A Study on Comparative Analysis of Cement Industries by Using Malmquist Method

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ARTICLE DETAILS	ABSTRACT
Research Paper	This study employs the Malmquist Productivity Index (MPI) method to analyse the productivity changes in three leading cement companies—Ultratech Cement, Shree Cement, and Birla Cement—across the years 2017 to 2023. The MPI method is utilized to assess the relative productivity changes over time by considering technological progress and efficiency changes. By applying MPI, this study aims to identify and understand the factors driving productivity shifts within the cement industry, highlighting areas of improvement and stagnation. Through a comprehensive examination of financial and operational data spanning multiple years, this analysis seeks to unveil the dynamics of productivity growth among the selected companies. Total assets and operating expenses are considered as inputs, reflecting the companies' investment levels and operational costs, while total revenue and net income are used as outputs, indicating market competitiveness and operational performance. The MPI method enables the comparison of productivity changes over time, allowing for insights into relative performance improvements or declines within the industry. Insights derived from this analysis can inform strategic decision-making, resource allocation, and operational enhancements for the companies
Keywords : *Data Envelopment Analysis, Malmquist, Technical Efficiency, Scale Efficiency, Pure technical efficiency, Cement Industries*	

under study. Ultimately, this study contributes to a deeper understanding of the productivity dynamics within the cement sector, offering valuable insights for industry stakeholders, investors, and policymakers.

INTRODUCTION

The cement industry stands as a cornerstone of infrastructure development, pivotal in driving economic growth and societal progress. Within this sector, companies strive for operational excellence and efficiency to maintain competitiveness and meet evolving market demands. Understanding the dynamics of productivity changes over time is crucial for companies, investors, and policymakers alike, as it provides insights into the industry's overall health and potential areas for improvement(Wei et al., 2018). This research aims to conduct a comprehensive productivity analysis of three prominent cement companies—UltraTech Cement, Shree Cement, and Birla Cement—over the period from 2017 to 2023. The study employs the Malmquist Productivity Index (MPI) method, a widely recognized approach for assessing productivity changes over time. The selected inputs for the analysis are total assets and operating expenses, representing the companies' investment levels and operational costs, respectively. These inputs are juxtaposed against two crucial outputs: total revenue and net income. Total revenue signifies market competitiveness and sales performance, while net income reflects operational capacity and market demand fulfilment (Sohail et al., 2016). The outcomes of this study are expected to contribute significantly to the understanding of productivity trends within the cement sector, offering actionable insights for industry stakeholders, investors, and policymakers (Hu et al., n.d.). By identifying areas of improvement and best practices, this research aims to inform strategic decision-making, resource allocation, and operational enhancements for the companies under study, ultimately fostering sustainable growth and competitiveness within the cement industry.

REVIEW LITERATURE

Several studies have investigated productivity dynamics across different industries and regions using various methodologies . (Dergisi & 2021, n.d.) focused on the renewable resources industry in Hubei Province, China, employing the DEA-Malmquist index model to assess efficiency over a specific time period. Sohail and Anjum explored the efficiency and productivity growth of Initial Public Offerings (IPOs) listed on the Karachi Stock Exchange, Pakistan, using DEA and the Malmquist Productivity

Index (MPI)(Fei et al., 2023). Delved into the efficiency of green development in Chinese oil and gas cities, utilizing the super-efficient SBM-DEA model and Malmquist index. Hajihassaniasl measured Total Factor Productivity (TFP) in Iranian economic sectors, employing the Malmquist index analysis. Wang et al. analyzed the total factor CO_2 emission performance of Liaoning province's heavy industry sector in China. (Wang et al., n.d.) investigated energy efficiency and technical change in the US metal-based durable manufacturing sector using stochastic frontier analysis. (Zhenshan et al., n.d.) studied the total factor productivity (TFP) of the bioenergy industry in the European Union, focusing on productivity growth and its determinants using the Malmquist productivity index of DEA. (Boyd et al., n.d.)These studies collectively contribute to understanding productivity trends and efficiency dynamics across various sectors, providing valuable insights for policymakers and industry stakeholders.

