Educational Administration: Theory and Practice
2024, 30(7), 1489-1499
ISSN: 2148-2403
https://kuey.net/

Research Article

A Comparative DEA-MPI Study of Financial Efficiency and Productivity in India's Cement and Steel Industries

Urwashi Soni[1*], Dr. Biswajit Satpathy[2]

[1*]Research Scholar, Department of Business Administration, Sambalpur University
[2]Professor, Department of Business Administration, Sambalpur University

Citation: Urwashi Soni et al. (2024). A Comparative DEA-MPI Study of Financial Efficiency and Productivity in India's Cement and Steel Industries, *Educational Administration: Theory and Practice*, 30(7) 1489-1499
Doi: 10.53555/kuey.v30i7.11005

ARTICLE INFO

ABSTRACT

This paper examines and compares the financial performance efficiency of the two major industries in India i.e.; cement and steel industries using Data Envelopment Analysis (DEA) and the Malmquist Productivity Index (MPI). A panel dataset of 30 companies, comprising 15 firms from each sector over a ten-year period, was analysed to assess the efficient use of resources and productivity trends. Total assets, total equity, and operating expenses were taken as inputs, while return on assets (ROA) and net profit margin (NPM) were considered as outputs. An output-oriented DEA model under variable returns to scale (VRS) was applied to measure efficiency of the industry, and MPI was used to evaluate changes in productivity and technological progress over time. The findings indicate that both sectors operate at relatively high efficiency levels, but the steel industry demonstrates higher resource utilization and slightly stronger productivity gains, whereas the cement sector shows greater consistency but relatively smaller improvements. Malmquist index results show positive total factor productivity (TFP) growth in both sectors, with steel demonstrating slightly higher technological change, suggesting greater adaptability and innovation. The findings provide valuable insights for managers and investors on resource allocation and cost control and offer policymakers guidance on strengthening competitiveness in these capital-intensive sectors. The study also demonstrates the applicability of DEA and MPI as effective tools for multi-dimensional financial performance evaluation.

Keywords: Data Envelopment Analysis, DEA, Malmquist Productivity Index, Financial Performance, Cement Industry, Steel Industry, India

Executive Summary

This paper compares India's cement and steel industries. It studies their financial efficiency from 2015 to 2024. The study uses Data Envelopment Analysis (DEA) and the Malmquist Productivity Index (MPI). Both industries are very efficient. But the steel industry is slightly better. It uses resources more effectively and has bigger productivity gains. The cement industry is more consistent but with smaller improvements. The paper also looked at individual companies. In the cement industry, Prism Johnson, JK Laxmi Cement, and Star Cement had the highest productivity growth. For steel, the top companies were Prakash Industries, Bansal Wire, and Welspun Speciality. These steel companies showed stronger growth due to new technology. The main reason for productivity growth in both sectors is technological change. Technology is more important than small efficiency gains. This shows that investing in new technology is the key for growth. Managers can use these findings to make better choices about resources. Policymakers can use them to make these industries more competitive.

Introduction

Financial performance evaluation is central to understanding how effectively firms manage their resources to achieve profitability and long-term sustainability. It reflects a company's ability to balance investments, control costs, and generate returns for shareholders and other stakeholders. In capital-intensive industries, where large-scale investments in assets, equity, and operating expenditure are essential, efficiency becomes even more critical. Firms must not only maintain operational stability but also ensure that their financial resources are deployed optimally to withstand competition, economic fluctuations, and policy changes. A strong financial

performance is often linked to better investor confidence, access to capital, and resilience in the face of market shocks.

The cement and steel industries are particularly significant in India's industrial landscape, forming the backbone of infrastructure development and economic growth. The cement sector supports construction, real estate, and infrastructure, while the steel sector underpins manufacturing, transportation, engineering, and allied industries. Despite their importance, the two industries differ in structure, scale, and market conditions. Cement production is often influenced by regional demand, energy costs, and environmental regulations, while the steel sector faces challenges such as global price volatility, raw material supply, and the need for technological upgrades. Both sectors are resource-intensive and require continuous investment in assets and technology to maintain competitiveness. Despite their common role as foundational industries, they differ considerably in cost structures, capital intensity, and market dynamics, making a comparative analysis of their financial efficiency both relevant and valuable. Evaluating their financial performance provides valuable insights into their ability to manage resources efficiently and sustain profitability in dynamic market environments.

Traditional financial analysis tools, such as ratio analysis, offer useful insights but often fall short when multiple inputs and outputs must be considered simultaneously. Data Envelopment Analysis (DEA), a non-parametric technique introduced by Charnes, Cooper, and Rhodes, overcomes this limitation by benchmarking firms against the best performers in the dataset. DEA allows efficiency to be measured relative to a frontier, providing a score that indicates how well each firm converts its resources into outputs compared to peers. In this study, DEA is applied under a variable return to scale (VRS) framework to account for differences in firm size and operational scale. Total assets, total equity, and operating expenses are used as inputs, reflecting the financial resources deployed, while return on assets (ROA) and net profit margin (NPM) are used as outputs, capturing profitability and performance. While DEA captures efficiency at a point in time, industries are dynamic and subject to change. To understand how productivity evolves, the Malmquist Productivity Index (MPI) is used alongside DEA. The MPI decomposes productivity changes into efficiency gains, technological shifts, pure technical efficiency, and scale efficiency. This combined approach offers a richer view of performance, highlighting not only which firms are efficient but also how they improve or decline over time. Applying these techniques to the cement and steel sectors helps identify best practices, areas for improvement, and the impact of technology and scale on financial outcomes. The primary objective of the study is to evaluate and compare the financial performance efficiency of the cement and steel industries in India. The secondary objectives are:

1. To examine and compare year-wise variation in efficiency across both sectors
2. To analyse and compare firm-level efficiency across both sectors
3. To measure productivity change over the study period using the Malmquist Index and analyse the drivers of these changes.

