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Is Efficiency of Indian Cement Firms Linked with PAT? A DEA-Tobit Analysis of Select Firms

Hena Oak

ABSTRACT

Promoting energy efficiency through policy mechanism will help to reduce India's dependence on fossil fuels and lead to energy saving. This cannot happen without industry participation. The Perform-Achieve-Trade (PAT) scheme started in 2012 is such a policy measure, that is specifically designed for the high energy consuming industries of India. Select plants from these industries are selected for every PAT Cycle for implementation of the scheme. Currently PAT is in its sixth phase. One of the industries under its purview is the cement industry. But the cement firms that were included under PAT-I and II were dropped from PAT-III and IV. Using a sample of 27 such firms for the period 2007-2021, the paper estimates efficiency scores using input-oriented BCC model to analyze if the scores were improving for the firms after they were excluded from the PAT Cycles. Results show that on an average, efficiency scores were higher when the firms were a part of PAT-I and II, and it declined thereafter. The top 10 cement producers recorded higher efficiency scores than the other firms. Tobit regression results show that royalty and degree of capitalization help to increase efficiency scores, while with age the scores decline for all firms.

Keywords: Data Envelopment Analysis, Efficiency Scores, Indian Cement Industry, Perform-Achieve-Trade, Tobit Model.

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H. Oak*
Associate Professor, Department of Economics, Miranda House College, University of Delhi, India
(e-mail: henaoak@gmail.com)

Corresponding Author

I. Introduction

Promoting energy efficiency in the country helps to achieve two objectives, viz., lesser use of non-renewable fossil fuels and decline in carbon dioxide (CO_2) emissions from burning of fossil fuels. At the global level, data retrieved from the World Bank (2022) and BP Statistical Review (2021) shows that the consumption of fossil fuels remained above 80% for the period 2000-2020. The World Bank data (2022) on CO_2 emissions from solid fuel consumption as a percentage of total for the period 2000-2016 has also shown an increasing trend, with the cumulative growth in this period being 0.77%, where solid fuel consumption refers to emissions from the use of coal as an energy source. Therefore, it becomes imperative to introduce policies that will help in a more efficient utilization of energy resources.

One of the earliest examples of such a policy comes in the form of white certificates used in many European countries (Santo *et al*., 2016) and United States of America. These certificates, also known as Energy Saving Certificate, or Energy Efficiency Credit, are tradable certificates that guarantee that a certain amount of energy saving has been achieved. The energy saving obligations are imposed on some category of energy market operators, and result in possession of a white certificate after the energy saving has been achieved (Bertoldi & Rezessy, 2009). Santo *et al*. (2016) show that UK, Italy, France and Denmark have had some positive results from these schemes. Another example is Poland which introduced an energy efficiency obligation in 2012 to meet its targets as a part of EU's Energy Efficiency Directive (Rosenow *et al*., 2020), although the energy savings achieved were not enough to meet the target. Efficient use of energy is essential for all sectors, and it is especially crucial for the industrial sector because of its considerable dependence on non-renewable energy. However, despite the high consumption of the industrial sector, the Energy Efficiency Directive for the EU member nations do not have a policy that is specifically designed for the industrial sector (Malinauskaite *et al.*, 2019).

In the Indian case, Perform-Achieve-Trade (PAT) is a policy similar to the White Certificate as it aims to improve energy intensity through the use of tradable energy saving certificates or ESCerts. But the scheme has been designed specifically for the industrial sector, unlike the policies of EU or USA. As per the report on Energy Statistics, India (2021) published by the Ministry of Statistics and Programme Implementation, the industrial sector's share in final energy consumption has been the highest, at 55.85% of the total final energy consumption in 2019-20. Therefore, the PAT scheme was designed to improve the energy intensity of the most energy intensive industries of India. The scheme started in 2012-13 with PAT Cycle-I, and is currently in its sixth cycle. Eight high energy consuming industries, that included the cement industry, were identified for the implementation of PAT-I. Within the cement industry, 85 plants called designated consumers, were selected for PAT-I. Each plant was given a target that had to be achieved by 2014-15. In case the plant achieved the target, it would be given tradable ESCert that could be sold to other plants that failed to meet its assigned target.

