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Relationship Between Capital Structure and Financial Performance: A Dynamic Network Approach Across Cement and Steel Industries

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ABSTRACT
Establishing an optimal capital structure is the most important aspect of corporate financial policy because it directly shapes financial performance of an industry. The aim of this paper is to evaluate and compare the relationship between capital structure and financial performance of cement and steel industries in India. Data was collected from secondary sources such as EMIS and annual reports of 15 cement and 15 steel industries in India over the period of 10 years (2015-2024). The data was collected and arranged in firm-year panel data and is quantitative in nature. A correlation-based network analysis was executed using Python to visualize the evolving interdependencies between variables. Variables of capital structure (debt–asset ratio, debt–equity ratio, and equity–asset ratio), financial performance (return on assets, return on equity, net profit margin and current ratio) and control variable (firm size) were taken for the study. The findings reveal the clear difference between the two industries. Steel industry has stronger and more volatile negative relation between debt and financial performance. On the other hand, cement industry has more stable network. The study provides a new perspective by applying a dynamic network approach in capital-intensive sectors that can help managers and policymakers.
Keywords: Financial Performance, Capital Structure, Panel Data, Network Analysis, Correlation Analysis, Steel Industry, Cement Industry.

1. INTRODUCTION

Capital structure decision plays an essential role in determining firm performance, particularly within capital intensive industries where financing decisions affect profitability, liquidity, and long-term financial stability. The balance between debt and equity influences not only the cost of capital but also determines a firm's financial risk exposure and its ability to absorb economic fluctuations. Consequently, the relationship between capital structure and financial performance has been explored across global economies.

Among India's industrial sectors, cement and steel industry hold strategic importance. Cement production supports infrastructure development and construction activity, while the steel industry forms the backbone of manufacturing, transportation, defence, and large-scale industrialization. Although both sectors contribute significantly to national growth, their operational contexts differ. Cement producers typically face more predictable demand patterns, whereas steel firms are highly sensitive to business cycles, global price fluctuations, and raw-material cost volatility. These differences suggest that financing choices may have uneven effects across the two industries, yet comparative evidence remains limited.

However, empirical findings on this relationship remains inconclusive. While many studies report that higher leverage adversely affects profitability, others find positive or mixed effects depending on firm characteristics, industry structure, and economic conditions. These inconsistencies are particularly evident in heavy industries such as cement and steel, where high fixed costs, cyclical demand, and substantial dependence on external financing magnify the consequences of financing decisions. In emerging economies like India, these sectors are strategically important due to their contribution to infrastructure development and industrial growth. Both sectors require substantial long-term investment, operate under cyclical market conditions. Despite these similarities, the two industries differ in terms of operating risk, demand volatility, and financial resilience, suggesting that capital structure may influence their financial performance in different ways.

2. REVIEW OF LITERATURE

The relationship between capital structure and financial performance has been widely examined whether the way firms finance their operations through debt or equity enhances or weakens their financial outcomes. Despite decades of research, the findings remain mixed, suggesting that the impact of capital structure on performance is neither uniform nor stable across firms, industries, or economic conditions.

A large body of empirical work reports that higher leverage is associated with poorer financial performance. Studies such as (Ahmed et al., 2023) show that firms with greater reliance on debt tend to experience lower profitability, largely due to increased financial risk and agency costs. Their analysis of manufacturing firms indicates that while moderate debt may reduce agency problems, excessive leverage ultimately weakens firm performance. Similar negative effects of leverage on profitability are reported in diverse settings, including

Indian service firms (Farhan et al., 2020), textile firms in Pakistan (Ullah et al., 2020) and agricultural firms in China (Xu et al., 2021), (Steklá & Gryčová, 2016) where both total debt and short-term debt negatively affect return on assets and return on equity. (Chang et al., 2019) using a large dataset from the Four Asian Tiger economies, also report a strong inverse relationship between leverage and profitability. Collectively, these studies suggest that, particularly in environments characterised by uncertainty and volatility, higher debt levels tend to undermine firm performance.

However, several studies highlight that the effect of capital structure and performance relationship is not universally negative and depends on the type of debt, firm efficiency, and financial context. (Nguyen et al., 2023) show that while long-term debt negatively affects profitability in Vietnamese firms, short-term debt can have a positive effect by improving liquidity management. (Shamsuddin et al., 2020) reports similar findings in the Jordanian insurance sector, where short-term debt improves ROA and ROE, while long-term debt shows mixed effects. These results suggest that firms may benefit from flexible financing arrangements, lending partial support to the pecking order theory.

Firm characteristics and operational efficiency also play an important role in shaping capital structure outcomes. (Thi Nhan & Thanh Cong, 2023), focusing on Vietnamese small and medium enterprises, demonstrate that more efficient firms are better positioned to manage leverage. Their use of efficiency-based measures highlights that financial performance cannot be fully understood using accounting ratios alone. This perspective helps explain why firms within the same industry may exhibit different leverage–performance relationships.

Sector-specific studies further underline the complexity of this relationship. Research on pharmaceutical firms by (Tretiakova et al., 2021) and (Khan & Chowdhury, 2018) reveal mixed effects of debt and equity on performance measures, depending on whether profitability, market valuation, or shareholder returns are considered. Such findings indicate that the choice of performance indicators plays a crucial role in shaping empirical conclusions.

From a methodological perspective, most existing studies rely on regression-based panel data models to estimate average effects of capital structure on financial performance. While these methods are valuable, they often treat financial variables independently and overlook the fact that leverage, profitability, liquidity, and firm size are closely interconnected. Studies using correlation analysis, such as (Steklá & Gryčová, 2016) and (Mireku et al., 2014), confirm negative associations between debt and profitability but do not explore how these relationships interact within a broader financial structure.

More recently, network-based approaches have gained attention for their ability to capture interdependencies within financial systems. (Sattiraju et al., 2020) apply network analysis to Indian firms and find that firms occupying more central positions tend to maintain lower debt–equity ratios. (Moghadam et al., 2019) similarly show that firms with lower debt and higher liquidity are more central within stock market networks. Studies on systemic risk and financial networks, such as (Chen et al., 2014) and (A. Chan-Lau, 2018), emphasise the stabilising role of equity capital and interconnectedness in reducing financial vulnerability.