The literature review encompasses several studies spanning diverse industries and regions, employing various methodologies to assess efficiency, productivity, and environmental impact. (Wang et al., 2020)One study focuses on the efficiency of Waqf funds management in two Malaysian states, using Data Envelopment Analysis (DEA) to measure technical efficiency scores over a consecutive period. Another explores the probiotic characteristics and aflatoxin binding abilities of lactic acid bacteria (LAB) isolated from traditional fermented foods, emphasizing their potential in food safety(Alsaleh et al., 2020). In the realm of industrial green development, research evaluates the efficiency of oil and gas cities in China, employing the Super-SBM model and Malmquist index to analyze temporal and spatial trends. Additionally, productivity measurement in the construction industry incorporates carbon reduction considerations, highlighting the need for sustainable development strategies (Hasan et al., n.d.). Studies also examine environmental efficiency in sectors like cement production, identifying factors influencing efficiency and proposing restructuring and policy recommendations. Further research explores total factor productivity (TFP) growth in manufacturing industries, employing Malmquist productivity index methods to analyse technical efficiency and technological change. Additionally, studies delve into the environmental efficiency of renewable energy sources and road transportation, employing Malmquist Index and Global Malmquist-Luenberger Index approaches, respectively(Nouban & Abazid, 2017a). Another study introduces a novel approach combining DEA and machine learning algorithms to assess eco-efficiency in the cement industry, addressing CO_2 emissions and energy balance concerns (Finance & 2015, 2015). These studies collectively contribute to understanding efficiency dynamics, productivity growth, and environmental impact across various sectors, informing

policymakers and stakeholders about sustainable development strategies (Fei, Chongliang, Jie, Yana, et al., 2023).

The review of literature provides a comprehensive overview of studies conducted in various countries and industries using different methodologies to assess productivity and efficiency (Kang et al., n.d.). Several articles focus on specific industries such as cement, pharmaceuticals, and manufacturing, employing methods like Data Envelopment Analysis (DEA) and Malmquist Productivity Index (MPI) to evaluate technical efficiency and productivity growth. For instance, studies in Pakistan and India analyze the technical efficiency of the cement industry using panel data and stochastic frontier analysis, highlighting the importance of factors like GDP growth and exchange rates (Şahin et al., n.d.). Similarly, research in Iran assesses productivity in pharmaceutical companies, while studies in China examine the eco-efficiency of industrial sectors and the impact of green technology innovation on emerging industries. Moreover, investigations in Turkey explore the environmental efficiency of the cement industry, emphasizing the role of CO_2 emissions as an undesirable output (Zhang et al., 2016). Other studies extend beyond specific industries, examining productivity transition and resource flow sustainability in countries like Vietnam over several decades. Overall, these studies contribute valuable insights into productivity dynamics, efficiency improvements, and sustainability concerns across different sectors and regions (Woo et al., n.d.).

The reviewed literature covers a wide range of topics related to efficiency, productivity, and performance analysis across various industries and regions. Several studies employ methodologies like Data Envelopment Analysis (DEA) and Malmquist productivity index to assess the relative efficiency and productivity changes within industries over time (Makridou et al., n.d.). For instance, research on the United Arab Emirates' listed companies explores the impact of the financial crisis on efficiency, while another study focuses on the energy and GHG emission efficiency in the Chilean manufacturing industry. Additionally, there are studies evaluating the technical efficiency, technological progress, and productivity growth in sectors such as Ethiopian manufacturing, Pakistani cement, and Indian cement firms (Mirmozaffari et al., 2021). These analyses often delve into factors influencing efficiency, such as ownership structure, industry deregulation, privatisation, and regional differences(P. Jiang et al., n.d.). Moreover, some studies extend their scope to assess the effects of cross-border acquisitions on the efficiency and productivity of acquired companies, as well as the development efficiency of China's innovative industrial clusters(Han et al., n.d.). Overall, the literature provides valuable insights into the

dynamics of efficiency and productivity across different industries and geographical regions, offering implications for policymakers, industry stakeholders, and researchers alike.