By addressing these objectives, the paper contributes to the literature on financial performance evaluation in resource-intensive industries and offers evidence-based insights for improving efficiency and competitiveness in two key sectors of the Indian economy.

Literature Review

Over the past two decades, studies on efficiency and financial performance have increasingly relied on tools such as the Data Envelopment Analysis (DEA) and the Malmquist Productivity Index (MPI)**.** These methods allow researchers to go beyond simple financial ratios by capturing the relationship between multiple inputs and outputs, offering a more holistic view of how firms and industries perform.

In the Indian context, (Mahalakshmi & Kumar, 2024) examined the productivity trends of leading cement firms using the Malmquist Productivity Index. Their findings showed how shifts in technology and operational efficiency influenced long-term growth in the sector. On the other hand, (Çağlar & Nişel, 2024) explored the fast-growing FinTech industry with a two-stage DEA model and found that profitability was generally stronger than marketability, reflecting structural differences within sub-sectors. Similar comparisons were carried out by (Wibowo et al., 2024) in Indonesia's construction industry. They found that state-owned enterprises lagged behind private firms due to high debt exposure and liquidity constraints. The impact of external shocks has also been explored; for instance, (Velickovic et al., 2023) compared e-commerce and hospitality during the pandemic and showed how the two industries adapted differently to the crisis, particularly in their debt-financing strategies.

Banking has attracted significant attention in efficiency research. (Ullah et al., 2023) studied commercial banks in Pakistan and found that good governance, ownership structure, and higher returns improved efficiency, whereas weak risk management and leverage reduced it. (Simonović et al., 2023) applied DEA to banks in Serbia and Montenegro, identifying a handful of institutions that consistently outperformed their peers. Work on Indonesia's rural banks by (Wasiaturrahma et al., 2020) highlighted how capital strength and geographic location play crucial roles in determining efficiency. Earlier studies in developed economies laid much of this groundwork: (Pille & Paradi, 2001) used DEA to assess Canadian credit unions, while (Feroz et al., 2003) argued that DEA could complement ratio analysis by providing more consistent measures of firm performance.

Efficiency studies in the service sector underline DEA's flexibility. (Habib & Shahwan, 2020) assessed private hospitals in Egypt and found that inefficiencies were largely due to technical shortcomings rather than resource shortages. (Raei et al., 2017) studying Iranian hospitals, also found mixed results, particularly before and after health reforms. In Italy, (Campisi et al., 2019) examined knowledge-intensive business services and concluded that innovation, or the lack of it, was a major bottleneck in productivity growth.

Several studies have focused on manufacturing and heavy industries. (Najadat et al., 2020) combined DEA with machine learning techniques to classify industrial firms in Jordan, demonstrating the potential of hybrid approaches. (Anthony et al., 2019) compared Indian chemical firms using DEA alongside ranking methods like TOPSIS and COPRAS, which helped to identify efficiency leaders within the sector. In India's steel industry, (Mitra Debnath & Sebastian, 2014) reported that public sector companies were often disadvantaged compared to private firms, partly because of unfavourable locations and supply chain issues. Similar work by (Li et al., 2014) on Chinese coal companies emphasized the importance of improving operational efficiency for long-term sustainability. (Chaitip et al., 2014) applied a panel DEA with bootstrapping to Thailand's sugarcane sector and found that local conditions, such as rainfall, had a significant impact on efficiency.

A number of scholars have also looked at broader applications of DEA. (Tehrani et al., 2012) proposed a DEA-based model to evaluate financial performance across multiple companies, while (Fenyves et al., 2015) showed how DEA could complement ratio analysis in agriculture, especially for benchmarking. In the Indian SME sector, (Mehta & Brahmbhatt, 2019) identified profitability, liquidity, and leverage as the most important drivers of competitiveness. Taken together, these studies confirm the usefulness of DEA in both traditional industries and emerging sectors. However, there remains a gap for comparative studies across heavy industries such as cement and steel in India, where differences in capital structure and financial performance may provide new insights for both policymakers and industry stakeholders.

Methodology

This study adopts a quantitative research design to evaluate and compare the financial performance efficiency of the cement and steel industries in India over a ten-year period. Panel data were collected for 30 companies, comprising 15 firms from each sector, covering the period from 2015 to 2024. Data were compiled from EMIS and published annual reports to ensure accuracy and consistency. The dataset includes key financial variables representing both resource deployment and profitability outcomes. To capture efficiency in resource utilization, three input variables were considered: total assets, total equity, and operating expenses, as they reflect the capital base and operational costs of each firm**.** Return on assets (ROA) and net profit margin (NPM) were used as output variables, capturing the profitability generated from these resources. The selection of these indicators was based on their relevance in financial performance analysis and their common use in industry benchmarking studies. Negative or missing values were adjusted, as standard DEA models require non-negative data.

Type	Variable	Description
Inputs	Total Assets	Represents the total resources owned by the firm
	Total Equity	Shareholders' funds invested in the business; reflects owners' capital
	Operating Expense	Total operating costs incurred during the year
Outputs	Return on Assets	Measures how efficiently assets generate earnings
	Net Profit Margin	Percentage of net income to sales, indicating cost control and profitability.

