Research Paper
Impact Factor: 7.358
Peer Reviewed & Indexed Journal
www.ijmsrr.com

IJMSRR
E- ISSN - 2349-6746
ISSN -2349-6738

AN ANALYSIS OF THE PRODUCTION EFFICIENCY OF THE INDIAN CEMENT INDUSTRY

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Abstract
India is the second largest cement producer in the world, reflecting the cement industry's vital importance to economic growth and development. The cement sector directly and indirectly employs over a million people, significantly contributing to the country's workforce and overall economy. India's total installed cement manufacturing capacity is approximately 600 million metric tons, while its actual production capacity is 391 million metric tons as of the 2022-23 fiscal year. In this paper, the production efficiency of India's cement industry is evaluated using data envelopment analysis (DEA) to measure different performance measures, such as scale efficiency and technical efficiency, for the period of five years from March 2020 to March 2024.

Keywords: Cement Industry, Technical Efficiency, Scale Efficiency, Input Variables, Output Variables, Data Envelopment Analysis (DEA).

Introduction

India’s Cement Industry is one of the oldest industries, boosting the country's economy. It ranks second globally in the cement industry, after China, reflecting the cement industry's vital importance to economic growth and development. The cement sector directly and indirectly employs over a million people, significantly contributing to the country's workforce and overall economy. India's total installed cement manufacturing capacity is approximately 600 million metric tons, while its actual production capacity is 391 million as of the 2022-23 fiscal year. Materials such as cement have been used in India since ancient times, but modern cement production began in the 20th century. Early structures such as the Indus Valley Civilization used clay and lime as binding agents. During the British colonial period, the demand for cement increased with the development of infrastructure facilities such as railways and public buildings. The cement production industry officially began in 1904, when South India Industries Ltd set up the first cement plant in Maharashtra (now Chennai). However, production was slow and technology was poor. In 1914, the Indian Cement Company Limited established its plant in Porbandar, Gujarat, marking the beginning of the industry. By the 1920s, three more companies had been established: India Cement Company Limited, ACC Limited, and Dalmia Cement. After India gained independence in 1947, the government promoted the cement industry as part of the country's industrial development strategy. The industry was regulated and price controls were imposed to ensure affordability. During the 1950s and 1960s, the government implemented several five-year plans that emphasized infrastructure development. Cement production was an important part of these plans. New cement plants were set up across the country under government licenses. Despite the growth, the industry faced many challenges, including outdated technology, inefficiencies, and frequent power shortages. Production was unable to meet domestic demand, leading to imports. The government partially deregulated the cement industry in 1982, allowing producers to set their prices for 66% of their output while retaining control over the remaining 34%. This policy was intended to promote growth and encourage investment. Partial deregulation led to increased competition and investment in modern technology. Plants began adopting the dry process of cement manufacture, which was more energy-efficient than the old wet process.

Cement production capacity increased significantly during this period, with many new plants being set up by private players. The cement business was completely deregulated by the government in 1991 as part of macroeconomic liberalization efforts. This allowed market forces to determine pricing and production levels, increasing competition and efficiency. Deregulation attracted private investment and foreign firms to the market. Multinational corporations including Lafarge, Holcim and Heidelberg Cement invested in the Indian cement sector. The industry grew rapidly with the establishment of new plants and modernization of old plants. It diversified into other cement products including Portland pozzolana cement (PPC) and Portland slag cement (PSC). Today, it plays a vital role in the development of India's infrastructure and contributes significantly to the economy.

Review of Literature

A literature review summarises and evaluates previous studies, which provide the basis for current and future research. This process gives the researcher an understanding of existing knowledge on the topic and potential gaps and limitations in prior research. Some of the important research papers and articles related to measuring the performance and analysis of production efficiency of the Indian cement industry are discussed in this section.

Seema Sharma, (2008) analysed the Technical Efficiency and Scale Efficiency of the Cement Industry in India. The study collected data from the top 20 cement companies, which accounted for 85.5% of the cement market between 2005 and 2006. Data analysis (DEA) was used to analyse the efficiency and productivity of the cement sector. At the end of the study, the researchers found that 50% of the companies were performing well and operating at the best possible level. It was determined that 25% of the companies were using more than their factory capacity, which caused a decline in scale, while the remaining 25% were under-utilizing their factories, indicating an increasing trend in the precaution against business misuse.