In this context, no research has been undertaken to study the location of these identified plants on an efficiency frontier. Though PAT targets have been achieved under cycles I and II, have these plants also moved close to an efficiency score of 1? This paper uses data envelopment analysis (DEA) to examine this research question. Several studies in the literature have used DEA to estimate efficiency scores at regional level and industrial level. Borozan (2018) analyses if European Union uses energy efficiently, and what is the impact of various environmental variables on energy efficiency for 25 EU nations. Pure technical efficiency was found to be less than 1 for most regions, indicating inefficiency. The total factor energy efficiency scores show that most of the developed EU nations are also the more efficient ones. Tobit regression results show that besides climate conditions, development levels and electricity prices having a statistically significant relation on efficiency scores, human education is also important. Aldieri *et al*. (2021) studies the extent and dynamics of energy efficiency in OECD and non-OECD countries, by taking a sample of 136 countries for 2009-2014. Trends in efficiency scores are found to be decreasing overtime for developing countries and increasing for the developed countries. Tobit regression analysis shows that electrical power losses cause efficiency scores to rise, while higher the time required to access electricity and higher the per capita GDP, lower is the efficiency score. Liang *et al*. (2021) calculates regional efficiency scores for eastern, central and western regions of China using super-efficient DEA model. Zhao & Lin (2020) calculate the efficiency scores for China's textile industry and construct a simultaneous equation model that includes the Tobit model.

For the Indian case, PAT has been an important milestone in encouraging energy efficiency steps to be taken at the industrial level. Cement industry has been a part of all the six PAT cycles. However, some of the largest cement producers under PAT Cycles I and II, were dropped from PAT Cycles III, IV and V and few of them were included again under PAT Cycle-VI. The objective of this paper is to use input-oriented data envelopment analysis to estimate the efficiency scores of cement firms for the years 2007-2021. These firms were a part of PAT-I and II, but not of PAT-III and IV. The paper studies if an improvement in efficiency scores was the reason behind exclusion of the firms from the subsequent PAT cycles. The paper then estimates a Tobit model to analyze the factors influencing the efficiency scores of these firms. To the best of my knowledge, such a study has not been undertaken for the Indian cement industry.

Results show that the average efficiency scores are higher for the years PAT-I and II were implemented as compared to the other years. Between 2018-19 to 2020-21 almost 60% of the firms recorded a decline in efficiency scores. This was also a period where energy intensity was higher, implying a rise in the power and fuel expenditure per unit production. Classification of cement firms into two categories, viz., top ten producers and other producers showed that the former had a higher average efficiency score than the latter. Results from the Tobit model shows that a rise in royalties and degree of capitalization helps to increase efficiency scores, but they decline as the firms get older.

II. Econometric Methodology, Variables and model

The paper first calculates efficiency scores of 27 cement firms. These firms are the decision-making units (DMUs) under study, i.e., those units whose performance is studied using DEA model, as they convert inputs into output. This paper uses the model given by Banker, Charnes and Cooper (BCC) to estimate the efficiency scores. BCC model can be input oriented or output oriented. The model used is input-oriented BCC model, that aims to minimize inputs while keeping the output at the given levels. Equations (1)-(3) give the BCC input-oriented model for the j^{th} DMU (Cooper *et al*., 2007).

$$Minimize\ \theta_{BCC} \tag{1}$$

Subject to $\theta_{BCC}x_j - X\lambda \geq 0$

$$Y\lambda \geq y_j$$
$$\sum_{j=1}^{n} \lambda_j = 1$$
$$\lambda_j \geq 0$$

where X and Y are the input and output data matrix respectively. θ^*_{BCC} is the optimal value obtained from (1).

The value of θ^*_{BCC} is then used to maximize the sum of input and output slacks as (2).

$$Maximize\ \epsilon s^- + \epsilon s^+ \quad (2)$$

where $\epsilon = (1, \dots, 1)$ is a vector of ones.
subject to $s^- = \theta^* x_j - X\lambda$
$s^+ = Y\lambda - y_j$
$\lambda \geq 0, s^- \geq 0, s^+ \geq 0$

The optimal solution obtained henceforth is $(\theta^*_{BCC}, \lambda^*, s^{-*}, s^{+*})$. If it satisfies the condition that $\theta^*_{BCC} = 1$ and $(s^{-*} = 0, s^{+*} = 0)$ i.e. no slacks, then j^{th} DMU is said to be BCC-efficient. Otherwise the j^{th} DMU is BCC-inefficient. The inefficient DMUs will have reference set/sets with weights λ assigned to reference sets. The reference set with the largest weight is selected for the inefficient DMU.