Table 1- Inputs and Outputs under Study

The analysis employs Data Envelopment Analysis (DEA) to measure efficiency scores at both the firm and sector levels. DEA is a non-parametric linear programming method that evaluates the relative efficiency of decision-making units by comparing them to a best-practice frontier. Unlike traditional ratio-based analysis, DEA allows for the simultaneous assessment of multiple inputs and outputs, making it well suited to complex financial data. An output-oriented model under variable returns to scale (VRS) was applied as proposed by Banker, Charnes, and Cooper (1984) to account for differences in firm size and to focus on maximizing financial performance given existing resources. Efficiency scores were calculated annually for each firm and then aggregated to analyse sectoral performance and identify leading and lagging firms. The model focuses on maximizing outputs while keeping inputs constant and is expressed as:

Maximize ϕ Subject to:

$$\sum_{j=1}^{n} \lambda_j x_{ij} \leq x_{io} \text{ (i = 1, 2, 3, ... , m)}$$

$$\sum_{j=1}^{n} \lambda_j y_{rj} \geq \phi y_{ro} \quad (r = 1, 2, 3, \ldots, s)$$

$$\sum_{j=1}^{n} \lambda_j = 1$$

$$\lambda_j \geq 0 \quad (j = 1, 2, 3, \ldots, n)$$

Here:

- ϕ is the proportional increase in outputs (efficiency score) for the firm being evaluated.
- x_{ij} and y_{rj} are the inputs and outputs of firm j.
- λ_j are weights assigned to peer firms to form a virtual composite.

To capture productivity dynamics over time, the study also uses the Malmquist Productivity Index (MPI)**.** This approach decomposes productivity changes into efficiency change (catch-up effect)**,** technological change (frontier shift)**,** pure technical efficiency change (managerial efficiency)**,** and scale efficiency change (size-related effects)**.** MPI allows the study to go beyond static efficiency measures and examine whether firms are improving, declining, or maintaining their performance across the study period. All DEA and MPI analyses were conducted using DEAP software, which is widely recognized for efficiency and productivity studies. The results were interpreted through sectoral comparisons, firm rankings, and year-on-year trends to provide meaningful insights into industry performance. The index is defined as:

$$M_0^{t,t+1}(x^{t+1}, y^{t+1}, x^t, y^t) = \left[\frac{D_0^t(x^{t+1}, y^{t+1})}{D_0^t(x^t, y^t)} \times \frac{D_0^{t+1}(x^{t+1}, y^{t+1})}{D_0^{t+1}(x^t, y^t)}\right]^{1/2}$$

Where:

- x^t, y^t are input and output vectors in period t, and x^{t+1}, y^{t+1} are the corresponding vectors in period t+1.
- $D_0^t(x, y)$ is the distance function, which measures how far a firm is from the efficiency frontier at a given time.

Analysis

1. Descriptive Statistics

	TA	TE	OP Exp	ROA	NPM
Mean	14583.65	9011.69	7323.03	1.07	1.12
Median	7128.03	3240.31	4265.02	1.07	1.11
Maximum	96630.99	59095.24	5668.96	2.00	2.52
Minimum	851.89	435.67	374.71	1.00	1.00
Std. Dev	19606.66	13311.74	8777.86	0.08	0.13

Table 2-Descriptive Statistics of Cement Industry
Source- Compiled by Author

	TA	TE	OP Exp	ROA	NPM
Mean	33417.63	16060.94	17062.52	1.31	1.53
Median	3653.84	3076.50	3401.39	1.31	1.53
Maximum	245634.10	139427.70	118733.00	1.59	2.50
Minimum	30.54	1.00	4.77	1.00	1.00
Std. Dev	55990.52	2692.30	27460.69	0.09	0.13

Table 3- Descriptive Statistics of Steel Industry
Source- Compiled by Author

Table 2 provides descriptive statistics of cement industries. The cement firms show a moderate operational scale, with mean total assets of about Rs.14,584 million and equity of Rs.9,012 million. Operating expenses average Rs.7,323 million. The large gap between mean and median values and high standard deviations indicate a few large players dominating and there is significant variation in firm size. Profitability is steady across firms, with ROA and NPM averaging 1.07 and 1.12, and has very little variation.

On the other hand, Steel firms are much larger, with average of Rs.33,418 million in assets and Rs.16,061 million in equity. Operating expenses are nearly Rs.17,063 million (as shown in Table 3). The difference between means and medians and the high standard deviations point to a skewed distribution caused by very

large firms. Profitability of the steel industry is slightly higher than cement, with ROA and NPM at 1.31 and 1.53 on average, showing consistency across firms despite size differences.
Overall, the descriptive statistics reveal that while both industries show stable profitability, the steel industry operates at a larger scale and demonstrates comparatively higher financial returns, whereas the cement industry is smaller in scale with lower but stable profitability levels. These patterns support the use of DEA, which accounts for differences in scale and multiple inputs and outputs when assessing efficiency.

2. Yearly Efficiency Score Table

Table 4 and Figure 1 present the yearly DEA efficiency scores for the cement industry. Over the period, the scores remain generally high and operated near the efficiency frontier. From 2015 to 2024, the cement industry maintained high level of efficiency, with averages mostly above 0.95. The high efficiency in 2018 (0.994) represents a peak year of optimal performance, and stayed stable until a small decline in 2020 which is likely due to global disruptions. Overall, the cement sector shows stable, strong technical performance. The cement sector faced a sharp efficiency decline in 2023 to 0.737, pointing to industry-wide challenges. By 2024, efficiency improved to 0.952, reflecting strong resilience. The trend highlights both the industry's ability to recover and the need for strategies that protect against sudden declines.