Latha Chari et al., (2009) analysed the Technical and Scale Efficiencies of the Cement Industry of India Using Data Envelopment Analysis (DEA). The study extends for three years from 2006 to 2008. The study examines the technical and scale efficiency of 32 cement producers in India by using Data Envelopment Analysis (DEA).The study revealed that a significant proportion,constituting approximately 25%, of the companies in the sector were operating inefficiently during the specific period. This scale inefficiency could be due to the recent capacity expansion witnessed in the industry.
Sarbapriya Ray, (2011) analysed the efficiency of the cement industry in India. The study asses the total factor productivity performance and efficiency growth pattern for the cement industry in India for the period, 1979-80 to 2008-09. The study observes the performance of 32 leading firms in the cement industry. Data Envelopment Analysis (DEA) has been used to evaluate changes in technology efficiency and productivity growth. The study examined the performance of 32 companies in the cement sector. Data Envelopment Analysis (DEA) was used to assess the changes in productivity and productivity growth. The study concludes that total credit, output growth and foreign direct investment (FDI) all have a significant impact on total productivity growth, but open-mindedness has negative effects. The cement sector needs to improve productivity and technology.

Vaibhav Vishwakarma, (2011) analysed the Technical and Scale Efficiency of the Indian Cement Industry. The study obtained data for the years 2005-2006, 2011-12 and 2015-16 of the six largest cement companies.Data Envelopment Analysis (DEA) is used to analyse the efficiency and productivity of the cement sector. The research concluded that the efficiency and performance of the cement sector was good in the years 2005-2006, 2011-2012 and 2015-2016.The results suggest that none of the firms were under-utilising or over-utilising their plant capacities.

Mini Kundi and Seema Sharma, (2015) analysed the Efficiency and Flexibility of Cement Firms in India. The study asses the technical and super-efficiency of the cement industry in India for the year 2012-13. The study observes the performance of 47 cement companies that control approximately 99 % of the market share in the cement industry. Stochastic Frontier Analysis (SFA) and Data Envelopment Analysis (DEA) have been used to evaluate the technical and super-efficiency of firms. The research found that 20 companies were operating efficiently, indicating a healthy cement industry overall. However, to improve the overall efficiency of the industry, less efficient companies could benefit from adapting their production processes to accommodate changes in inputs and production scale.

Chandra Shekhar, (2017) analysed the performance efficiency of the cement sector in India. The study is based on the twenty-six cement industries. The study extends over five years from 2011 to 2015 and the performance efficiency of the cement industries was analysed by using Data Envelopment Analysis (DEA). At the end of this research, the researcher found that the cement industry performed more efficiently in 2015 as compared to the previous year 2011 to 2014 and reduced inefficiency in performance in 2015 as compared to 2011 to 2015.

Satish Chandrasekaran and Asmita Chitnis, (2019) analysed the performance of Indian Cement Companies: A super Efficiency DEA study. The study obtained data from 17 Indian Cement Companies. The data have been obtained from the financial year 2017-18. The performance efficiency of the cement industries was analysed by using Data Envelopment Analysis (DEA). At the end of this research, the researcher found that most of the firms in the cement industry are efficient. These firms have major market shares but there is still some scope to improve in cement industries.

Dr. Y Kesava Reddy, (2020) analysed the production Efficiency of the Indian Cement Industry. The study extends from 1950-51 to 2017-18. The chi-square test was used to assess the production capacity of the cement industry in terms of capacity utilization. The research suggested that cement plants should be more evenly distributed across India and that there is an urgent need to modernize these facilities with advanced technology, including improved machinery, process control systems, and instrumentation.

Dr. D. Silambarasan and Dr. K. Selvadurgadevi, (2022) analysed the Operating Efficiency of the Cement Industry in India Based on the DEA Model. The study asses the Cost Efficiency, Revenue Efficiency and Profit Efficiency of the Cement Industry for the period, of 10 years, from 2012 to 2021. The study obtained data from 19 cement companies in India which is listed in BSE. The study revealed that the VRS approach shows that Ambuja Cement, Everest Industry, J. K. Cement, Keerthi Industry, and NCL Industry have achieved 100% efficiency during the study period. CRS and scale efficiency also show that Everest Industry has achieved 100% in overall efficiencies.

Research Gap

There have been many studies on the analysis of the performance of Cement Industries in India. These studies are based on different performance measures like Cost Efficiency, Revenue Efficiency Profit Efficiency, Technical Efficiency and Scale Efficiency by obtaining data from different Decision-Making Units. This Study will measure the Technical Efficiency and Scale Efficiency of large firms that capture the maximum share of the cement market. The study covers a period of Five years from 2020 to 2024.