Two inputs are used in the calculation of efficiency scores. Input one is power and fuel expenditure that represents an energy input and is defined as the cost of consumption of energy for carrying out the business of a company that includes the cost of consumption of electricity, petroleum products, coal and other sources of energy. Input two is raw materials used that represents a non-energy input. Both are expressed in millions of rupees. Cement production in millions of rupees is the output.

Next, the paper uses a Tobit model to analyze the factors influencing the efficiency scores of the firms. Tobit model is appropriate because the dependent variable is censored from lower and upper bound (Deng *et al*., 2020). The model is estimated using (3).

$$Y_i = \begin{cases} \beta_1 + \beta_2 X_i + e_i \ if \ Y_i^* > 0 \\ 0, \ Y_i^* \leq 0 \end{cases} \quad (3)$$

where Y_i^* is the optimal value of the efficiency score obtained from BCC model and X_i refers to the explanatory variables influencing the efficiency score. X_i includes the following variables.

Royalties: This is the payment made by the firm in millions of rupees, for using technical know-how/technology that the firm uses. This is taken as an indication that the firm is using improved technology, and it is hypothesized that royalties will have a positive effect on efficiency scores.

Degree of capitalization: This is defined as the ratio of gross fixed assets and compensation to employees, both measured in millions of rupees. A fixed asset is defined as an asset that is held by an entity with the intention of being used for the purpose of producing or providing goods or services and is not held for sale in the normal course of business. Compensation to employees reflects the total remuneration in cash or in kind paid by a company to or on behalf of all its employees. Employees are remunerated in exchange for services rendered by them. The ratio is a proxy for the amount of capital used per unit labour. Higher the degree of capitalization of the firm, higher will be the efficiency score. In order to check the rate at which the efficiency score changes with a change in the degree of capitalization, the square of degree of capitalization is also used.

Age is a quantitative variable that is defined as the difference between the current year and the year of incorporation of the firm. The hypothesis is that as the firm gets older, the efficiency score declines. A dummy variable, *Age Dummy*, is also used to capture the effect of age. It is defined to take value 1 if the year of incorporation of the firm is before 1991, and 0 otherwise. 1991 was the year of economic liberalization for India, where a number of reforms like allowing 51% foreign equity participation, that allowed foreign companies to bring modern technology into the country, etc. helped in industrial development.

Large firms dummy is a qualitative variable that takes value 1 if the firm is one of the top ten cement producers of the year 2014-15, and 0 otherwise. Large firms are defined with respect to 2014-15 as it was the last year of implementation of PAT Cycle-I.

PAT year dummy is a qualitative variable takes value 1 if the year is the implementation period of PAT-I or PAT-II, i.e., 2012-13 to 2014-15 for PAT-I and 2016-17 to 2018-19 for PAT-II, and 0 otherwise.

Data and the given definitions on all the quantitative variables have been taken from the ProwessIQ database provided by Centre for Monitoring Indian Economy Private Limited. The names of the cement firms that were a part of PAT-I and II have been retrieved from two Government of India publications, viz., Perform Achieve and Trade (2012) and The Gazette of India (2016).

III. Econometric Results and Discussion

Table I gives the summary statistics of the data.

TABLE I: Summary Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Power & Fuel	405	6662.15	10146.49	4.2	87752.4
Production	405	33617.17	51332.9	889.4	394020.1
Royalties	200	979.68	1708.49	5.5	10768.5
Gross fixed assets	401	34564.85	62493.67	550.7	565047
Age	405	0.74	0.44	0.00	1.00
Large firms	405	0.41	0.49	0.00	1.00
PAT year	405	0.4	0.49	0.00	1.00

Table II reports the summary statistics for select variables for two time periods, 2007-2017, that includes PAT-I and II implementation periods and 2018-2021, that includes PAT-III and IV implementation periods.

TABLE II: Summary Statistics for 2007-17 and 2018-21

Variable	Obs	Mean	Std. Dev.	Obs	Mean	Std. Dev.
-	-	**2007-2017**	-	-	**2018-2021**	-
Power & Fuel	297	5594.30	7500.59	108	9598.7	14873.2
Production	297	29021.80	41057.64	108	46254.4	71176.5
Energy Intensity	297	0.22	0.070396	108	0.237	0.07

Source: Own calculations of the author.
Note: Minimum and maximum values have not been reported due to brevity.