Despite these advances, the application of network-based methods to firm-level capital structure research remains limited. Recent work by (Essa et al., 2024) show that sectors with higher network centrality in emerging economies exhibit greater resilience and higher risk-adjusted returns. (Guo and Li, 2025) demonstrate complex corporate financial networks and find that leverage and liquidity indicators act as key nodes in the transmission of financial risk and efficiency. Additional studies on corporate networks and governance further support the relevance of network structures. Research by (Otieno & Ngwenya, 2015) (Kim et al., 2023), (Steklá & Gryčová, 2015) and (Javed & Akhtar, 2012) demonstrates that interlocking relationships, ownership structures, and group affiliations significantly influence firm performance and financial behaviour. These studies underline that firms operate within interconnected systems rather than in isolation, yet such approaches have rarely been used to examine capital structure and financial performance relationships at the industry level. In particular, comparative studies especially in the Indian context focusing on capital-intensive industries such as cement and steel are scarce.

Overall, the existing literature suggests that capital structure has mixed influence on financial performance. Comparative evidence between capital-intensive industries such as cement and steel in the Indian context remains limited. The dominance of regression-based approaches, and the limited use of dynamic and correlation-based network analysis point to an important gap in the literature. Addressing this gap requires an analytical perspective that captures both interdependence among financial variables and their evolution over time. The present study contributes to this objective by employing a firm-year panel correlation framework combined with dynamic network analysis to examine and compare the cement and steel industries in India. To address these gaps, the study pursues the following objectives:

To evaluate and compare the yearly relationship between capital structure and financial performance in the Indian cement and steel industries.

To analyse and compare the overall relationship between capital structure and financial performance in the Indian cement and steel industries.

Based on the stated objectives and the evidence reviewed in the literature, the following hypotheses are formulated to guide the empirical analysis.

H01-There is no significant relationship between Debt-based capital structure (DA, DE) and financial performance in cement industry

H11- There is a significant relationship between Debt-based capital structure (DA, DE) and financial performance in cement industry

H02-There is no significant relationship between Debt-based capital structure (DA, DE) and financial performance in steel industry

H12- There is a significant relationship between Debt-based capital structure (DA, DE) and financial

performance in steel industry
H03-There is no significant relationship between Equity ratio (EA) and financial performance in cement industry
H13- There is a significant relationship between Equity ratio (EA) and financial performance in cement industry
H04-There is no significant relationship between Equity ratio (EA) and financial performance in steel industry
H14- There is a significant relationship between Equity ratio (EA) and financial performance in steel industry

3. METHODOLOGY

This study uses a quantitative research approach to examine the relationship between capital structure and financial performance in the Indian cement and steel industries. The analysis is based on firm-year panel data collected from 15 listed cement companies and 15 listed steel companies over a ten-year period from 2015 to 2024. Using firm-level data across multiple years allows the study to capture both industry differences and changes over time. The data are collected from secondary sources, including the EMIS database and published annual reports of the selected firms. The balanced panel structure ensures consistency across firms, industries, and years.

Capital structure is measured using three ratios: debt-to-asset ratio (DA), debt-to-equity ratio (DE), and equity-to-asset ratio (EA). Financial performance is evaluated through return on assets (ROA), return on equity (ROE), net profit margin (NPM), and current ratio (CR), which together reflect profitability and liquidity. Firm size, measured as the natural logarithm of total assets, is included as a control variable to account for scale differences across firms.

Variables		Ratio	Description
Capital Structure	Debt-to-Asset Ratio	Total Debt/Total Asset	Proportion of assets financed through debt
	Debt-to-Equity Ratio	Total Debt/Total Equity	Proportion of debt relative to shareholders' equity
	Equity-to-Asset Ratio	Total Equity/Total Asset	Proportion of assets financed through equity
Financial Performance	Return on Assets	Net Profit/Total Asset	Measures asset efficiency.
	Return on Equity	Net Profit / Shareholder's Equity	Reflects return to investors.
	Net Profit Margin	Net Profit/Sales	Indicates overall profitability after all expenses
	Current Ratio	Current Assets / Current Liabilities	Indicates financial liquidity.
Control Variable	Firm Size	Log of Total Assets	Controls size effect.

Table 1: Variables under Study

Source: Compiled by the Author

The analysis is carried out in two steps. First, year-wise correlation matrices are constructed separately for the cement and steel industries to examine firm-level observations for each year to know the changes in the relationship between capital structure and financial performance over time. Second, an overall correlation matrix is estimated using all firm-year observations to capture the general pattern of relationships within each industry. The Pearson correlation coefficient is calculated using the following formula:

$$r_{xy} = \frac{\sum(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum(x_i - \bar{x})^2 \sum(y_i - \bar{y})^2}}$$

To better understand the interconnections among variables, the yearly network analysis utilizes a correlation-based network from 2015-2024. Each node represents a key financial variable of capital structure and financial performance (such as-DA, DE, EA, ROA, ROE, NPM, CR and Firm Size) and the edges (the connecting lines) represent the statistically significant correlation coefficients between those variables. The thickness of edge reflects correlation strength and edge colour indicates the direction of relationships (green = positive, red = negative). A threshold value of $|r| \geq 0.2$ is applied to focus on economically relevant relationships. The analysis was conducted using Python to construct network diagram. This approach helps identify key variables and highlights structural differences between the two industries. By combining correlation analysis with network visualisation, the study provides a clear and comparative understanding of how capital structure influences financial performance in the cement and steel industries over time.

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4. ANALYSIS

4.1. Yearly Network Analysis

The Yearly Network Analysis utilizes a Correlation-Based Network from 2015-2024. Each node represents a key financial variable of capital structure and financial performance (such as- DA, DE, EA, ROA, ROE, NPM, CR and Firm Size) and the edges (the connecting lines) represent the statistically significant correlation coefficients between those variables. Threshold of 0.2 has been used for the study. The analysis was conducted using Python to construct network diagram

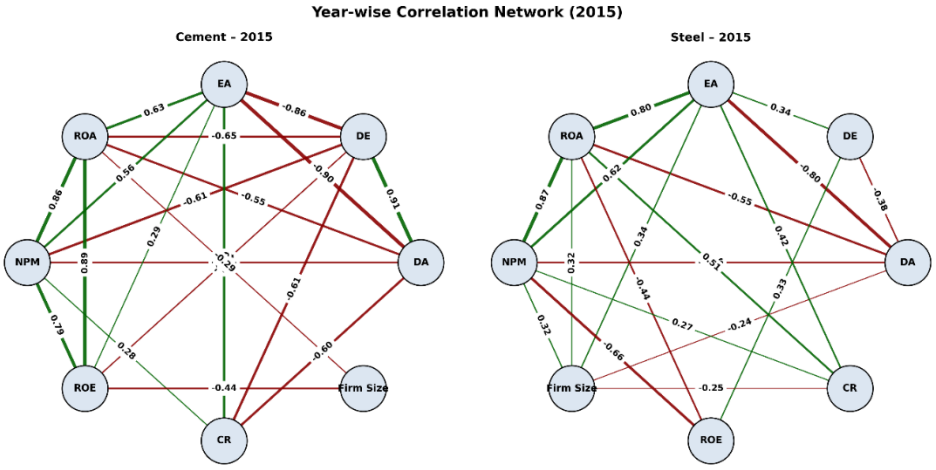


Figure 1: 2015 Network Diagram of cement and Steel Industry

Source: Python

In Figure 1, The 2015 network diagram of cement industry shows clear negative relationships between debt and profitability. DA is negatively related to ROA (–0.55), NPM (–0.48), and CR (–0.60), indicating that debt decreases profitability and liquidity , though the effects remained manageable. DE also shows negative associations with ROA (–0.65) and NPM (–0.61). In contrast, equity intensity (EA) has positive links with ROA (0.63) and NPM (0.56), suggesting that firms with more equity performed better. Profitability indicators move closely together, especially ROA–ROE (0.89) and ROA–NPM (0.86), showing consistent operating performance.

