



Comparative Analysis of Cement Industries Sector by Using DEA Analysis

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ABSTRACT

This study employs the Data Envelopment Analysis (DEA) method to conduct a comparative analysis of three leading cement companies—Ultratech cement, Shree cement, Birla cement—across the years 2017 to 2023. The DEA method is utilized to evaluate the relative efficiency of these companies in converting inputs (total assets and operating expenses) into outputs (total revenue and net income). By applying DEA, this study aims to identify the efficiency frontier within the cement industry, showcasing the optimal combination of inputs to achieve maximum outputs. Through a comprehensive examination of financial data spanning multiple years, this analysis seeks to unveil performance differentials and strategic insights among the selected companies, Total assets and operating expenses serve as crucial inputs, reflecting the companies' investment levels and operational costs. These inputs are juxtaposed against the outputs of interest: total revenue, which signifies market competitiveness and sales performance, and net income, indicating operational capacity and market demand fulfilment. The DEA method allows for the identification of efficient and inefficient companies within the industry,

enabling comparisons and benchmarking against the best practices observed. Insights derived from this analysis can inform strategic decision-making, resource allocation, and operational improvements for the companies under study. Ultimately, this study contributes to a deeper understanding of the relative performance and efficiency dynamics within the cement sector, offering valuable insights for industry stakeholders, investors, and policymakers.

INTRODUCTION:

The cement industry plays a pivotal role in the infrastructure development of any nation,(Mandal & Ghosh Dastidar, 2014) serving as a fundamental building block for construction projects ranging from residential buildings to infrastructure megaprojects.(Cooper et al., 1999) Within this sector, companies strive for operational efficiency and productivity enhancement to maintain competitiveness and meet the burgeoning demand for construction materials(Fare & Grosskopf, 1997). In this research, we embark on a comprehensive comparative analysis of three prominent players in the cement industry: UltraTech Cement, Shree Cement, and Birla Cement Text.(Hu et al., 2020)

The study employs Data Envelopment Analysis (DEA) as the primary analytical tool to evaluate the efficiency of these companies over a period of seven years.(Simar & Wilson, 2011) DEA offers a robust methodology to assess relative efficiency by comparing input-output relationships, The DEA method is utilized to evaluate the relative efficiency of these companies in converting inputs (total assets and operating expenses) into outputs (total revenue and net income). (Tone & Tsutsui, 2010)making it an ideal framework for examining the performance of firms within the same industry. Additionally, the analysis incorporates technical and scale efficiency assessments, including Variable Returns to Scale (VRS) and Constant Returns to Scale (CRS), to provide nuanced insights into the operational dynamics of the selected companies.

Furthermore, (Sanei et al., 2022)this research integrates elements of technical analysis and pure technical analysis to delve deeper into the operational intricacies and identify areas for potential improvement within each company. (Nourani et al., 2018)By examining balance sheets and profit and loss accounts spanning seven years, we aim to provide a comprehensive understanding of the financial performance and operational efficiency of UltraTech Cement, Shree Cement, and Birla Cement Text.

(Emrouznejad & Yang, 2018)The cement industry, characterized by high capital intensity, substantial energy consumption, and environmental considerations, operates within a dynamic global market influenced by factors such as infrastructure development, urbanization trends, and regulatory frameworks. (Yang & Pollitt, 2009)Additionally, the industry faces challenges related to raw material procurement, transportation logistics, and market fluctuations, which necessitate continuous innovation and strategic management practices.

(S, 2021)Through this comparative analysis, we seek to contribute to the existing body of knowledge on the cement industry's operational efficiency while offering valuable insights for industry practitioners, policymakers, and stakeholders.(Micajkova, 2015) By identifying best practices and areas for improvement, this research aims to assist cement companies in enhancing their competitive positioning and achieving sustainable growth amidst evolving market dynamics