The review of literature on productivity analysis in the cement industry spans various methodologies and contexts (Tanaka et al., n.d.). Studies have explored the impact of cross-border acquisitions on efficiency and productivity, particularly in transitional and emerging economies like Serbia and India. Utilizing techniques such as Data Envelopment Analysis (DEA) and Malmquist Productivity Index, researchers have assessed both partial and total factor efficiency and productivity, considering inputs like material, labor, and capital (Economy & 2023, n.d.). These analyses have yielded insights into the effects of acquisitions on industry performance over time, revealing nuanced patterns such as increased efficiency in certain input factors post-acquisition. Additionally, research has extended to specific national contexts, such as Pakistan, where non-parametric approaches like DEA have been employed to unravel productivity trends in major cement manufacturing industries (P. P. Jiang et al., 2023). Moreover, studies have delved into the comparison analysis of total factor productivity and eco-efficiency in China's cement manufactures, highlighting the importance of considering environmental factors alongside productivity metrics. Further investigations have explored efficiency in the Indian cement industry using econometric analysis, providing valuable insights for industry stakeholders and policymakers (Han et al., 2015). Additionally, the literature extends beyond the cement industry, encompassing productivity analysis in other sectors like insurance, where methodologies like the Malmquist index have been utilized to assess total factor productivity growth and the impact of regulatory frameworks on industry efficiency and competitiveness (Dirik et al., 2019). These studies collectively contribute to a deeper understanding of productivity dynamics, offering valuable implications for industry practitioners and policymakers alike.

Objective

1. To analyse the efficiency changes
2. To study productivity changes in the cement industries.

Hypothesis

H1: There is significance difference between the efficiency and productivity changes among the cement industries throughout the years.

Research Methodology

The research methodology for this study involves the application of Data Envelopment Analysis (DEA), specifically focusing on the Malmquist Productivity Index (MPI) method,(Mahapatra et al., n.d.) to analyse the efficiency and productivity changes within the cement industry, with a specific focus on Ultratech Cement, Shree Cement, and Birla Cement. DEA is utilized as the primary research tool, with the MPI method serving as a subcomponent for assessing productivity changes over the period from 2017 to 2023. The study collects comprehensive financial and operational data for the selected cement companies, including total assets and operating expenses as inputs, reflecting investment levels and operational costs, respectively. Additionally, total revenue and net income are considered as outputs, indicative of market competitiveness and operational performance.

Table -1: Input and output description

Input/Output	Variables	Description
INPUT 1	Total asset	Current asset, fixed asset
INPUT 2	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

By applying DEA, the study evaluates the relative efficiency of each company within the industry, identifying areas of inefficiency and potential improvement opportunities. The MPI method within DEA enables the assessment of productivity changes over time by comparing the relative efficiency scores across different time periods. This analysis aims to uncover factors driving productivity shifts within the cement industry, offering insights into areas of improvement and stagnation.

Components of DEA

EFFCH: Efficiency factor changes

TECHC: Technical Efficiency change

PECH: Pure efficiency change

SECH: Scale efficiency change

TFPCH: Total factor productivity change

Analysis and Interpretation

In this research the productivity change of three prominent cement industries: Ultra tech, Shree cement and Birla cement for the period of 7 years.

**Table-2: Showing the productivity change of cement industries.**

Year	Ultra	Shree	Birla
2018	2.326	1.356	1.845
2019	1.278	0.746	1.028
2020	0.798	1.887	0.693
2021	12.625	8.882	0.737
2022	0.091	0.102	1.735
2023	1.241	3.914	2.144

**Chart -1: Showing the productivity change of cement industries in the 2018**
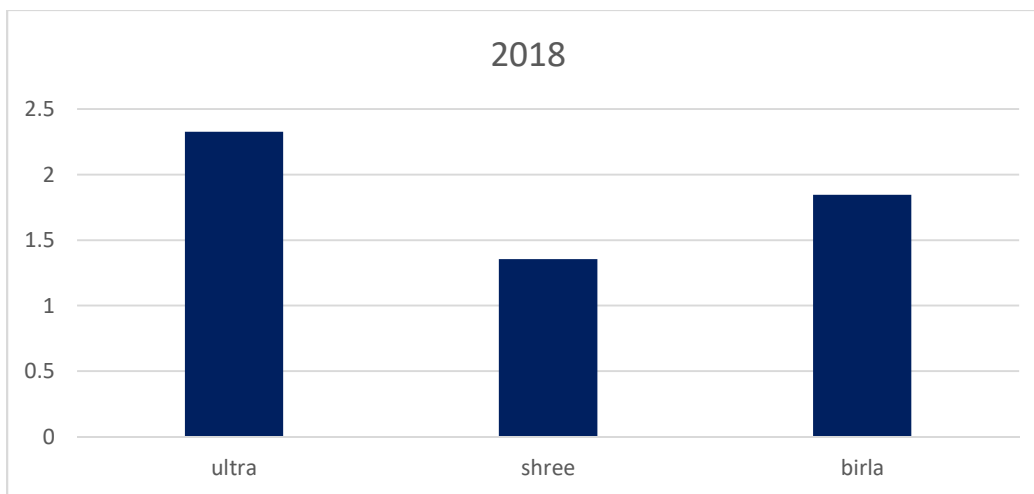
In 2018, Ultratech Cement led the pack with an impressive productivity change score of 2.326, signaling substantial strides in enhancing its operational efficiency. Shree Cement trailed closely behind with a respectable score of 1.356, indicating notable progress but at a slightly lower level compared to Ultratech. Birla Cement also demonstrated significant improvement, achieving a score of 1.845 during the same period. These results highlight Ultratech Cement's dominance in driving productivity growth within the cement industry, with Birla Cement also showcasing commendable advancements. Shree Cement, while performing well, lagged slightly behind its peers in terms of productivity enhancement. Overall, the findings underscore the dynamic nature of productivity changes among the leading cement companies in 2018, shedding light on the diverse strategies and performance levels within the sector.