Year	Efficiency
2015	0.981
2016	0.981
2017	0.966
2018	0.994
2019	0.971
2020	0.952
2021	0.980
2022	0.971
2023	0.737
2024	0.952

Table 4- Cement Industry Efficiency Score
Source- Compiled by Author

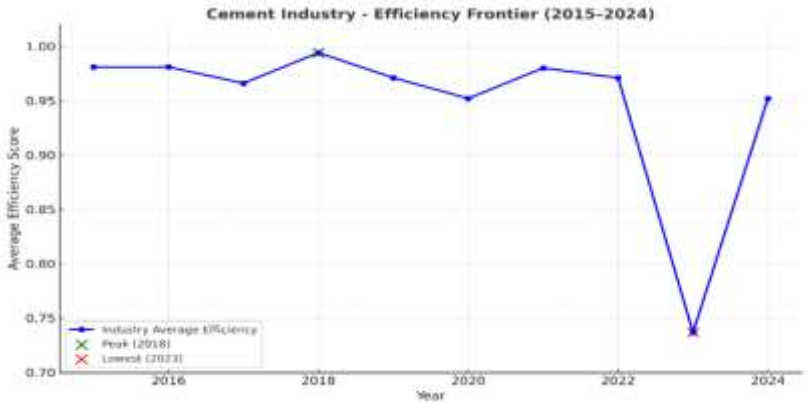
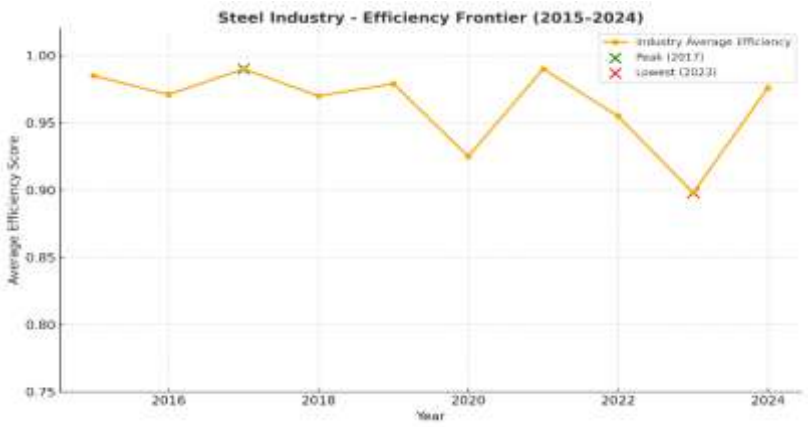


Figure 1- Cement Industry Efficiency Frontier
Source- Compiled by Author

Year	Efficiency
2015	0.985
2016	0.971
2017	0.990
2018	0.970
2019	0.979
2020	0.925
2021	0.990
2022	0.955
2023	0.898
2024	0.976

Table 5- Steel Industry Efficiency Score
Source- Compiled by Author



Source- Compiled by Author

Table 5 and Figure 2 show the yearly DEA efficiency scores for the steel industry. while several firms consistently reach full efficiency, Steel firms comparatively show more variation than cement industry. Peak efficiency in years like 2017 and 2021 indicates that steel firms significantly increased their conversion of inputs to ROA/NPM which can be possibly due to cost restructuring, scale effects, or favourable market conditions. The steel industry's efficiency remained strong across most years, with averages mostly above 0.95. The highest efficiency was recorded in 2017 (0.990), reflecting peak operational performance across firms. A noticeable slowdown occurred in 2020 (0.925), likely due to global disruptions, followed by recovery in 2021 (0.990). The sharpest decline came in 2023, with the average falling to 0.898, indicating sector-wide operational or market challenges. In 2024, efficiency improved to 0.976, showing resilience and partial recovery. The trend suggests that while the sector is generally efficient, it remains prone to supply chain and economic fluctuation.

3. Comparative Analysis of Efficiency

Year	Cement	Steel	Most Efficient
2015	0.981	0.985	steel
2016	0.981	0.971	cement
2017	0.966	0.990	steel
2018	0.994	0.970	cement
2019	0.971	0.979	steel
2020	0.952	0.925	cement
2021	0.980	0.990	steel
2022	0.971	0.955	cement
2023	0.737	0.898	steel
2024	0.952	0.976	steel

Table 6-Comparison of average efficiency score
Source-Compiled by Author

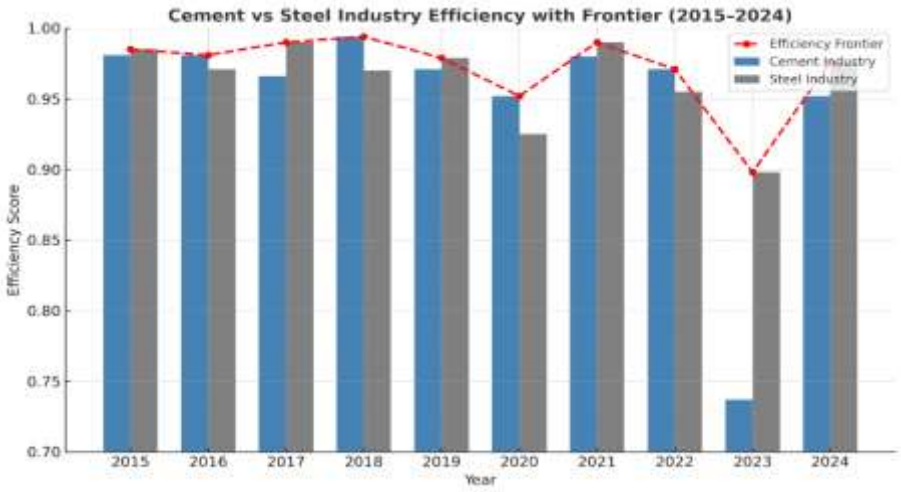


Figure 3-Cement vs Steel Efficiency frontier

Table 6 and Figure 3 provide a comparative view of yearly average efficiency scores between the cement and steel industries for the period 2015 to 2024. Both cement and steel industries generally maintained high efficiency, but alternated in performance leadership. Steel industry emerged as the more efficient sector in 6 out of 10 years (2015, 2017, 2019, 2021, 2023, and 2024), while cement industry maintains strong efficiency in 4 years (2016, 2018, 2020, and 2022). Steel industry has achieved its highest efficiency (0.990) in the year 2017 and 2021, whereas the cement industry has (0.994) as highest efficiency in 2018. Both industries experienced a significant efficiency decline in 2023, with cement industry falling sharply to 0.737 and steel industry to 0.898, marking the widest gap between the two sectors in the decade. Overall, steel holds a slight edge in efficiency dominance over the study period.