In contrast, the steel industry displays much stronger sensitivity to debt, reflecting the capital-intensive nature of the sector. DA shows sharp negative relationships with ROA (–0.55) and NPM (–0.46), highlighting significant profitability pressure from debt. A very strong negative relationship between DA and EA (–0.80) suggests that highly leveraged firms operate with much lower equity support. Whereas, equity intensity (EA) shows strong positive associations with ROA (0.80) and NPM (0.62), indicating that firms with higher equity levels perform better. Profitability indicators also move closely together, particularly ROA–NPM (0.87), reflecting consistent performance behaviour.

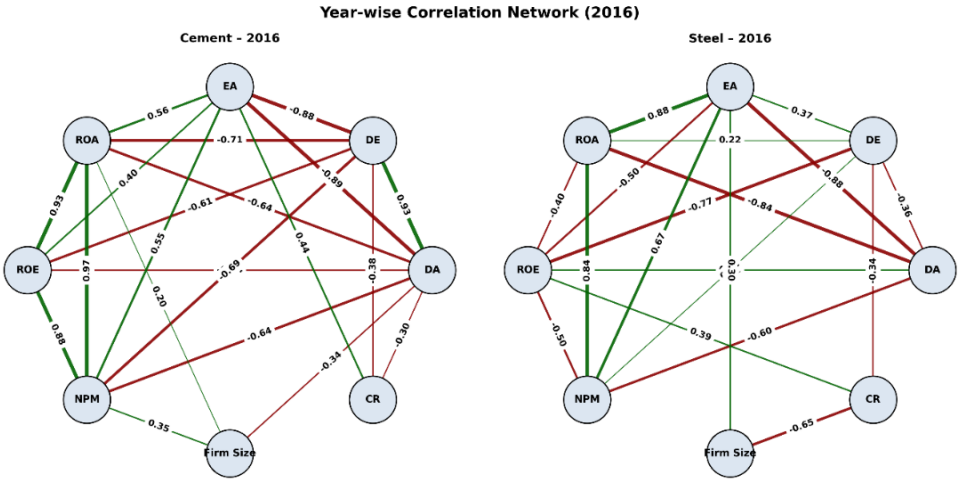


Figure 2: 2016 network Diagram of cement and Steel Industry

Source: Python

The 2016 network diagram (Figure 2) of the cement industry shows continued negative relationships between debt and profitability. DA is negatively related to ROA (-0.64), NPM (–0.64) indicating that higher debt sharply reduces profitability and liquidity compared to 2015. Similarly, the negative connection between DE and ROA (-0.71) and NPM (-0.69) is stronger than in 2015, suggesting that rising debt has greater effect on returns. At the same time, EA continuing to have positive relation with ROA (0.56), ROE (0.40), and NPM (0.55), indicating better performance among equity-financed firms.

In contrast, the steel industry shows an even stronger impact of debt on returns compared to cement. DA has a very strong negative relationship with ROA (–0.84) and NPM (–0.60), indicating that higher debt sharply reduced profitability. DA is also strongly negative with equity intensity (EA) (–0.88), indicating that highly leveraged steel industry operated with weaker equity support. On the other hand, EA maintains strong positive connections with

ROA (0.88) and NPM (0.67), suggesting that equity-based financing improved performance. Notably, DE with ROA shows a small positive relationship (0.22), indicating that firms that took on more debt relative to equity generated slightly higher returns. it implies that debt to a certain extent was being used productively to expand capacity and support output.

The 2017 analysis in Figure 3 highlights negative relationship between debt and financial performance further intensified compared to 2016 in both industries. In cement industry, DA shows stronger negative relationship with NPM (–0.81), ROA (–0.73) compared to previous year, indicating higher debt reduces profit margin. Similarly, DE maintains negative relation with ROA (–0.76), ROE (–0.55), and NPM (–0.81), indicating rising burden of debt. Liquidity also weakened, as reflected by the stronger negative DA relation with CR (–0.68), suggesting tighter cash conditions among highly leveraged firms. Whereas; equity intensity (EA) remains a positive driver of performance, showing supportive connection with ROA (0.72), ROE (0.51), and NPM (0.82)

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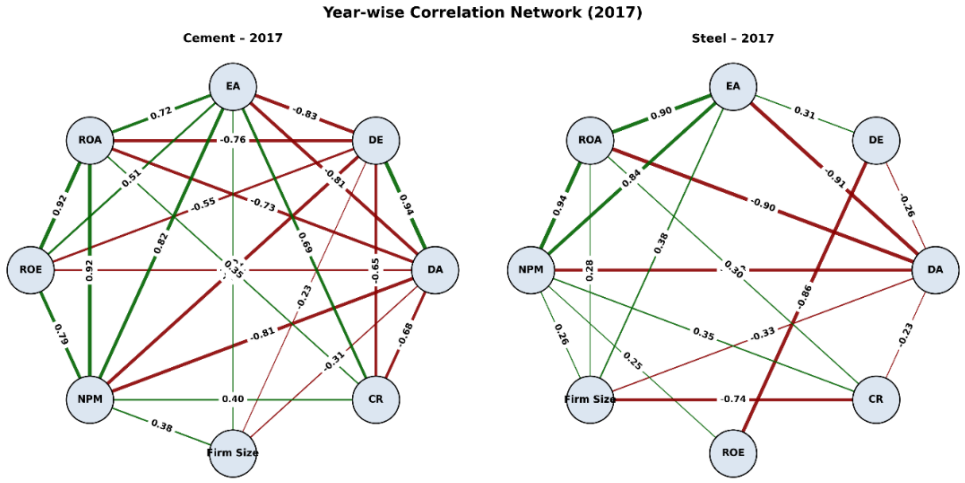


Figure 3: 2017 Network Diagram of cement and Steel Industry

Source: Python

In steel industry, the pattern of sensitivity to debt became much stronger. DA showing very strong negative correlations with ROA (–0.90) and NPM (–0.83), indicating that steel industry continued to struggle under financial pressure. DA is also heavily negative with EA (–0.91), highlighting limited equity support among more indebted firms. EA maintains strong positive links with ROA (0.90) and NPM (0.84), indicating the role of equity in driving performance. Unlike 2016, DE no longer provides any benefit and instead turns negative with ROE (–0.86), signalling rising financial pressure.