Chart -2: Showing the productivity change of cement industries in the 2019
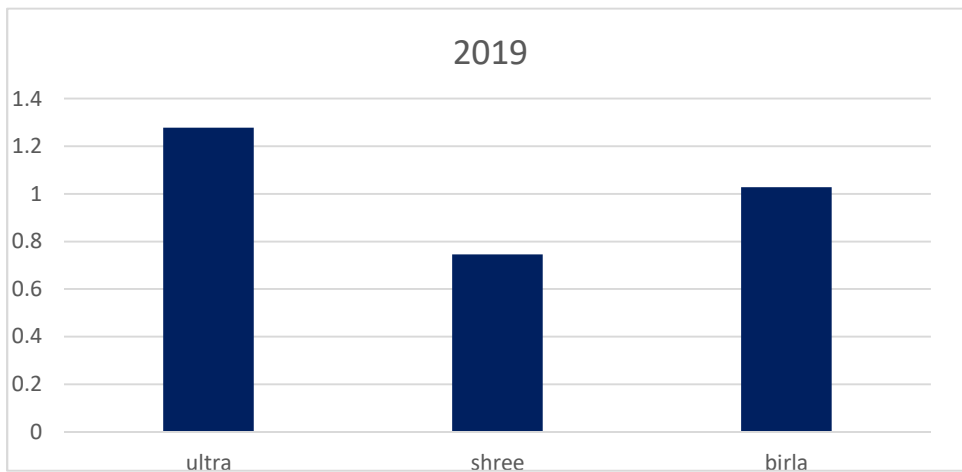

In 2019, Ultratech Cement displayed the highest productivity change score of 1.278, reflecting significant advancements in its operations. Shree Cement followed closely behind with a score of 0.746, indicating moderate progress in productivity. Birla Cement also demonstrated notable improvement, achieving a score of 1.028 during the same period. The results suggest that Ultratech Cement excelled in enhancing productivity compared to its counterparts, with Birla Cement also showing considerable growth. Shree Cement's performance, while positive, was relatively more moderate. These findings highlight the diverse trajectories of productivity growth among the three leading cement companies in 2019, underscoring the sector's dynamic nature and the varying strategies adopted by individual firms.