REVIEW LITERATURE

The literature reviewed encompasses diverse applications of Data Envelopment Analysis (DEA) across various sectors, shedding light on efficiency assessments and operational dynamics.(Karbhari et al., 2004) focus on Islamic banking in the UK, highlighting challenges such as regulatory hurdles and competition from conventional banks.(Benyoussef & Hemrit, 2019) examine the efficiency of insurance companies in Saudi Arabia, revealing discrepancies between Takaful and cooperative insurers and advocating for better resource allocation. (Aparajita.s@icicilombard.com, 2020) delve into risk management components in the general insurance sector, emphasizing the significance of structured risk assessments for efficient operations. (Chakraborty, 2018) evaluates the efficiency and productivity of public sector general insurance firms in India post-deregulation, indicating variations in technical and scale efficiency among companies. (Garg & Garg, 2020)assess the efficiency of Indian general insurance companies, attributing inefficiencies primarily to scale inefficiency and advocating for strategic adjustments in resource allocation. (Afzal, 2014)explores national innovation systems' efficiency using DEA, providing insights into innovation performance and suggesting policy implications for enhancing efficiency. Lastly, (Ozcan & McCue, 1996)propose a financial performance index for hospitals using DEA, facilitating comprehensive assessments of hospital financial health. These studies collectively underscore the utility of DEA in evaluating efficiency and operational

performance across diverse industries, offering valuable insights for strategic decision-making and resource optimization.

The articles discuss various aspects of efficiency, productivity, and performance evaluation in healthcare and insurance sectors across different countries. (Sinha, 2015) In Brazilian private health companies, management practices crucial for financial sustainability were identified using data envelopment analysis (DEA), (Grmanova & Strunz, 2017) highlighting the significance of professional financial management and effective claims control. Similarly, (McDonald, 2009) the Indian non-life insurance sector's efficiency and productivity were analyzed using a two-stage DEA bootstrap approach, revealing moderate efficiency levels with opportunities for improvement. In Saudi Arabia, the performance of Takaful and conventional insurance companies was assessed, indicating a need for larger firms to enhance efficiency through market consolidation and product specialization. (Ferrier et al., 2006)

Moreover, (Zhu, 2022) the articles explored productivity and quality changes in Catalan hospitals using DEA and Malmquist index, emphasizing improvements in technical quality over time. Efficiency in the healthcare systems of OECD countries was evaluated through DEA, uncovering inefficiencies in a majority of the countries and suggesting room for improvement. (Wu et al., 2021) Additionally, the impact of uncompensated care on hospital performance was investigated, demonstrating its adverse effects on hospital outputs despite potential efficiency gains.

Lastly, (Raj et al., 2023a) a hybrid DEA and game theory model were proposed for measuring the performance and productivity of healthcare centers, showcasing its applicability in assessing efficiency levels. Overall, these studies contribute to understanding the factors influencing efficiency and performance in healthcare and insurance sectors, providing insights for policymakers, regulators, and practitioners aiming to enhance organizational sustainability and effectiveness. Click or tap here to enter text.

The efficiency of healthcare systems and insurance companies is a critical aspect of their performance and sustainability. Several studies have addressed this issue across various countries and sectors (Muhammad et al., 2018). (Rahimpour et al., 2020) In the United States, a study on Local Health Departments (LHDs) revealed that while many operate with significant inefficiencies, factors such as centralization and urbanization contribute to lower efficiency levels (Lavado et al., 2010). However, LHDs that offer a wider range of services internally and rely more on internal funding tend to exhibit higher efficiency. Meanwhile, in Brazil, private health companies are exploring management practices

for financial sustainability.(Li et al., 2021) Through a two-step approach involving Data Envelopment Analysis (DEA) and qualitative analysis, practices such as professional financial management and effective claims control are identified as key drivers of sustainable performance.(Miszczyńska & Miszczyński, 2022)

(Abbasi & Kaviani, 2016)India's private hospital sector has also been subject to efficiency analysis, with factors like affiliation, specialization, and location influencing efficiency levels.(Cummins et al., 2010) In the Philippines, the efficiency of public health units is assessed using DEA, revealing inefficiencies in resource allocation and service delivery. (Oikonomou et al., 2016)Similarly, in Poland, an analysis of the healthcare sector's efficiency identifies factors such as accreditation certificates and medical personnel availability as significant determinants. Meanwhile,(Zavras et al., 2002) in China, the impact of healthcare reforms, specifically the New Rural Cooperative Medical System (NRCMS), on hospital efficiency is explored. (Wanke & Barros, 2016)Results suggest moderate efficiency levels, with the NRCMS reform positively influencing efficiency, particularly in non-coastal regions.