Results show that after PAT-III and IV implementation periods started (2017-18 to 2019-20 and 2018-19 to 2020-21 respectively), the average power and fuel expenditure was 71.58% higher than the period 2007-2017, while production was only 59.38% higher, thereby causing the average energy intensity to be 7.15% higher in the second period. Therefore, being part of the PAT scheme kept the average energy intensity of the cement industry lower. This is true because the 2018-2021 also includes the COVID pandemic period, where the economy experienced lockdown and a general sense of economic slowdown globally. Even then the average power and fuel expenditure and energy intensity was higher.

A. Analyzing Efficiency Scores of Cement Firms

Table III reports the efficiency scores of 27 cement producers. They have been divided into two categories: Top ten producers of cement in the year 2014-15 and other cement producers.

TABLE III: Efficiency Scores of Cement Producers

DMU	2014	2015	2016	2017	2018	2019	2020	2021
Top 10 cement producers of 2014-2015								
ACC Ltd.	0.89	0.90	0.83	0.82	0.92	1.00	0.86	0.83
Ambuja Cement	0.89	0.90	1.00	1.00	0.98	0.95	1.00	1.00
Birla Corp. Ltd.	0.76	0.70	0.65	0.66	0.65	0.63	0.56	0.45
Chettinad Cement	0.73	0.74	0.82	0.77	0.64	0.26	0.29	0.41
Deccan Cements	0.98	1.00	1.00	0.90	0.88	0.89	0.65	0.68
India Cements	0.97	0.86	0.84	0.77	0.73	0.54	0.56	0.60
J K Cement	0.83	0.84	0.78	0.86	0.81	0.81	0.76	0.76
JK Lakshmi Cement	1.00	1.00	0.98	0.85	0.80	0.59	0.64	0.62
Ramco Cements	0.85	0.91	1.00	1.00	0.86	0.70	1.00	1.00
Shree Cement	0.78	1.00	0.96	1.00	1.00	1.00	0.94	0.98
Ultratech Cement	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Average of top 10 producers	**0.88**	**0.89**	**0.89**	**0.88**	**0.84**	**0.76**	**0.75**	**0.76**
Other cement producers of 2014-2015								
Anjani Portland	1.00	1.00	1.00	0.99	1.00	1.00	1.00	1.00
Gujarat Sidhee	0.98	0.76	0.60	0.58	0.80	0.73	0.64	0.60
Heidelberg Cement	0.73	0.73	0.64	0.66	0.69	0.31	0.33	0.34
K C P Ltd.	0.88	0.84	0.84	0.72	0.72	0.34	0.32	0.33
Kesoram Industries	1.00	1.00	1.00	0.75	1.00	1.00	1.00	1.00
Mangalam Cement	0.94	0.81	0.83	0.79	0.67	0.39	0.33	0.37
Meghalaya Cement	1.00	1.00	0.91	1.00	1.00	1.00	0.69	0.73
My Home Inds.	0.75	0.70	0.66	0.76	0.69	0.28	0.30	0.31
Penna Cement	0.83	0.91	0.73	0.73	0.78	0.30	0.34	0.38
Prism Johnson	1.00	0.99	0.81	1.00	0.78	1.00	0.80	0.61
Rain Cements	0.84	0.86	0.94	0.81	0.85	0.53	0.47	0.54
Sagar Cements	0.81	0.68	0.80	0.71	0.72	0.46	0.39	0.43
Sanghi Industries	1.00	1.00	1.00	1.00	1.00	0.80	0.55	0.93
Saurashtra Cem.	1.00	0.90	0.99	1.00	1.00	0.95	1.00	1.00
Shree Digvijay	0.85	0.72	0.72	0.71	0.78	0.70	0.66	0.59
Zuari Cement	0.63	0.60	0.70	0.65	0.69	0.30	0.31	0.28
Average of remaining firms	**0.89**	**0.84**	**0.82**	**0.80**	**0.82**	**0.63**	**0.57**	**0.59**
Average of 27 firms	**0.89**	**0.86**	**0.85**	**0.83**	**0.83**	**0.68**	**0.64**	**0.66**

Note: Efficiency scores have been calculated for 2007-2021. But scores have been reported 2014 onwards due to brevity.

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2014-15 was the last year of the implementation period of PAT-I. The top ten producers have been selected on the basis of the data on company-wise cement production in India in 2014-15, derived from the data source IndiaStat (2022).