**Chart -3: Showing the productivity change of cement industries in the 2020**
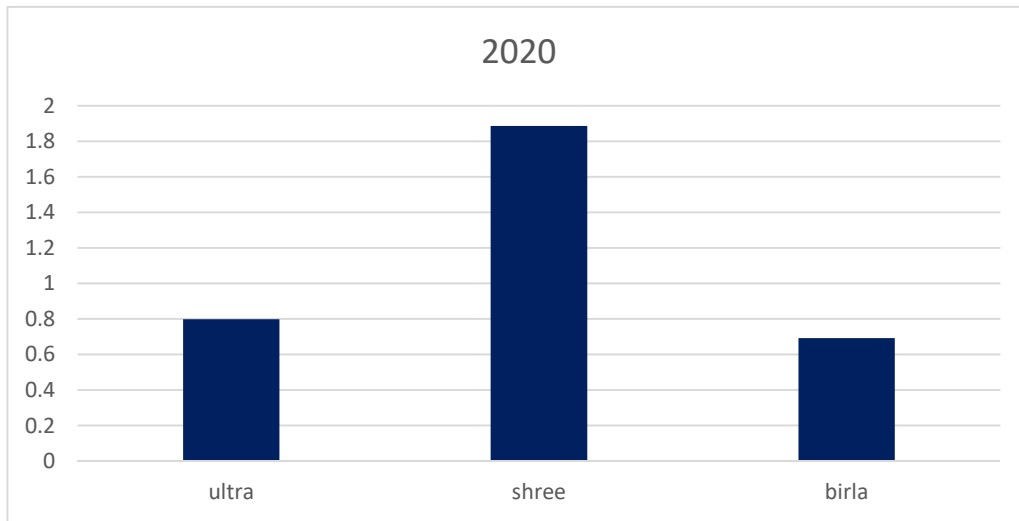
In 2020, Shree Cement demonstrated remarkable productivity improvement with a score of 1.887, indicating significant operational efficiency enhancements. Conversely, Ultratech Cement showed moderate progress, achieving a score of 0.798, suggesting comparatively less pronounced productivity gains. Birla Cement, however, experienced a slight decline in productivity, reflected in its score of 0.693, possibly due to operational challenges or market conditions. Shree Cement's exceptional performance underscores its leadership in optimizing operations and driving productivity growth within the cement industry. Ultratech Cement's progress, though positive, fell short of Shree Cement's achievements, while Birla Cement faced challenges hindering its productivity. These findings highlight the dynamic landscape of productivity within the cement sector and emphasize the importance of operational efficiency for industry players.

Chart -4: Showing the productivity change of cement industries in the 2021
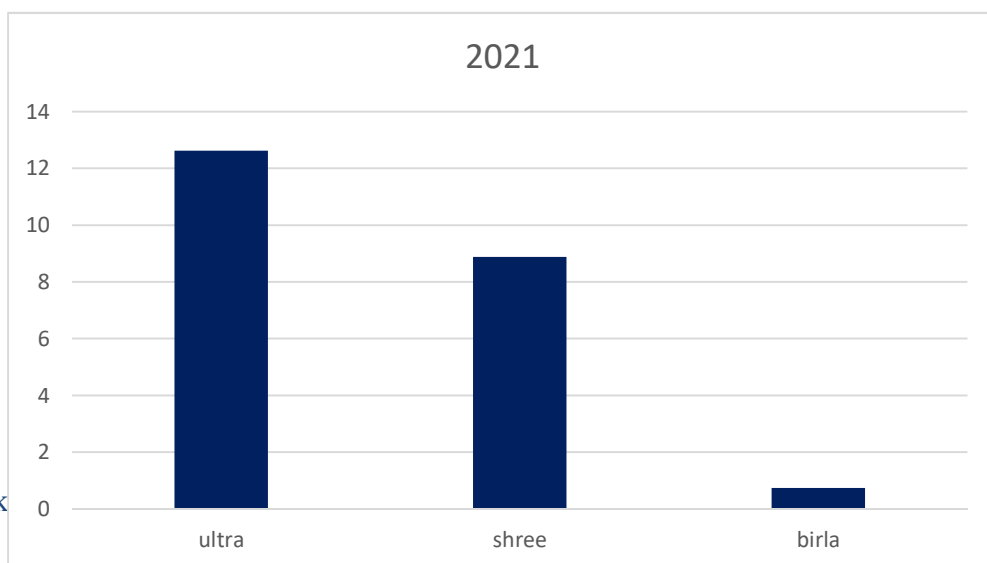
In the year 2021, Ultratech Cement surged ahead with a remarkable productivity change score of 12.625, showcasing unparalleled progress and efficiency within the cement industry. Shree Cement followed closely behind with a substantial score of 8.882, indicating significant improvement but trailing Ultratech's exceptional performance. However, Birla Cement lagged behind its counterparts with a modest score of 0.737, highlighting a relatively lower level of productivity enhancement compared to Ultratech and Shree. Ultratech Cement's dominant performance underscores its strategic prowess and operational excellence, positioning it as a frontrunner in driving productivity growth. Shree Cement's commendable progress reflects its commitment to efficiency and innovation, although falling short of Ultratech's extraordinary achievement. Meanwhile, Birla Cement's comparatively lower score suggests the need for further improvements to compete effectively within the industry landscape. Overall, the productivity changes in 2021 underscore the diverse performance dynamics and competitive landscape within the cement sector.