In 2018 (Figure 4), Cement industry shows that the negative effect of debt on profitability became slightly weaker compared to 2017. DA shows a smaller negative connection with ROA (–0.39), NPM (–0.63), highlighting that it continues to strongly reduce profit margins. DE also stays negative with NPM (–0.67), which means borrowing continued to reduce earnings. In contrast, equity intensity (EA) remains positive, showing better performance among firms with stronger equity support (EA–ROA = 0.45; EA–NPM=0.50). Liquidity looks marginally better than last year, with DA–CR (–0.42) improving compared to 2017.

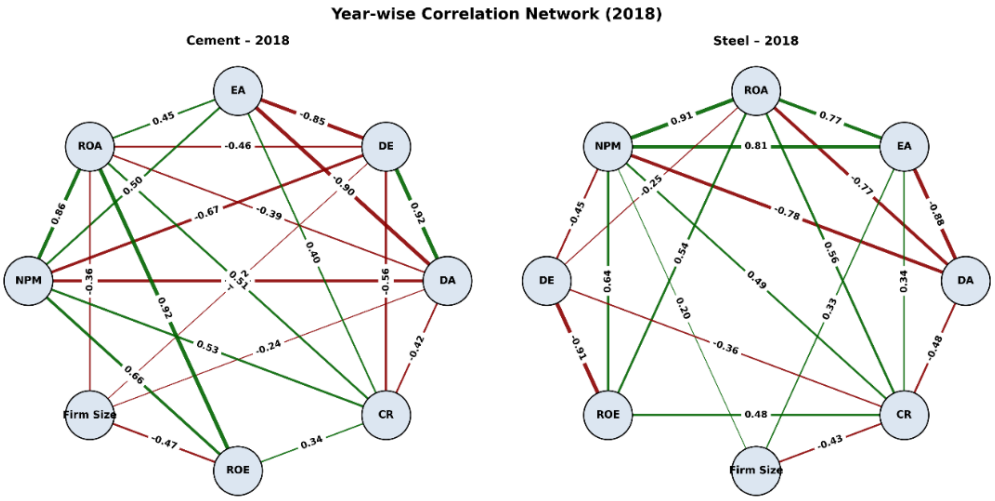


Figure 4: 2018 network Diagram of cement and Steel Industry

Source: Python

Steel industry remains highly sensitive to debt pressure in 2018. DA continues to show large negative rconnection with ROA (–0.77) and NPM (–0.78), meaning high debt firms still struggled to perform. Debt is also negatively related to equity to asset (DA–EA –0.88), showing that showing that highly leveraged firms generally operated with limited equity support. EA strongly supports ROA (0.78) and NPM (0.81), proving that equity-financed steel industry performed better. DE turns heavily negative with ROE (–0.91), showing that rising debt sharply reduced equity returns. The negative relation between DA and CR indicates that liquidity also remained under pressure (–0.48). Overall, Steel industry in 2018 shows much stronger negative relation with debt and a clearer advantage for equity-funded firms, highlighting greater financial risk and dependence on capital structure in the steel industry.

The 2019 results in Figure 5 shows that the relationship between debt and profitability weakened noticeably compared to previous years. In Cement industry, DA is slightly negative with ROA (–0.23) and NPM (–0.25), meaning that indicating that debt had very little effect on profits in 2019. EA has almost no relationship with ROA and NPM, indicating that equity structure did not play a major role in determining profitability. Liquidity shows continued sensitivity to debt, with DA and CR (–0.41) reflecting that firms carrying more debt continued to operate under limited liquidity

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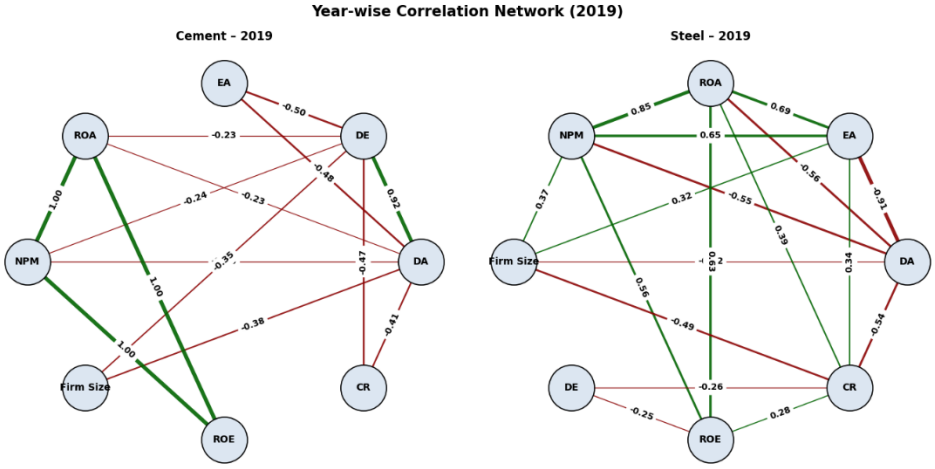


Figure 5: 2019 network Diagram of cement and steel Industry

Source: Python

In contrast, the steel industry continues to demonstrate influence of debt on financial performance, though less intense than in 2018. DA is moderately negative with ROA (–0.56) and NPM (–0.55), showing that indebted firms still faced performance pressure. EA remains strongly positive with ROA (0.69) and NPM (0.65), confirming that equity support continued to enhance profitability. Liquidity was still affected by debt, as shown by the DA–CR (–0.54), indicating that high-debt firms influence liquidity. Overall, 2019 marks a year of reduced debt sensitivity in cement industry, whereas; steel industry continues to show debt-driven performance pressure and equity supported firms