IJMSRR
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ISSN -2349-6738

Research Objectives

The objectives for the present study on the topic "An Analysis of Production Efficiency of the Indian Cement Industry" are as follows:

To Assess the current production efficiency of the Indian cement industry in comparison to the benchmark.

To Analyse and compare the production efficiency of leading cement companies in India.

To Examine and analyse the primary factors influencing production efficiency within the Indian cement industry, such as technological developments, raw material quality, and employee capabilities.

Research Methodology

The Research Methodology section of a paper outlines the approaches and techniques used to collect and analyze information and data related to a specific research topic. This component is essential, as it ensures the validity and reliability of the study.

Research Design

The study will be based on the following research design:

Descriptive Analysis: The study would be based on various charts and graphs (histogram, line charts)

Performance Analysis: The study will use a performance measurement model like Data Envelope Analysis (DEA) to measure different performance measures, such as scale efficiency and technical efficiency.

Comparative Analysis: The study will use benchmark comparison. Different leading cement companies will be compared.

Data Collection

Secondary Data: This paper is based on secondary data for five years from March 2020 to March 2024. The data will be collected from books, journals, and newspapers like The Economic Times and Financial Times. It will also be collected from industry reports, production data from cement companies, and databases of the Indian Bureau of Mines, and the Ministry of Commerce and Industry.

Sample Selection: The study measures the performance of fifteen top-performing Cement Companies. The following fifteen Cement Companies are taken for the research. They are UltraTech Cement Ltd., Ambuja Cement Ltd., ACC Ltd., Shree Cement Ltd., Heidelberg Cement India, Ramco Cements Ltd., Grasim Industries, JK Cement Ltd., RHI Magnesita India Ltd., JK Lakshmi Cement Ltd., Birla Cement, Orient Cement, Mangalam Cement, Sagar Cements and India Cement.

Variables: Input-output variables have been selected by the company's annual reports and previous studies. The study uses four input variables and one output variable which are raw material cost, Power and Fuel Expenses, Salary and Wages, Total Assets and Total Revenue.

Statistical Tools

The analysis of production efficiency of the Cement Industries of India is evaluated using Data Envelopment Analysis (DEA) to measure different performance measures, such as Scale Efficiency and technical efficiency. In this study, we have applied Constant Returns to Scale (CRS)-DEA and Variable Returns to Scale (VRS)-DEA models to estimate technical efficiencies and Scale Efficiencies.
Technical Efficiency (TE): The Firm can get maximum output from a given input set.

Scale Efficiency (SE): SE means that any changes to the size of the unit would make it less efficient.

Scale Efficiency = $\frac{CRS\ TE}{VRS\ TE}$

MS Excel will be used for the statistical calculations.

Data Envelopment Analysis (DEA): DEA is a nonparametric technique that compares the inputs and outputs of decision-making units to determine their relative efficiency. Farell developed the DEA methodology (1957), further initiated by Charnes, Cooper, and Rhodes (1978).

Results and Discussions

Table 1 shows the average of five years of input and output data of 15 Indian cement companies from March 2020 to March 2024. Four input variables, namely Raw Material Cost, Power and Fuel Cost, Employee Cost, and Total Assets, and one output variable, total Revenue, have been taken.

Table 1: Input & Output data on Indian Cement Companies **(₹ in crore)**

S.N.	DMU Name	Raw Material	Power & Fuel	Employee Cost	Total Assets	Total Revenue
1.	UltraTech	11775.94	12113.88	2469.86	60539.20	53708.89
2.	Ambuja	2893.73	3,113.72	673.206	27,249.57	16,430.70
3.	ACC Ltd	4769.01	3921.28	862.69	14238.71	18352.88
4.	Shree Cement	1889.25	3748.76	820.336	18868.87	15548.77
5.	Heidelberg	495.13	609.28	134.98	1673.72	2286.23
6.	Ramco	1482.98	1690.16	434.32	10015.24	6868.34
7.	Grasim	10580.52	3374.44	1778.81	51216.71	21249.39
8.	JK Cement	1786.76	1690.98	516.04	7598.99	7946.53
9.	RHI Magnesita	1233.11	50.60	137.39	1977.15	1710.22
10.	JK Lakshmi	1629.77	1119.76	337.67	3301.06	5247.48
11.	Birla Corp.	1413.01	939.93	334.50	5899.42	5114.50
12.	Orient	694.08	697.70	161.90	2009.35	2741.47
13.	Mangalam	296.44	451.10	115.73	1284.04	1571.50
14.	Sagar Cement	258.95	455.35	74.95	1855.68	1447.02
15.	India Cement	848.55	1335.17	349.22	8311.54	4906.11