Chart -5: Showing the productivity change of cement industries in the 2022
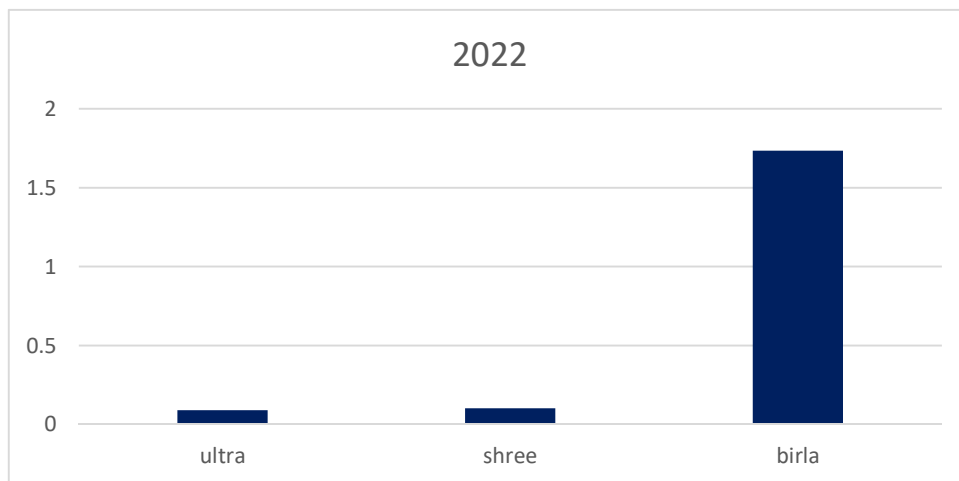
In 2022, Birla Cement exhibited the highest productivity change score of 1.735, marking a notable improvement in its operational efficiency within the cement industry. This substantial score positions Birla Cement as a frontrunner in driving productivity growth, reflecting strategic initiatives and operational enhancements implemented by the company. Shree Cement followed with a modest score of

0.102, indicating a relatively lower level of progress compared to Birla Cement. Meanwhile, Ultratech Cement lagged behind its counterparts with a minimal score of 0.091, suggesting challenges or stagnation in its productivity improvement efforts during the year. Birla Cement's impressive performance underscores its commitment to operational excellence and innovation, positioning it as a key player in the competitive landscape. Shree Cement's moderate progress highlights ongoing efforts to enhance productivity, albeit at a slower pace than Birla Cement. Conversely, Ultratech Cement's lower score signals the need for strategic adjustments or investments to bolster productivity in alignment with industry standards. Overall, the productivity changes in 2022 reflect the varying performance dynamics and competitive positioning among the major cement companies.

Chart -6: Showing the productivity change of cement industries in the 2023
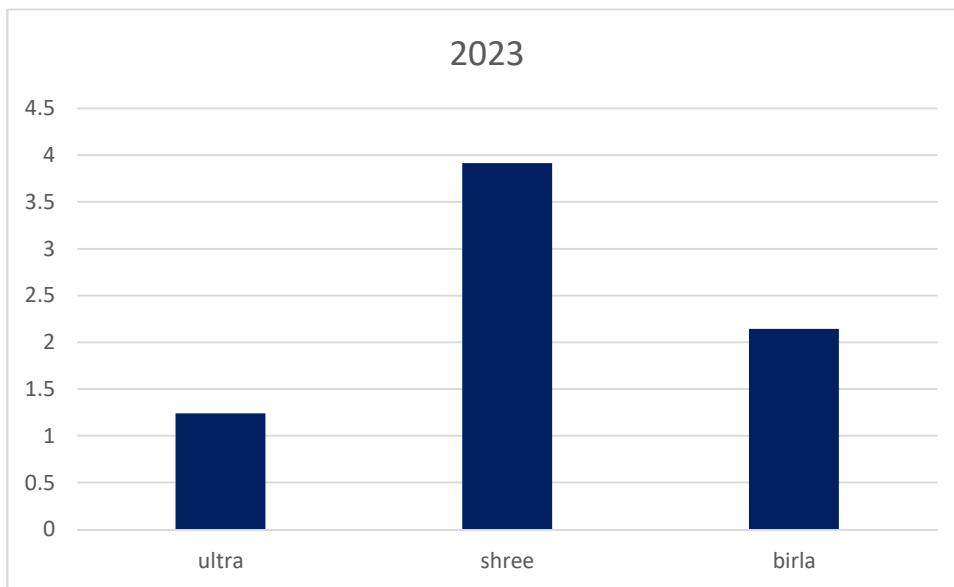
In 2023, Shree Cement emerged as the leader in productivity change with a significant score of 3.914, showcasing remarkable progress in enhancing operational efficiency within the cement industry. This substantial score positions Shree Cement as a frontrunner in driving productivity growth, reflecting strategic initiatives and operational enhancements implemented by the company. Birla Cement followed with a commendable score of 2.144, indicating substantial improvement in its productivity metrics compared to the previous year. Meanwhile, Ultratech Cement lagged behind its counterparts with a score of 1.241, suggesting challenges or slower progress in its productivity improvement efforts during the year. Shree Cement's impressive performance underscores its commitment to operational excellence and innovation, solidifying its position as a key player in the competitive landscape. Birla Cement's