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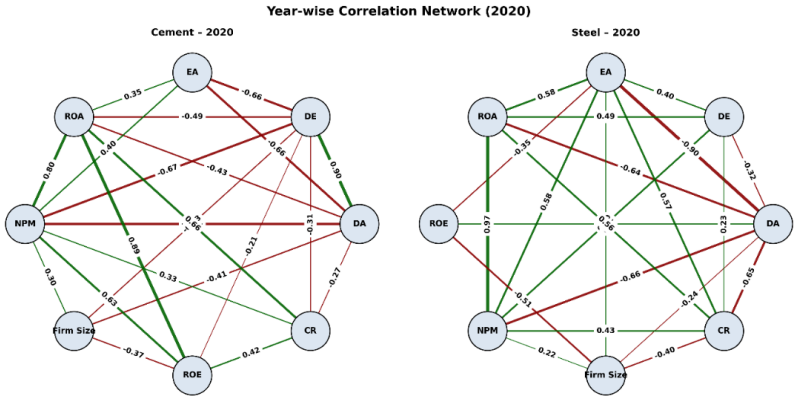


Figure 6: 2020 network Diagram of cement and steel Industry

Source: Python

Throughout 2020 (Figure 6), debt continued to play a role in shaping the financial performance of cement firms, although the degree of its influence changed compared to previous years. The DA remained negatively associated with ROA (–0.43) and more strongly with NPM (–0.69), indicating that meaning higher debt continued to reduce profitability. DE remained similarly negative with ROA (–0.49) and NPM (–0.67), suggesting that firms relying more on borrowed funds faced weaker earnings. EA still

showed a positive relation with ROA (0.35) and NPM (0.40), but the strength of this relationship was weaker than in earlier years.

The steel industry again shows a strong reaction to debt levels. DA remains negatively connected to ROA (–0.64) and more strongly with NPM (–0.66), showing profitability was still heavily pressured by leverage. DA is also having strong negative relation with EA (–0.90), indicating that highly indebted firms continued operating with weak equity. Equity intensity (EA) kept a positive association with ROA (0.58) and NPM (0.58), reinforcing that equity-financed firms performed measurably better. Notably, DE–ROA turned positive (0.49), suggesting some steel industries were able to use debt productively to support returns. DA–CR (–0.65) reveals that companies with more debt had greater cash-flow problems in 2020. Overall, cement industry showed a softer and more contained link between leverage and profitability, while steel industry remained significantly more affected by capital structure, making equity support much more crucial to performance in that industry

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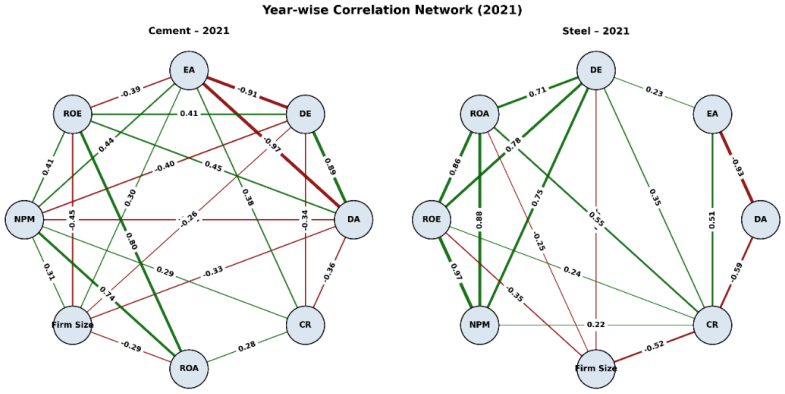


Figure 7: 2021 network Diagram of cement and steel Industry

Source: Python

The 2021 results reveal that the connection between debt levels and profitability in the cement industry was noticeably weaker. DA shows a negative association with NPM (–0.34), suggesting that debt had a much smaller effect on earnings this year. DE reflects similarly negative associations with NPM (–0.40), suggesting that the impact of debt financing on firm performance was limited. Equity intensity (EA) maintains a positive connection with performance NPM (0.44), suggesting equity-supported firms still held a performance advantage. Liquidity pressure remains noticeable, with DA–CR (–0.36) showing that firms with higher leverage continued to experience tighter cash positions.

Steel industry showed a very different pattern in 2021 compared to earlier years. The relationship of debt showed little impact on profitability. DE turned strongly positive with ROE (0.78) in 2021, suggesting higher debt was linked to better performance. EA is still heavily negative with DA (–0.93), which shows that high-debt firms had comparatively low equity support. DA–CR (–0.59) shows that companies with more debt faced tighter cash flow. Overall, 2021 represented a shift in trend: cement industry became less influenced by capital structure, while steel industry showed signs of benefiting from leverage, indicating a short-term recovery effect.

The 2022 results in (Figure 8) show that both industries continue to experience negative leverage performance relationships, although the effect is considerably stronger in the steel industry. Cement industries show moderate sensitivity to debt. DA remained negative with ROA (–0.32) and stronger with NPM (–0.47), indicating that debt continued to reduce profitability. DE is also negatively related with ROA (–0.39) and NPM (–0.51), meaning debt still put pressure on profitability. Equity to asset (EA) continued to remain positive as EA–ROA (0.30) and EA–NPM (0.62), suggesting equity-backed firms performed better.

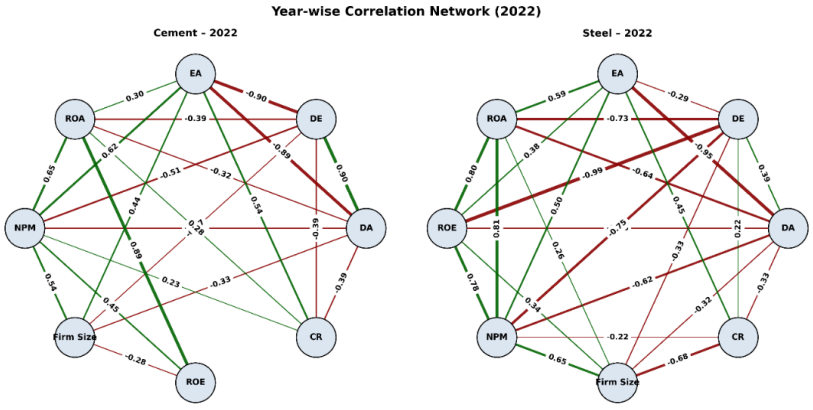


Figure 8: 2022 network Diagram of cement and steel Industry

Source: Python

Steel industry faces substantial profitability and liquidity pressures from debt, due to the risks associated with excessive debt in a capital-intensive sector. DA is strongly negative with ROA (–0.64) and NPM (–0.62), and DA–EA (–0.95) indicates heavy debt industries experienced weaker financial performance and lower equity strength. overall, capital structure mattered more for steel industries than cement industries, with steel firms showing a much clearer performance divide based on debt versus equity financing.

The 2023 results highlight that the debt continued to have a negative relationship with financial performance. In cement industry, DA shows clear negative connection with ROA (–0.57) and NPM (–0.66), and DE reflects a similar pattern from previous year (–0.62, –0.61), indicating firms that relied more on debt earned lower returns. EA remains positive with ROA (0.59), showing equity-backed firms performed better. Liquidity was not heavily impacted, with DA–CR only mildly negative (–0.25).