4. Company Efficiency Score Table

Company	Cement	Company	Steel
Ultratech cement	0.949	Tata steel	0.978
Grasim Industries ltd	0.950	JSW steel	0.980
Heidelberg Cement	0.949	Jindal steel	0.982
Shree cement	0.929	Jindal Stainless Steel	0.961
Ambuja cement	0.961	Welspun Corp. ltd.	0.976
JK cement	0.944	Lloyd Metals	0.931
Ramco cements	0.945	SAIL	0.972
Star cement	0.936	Jai Krishna steel pvt ltd.	0.942
Prism Johnson ltd.	0.917	Usha Martin ltd.	0.948
JK Laxmi Cement	0.916	Surya Roshni ltd.	0.951
Birla corporation ltd.	0.969	JTL Industries ltd.	0.988
India cements	0.974	Steel Exchange India ltd.	0.98
Aditya Birla real estate ltd.	0.974	Welspun Speciality solution ltd.	0.968
HIL ltd.	0.958	Bansal wire industries ltd.	0.937
Orient cement	0.957	Prakash Industries ltd.	0.963

Table 7-Company Average Efficiency Score
Source-Compiled by Author

In Table 7, The company-level efficiency analysis reveals that both cement and steel industries demonstrate strong financial performance, with most firms operating near the efficiency frontier. However, efficiency scores vary across individual companies within each sector, indicating differences in the ability to utilize financial resources effectively.

In the cement industry, efficiency scores range from 0.916 (JK Laxmi Cement) to 0.974 (India Cements and Aditya Birla Real Estate Ltd.), suggesting that while no company has achieved perfect efficiency, most firms perform at a relatively high level. India Cements and Aditya Birla Real Estate Ltd. emerge as the most efficient performers in the sector. In contrast, Prism Johnson Ltd. (0.917) and JK Laxmi Cement (0.916) show relatively lower efficiency, indicating scope for improvement in resource utilization and cost management.

On the other hand, the steel Industry shows higher efficiency scores overall, with a range from 0.931 (Lloyd Metals) to 0.988 (JTL Industries Ltd.). JTL Industries Ltd. emerged as the most efficient company, followed by Jindal Steel (0.982) and JSW Steel (0.980). Tata Steel (0.978), SAIL (0.972), and Steel Exchange India Ltd. (0.980) which highlights the sector's overall financial strength likely benefiting from operational strengths or technological advantages.

Comparatively, the steel industry achieves higher efficiency scores on average than cement industry. While cement firms show relatively stable and clustered efficiency values, the steel industry shows both higher score and a stronger overall performance profile. This suggests that the steel sector is generally more effective in converting assets, equity, and operational expenses into financial returns, possibly due to process innovations, better cost control, or industry dynamics. Whereas, cement companies, although efficient, tend to operate at slightly lower levels of performance.

5. Malmquist Index Summary

YEAR	EFFCH	TECHCH	PECH	SECH	TFPCH
2016	0.918	8.387	1.000	0.918	7.699
2017	1.567	0.196	0.986	1.590	0.307
2018	0.944	1.699	1.028	0.918	1.604
2019	0.637	3.649	0.976	0.652	2.324
2020	2.329	0.667	0.980	2.375	1.553
2021	0.968	0.589	1.031	0.939	0.570
2022	1.048	0.526	0.991	1.057	0.551
2023	0.332	9.137	0.731	0.455	3.035
2024	2.380	0.541	1.341	1.775	1.288
mean	1.055	1.297	0.997	1.058	1.368

Table 8-Malmquist index summary of annual means of Cement Industry
Source-DEAP Software

YEAR	EFFCH	TECHCH	PECH	SECH	TFPCH
2016	0.778	2.002	0.986	0.790	1.559
2017	1.171	6.023	1.020	1.148	7.053
2018	0.971	3.266	0.978	0.993	3.172
2019	0.160	0.620	1.010	0.158	0.099
2020	6.938	1.796	0.942	7.366	12.462
2021	0.937	1.183	1.074	0.873	1.109
2022	1.268	0.762	0.964	1.315	0.966
2023	0.959	1.215	0.937	1.023	1.165
2024	0.758	0.446	1.091	0.694	0.338
mean	0.982	1.406	0.999	0.983	1.380

Table 9-Malmquist index summary of annual means of Steel Industry
Source-DEAP Software

The Malmquist index summary indicate that both the cement and steel industries experienced overall productivity growth during the study period. Productivity growth was largely driven by technological progress rather than better use of existing resources.

In the cement sector, the mean efficiency change (EFFCH) was 1.055, suggesting modest improvement in operational efficiency over the study period. However, there were significant fluctuations. Lower efficiency in Year 2016 (0.918) and Year 2023 (0.332) could indicate temporary cost pressures, capacity underutilization, or demand slowdowns affecting operational output. whereas, years 2020 and 2024 showed strong gains (EFFCH 2.329 and 2.380), likely reflecting improved resource utilization, higher capacity deployment, or favourable market conditions. Technological change (TECHCH) was the primary driver of productivity, with sharp spikes in Year 2017 (8.387) and Year 2023 (9.137). Such peaks may reflect major technology adoption,

process upgrades, or structural changes in production practices. Declines in later years (e.g., 0.526–0.667) might indicate slower innovation or delayed investment cycles. Managerial efficiency (PECH) remained consistent (mean 0.997), while scale efficiency (SECH) varied (mean 1.058), implying adjustments in plant size or production levels relative to demand. Overall, total factor productivity change (TFPCH) averaged 1.368, showing that technology contributed more to sectoral gains than pure efficiency improvements.