Data shows that every year, on an average, efficiency scores of the top 10 producers of the year 2014-15 were higher than the average of the other 17 cement producers, except in the years 2012 and 2014 (Fig. 1). However, there were firm level differences under each category. Comparison of average efficiency score between the years 2013-2017 and 2018-2021 shows that the scores are higher in the former period that includes both PAT Cycles I and II[1]. This indicates that PAT did play a role in encouraging firms to improve production efficiency.

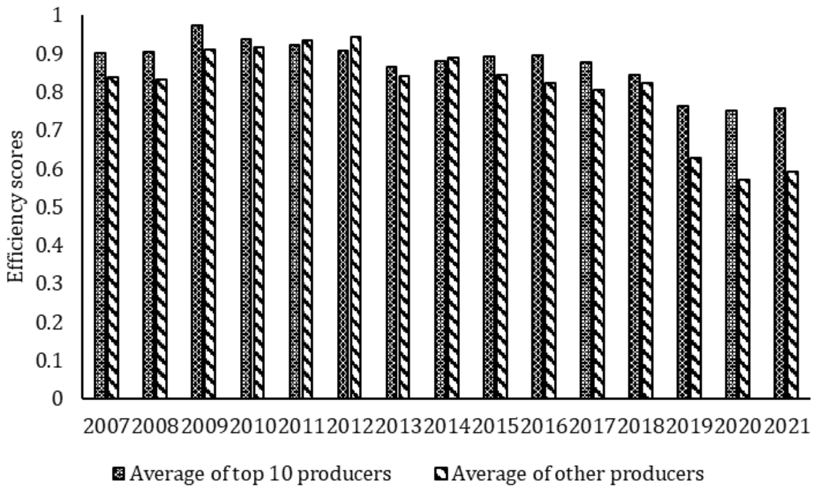


Fig. 1. Average efficiency scores of top ten producers and other producers.

The firm level discrepancy can be better understood by looking at the box and whiskers plot given in Fig. 2. It shows how the average efficiency score of cement firms belonging to the two categories, were distributed for the period 2007-2021.

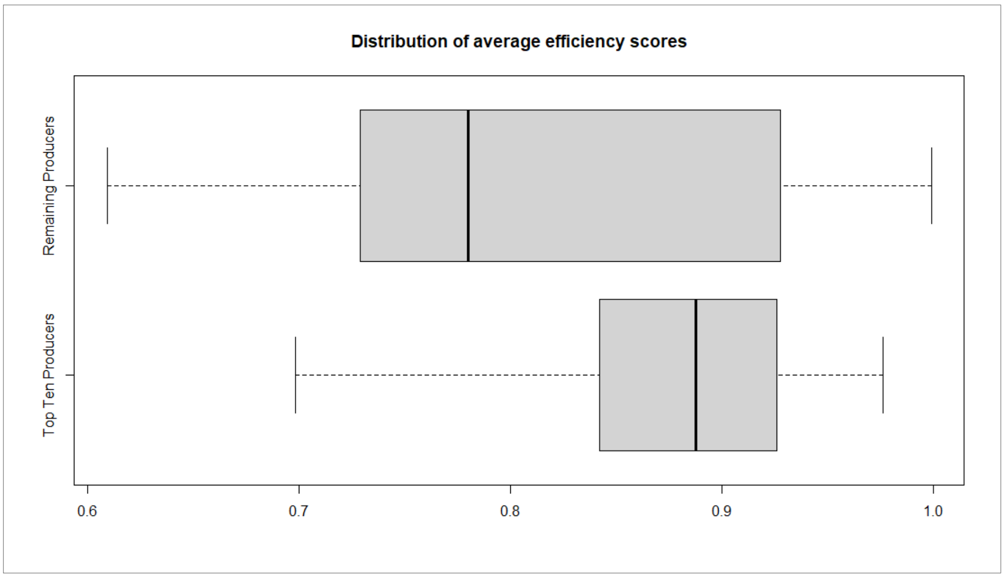


Fig. 2. Distribution of average efficiency scores of top ten producers and the other producers
Source: Own calculations.

The boxplot for the top ten producers has a negatively skewed distribution with a long lower whisker, that implies that bulk of the efficiency scores lie on the upper end of the scale. The boxplot for the other producers has a positively skewed distribution, that implies that most of the efficiency scores lie on the lower end of the scale. The median scores of the two distributions are such that 50% of the efficiency scores for the top ten and other producers are below 0.89 and 0,78 respectively. The results for the first quartile show that 75% of the top ten producers have an efficiency score above 0.84, while 75% of the other producers have an efficiency score above 0.73. Clearly, on an average, more firms from the top ten

[1] Average efficiency score for 2013-2017 and 2018-2021 is 0.8573412 and 0.7044229 respectively.

producers, have a higher efficiency score, although the results from the third quartile and the maximum efficiency score is not very different for the two categories. But an interesting result here is that the total number of efficient DMUs for most of the years was from the other cement producers, and not from the top ten cement producers, as shown in Fig. 3 below.