(Almulhim, 2019)Efficiency assessments in insurance sectors have also been conducted, with studies covering regions like Saudi Arabia, the BRIC countries, Indonesia, Germany, and the Gulf Cooperation Council (GCC) countries. (Chen et al., 2019)These analyses provide valuable insights into the determinants of efficiency and productivity, aiding policymakers and practitioners in improving the performance and sustainability of healthcare and insurance systems worldwide.

(Al-Amri et al., 2012)investigated the technical efficiency of insurance companies in GCC countries like Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and the United Arab Emirates using Data Envelopment Analysis (DEA). (Oikonomou et al., 2016)They aimed to identify factors influencing efficiency levels.(Zhang & Bartels, 1998)The study highlighted the importance of investment stage leadership for overall efficiency improvement, suggesting managerial implications for insurance companies in enhancing investment strategies.(Suvvari, 2019) explored efficiency and performance in India's life insurance industry, emphasizing the importance of DEA in assessing relative efficiency.(Zhang & Bartels, 1998) It reviewed 132 DEA application studies from 1993 to 2018, identifying gaps in methodologies and applications within the insurance industry. (Kaffash et al., 2020)investigated efficiency in China's property insurance sector, using DEA to identify determinants of technical efficiency and propose paths for improvement. The study emphasized the role of firm size, reinsurance rate, and claim ratio in affecting efficiency.(Brockett et al., 2007)

Objectives .

1. To study the scale efficiency of cement industries.
2. And to study the Factors which impacts the efficiency.

Hypothesis.

H0 = There is no significant difference in the technical efficiency and pure technical efficiency among cement industries

H1= There is a significant difference between technical efficiency and pure technical efficiency among cement industries

RESEARCH METHODOLOGY.

DATA SOURCE AND DATA COLLECTION: The research methodology involves utilizing secondary data sourced from the financial reports of cement industries for analysis.

TOOLS USED: This approach is chosen due to its accessibility and relevance to the study's objectives. Data Envelopment Analysis (DEA) serves as the primary analytical tool for assessing efficiency within the cement industry. Specifically, both Constant Returns to Scale (CRS) and Variable Returns to Scale (VRS) DEA models are employed to evaluate the efficiency of cement companies. These models enable a comprehensive assessment of performance, considering different scales of operation and production levels. The inputs considered in the analysis are Total Assets and Operating Expenses, while the outputs are Net Income and Total Revenue. These metrics are selected based on their significance in evaluating the financial performance and operational efficiency of cement companies. The application of DEA allows for the identification of efficient and inefficient units within the industry, providing valuable insights into factors influencing productivity and resource utilization. Additionally, specialized software for DEA analysis is utilized to facilitate robust and accurate data interpretation, ensuring the reliability of the findings.

Table -1

Input and output description

I/O	VARIABLES	DESCRIPTION
INPUT 1	Total asset	Current asset, fixed asset
INPUT2	Operating expenses	Cost of material, work in progress, stock, freight & other expenses
OUTPUT 1	Total revenue	Revenue from operation, other income
OUTPUT 2	Net income	Profit of the year after tax

ANALYSIS AND INTERPRETATION

Table -2 Showing CRS of 3 cement industries

DMUs/Cement industries	TE SE 2016-2017	TE SE 2017-18	2018-19	2019-20	2020-21	2021-22	2022-23	avg. TE (17-23)	RANK
Table 4: Technical Efficiency Scores Under CRS									
Ultra tech	1	0.939	0.920	0.951	1	1	1	0.972	2
Shree cement	1	0.967	0.936	0.939	1	0.972	0.893	0.958	3
Birla	0.991	0.931	0.945	1	1	0.971	1	0.977	1
AVG	0.997	0.945	0.933	0.963	0.963	0.981	0.964		
Number of Efficient DMUs	2	NIL	NIL	1	3	1	2		
Number of Inefficient DMUs	1	3	3	2	NIL	2	1		

DMUs/Cement industries	TE SE	TE SE 2017-18	2018-19	2019-20	2020-21	2021-22	2022-23	avg. TE	RANK
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UltraTech

ch demonstrates consistent improvement in efficiency in the 2016-2017 with the score of 1, the score came down to 0.94 in the year 2017-2018. It remained low in next two years. It eventually increased in the next three years from 2020-2021 till 2022-2023, achieving a perfect score of 1 in the last three years.