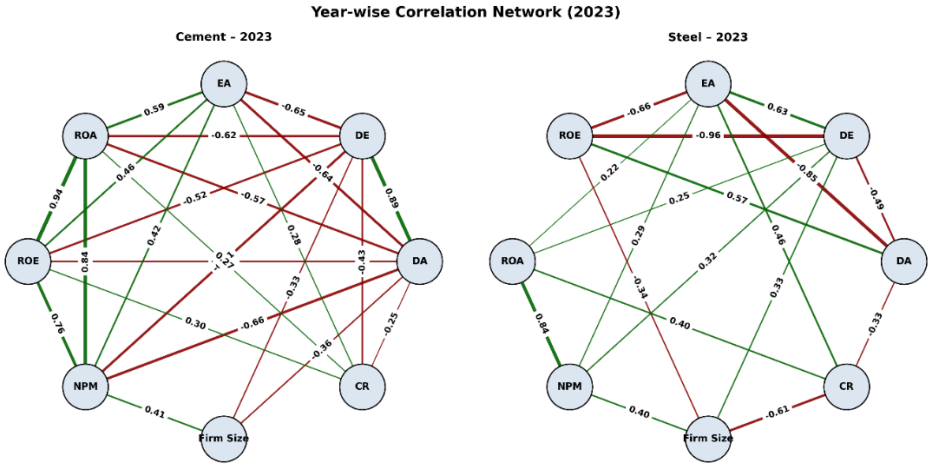


Figure 9: 2023 network Diagram of cement and steel Industry

Source: Python

In steel industry, Debt had a weaker effect than in prior years. DA has slightly negative relation with ROA (–0.08) and NPM (–0.19). DE has positive relation with ROA (0.25) but sharply negative relation with ROE (–0.96), meaning more debt improved output but lowered equity return. EA remains positive (EA–ROA=0.22). Liquidity pressure continues between DA and CR (–0.33). Overall in 2023, debt had a bigger impact on cement industry than steel industry, as cement industry performance dropped more noticeably while steel industry results were more balanced.

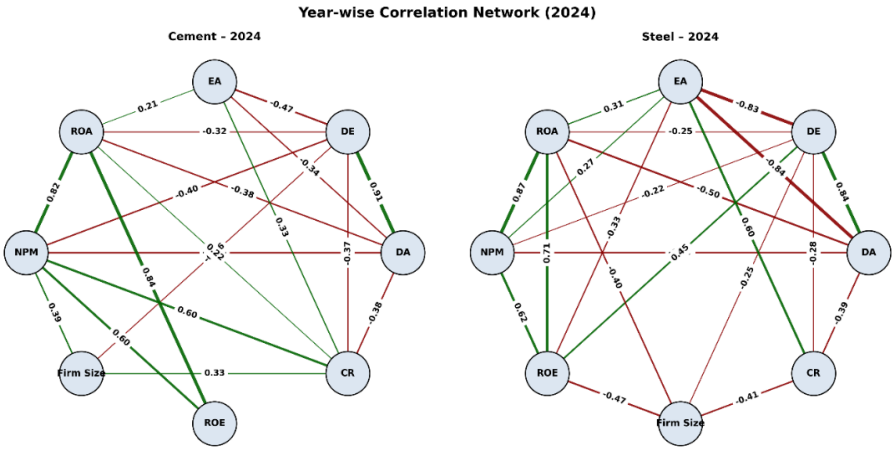


Figure 10: 2024 network Diagram of cement and steel Industry

Source: Python

The 2024 findings reinforce the well-established pattern across both industries. Cement industry continue to experience moderate negative effects of debt on financial performance. DA is moderately negative with ROA (–0.38) and NPM (–0.45), showing that leverage continued to reduce returns. DE shows a similar pattern with ROA (–0.32) and NPM (–0.40). EA showed only a mild positive association with ROA (0.21), indicating that equity contributed less to performance this year. Liquidity remained moderately sensitive to debt, with DA–CR (–0.38) indicating that firms carrying more debt still faced tighter working capital conditions.

Steel industry continued to demonstrate a clearer divide in performance based on capital structure. DA is moderately negative with ROA (–0.50) and NPM (–0.46), suggesting

leverage continued to have influence on financial results. DE gives a mixed outcome, showing negative relation with ROA (–0.25) and NPM (–0.22) and a positive association with ROE (0.45), implying that higher borrowing corresponded with stronger returns to equity holders. EA is still positive with ROA (0.31), but its influence on performance is weaker than before. Liquidity was again affected by leverage, shown by DA–CR (–0.39). Overall, 2024 marks another year in which capital structure plays a decisive role in shaping firm performance, with steel industries affected more intensely than cement industries.

4.2. Trend-Based Interpretation of Network Analysis (2015–2024)

A detailed review of the yearly network diagrams shows that the relationship between capital structure and financial performance changes over time in both industries. Based on the pattern of results, the entire period from 2015 to 2024 can be divided into three phases according to how debt influences performance.

Phase I (2015–2017): Rising Debt Pressure

In this phase, both industries, especially the steel industry, show a strong and increasing negative relationship between debt (DA, DE) and profitability (ROA, NPM). The connections between variables also appear stronger, indicating that financial factors were closely linked with each other. This suggests that higher use of debt created greater financial pressure, particularly in steel firms where capital requirements and costs are relatively high.

Phase II (2018–2020): Adjustment Period

During this period, the negative effect of debt on performance becomes relatively weaker, especially in the cement industry. Although debt continues to affect profitability, its impact is less severe compared to earlier years. This indicates some level of financial adjustment and better management of debt. However, the steel industry still shows a noticeable sensitivity to leverage, suggesting continued dependence on external financing.

Phase III (2021–2024): Recovery and Mixed Leverage Effects

In the later years, the relationship between capital structure and performance shows some changes. In certain cases, particularly in the steel industry, debt shows a mixed impact and even a positive relationship with some indicators like ROE. This may indicate that firms started using debt more efficiently during the recovery period. At the same time, equity (EA) continues to show a positive and stabilizing effect in both industries. The overall network becomes less negative, suggesting a more balanced financial structure.

Overall, the analysis shows that the effect of capital structure is not constant over time. The impact of debt varies across different periods depending on industry conditions, while equity remains a stable and supportive source of financing throughout the study period.

4.3. Overall Correlation Matrix

The ten-year network analysis indicates that capital structure plays a substantial role in shaping financial performance across both the cement and steel industries in India. Although debt generally corresponds with weaker performance in both sectors, the magnitude of this effect varies distinctly.