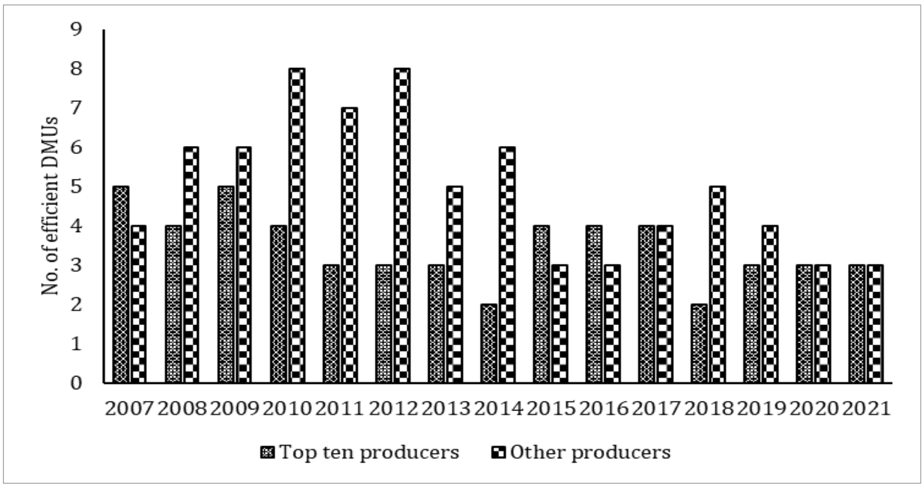


Fig. 3. Total number of efficient DMUs for the period 2007-2021.

Except for Ultratech Cement Limited, none of the top 10 cement producers have been on the efficiency frontier for more than ten times. Anjani Portland Cement Limited, Kesoram Industries, Meghalaya Cement Limited have been on the efficiency frontier the highest number of times. Even during the years PAT-I and II were being implemented, Ultratech Cement Limited was the only top ten producer on the efficiency frontier for all the years. It was followed by Sanghi industries, Anjani Portland Cement Limited, and Kesoram Industries, none of which were among the top cement producers.

Fig. 4 uses sparklines to compare the trends in efficiency scores of the cement producers from 2018-19 to 2020-21. This covers the period after the implementation of PAT-II, to study the changes in the efficiency scores after the firms were excluded from PAT-III and IV.

Top Ten Producers		Other Producers			
DMU	**Sparklines**	**DMU**	**Sparklines**	**DMU**	**Sparklines**
ACC Ltd.		Anjani Portland		Prism Johnson	
Ambuja Cement		Gujarat Sidhee		Rain Cements	
Birla Corp. Ltd.		Heidelberg Cement		Sagar Cements	
Chettinad Cement		K C P Ltd.		Sanghi Industries	
Deccan Cements		Kesoram Industries		Saurashtra Cement Ltd.	
India Cements		Mangalam Cement Ltd.		Shree Digvijay Cement	
J K Cement		Meghalaya Cement Ltd.		Zuari Cement Ltd.	
J K Lakshmi Cement Ltd.		My Home Inds.		**Average of other producers**	
Ramco Cements		Penna Cement			
Shree Cement Ltd.					
Ultratech Cement Ltd.					
Average of top 10 producers					

Fig. 4. Trends in efficiency scores for 2019-2020.

The end of the implementation period of PAT-II was in 2018-19. After that, since these firms were no longer a part of the PAT scheme, the sparklines show if the efficiency scores declined henceforth. Among the top ten producers, except for ACC Limited, Ambuja Cement, Shree Cement Limited and Ultratech Cement Limited, the rest of the firms showed a decline in the efficiency scores in 2018-19 compared with their 2014-15 values. Among the other seventeen producers, Anjani Portland Cement Limited, Kesoram Industries, Meghalaya Cement Limited, Prism Johnson Limited and Saurashtra Cement limited showed a rise in the efficiency scores in 2018-19 from the 2014-15 values, while the others showed a decline. The sparklines in Table 2 show that from 2018-19 to 2020-21, 45% of the top cement producers and 59% of the remaining cement producers registered a decline in the efficiency scores. The averages of the two groups and the overall average also declined in this period. Results suggest that for most of the firms, inclusion under the PAT cycles was an incentive to get closer to the efficiency frontier.