Source: Money Control

Table 2 shows the descriptive statistics of input and output variables of the cement industry in India. In Input variables Raw material Cost ranges from a minimum of Rs. 258.95 crores (Sagar cement) to Rs. 11775.94 crores (UltraTech Cement), Power &Fuel Cost ranges from a minimum of Rs. 50.60 crores (RHI Magnesita India Ltd.) to Rs. 12113.88 crores (UltraTech Cement), Employee Cost ranges from minimum of Rs. 74.95 crores (Sagar cement) to Rs. 2469.86 crores ((UltraTech Cement) and Total Assets ranges from minimum of Rs. 1284.04 crores (Mangalam Cement) to Rs. 60539.20 crores (UltraTech Cement) with mean of 2803.15, 2354.14, 613.44 and 14402.62 respectively. The median of these inputs are 1482.98, 1335.17, 349.22 and 7598.99 respectively and the standard deviation for input variables are 3591.75, 2988.50, 674.81 and 18451.87 respectively. In the Output Variable, Total Revenue ranges from a minimum of Rs. 1447.02 crores (Sagar cement) to Rs. 53708.89 crores (UltraTech Cement) with a mean of 11008.67. The median and Standard Deviation are 5247.48 and 13562.54 respectively.

Table 2: Descriptive Statistics of Inputs and Output Variables of Cement Industry in India

Input/Output	Variables	Min	Max	Mean	Median	Std. Dev.
Input Variables	Raw Material Cost	258.95	11775.94	2803.15	1482.98	3591.75
	Power & Fuel Cost	50.60	12113.88	2354.141	1335.17	2988.50
	Employee Cost	74.95	2469.86	613.44	349.22	674.81
	Total Assets	1284.04	60539.20	14402.62	7598.99	18451.87
Output Variables	Total Revenue	1447.02	53708.89	11008.67	5247.48	13562.54

Source: Author's Calculation

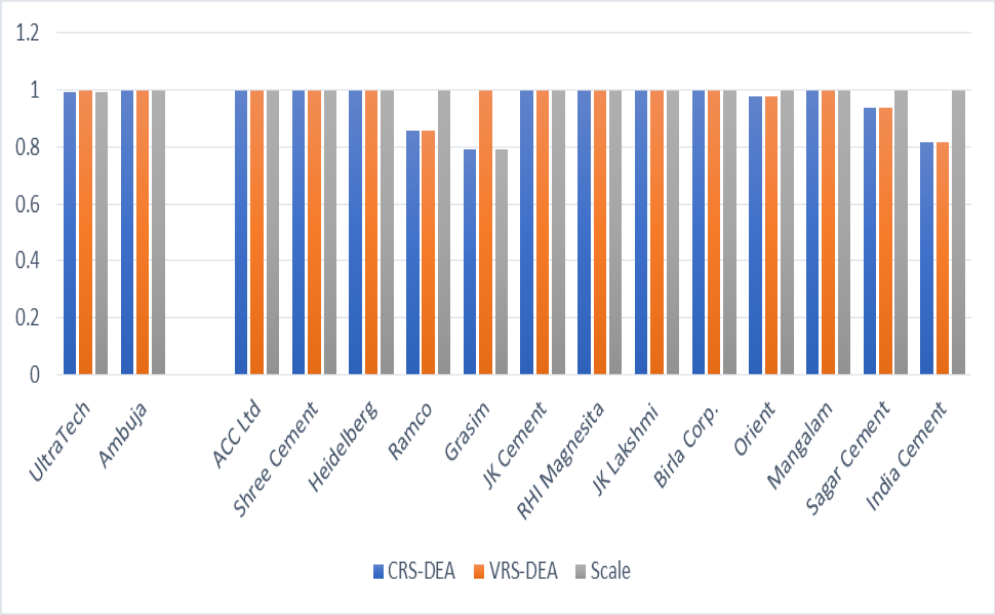
Table 3 shows the Technical Efficiency and Scale Efficiency of fifteen cement firms in India. Four Input variables, namely raw material cost, Power and Fuel Expenses, Salary and Wages, Total Assets, and one output variable, Total Revenue, have been used to calculate Output-Oriented Constant Return to Scale Data Envelopment Analysis (CRS-DEA) and Variable Return to Scale Data Envelopment Analysis (VRS-DEA) Models to compute the Technical Efficiency and Scale Efficiency of these DMUs. Table 3 also shows the individual ranks of these cement companies based on CRS-DEA Efficiency and VRS-DEA Efficiency.