The steel sector recorded an average EFFCH of 0.982, showing relatively steady but modest efficiency. Year 2020 (EFFCH 6.938, SECH 7.366, TFPCH 12.462) and Year 2017 (TFPCH 7.053) showed strong gains, possibly due to capacity expansion, technology-driven productivity boosts, or favourable commodity cycles. In contrast, significant downturns in Year 2019 (EFFCH 0.160, TFPCH 0.099) and Year 2024 (TFPCH 0.338) may reflect market disruptions, input cost volatility, or production bottlenecks. Technological change averaged 1.406, slightly higher than cement. This implies that productivity growth is driven primarily by innovation and technology adoption, while efficiency gains are less consistent. Managerial efficiency (PECH) remained near unity (0.999), indicating stable internal practices, though scale adjustments were significant, suggesting periodic capacity shifts in response to demand or price cycles. Overall, the steel sector records an overall increase in productivity, with an average TFPCH of 1.380.

Overall, both industries rely more heavily on technological progress than efficiency improvements for productivity growth. The cement sector shows steadier but moderate gains, while the steel industry demonstrates greater volatility reflecting greater sensitivity to technology, market conditions, and raw material fluctuations. On average, steel records slightly higher TFP growth than cement, but its performance is less stable. These findings highlight the need for continuous investment in technology, better capacity planning, and risk management to stabilize productivity trends and sustain competitiveness.

6. Malmquist Index Summary of Firm Means

FIRM	EFFCH	TECHCH	PECH	SECH	TFPCH
Ultratech	1.058	1.277	1.002	1.055	1.35
Grasim	1.074	1.297	1.002	1.071	1.393
Heilberg	1.073	1.281	1.000	1.073	1.375
Shree	1.071	1.268	0.999	1.072	1.358
Ambuja	1.083	1.244	0.999	1.085	1.347
JK	1.106	1.297	0.999	1.107	1.434
Ramco	1.108	1.289	0.994	1.115	1.429
Star	1.131	1.292	0.986	1.147	1.461
Prism Johnson	1.133	1.324	0.993	1.141	1.501
JK Laxmi	1.143	1.297	0.992	1.153	1.483
Birla	0.948	1.322	0.992	0.956	1.254
India	0.957	1.294	0.997	0.96	1.239
Aditya	0.964	1.28	0.998	0.966	1.234
HIL	0.984	1.343	0.995	0.989	1.322
Orient	1.015	1.359	1.002	1.013	1.378
mean	1.055	1.297	0.997	1.058	1.368

Table 10- Malmquist index summary of firm means of Cement Industry
Source-DEAP Software

FIRM	EFFCH	TECHCH	PECH	SECH	TFPCH
Tata	1.000	1.094	1.000	1.000	1.094
JSW	0.998	1.101	1.000	0.998	1.099
Jindal	1.011	1.168	1.002	1.009	1.181
Jindal SS	1.016	1.348	1.003	1.013	1.369
Welspun	1.014	1.396	1.000	1.014	1.415
Lloyd	0.945	1.308	0.994	0.950	1.236
SAIL	1.047	1.201	1.000	1.047	1.257
Jai Krishna	1.072	1.243	1.000	1.072	1.333
Usha Martin	1.027	1.386	1.007	1.019	1.423
Surya	1.028	1.423	1.011	1.017	1.463
JTL	0.917	1.608	0.993	0.923	1.475
Steel Exchange	0.910	1.673	0.992	0.918	1.523
Welspun S	0.908	1.707	0.993	0.914	1.549
Bansal	0.918	1.833	0.994	0.924	1.684
Prakash	0.939	1.929	0.997	0.942	1.810
mean	0.982	1.406	0.999	0.983	1.380

Table 11- Malmquist index summary of firm means of Steel Industry
Source-DEAP Software

Table 10 and 11 reflects the Malmquist index summary of firm means of cement and steel industry respectively. The result for cement firms indicates overall positive productivity growth, with an average total factor productivity change (TFPCH) of 1.368. This improvement is supported by moderate efficiency gains (mean EFFCH 1.055) and consistent technological progress (TECHCH 1.297). Firms such as Prism Johnson (1.501), JK Laxmi (1.483), and Star Cement (1.461) emerged as the strongest performers. These firms appear to benefit from better utilization of resources and steady technology adoption. By contrast, Birla Corporation (1.254), India Cements (1.239), and Aditya Birla (1.234) recorded relatively slower productivity growth, suggesting slower adaptation to new technologies or weaker scale efficiency. Overall, the cement sector demonstrated steady gains, reflecting the benefits of modernization in production facilities and a gradual shift towards energy-efficient practices.

Steel firms also demonstrate productivity growth, with a mean TFPCH of 1.380, slightly higher than cement. It is driven largely by technological progress (TECHCH = 1.406), while efficiency change remained below unity (EFFCH = 0.982). Several firms recorded high productivity growth, including Prakash Industries (1.810), Bansal Wire (1.684), and Welspun Speciality (1.549), which can be attributed to strong technology adoption. On the other hand, firms such as Steel Exchange (1.523) and JTL Industries (1.475) also showed growth, mainly due to technology advancement rather than efficiency. In contrast, Lloyd Metals (1.236) and Tata Steel (1.094) showed relatively smaller productivity improvements, suggesting stable but slower growth.