B. Analyzing Tobit Regression Model

Table IV reports the results from Tobit regression model, with the efficiency scores being the dependent variable. There are 27 cement firms, and the sample period runs from 2007 to 2021. Model 1 is for all the cement firms. Model 2 and Model 3 give the results for the top ten cement producers or the large firms and the other cement producers respectively. Model 4 is for all firms, but with *Age* as quantitative variable, instead of a dummy variable as in the other three models.

Royalties have a positive and statistically significant effect on efficiency scores. A rise in royalty and technical know-how fees helps to increase the efficiency score in all the three models. Degree of capitalization of a firm also has a positive effect on efficiency scores. A rise in the degree of capitalization causes the efficiency scores to rise, but at a decreasing rate as (*Degree of capitalization*)^2 has a negative sign. But both variables have a statistically significant effect in all three models.

TABLE IV: FACTORS AFFECTING EFFICIENCY SCORES OF CEMENT FIRMS (2007-2021)

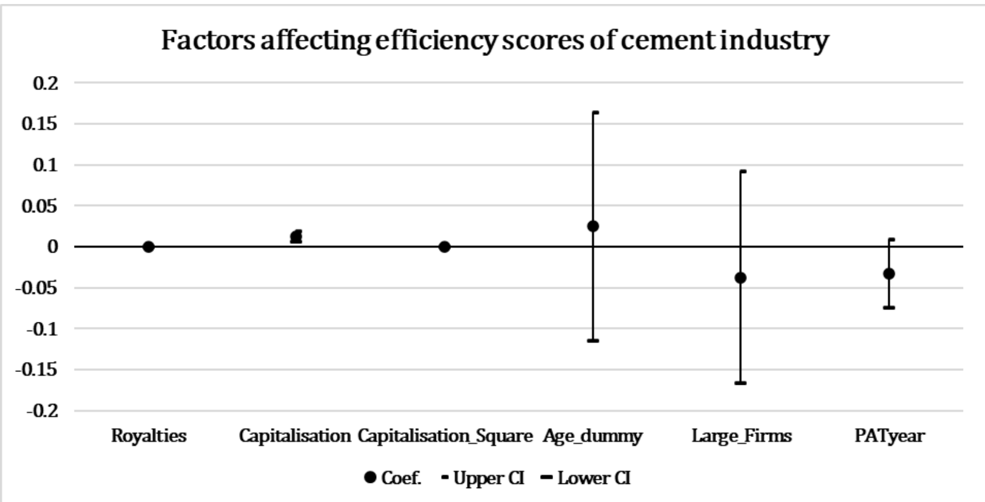
Variables	All firms Model 1	Large firms Model 2	Other firms Model 3	All firms Model 4
Royalties	7.13e-05*** (2.12e-05)	8.05e-05*** (1.64e-05)	0.000529*** (0.000190)	0.000094*** (0.00002)
Degree of Capitalization	0.0129*** (0.00334)	0.0178*** (0.00553)	0.0125*** (0.00443)	0.007807** (0.00315)
(Degree of Capitalization)^2	-0.000115** (4.52e-05)	-0.000165* (8.53e-05)	-0.000123** (5.68e-05)	-0.00009** (0.00004)
Age Dummy	0.0247 (0.0713)	-0.00266 (0.0515)	0.0961 (0.123)	-
Age	-	-	-	-0.01854*** (0.003302)
Large firms Dummy	-0.0371 (0.0659)	-	-	0.143807 (0.191174)
PAT year Dummy	-0.0328 (0.0212)	-0.0426 (0.0261)	-0.0283 (0.0304)	0.015032 (0.020245)
Constant	0.642*** (0.0836)	0.525*** (0.101)	0.581*** (0.131)	1.50004*** (0.195653)
Obs.	401	165	236	401
Number of id	27	11	16	27

*,** and ***: Null hypothesis rejected at 10%, 5% & 1%; levels of significance.
Standard Errors in parenthesis.
Efficiency score is the dependent variable.
Degree of Capitalization is the ratio of gross fixed assets to compensation to employees.