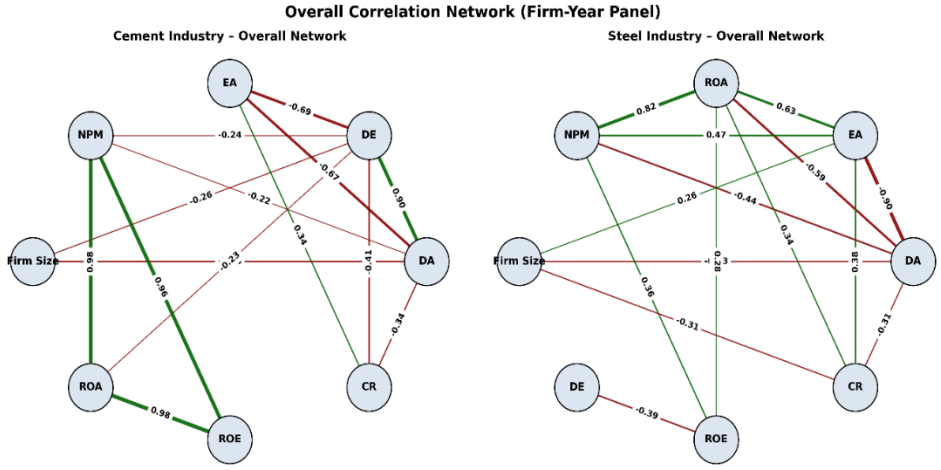


Figure 11: Overall network Diagram of cement and steel Industry

Source: Python

In the cement industry, DE show moderate negative relation with ROA (–0.23) over the decade, suggesting that the use of debt tends to reduce returns, though the impact is not severe. Liquidity has negative relation between DA and CR (–0.34), indicating that debt gradually tightens working capital. In contrast, EA provides mild but consistent support to financial performance, while profitability indicators move almost perfectly together (ROA–ROE is 0.98; ROA–NPM is 0.98), reflecting a stable and predictable performance structure. Firm Size shows only small negative relations with profitability and leverage, suggesting scale did not significantly alter financial outcomes. Overall, the cement industry maintains a stable financing profile, where leverage weakens performance slowly and equity offers steady support.

The steel industry displays a stronger capital-structure relation with financial performance. DA is strongly negative with ROA (–0.59) and NPM (–0.44), and highly negative with EA (–0.90), indicating that heavily indebted steel firms operate with reduced profitability and usually

lack strong equity backing. EA has positive relation with ROA (0.63) and NPM (0.47) which indicate that equity-backed firms are better positioned to sustain profitability. Liquidity also shows sensitivity between DA and CR (–0.31), suggesting that higher leverage is associated with tighter cash-flow conditions. Overall, the network pattern indicates that changes in one aspect of performance tend to transmit rapidly to others within steel industry.

Comparatively, the steel industry is more debt-vulnerable and its outcomes are more dependent on capital structure, while the cement industry displays a more stable and have controlled financial structure. Equity helps both industries, but it is especially important for steel firms.

4.4. Partial correlation Network

To further examine the relationships among capital structure, financial performance, and firm size, partial correlation analysis was conducted. Unlike simple correlation, partial correlation measures the relationship between two variables while controlling for the influence of other variables in the model. This approach helps in identifying the direct association between variables by removing the effect of confounding factors. The analysis was carried out using the same set of variables, including capital structure indicators (DA, DE, EA), financial performance measures (ROA, ROE, NPM, CR), and firm size. The resulting partial correlation matrix provides a refined view of the relationships by isolating the net effect of each variable.

	Cement Industry				Steel Industry			
Variable	ROA	ROE	NPM	CR	ROA	ROE	NPM	CR
DA	-0.23	-0.10	-0.20	-0.34	-0.59	-0.05	-0.42	-0.41
DE	-0.26	-0.14	-0.23	-0.41	0.03	-0.40	0.01	-0.02
EA	0.15	0.06	0.14	0.34	0.64	0.03	0.45	0.49

Table 2: Partial Correlation Matrix

Source: Compiled by Author

Based on the partial correlation matrix, a network diagram was constructed using a threshold of 0.2 to highlight only meaningful relationships. The diagram provides a simplified representation of the direct connections among variables.

The partial correlation results (Figure 12) show the direct relationship between capital structure and financial performance after controlling for other factors. In the **Cement industry**, debt shows a moderate negative relationship with performance. DA is negatively associated with ROA (–0.23) and NPM (–0.20), while DE also shows negative relationships with ROA (–0.26) and NPM (–0.23). Both DA and DE are negatively related to liquidity, with DA–CR (–0.34) and DE–CR (–0.41). Equity (EA) shows a positive relationship with ROA (0.15), NPM (0.14), and CR (0.34), indicating a supportive role.

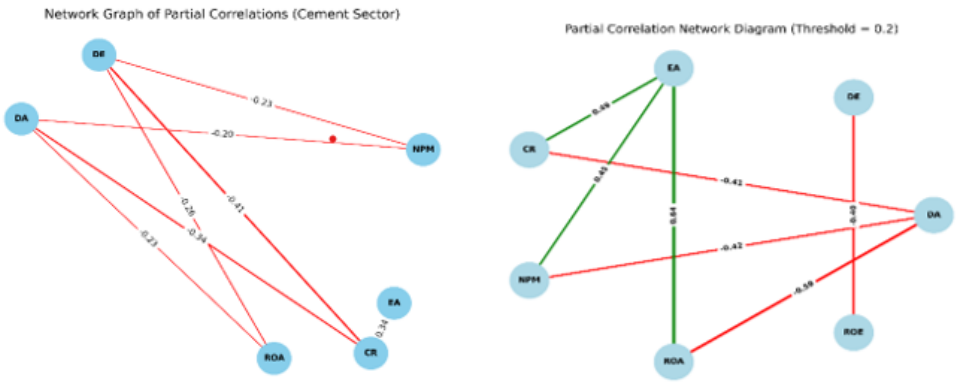


Figure 12: Network graph of partial correlation of cement and steel Industry
Source: Python

In the **Steel industry**, the negative relationship is stronger. DA shows a strong negative association with ROA (–0.59), NPM (–0.42), and CR (–0.41). DE shows very weak relationships with ROA (0.03) and NPM (0.01), but a negative relationship with ROE (–0.40). Equity (EA) shows strong positive relationships with ROA (0.64), NPM (0.45), and CR (0.49).

Overall, leverage is negatively associated with financial performance in both industries, with a stronger relationship in steel, while equity is positively associated with performance in both sectors.

4.5. Centrality Weight for the Overall Network

The following table summarizes the key correlation-based relationships used in Figure 11, highlighting the importance (centrality) of each variable within the overall decade-long study (2015–2024).