Overall, cement companies showed balanced growth through steady technological adoption and moderate efficiency improvements. Technology plays a major role in steel industry productivity gains, however frequently with efficiency losses. The leading cement firms such as Prism Johnson, Star Cement and JK Laxmi Cement perform well, but the top steel firms such as Prakash Industries, Welspun Speciality solution ltd., etc, achieve higher productivity levels, which may be due to greater innovation and investment. This highlights the capital intensive and globally integrated nature of steel production, where technological shifts can create sharp gains but also expose firms to risk.

Discussion

The present study examined and compared the financial performance efficiency of cement and steel industry in India over the study period. The findings provide a comprehensive picture of the financial performance. Across the annual results, both industries demonstrate relatively high efficiency, with scores mostly between 0.91 and 0.99. Cement firms showed stable performance in many years, but a notable dip in 2023 indicates sensitivity to market or cost factors. Steel companies, while slightly more variable, achieved higher average annual efficiency, outperforming cement in six out of ten years. This suggests that steel firms generally use assets, equity, and operating expenses more effectively to generate returns. Firm-level result further highlights that companies such as Prism Johnson, JK Laxmi, and Star Cement in the cement sector, and Prakash Industries, Bansal Wire, and Welspun Speciality in the steel sector, are top performers due to improvements in scale and technological adaptability. These results indicate a modest but consistent edge for steel, likely supported by technological or operational advantages.

The Malmquist productivity results highlight that technological change was the primary driver of productivity growth in both sectors. For cement firms, average total factor productivity change (TFPCH = 1.368) was largely driven by technological progress (TECHCH = 1.297) rather than efficiency improvements, indicating stable productivity growth. Similarly, the steel sector recorded higher average productivity growth (TFPCH = 1.380), also led by technological advancements (TECHCH = 1.406). However, the steel industry's efficiency change (EFFCH = 0.982) was weaker than cement's (EFFCH = 1.055), suggesting that while steel firms rapidly adopted new technologies, they did not always use them optimally. Firm-level results confirmed this trend, with Prism Johnson (1.501), JK Laxmi Cement (1.483), and Star Cement (1.461) showing the highest productivity gains in cement industries, mainly through improvements in scale efficiency and technology adoption. In contrast, firms such as Birla Corporation (1.254) and India Cements (1.239) showed relatively weaker gains, indicating slower adoption of technology. In steel, Prakash Industries (1.810), Bansal Wire (1.684), and Welspun Speciality (1.549) achieved strongest growth, reflecting strong technology adoption, though some firms showed efficiency shortfalls despite high tech scores. Across both industries, managerial efficiency (PECH) was stable near unity, indicating that technology and scale were the main differentiators. Overall, the results show that cement firms saw constant growth through balanced efficiency and technological gains, while steel firms achieved higher but more volatile productivity which was strongly influenced by technological progress.

Conclusion

This study set out to evaluate and compare the financial performance efficiency of the cement and steel industries in India over a ten-year period, using Data Envelopment Analysis (DEA) under a variable return to scale model and the Malmquist Productivity Index. The analysis covered 15 companies in each sector, with total assets, total equity, and operating expenses as inputs and profitability indicators (ROA and NPM) as outputs. The findings provide a detailed perspective on both cross-sectional and temporal efficiency and productivity patterns.

The results indicate three key outcomes. First, both industries achieved high efficiency, but steel surpassed cement in most years despite higher volatility. Second, firm-level variations highlight the importance of managerial practices and scale efficiency in sustaining competitiveness. Third, technological change was the dominant factor behind productivity improvements, underlining the critical role of innovation and modernization in driving sectoral growth.

The company efficiency scores highlight that cement firms Prism Johnson, JK Laxmi Cement, and Star Cement are the best performers within their sector, while steel firms Prakash Industries, Bansal Wire, and Welspun Speciality achieved strongest growth. The Malmquist analysis adds a dynamic perspective, showing that both industries achieved productivity growth over time, but with differing patterns. Cement's growth is steadier with several significant increase in technology adoption in years 2016 and 2023. Steel industry shows stronger but more volatile improvements, with highest score in years 2017 and 2020, and occasional decline in years 2019 and 2024. Managerial efficiency remained stable across firms, suggesting that changes in productivity are largely caused by technology and scale effects rather than internal decision-making alone.

These findings have clear implications for industry managers and policymakers. Cement companies could improve by investing in innovation, upgrading technology, and optimizing operational scale to narrow the performance gap. Steel firms, while benefiting from stronger technological adoption, may need to focus on operational stability and efficiency to reduce volatility and fully exploit their investments. Investors and stakeholders can use these insights to benchmark company performance and identify leaders and laggards in each sector.

Despite its contributions, this study has some limitations. First, the analysis focuses on financial indicators only; operational metrics (e.g., production efficiency, energy use), environmental factors, or qualitative elements like management capability were not included. Second, the sample is restricted to 30 firms within India, limiting generalizability to other contexts. Third, the DEA and Malmquist methods, while robust, are sensitive to data quality; any inconsistencies in financial reporting may affect results. Finally, macroeconomic factors, market shocks, or policy changes that could influence firm performance were not explicitly modelled.

Future research could integrate operational and sustainability metrics alongside financial indicators to capture a more holistic view of performance. Examining the role of external factors such as economic cycles, raw material prices, or regulatory changes could strengthen the findings. Cross-country studies could provide broader benchmarking opportunities, while bootstrapped DEA or second-stage regression techniques could add statistical rigor. Extending the analysis to other sectors or using longitudinal data beyond ten years could also offer deeper insights into efficiency trends and industry evolution.