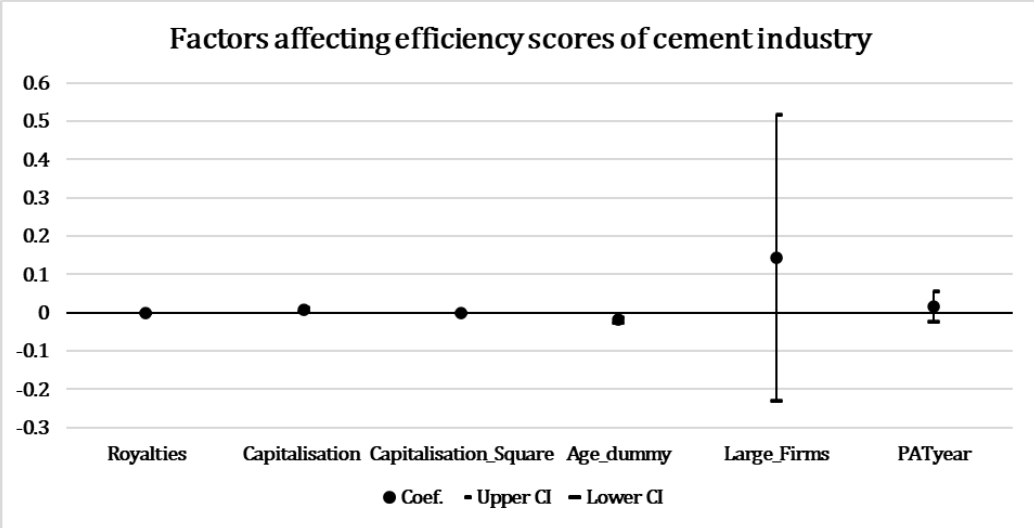
Dummy variables *Age Dummy* and *PAT year*, and *Large Firms* in Model 1, are not statistically significant. This implies that there is no difference in the average efficiency scores of older firms, or average efficiency scores of firms in the years PAT-I and II were implemented as compared to the other years.

However, when age is used as a quantitative variable, results show that it has a negative relationship with efficiency scores. As the firms get older, the efficiency score declines.

The signs and the statistical significance of the other variables do not change, compared to Model 1, as shown in the coefficient's plots given in Fig. 5.



(a)



(b)
Fig. 5. Coefficient Plot: a). Model 1; b) Model 4.

IV. Conclusion

The PAT scheme was announced as a regulatory policy that would reduce the energy intensity of high energy consuming industries of India. This included the cement industry. Though the cement industry continued to be a part of PAT Cycles III and IV, most of the firms identified under PAT Cycles I and II, especially the large producers, were dropped from the subsequent cycles. The paper attempts to study if there was an improvement in their efficiency scores that led to this outcome. Analysis of the efficiency scores obtained from the input-oriented BCC model shows that on an average the scores declined in the years 2018-2021, after these firms were dropped from the PAT cycles. The average energy intensity of these firms was also found to be higher in this period compared with the pre-2018 years. This indicates that the PAT scheme played a positive role in making firms more efficient. Therefore, dropping these 27 firms from PAT Cycles III and IV caused their efficiency scores to reduce and the firms moved further away from the efficiency frontier. Tobit regression results show that royalties and degree of capitalization have helped to improve the scores, and hence steps need to be taken to encourage more technological development in cement production.

PAT-I and II helped to reduce 1.93% and 2.5% of India's emissions respectively. Together Rs. 40945 crores worth energy saving was achieved from both cycles. Now the scheme has been expanded to include more industries. Given the achievements of the scheme and the trends in efficiency scores and energy intensity of the 27 cement firms after they were dropped from the cycle, it is recommended that the firms from the first two PAT cycles should be a part of the subsequent PAT cycles too. This will help to make them more energy efficient and achieve higher gains in emission reduction and energy savings.

Conflict of Interest

The Author declares that she does not have any conflict of interest.

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Dr. Hena Oak, (ORCID id is 0000-0001-5432-2193) has a Ph.D. in Economics from Jawaharlal Nehru University, Delhi, MPhil (Economics) from Delhi School of Economics, University of Delhi, India, and Masters in Economics from Delhi School of Economics, University of Delhi, India, and from Vancouver School of Economics, University of British Columbia, Canada.

She is working as Associate Professor, Department of Economics, Miranda House College, University of Delhi, India. She has taught courses on Microeconomics, Statistics and Econometrics. Her research interests include Environmental Economics and International Trade. She has presented papers on the problem of air pollution in the Indian context and on factors influencing energy intensity of Indian industries, in numerous national and international conferences.