Table 3: Technical Efficiencies and Scale Efficiencies of Cement Industry in India

DMU No.	DMU Name	CRS-DEA Efficiency	Rank	VRS-DEA Efficiency	Rank	Scale Efficiency	Rank	Return to Scale
1.	UltraTech	0.99127	10	1.00000	1	0.99127	14	Decreasing
2.	Ambuja	1.00000	1	1.00000	1	1	1	Constant
3.	ACC Ltd	1.00000	1	1.00000	1	1	1	Constant
4.	Shree Cement	1.00000	1	1.00000	1	1	1	Constant
5.	Heidelberg	1.00000	1	1.00000	1	1	1	Constant
6.	Ramco	0.85828	13	0.85828	14	1	1	Increasing
7.	Grasim	0.79097	15	1.00000	1	0.79097	15	Decreasing
8.	JK Cement	1.00000	1	1.00000	1	1	1	Constant
9.	RHI Magnesita	1.00000	1	1.00000	1	1	1	Constant
10.	JK Lakshmi	1.00000	1	1.00000	1	1	1	Constant
11.	Birla Corp.	0.99981	9	0.99981	11	1	1	Increasing
12.	Orient	0.97829	11	0.97829	12	1	1	Increasing
13.	Mangalam	1.00000	1	1.00000	1	1	1	Constant
14.	Sagar Cement	0.93972	12	0.93972	13	1	1	Increasing
15.	India Cement	0.81711	14	0.81711	15	1	1	Increasing

Source: Author's Calculation

Figure-1 Technical and Scale Efficiency of Cement Industry in India- CRS-VRS Approach



As can be seen from Table 3, According to CRS-DEA Efficiency, 8 out of 15 companies namely Ambuja Cement, ACC Ltd., Shree Cement, Heidelberg Cement, JK Cement, RHI Magnesita, JK Lakshmi Cement, Mangalam Cement are efficient with overall efficiency score 1. The computed data from the VRS-DEA Efficiency model shows that 10 cement firms namely, Ambuja Cement, UltraTech Cement, ACC Ltd, Heidelberg Cement, Grasim Cement, Shree Cement, JK Cement, RHI Magnesita Cement, JK Lakshmi Cement and Mangalam Cement are the efficient cement companies with efficiency score 1. Scale Efficiency of two companies namely UltraTech and Grasim are less efficient than other companies. CRS-DEA Efficiency shows that Grasim Cement, India Cement and Ramco Cement are less efficient with a minimum score of 0.79097, 0.81711 and 0.85828 respectively. VRS-DEA Efficiency shows that India Cement, Ramco Cement and Sagar Cement are less efficient with a minimum score of 0.81711, 0.85828 and 0.93972 respectively.

Conclusion

Cement industry in India is one of the oldest industries and has contributed to the economic developm ent of the country. It ranks second globally in the cement industry, after China, reflecting the cement industry's vital importance to economic growth and development. The cement sector directly and indirectly employs over a million people, significantly contributing to the country's workforce and overall economy. Data Envelopment Analysis shows the Technical and Scale Efficiency of fifteen cement companies by using Constant Return to Scale and Variable Return to Scale approaches. The Study concluded that the Data Envelopment Analysis model shows that the overall Technical Efficiency and Scale Efficiency of the many firms are improved in Constant Return to Scale and Variable Return to Scale approaches. In the Constant Return to Scale Approach, Ambuja Cement, ACC Ltd., Shree Cement, Heidelberg Cement, JK Cement, RHI Magnesita, JK Lakshmi Cement, Mangalam Cement have achieved 100 % efficiency with an overall efficiency score of 1 during the study period. In the Variable Return to Scale approach, UltraTech Cement, Ambuja Cement, ACC Ltd, Shree Cement, Heidelberg Cement, Grasim Cement, JK Cement, RHI Magnesita Cement, JK Lakshmi Cement and Mangalam Cement have achieved 100 % efficiency with an overall efficiency score of 1

during the study period. However, the scale efficiency also showed Ambuja Cement Ltd., ACC Ltd., Shree Cement Ltd., Heidelberg Cement India, Ramco Cements Ltd., JK Cement Ltd., RHI Magnesita India Ltd., JK Lakshmi Cement Ltd., Birla Cement, Orient Cement, Mangalam Cement, Sagar Cements and India Cement have achieved 100% efficiency with an overall efficiency score of 1 during the study period.

Limitations

Certain limitations of this study should be addressed in further research.
The study considered only 15 cement companies.
The study covers the analysis of five years from March 2020 to March 2024.
The study analyses only Technical Efficiency and Scale Efficiency.

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