substantial improvement highlights ongoing efforts to enhance productivity, positioning it as a strong competitor in the industry. Conversely, Ultratech Cement's lower score signals the need for strategic adjustments or investments to bolster productivity and remain competitive. Overall, the productivity changes in 2023 reflect the evolving dynamics and competitive positioning among the major cement companies

Table – 3: Showing the productivity changes of cement industries from 2018-2023

Year	year	effch	techch	pech	sech	tfpch
2018	2	1.073	1.676	1	1.073	1.799
2019	3	1.191	0.834	1	1.191	0.993
2020	4	0.603	1.682	1	0.603	1.015
2021	5	0.542	8.03	1	0.542	4.356
2022	6	2.119	0.119	1	2.119	0.252
2023	7	0.731	2.987	1	0.731	2.183

Chart -7:

**Showing the productivity change of cement industries from 2018-2023**
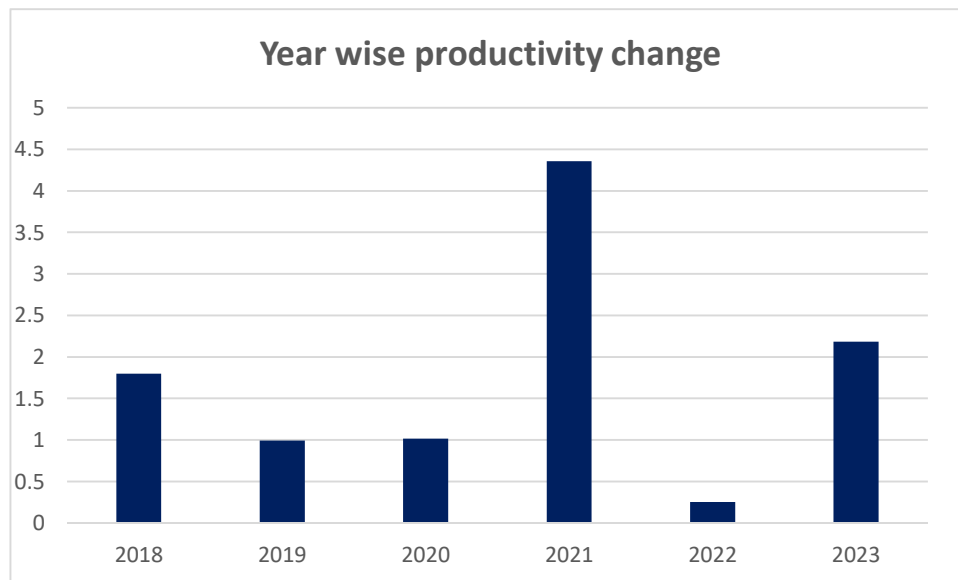
The overall productivity change from 2018 to 2023 reveals varying trends across the years. In 2021, the highest productivity change was observed, with a substantial score of 4.356, indicating significant improvement across the industry. Following closely, the year 2023 recorded the second-highest productivity change score of 2.183, reflecting continued progress and enhancement in operational efficiency. In 2018, productivity change scored 1.799, ranking third among the years analyzed, showcasing notable improvement. The year 2020 secured the fourth position with a score of 1.015, demonstrating moderate growth compared to other years. Meanwhile, 2019 recorded the fifth position with a score of 0.993, indicating a comparatively lower level of productivity change. Finally, in 2022, productivity change scored 0.252, ranking sixth among the analysed years, suggesting relatively limited progress or challenges in enhancing productivity during that period.