Shree Cement demonstrates fluctuating technical efficiency scores over the assessed years, ranging from 0.894 to 1. Despite a drop in efficiency in 2021-2022, it maintains a relatively high average efficiency of 0.958. This variability suggests potential changes in management practices or market conditions affecting operational effectiveness. Shree Cement ranks third among the assessed cement industries, indicating strong overall performance despite fluctuations. Further investigation into the factors behind efficiency fluctuations could inform strategies for maintaining consistency in performance.

Birla maintains relatively high efficiency scores throughout the period, except for a slight decrease in 2021-2022, indicating consistent efficiency overall. The average TE score for the period (2017-2023) reveals that Birla ranks highest with an average score of 0.977, followed by UltraTech with 0.973 and Shree Cement with 0.958. The number of efficient DMUs fluctuates across the years, with three efficient DMUs in 2019-2020 and 2020-2021, two in 2016-2017 and 2022-2023, and one in 2021-2022. Conversely, the number of inefficient DMUs varies, with three in 2017-2018 and 2018-2019, two in 2019-2020, and one in 2016-2017, 2020-2021, and 2022-2023. Overall, the analysis suggests that while all three cement industries generally operate efficiently under CRS, Birla demonstrates slightly higher and more consistent efficiency compared to UltraTech and Shree Cement.

	2016-17							(17-23)	
Table 4: Technical Efficiency Scores Under VRS									
Ultra tech	1	0.951	0.922	0.997	1	1	1	0.981	3
Shree cement	1	1	0.996	0.947	1	1	1	0.991	2
Birla	1	1	0.985	1	1	0.972	1	0.994	1
AVG	1	0.983	0.983	0.981	1	0.990	1		
Number of Efficient DMUs	3	2	NIL	1	3	2	3		
Number of Inefficient DMUs	NIL	1	3	2	NIL	1	NIL		

Table -3 Showing VRS of 3 cement industries

ULTRA TECH

2016-2017 Ultra Tech starts the assessment period with a technical efficiency score of 1, indicating a high level of efficiency in its operations. 2017-2018 There is a slight decrease in efficiency to 0.955, suggesting a minor decline in operational effectiveness compared to the previous year. 2018-2019 a slight decrease in efficiency to 0.922. 2019-2020. The efficiency remains consistently high, maintaining a score of 0.99, indicating optimal performance and operational effectiveness. 2020-2021 Ultra Tech continues to exhibit perfect efficiency with a score of 1, demonstrating a continued focus on operational excellence. 2021-2022 Efficiency remains unchanged at 1, indicating sustained excellence in operational management and practices. 2022-2023 There is no change in efficiency, with Ultra Tech maintaining a perfect score of 1, reflecting ongoing operational optimization and effective resource utilization. And ranked 3rd position.

SHREE CEMENT

2016-2017 Perfect score of 1, indicating optimal performance. 2017-2018: Maintained perfect efficiency 1.2018-2019: Slight decrease to 0.996, indicating a minor decline.2019-2020 Significant decline to 0.947, showing notable reduction. 2020-2021: Efficiency rebounds to 1, indicating improvement. From 2021 maintained consistently high efficiency 1 till 2023 and ranked 2nd position

BIRLA

2016-2017 Birla starts with a perfect efficiency score of 1, indicating optimal operational performance and resource utilization. 2017-2018 Maintained perfect efficiency, showing consistent excellence in operational management. 2018-2019 Efficiency slightly decreases to 0.986, indicating a minor decline in operational effectiveness compared to the previous year. 2019-2020 Efficiency returns to a perfect score of 1 till 2020-2021. In the year 2021-2022 Efficiency slight decrease to 0.973, indicating a minor decline in operational performance. In 2022-2023 there is a slight decrease in efficiency to 0.994, indicating a minor decline in operational effectiveness compared to the previous year, although overall efficiency remains high and ranked 1st position

