) 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 2000-2011. Table II gives the effect of PAT on the two set of firms and the difference in EI before and after the scheme was introduced.

TABLE II: Analysis of PAT Scheme

	Before PAT	After PAT	Difference (After-Before)
NDC	β_0	$\beta_0 + \beta_6$	β_6
DC	$\beta_0 + \beta_7$	$\beta_0 + \beta_6 + \beta_7 + \beta_8$	$\beta_6 + \beta_8$
Difference (DC-NDC)	β_7	$B_7 + \beta_8$	β_8

The coefficient of *PAT* (β_8) is the difference-in-differences estimate. It is the differential effect of being a designated consumer in the years 2007-2015. It is also called the average treatment effect i.e. the effect of the treatment PAT on the EI of designated consumers.

Finally as a robustness check we estimate Propensity Scores to estimate the effect of PAT on the EI of designated consumers. Each designated consumer is exposed to a single treatment i.e. targets under PAT that need to be achieved within 2012-2015. Let d_i be the binary treatment variable such that $d_i = 1$ if unit i is a designated consumer and 0 otherwise. $EI_i(1)$ is the potential EI with treatment and $EI_i(0)$ is the potential EI without treatment. The average treatment effect for the designated consumers (ATT) is defined as $E[EI_i(1)- EI_i(0)/d_i = 1]$. ATT is the average effect of treatment PAT for a randomly drawn individual from a set of designated consumers. Since ATT cannot be directly calculated, we use propensity scores (PS) to do the same where $PS = Pr(d_i=1/X) = p(x)$. X is defined to include *k, Size, Age* and *EI* that have influenced selection of designated consumers in the first place. ATT is redefined as

$$ATT = E[EI_i / d_i = 1, p(x)] - E[EI_i / d_i = 0, p(x)] \\ = E[EI_i(1) - EI_i(0) / p(x)]$$

In order to create a counterfactual $EI_i(0)$ for the i^{th} designated consumer and estimate PS, we estimate a Logit Model with variables *k, Size, Age* and *EI*. After PS are estimated we use the method of Nearest Neighbour for PS matching. In this method we get

$$ATT = \frac{1}{N^T} \sum_{i \in d=1} [EI_i(1) - \sum_{j \in d=0} \phi(i,j) EI_{ij}]$$

where N^T is the number of designated consumers and $\phi(i, j)$ is the weight such that for each designated consumer we find a non-designated consumer with the most similar PS. That observation gets weight 1, all others get weight 0.

IV. Empirical Results

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

TABLE III: Summary Statistics

Variable	Observations	Mean	Std. Dev	Min	Max
EI	659	0.282	.354604	0.000765	6
Sales	662	11609.13	26027.43	0.2	260300.5
Dom	577	1805.228	3627.068	0.6	34284
Imp	422	515.0573	1040.458	0.1	7419
k	690	11882.43	26319.03	3.4	318741.4
Size	702	11327.28	24981.58	0.1	277112.5
Age	784	0.735	0.442	0	1
PAT year	784	0.563	0.496	0	1
PAT firm	784	0.531	0.499	0	1

The section then looks at the impact of various factors on the EI of cement firms (see Table IV).

$Dom_{i,t}$ has a significant impact on EI. A 1% rise in domestic inputs intensity reduces EI by 0.088%. Since cement is an indigenously developed industry, so the result indicates a judicious use of raw materials.

TABLE IV: Factors Influencing EI of Cement Industry

Variable	Coefficient	t-Value
$Dom_{i,t}$	-0.088	-2.37^{**}
$Imp_{i,t}$	-0.026	-3.05^{***}
$k_{i,t}$	0.373	6.19^{***}
$(k_{i,t})^2$	0.063	3.86^{*}
$Size_{i,t}$	-0.348	-4.25^{***}
$Age_{i,t}$	-0.248	-1.64
PAT year	0.023	0.2
PAT firm	0.551	2.61^{***}
PAT	0.006	0.07
Constant	-2.142	-12.4^{***}
R^2	0.654	

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

Similarly $Imp_{i,t}$ has a significant impact on EI. A 1% rise in import intensity reduces EI by 0.026%. Since this variable also includes foreign exchange spending on technical know-how, there is possibility of technological spillover via trade.

$k_{i,t}$ and $(k_{i,t})^2$ are significantly positive. This implies that EI increases at an increasing rate with $k_{i,t}$. When capital intensity grows beyond the threshold of 0.0039 (see Appendix), EI increases even further. Since capital intensity is an indicator of technology, the result suggests that technological progress was directed towards other inputs or towards improving the characteristics of the product.