Reference

1. Anthony, P., Behnoee, B., Hassanpour, M., & Pamucar, D. (2019). Financial performance evaluation of seven indian chemical companies. *Decision Making: Applications in Management and Engineering*, *2*(2), 81–99. https://doi.org/10.31181/dmame1902021a
2. Çağlar, M., & Nişel, S. (2024). Efficiency measurement of fintech companies: a two-stage DEA approach. *Electronic Commerce Research*, *24*(2), 1335–1366. https://doi.org/10.1007/s10660-023-09804-3
3. Campisi, D., Mancuso, P., Mastrodonato, S. L., & Morea, D. (2019). Efficiency assessment of knowledge intensive business services industry in Italy: data envelopment analysis (DEA) and financial ratio analysis. *Measuring Business Excellence*, *23*(4), 484–495. https://doi.org/10.1108/MBE-09-2019-0095
4. Chaitip, P., Chaiboonsri, C., & Inluang, F. (2014). The Production of Thailand's Sugarcane: Using Panel Data Envelopment Analysis (Panel DEA) Based Decision on Bootstrapping Method. *Procedia Economics and Finance*, *14*, 120–127. https://doi.org/10.1016/s2212-5671(14)00693-5
5. Fenyves, V., Tarnóczi, T., & Zsidó, K. (2015). Financial Performance Evaluation of Agricultural Enterprises with DEA Method. *Procedia Economics and Finance*, *32*, 423–431. https://doi.org/10.1016/s2212-5671(15)01413-6
6. Feroz, E. H., Kim, S., & Raab, R. L. (2003). Financial statement analysis: A data envelopment analysis approach. *Journal of the Operational Research Society*, *54*(1), 48–58. https://doi.org/10.1057/palgrave.jors.2601475
7. Habib, A. M., & Shahwan, T. M. (2020). Measuring the operational and financial efficiency using a Malmquist data envelopment analysis: a case of Egyptian hospitals. *Benchmarking*, *27*(9), 2521–2536. https://doi.org/10.1108/BIJ-01-2020-0041
8. Li, H. M., Yang, X., & Yan, Z. Z. (2014). The financial performance assessment on the listed coal companies by using DEA model. *Advanced Materials Research*, *869–870*, 603–611. https://doi.org/10.4028/www.scientific.net/AMR.869-870.603
9. Mahalakshmi, K., & Kumar, D. K. (n.d.). *A Study on Comparative Analysis of Cement Industries by Using Malmquist Method*. www.theacademic.in
10. Mehta, N., & Brahmbhatt, M. (2019). An Empirical Study on the Financial Competitiveness Evaluation System of Stock Exchange Listed SMEs of Gujarat, India. *SEDME (Small Enterprises Development, Management & Extension Journal): A Worldwide Window on MSME Studies*, *46*(4), 256–263. https://doi.org/10.1177/0970846419894752

11. Mitra Debnath, R., & Sebastian, V. J. (2014). Efficiency in the Indian iron and steel industry – an application of data envelopment analysis. *Journal of Advances in Management Research*, *11*(1), 4–19. https://doi.org/10.1108/JAMR-01-2013-0005
12. Najadat, H., Al-Daher, I., & Alkhatib, K. (2020). Performance evaluation of industrial firms using dea and decorate ensemble method. *International Arab Journal of Information Technology*, *17*(5), 750–757. https://doi.org/10.34028/iajit/17/5/8
13. Pille, P., & Paradi, J. C. (n.d.). *Financial performance analysis of Ontario (Canada) Credit Unions: An application of DEA in the regulatory environment*. www.elsevier.com/locate/dsw
14. Raei, B., Yousefi, M., Rahmani, K., Afshari, S., & Ameri, H. (2017). Patterns of productivity changes in hospitals by using malmquist – DEA index: A panel data analysis (2011–2016). *Australasian Medical Journal*, *10*(10), 856–864. https://doi.org/10.21767/AMJ.2017.3094
15. Simonović, D., Milojević, S., Milašinović, M., & Dimitrijević, M. (2023). Analysis of the efficiency of banks in Serbia and Montenegro using the DEA method. *International Review*, *3–4*, 184–194. https://doi.org/10.5937/intrev2304181s
16. Tehrani, R., Mehragan, M. R., & Golkani, M. R. (2012). A Model for Evaluating Financial Performance of Companies by Data Envelopment Analysis - A Case Study of 36 Corporations Affiliated with a Private Organization. *International Business Research*, *5*(8). https://doi.org/10.5539/ibr.v5n8p8
17. Ullah, S., Majeed, A., & Popp, J. (2023). Determinants of bank's efficiency in an emerging economy: A data envelopment analysis approach. *PLoS ONE*, *18*(3 March). https://doi.org/10.1371/journal.pone.0281663
18. Velickovic, G., Stanojevic, J., & Veselinovic, M. (2023). Managing Financial Performance toward Achievements in Sustainability Prospects: Comparative Analysis of the e-Commerce and Hospitality Industries. In *Journal of Risk and Financial Management* (Vol. 16, Issue 9). Multidisciplinary Digital Publishing Institute (MDPI). https://doi.org/10.3390/jrfm16090395
19. Wasiaturrahma, Sukmana, R., Ajija, S. R., Salama, S. C. U., & Hudaifah, A. (2020). Financial performance of rural banks in Indonesia: A two-stage DEA approach. *Heliyon*, *6*(7). https://doi.org/10.1016/j.heliyon.2020.e04390
20. Wibowo, F. A., Satria, A., Gaol, S. L., & Indrawan, D. (2024). Financial Risk, Debt, and Efficiency in Indonesia's Construction Industry: A Comparative Study of SOEs and Private Companies. *Journal of Risk and Financial Management*, *17*(7). https://doi.org/10.3390/jrfm17070303