TABLE 4 showing scale efficiency of 3 cement industries

DMUs/Cement industries	TE SE 2016-2017	TE SE 2017-18	2018-19	2019-20	2020-21	2021-22	2022-23	avg. TE (17-23)	RANK
Table 5: SCALE Efficiency Scores									
Ultra tech	1	0.987	0.997	0.953	1	1	1	0.991	1
Shree cement	1	0.967	0.939	0.991	1	0.972	0.893	0.966	3
Birla	0.991	0.931	0.959	1	1	0.998	1	0.982	2
AVG	0.997	0.961	0.965	0.981	1	0.990	0.964		

1: Ultra Tech:

2016-2017 Begins with a high efficiency score of 1, indicating effective utilization of resources. In 2017-2018: Efficiency slight decrease to 0.987, showing enhanced resource optimization. 2018-2019: Experiences a slight increase in efficiency to 0.997, suggesting a minor decline in resource management. 2019-2020 Efficiency slight decrease to 0.953. and in 2020-2021 Maintains perfect efficiency 1 till 2022-2023, demonstrating sustained excellence in resource management. and ranked in 1st position

2. Shree Cement:

2016-2017: Starts with a high efficiency score of 1, indicating optimal resource utilization. 2017-2018: Efficiency decreases slightly to 0.967, suggesting a minor decline in resource optimization. 2018-2019: Efficiency further decreases to 0.937, indicating a continued decline in resource management. 2019-2020: Efficiency improves to 0.991, showing a recovery in resource utilization. 2020-2021: Efficiency returns to a score of 1, indicating improved resource management. 2021-2022: Efficiency decreases slightly to 0.973, suggesting a minor decline in resource optimization. 2022-2023: Efficiency decreases further to 0.894, indicating a significant decline in resource management.

3. Birla:

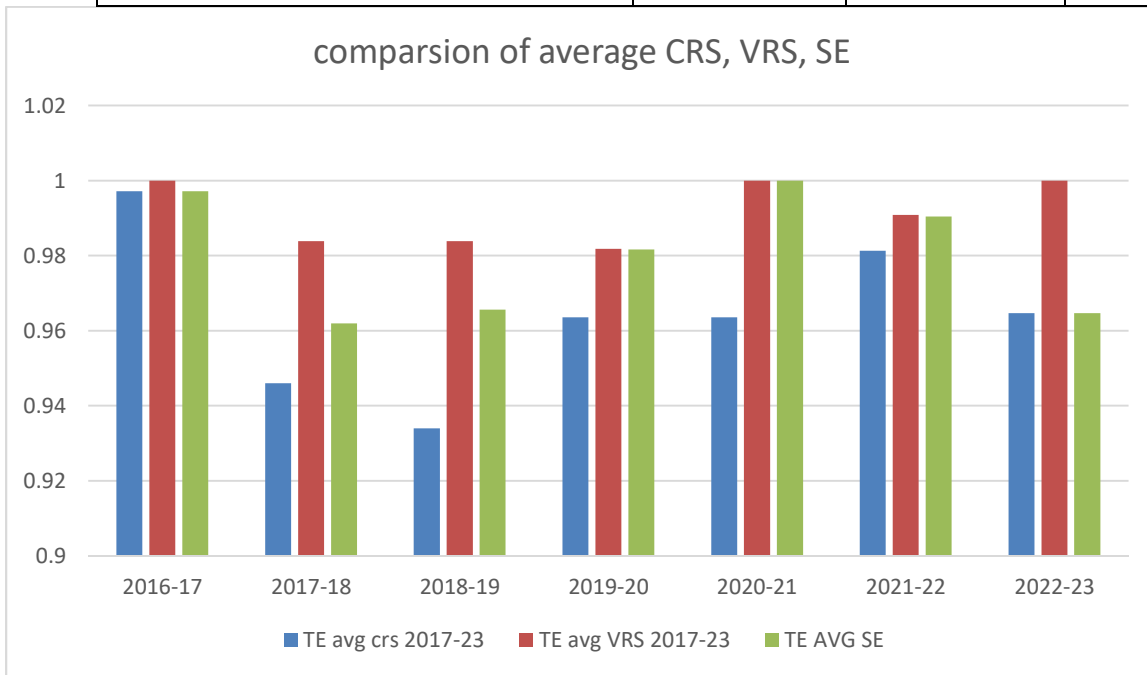
2016-2017: Starts with a high efficiency score of 0.991, indicating effective resource utilization. 2017-2018: Efficiency decreases slightly to 0.932, suggesting a minor decline in resource optimization. 2018-2019: Efficiency further decreases to 0.959, indicating a continued decline in resource management. 2019-2020: Efficiency improves to a perfect score of 1, showing a recovery in resource utilization. 2020-2021: Maintains perfect efficiency 1, demonstrating sustained excellence in resource management. 2021-2022: Efficiency decreases slightly to 0.998, suggesting a minor decline in resource optimization. 2022-2023: Maintains perfect efficiency, showing continued excellence in resource utilization.