A rise in size of the firm improves EI because as the firm grows bigger it also has more resources at its disposal to invest. Therefore large sized firms generally manage to use energy more efficiently.

Age dummy has a negative coefficient implying that the EI of firms that were established before 1991 is 24.8% lower than the firms incorporated in and after 1991. In other words the old firms are more efficient than the new firms. This could be because older firms may also have more resources at their disposal and can make more investments in research and development activities.

Next we look at the impact of BEE's policy PAT on the designated and non-designated consumers, both before and after the policy's implementation (see Table IV).

TABLE IV: EMPIRICAL ANALYSIS OF PAT SCHEME

	Before PAT	After PAT	Difference (After-Before)
NDC	-2.142	-2.119	0.023
DC	-1.591	-1.562	0.029
Difference (DC-NDC)	0.551	0.557	0.006

The results suggest that for the industry as a whole PAT has not been effective because EI for designated consumers and non-designated consumers is 2.9% and 2.3% higher respectively after the scheme was implemented. Comparing between the two set of firms we find that EI of designated consumers was 55.1% higher than the non-designated consumers before the scheme was implemented. But even after its implementation, EI for designated consumers was 55.7% higher.

If we look at the dummy variable values, we find that EI for the entire industry is 2.3% higher in 2012-2015 as compared with 2000-2011. However the effect is insignificant. But EI of designated consumers is 55.1% higher than the non-designated consumers. This indicates that at least BEE has correctly identified the most energy inefficient firms from the industry because the *PAT firm* is significant. Finally the difference-in-differences coefficient is 0.006. This implies that EI of designated consumers in 2012-2015 is 0.6% higher than non-designated consumers in 2000-2011. However the effect is insignificant.

As a robustness check of the effect of policy on the EI, we use the method of Propensity Score Matching to calculate the average effect of PAT on designated consumers for 2007-2015 (see Table V). The designated consumers were identified in 2007. The results show that because of PAT, EI declined for the years 2008 to 2011. However during the implementation period of 2012-2015, EI increased due to this policy. For example in the year 2012 the PAT scheme has increased the EI of the designated consumers by 0.131 on an average. Similarly in 2013 PAT scheme has increased the EI of designated consumers by 0.152 on an average. The results match what we found in the fixed effects regression with *PAT year* dummy variable. Therefore in general it seems PAT did not achieve the necessary effect on designated consumers. The announcement phase i.e. the period just before the actual PAT cycle began has achieved reduction in EI, unlike the implementation phase.

TABLE V: PROPENSITY SCORE MATCHING

Variable	Propensity Scores
2007	0.009
2008	-0.091
2009	-0.294
2010	-0.164
2011	-0.045
2012	0.131
2013	0.152
2014	0.266
2015	0.002

V. CONCLUSION

EI of Indian manufacturing sector has been declining. The India-based studies in the literature have corroborated the same. Cement industry has recorded downward trend overtime, especially after the government's PAT scheme was announced. However the empirical results suggest that PAT has not played a significant role in reducing EI. Propensity scores, that specifically capture the effect of PAT scheme, also show the average EI of designated consumers to be higher in the years 2012-2015. This implies that other factors have been responsible for the downward trend in EI. For example this industry may be becoming more energy efficient due to technological factors or better quality imports. Regression results show that domestic inputs and imports help in reducing EI.

Cement is a core infrastructural industry. The positive indication is that EI has been declining, even though the sample of firms used in this paper suggests that PAT scheme has not made a significant contribution to achieve the same. One reason could be that the study uses firm level data to capture the PAT effect, while BEE has used plant level data to calculate SEC of the cement industry. Use of plant level data for the cement industry will help in a more precise estimation of this policy. But due to non-availability of that data, firm level data is the closest proxy that can be used.

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

APPENDIX

A. Calculation of Threshold Value

Model: $\ln y = \alpha + \beta_1 (\ln x) + \beta_2 (\ln x)^2$

Differentiating w.r.t *x:*

$$\frac{\partial y}{\partial x} = \beta_1 + 2\beta_2(\ln x)$$

$$\frac{\frac{1}{y}\partial y}{\frac{1}{x}\partial x} = \beta_1 + 2\beta_2(\ln x)$$

Taking (*1/y*) and (*1/x*) to the right hand side to solve for *dy/dx*

$$\frac{\partial y}{\partial x} = [\beta_1 + 2\beta_2(\ln x)]\left(\frac{y}{x}\right)$$

We will solve for $\frac{\partial y}{\partial x}$ at the mean values *x* and *y*.

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