Table -4: Showing the productivity change of overall cement industries.

Cement company	effch	techch	pech	sech	tfpch
Ultra tech	0.904	1.355	1	0.904	1.225
Shree cement	1	1.374	1	1	1.374
Birla cement	0.89	1.391	1	0.89	1.238

Chart -8: Showing the productivity change of overall cement industries.
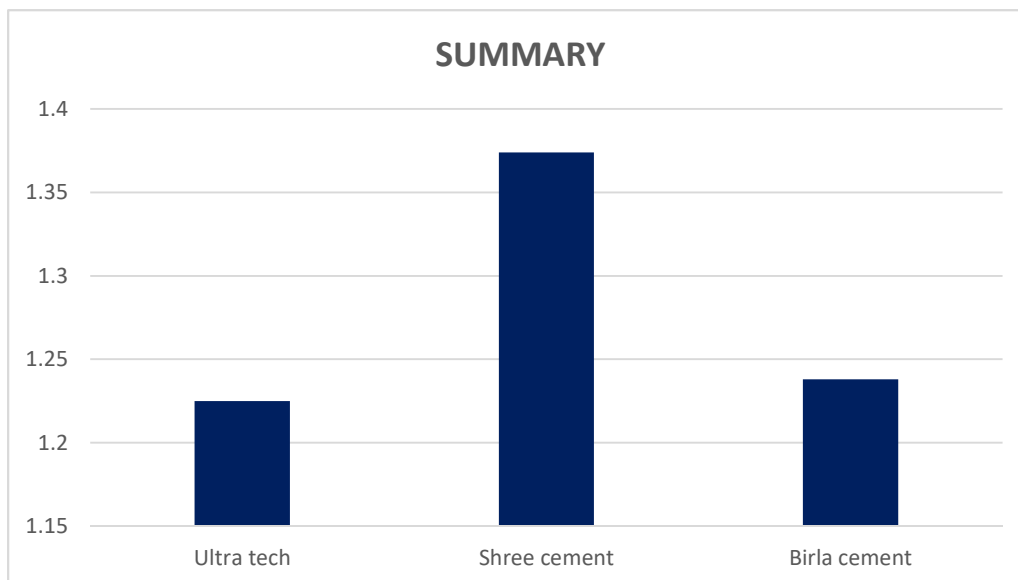
The chart presents an overview of the overall productivity change in three cement companies from 2017 to 2023. Shree Cement emerges as the leader in productivity improvement, boasting the highest score of 1.374, indicating significant enhancement in operational efficiency over the analyzed period. Following closely, Birla Cement secures the second position with a score of 1.238, demonstrating substantial progress in productivity metrics. Ultratech Cement, although slightly behind, still performs admirably with a score of 1.225, showcasing notable improvement in operational efficiency across the years. Overall, the analysis highlights the positive trajectory of productivity growth within the cement industry, with each company making commendable strides in enhancing their operational performance and efficiency over the specified timeframe.

There is significance difference between the efficiency and productivity changes among cement industries. Hence H1 is proved.

Limitation

While the analysis provides valuable insights, limitations exist. These include reliance on limited data availability and quality, potential bias from focusing on only three companies, and overlooking broader industry dynamics. The study's narrow scope may oversimplify productivity factors, and the short timeframe might miss long-term trends. Additionally, the Malmquist Productivity Index's sensitivity to outliers and assumptions about production technology pose constraints. Addressing these limitations would improve the study's robustness and applicability to the cement industry.

Conclusion

Based on the data presented, it is evident that Shree Cement consistently demonstrates the highest productivity change scores across the years 2017-2023, followed closely by Birla Cement and Ultra Tech Cement. This indicates that Shree Cement has been relatively more successful in enhancing its productivity compared to its counterparts in the cement industry. However, all three companies show varying degrees of improvement over the years, reflecting dynamic shifts within the industry. The analysis underscores the importance of continuous efforts to enhance productivity and efficiency to remain competitive in the market. Moving forward, strategic investments in technology, operational processes, and workforce development could further bolster productivity levels for these companies. Additionally, broader industry trends and external factors should be considered to inform future

decision-making and ensure sustainable growth. Overall, the findings provide valuable insights for industry stakeholders, guiding strategic initiatives aimed at optimizing productivity and maintaining competitiveness in the cement sector.

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