Findings and Implications

Table -5 Average of CRS, VRS, SE of all 3 cement industries

DMUs/Cement industries	TE avg Crs	TE avg VRS	TE AVG
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	2017-23	2017-23	SE
2016-17	0.997	1	0.997
2017-18	0.945	0.983	0.961
2018-19	0.933	0.983	0.965
2019-20	0.963	0.981	0.981
2020-21	0.963	1	1
2021-22	0.981	0.990	0.990
2022-23	0.964	1	0.964



Chat-1: The above chat shows the comparison between:

TE avg CRS (2017-23):

The average technical efficiency (TE) under Constant Returns to Scale (CRS) from 2017 to 2023 shows fluctuations but generally indicates a stable performance over the years.

The TE ranges from a low of 0.933 in 2018-19 to a high of 0.981 in 2021-22, with variations reflecting changes in operational effectiveness and resource utilization across the cement industries

TE avg VRS (2017-23):

The average technical efficiency under Variable Returns to Scale (VRS) from 2017 to 2023 also exhibits fluctuations but generally indicates a stable or slightly improving trend over the years.

The TE ranges from a low of 0.981 in 2017-18 to a high of 1 in 2020-21 and 2022-23, with variations reflecting changes in the efficiency of resource utilization considering different scales of operation.

TE AVG SE (2016-17):

The average technical efficiency under Scale Efficiency (SE) for the initial year 2016-17 is consistently high at 0.9971138, indicating efficient utilization of resources across the cement industries during that period.

LIMITATIONS

The limitations of the analysis stem from several factors. Firstly, the exclusive reliance on technical efficiency scores derived from financial reports overlooks broader operational dynamics, such as market conditions and managerial strategies. Additionally, the absence of contextual information regarding external influences like regulatory changes or economic trends limits the depth of the analysis. Moreover, the data's quality and consistency, sourced from secondary reports, might introduce biases or inaccuracies. Furthermore, the simplistic analysis metrics and lack of comparative benchmarking against industry standards hinder a comprehensive assessment. The analysis also suffers from a narrow time frame, potentially overlooking long-term trends. Finally, potential endogeneity issues, wherein external factors affect efficiency scores, are not adequately addressed.

CONCLUSION

It can be concluded that the three cement industries—Ultra Tech, Shree Cement, and Birla—have exhibited varying levels of technical efficiency over the years. Ultra Tech consistently demonstrates high efficiency scores under both CRS and VRS, indicating optimal resource utilization and operational management. Shree Cement follows suit, albeit with some fluctuations, maintaining competitive efficiency levels throughout the period. Birla, while generally efficient, experiences more variability in its efficiency scores, suggesting potential areas for improvement in operational practices. Despite these

differences, all three companies contribute significantly to the cement industry's overall efficiency landscape. Ultra Tech and Shree Cement particularly stand out for their consistent performance, while Birla shows room for enhancement in maintaining stable efficiency levels. This analysis highlights the importance of continuous monitoring and improvement efforts to ensure sustained efficiency and competitiveness in the cement industry.

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