Variable Node	Cement Industry Weight/Role	Steel Industry Weight/Role
DA	Moderate negative influence on profitability and liquidity.	Strong negative effect on financial performance.
DE	Moderate negative relation with profitability.	Limited direct association with performance.
EA	Provides steady support to performance and liquidity	Contributes to more stable performance
Profitability (ROA/NPM)	Highly interconnected and move together.	Highly sensitive; Profitability indicators are closely linked.
Firm Size	Low centrality; small relations with other variables.	Low centrality; scale did not significantly alter outcomes.

Table 3: Centrality Weight of Cement and Steel Industry

Source: Compiled by the Author

As illustrated in the above Table 3, the centrality weight of debt-based variables (DA and DE) is significantly higher in the steel industry network compared to the cement industry. This indicates that for steel industry, capital structure is not just a secondary factor but a central determinant that rapidly transmits financial shocks across the network.

The correlation-based importance reflected in the overall network supports the visual patterns observed in the network diagrams. In the steel industry, the strong negative influence associated with the Debt-to-Asset (DA) variable suggests that higher leverage is closely linked with weaker profitability and reduced equity support. In contrast, the cement industry displays a more decentralised risk structure. Although debt remains relevant, its influence on performance is weaker and more dispersed, indicating a greater capacity among cement firms to absorb leverage without immediate deterioration in financial outcomes.

Equity plays a supportive role in both industries; however, its importance is substantially greater in the steel sector, where it contributes critically to maintaining financial stability under high leverage conditions. Overall, the empirical evidence from the dynamic network analysis indicates that the steel industry is significantly more debt-sensitive and volatile than the cement industry. This divergence can be linked to the fundamental operational differences noted in the introduction: while cement producers enjoy more predictable demand patterns linked to local infrastructure, steel firms are perpetually exposed to global price fluctuations and raw-material cost volatility.

In the steel industry's network, the strong negative correlation between debt (DA) and profitability (ROA) reflects a 'magnified risk'. Given the steel sector's sensitivity to business cycles, a high-leverage structure leaves these firms with little margin to absorb economic shocks, leading to the rapid transmission of financial instability across the network. Conversely, the 'stable network' observed in the cement industry suggests that its predictable revenue streams allow for more effective debt management. For cement firms, debt acts as a manageable tool for growth, whereas for steel firms, it functions as a key source of financial vulnerability.

5. POLICY RECOMMENDATIONS

The findings of this study provide practical guidance for managing the cement and steel industries. Since they react differently to debt, different financial strategies are required.

In the steel industry, financial performance is highly sensitive to debt and global price changes. The network analysis shows that debt-driven risks spread very quickly in this sector. As a result, steel firms should be cautious towards borrowing. Managers in the steel industry should set a limit on how much they can borrow. Maintaining a large "equity safety buffer" is particularly important. This buffer acts as a shield when global prices fall. It prevents the company from becoming weak during tough times.

On the other hand, cement industries have more stable demand. They can handle moderate debt without losing much profit. However, it is essential to manage their cashflow effectively, as rising debt levels are still associated with tighter working capital conditions.

Across both sectors, debt should be employed selectively and primarily for productive investment. While leverage has supported expansion in certain periods, the network evidence shows that poorly timed or excessive borrowing can rapidly weaken financial stability. Continuous monitoring of financial interdependencies is therefore essential to ensure that borrowing decisions are aligned with long-term performance objectives.

6. CONCLUSION

This study provides a comprehensive examination of the relationship between capital structure and financial performance in the Indian cement and steel industries. Using a decade of firm-level data (2015–2024) and applying a correlation-based network approach, the study explored how debt, equity, profitability, liquidity, and size interact with each other. The results demonstrate that capital structure plays a significant and industry-specific role in shaping financial outcomes. Across both sectors, higher leverage measured through the debt ratio (DA) and debt-equity ratio (DE) is generally negatively associated with profitability and liquidity (ROA, ROE, NPM, CR), although the extent of this relationship varies.

Further, the partial correlation analysis, conducted after controlling for firm size, confirms that these relationships remain largely consistent, indicating that the observed associations are direct and not significantly influenced by firm size. This strengthens the reliability of the results and highlights that capital structure itself is a key determinant of financial performance.

Cement industry displays a moderate and comparatively stable sensitivity to debt, suggesting more effective debt management and relatively stable financing behaviour. Although is negatively associated with profitability, the effect occurs gradually, suggesting that most cement industries typically operate with debt levels within their capacity. The partial correlation results also show only slight changes in magnitude, indicating that the relationships in the cement industry are partly influenced by indirect factors but remain relatively stable. In contrast, steel industry reveals a stronger and more persistent negative debt–performance pattern, reflecting the financial pressures associated with high capital requirements and fluctuating demand. The partial correlation findings further reinforce that these negative relationships in the steel industry are strong and direct, particularly between debt and profitability indicators. Equity-based financing consistently supports better financial outcomes in both sectors, emphasising its role in enhancing financial strength. Network diagram further illustrates these differences: steel industry shows tighter and stronger negative debt relation, while cement industry shows milder and more scattered relationships.

Overall, the finding indicates that while capital structure is a critical determinant of financial performance in both industries, the steel industry is considerably more vulnerable to leverage. Cement industry can generally operate with moderate levels of debt without major decline to performance, whereas; steel industry needs to adopt tighter leverage controls to protect their financial stability. These industry-specific insights offer practical guidance for corporate managers, investors, and policymakers seeking to optimise financing decisions and promote sustainable growth. Future research could expand this work by integrating macroeconomic indicators; qualitative firm attributes, or advanced productivity models to further strengthen understanding of capital structure dynamics in heavy industries. This study provides a deep look into how capital structure affects the Indian cement and steel industries. By using a decade of data and network analysis, we show how debt, equity, and profit interact. The results prove that the way a company is financed is a key driver of its success.

Across both sectors, higher debt usually leads to lower profits and less cash on hand. However, the impact is not the same for everyone. The cement industry is more stable and manages its debt well. Even when debt increases, the drop in profit is slow and manageable. This industry can handle moderate borrowing because its demand is predictable. The steel industry tells a different story. It shows a much stronger negative link between debt and performance. Because steel firms face high costs and global price changes, they are more vulnerable to financial risk. For these firms, having strong equity is the best way to stay healthy and profitable.

As suggested in the policy recommendations, steel firms must keep a "safety buffer" of equity to survive market swings. Meanwhile, cement firms should focus on balancing growth with steady cash flow. These industry-specific insights help managers and investors make better financial choices. Future studies could look at how the wider economy or new technology affects these heavy industrie

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