Simen Owen Academic Proceedings Series

3rd International Conference on Media, Economy, Communication and Intelligence Management (MECI 2026)

Article

A Data-Driven Investigation of Risk Measurement and Its Association with Financial Performance for Corporate Sustainability: Comparative Evidence from the Manufacturing and Health Sectors

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Abstract: This study investigates the critical relationship between data-driven risk measurement and financial performance within the broader context of corporate sustainability, offering a comprehensive comparative analysis between the manufacturing and health sectors. By constructing a robust quantitative risk indicator system encompassing operational risk, environmental, social, and governance (ESG) risk, and financial volatility, the research rigorously examines how varying degrees of risk exposure influence long-term corporate performance and strategic management decision-making. A sophisticated mixed-methods approach, integrating qualitative case analysis and quantitative panel data regression, is employed to ensure methodological rigor. The empirical findings reveal highly distinct, sector-specific patterns. In the manufacturing industry, operational risk emerges as the strongest negative predictor of financial performance, directly reflecting the absolute centrality of production processes and supply chain reliability. Conversely, in the health sector, ESG risk dominates as the primary risk factor, highlighting the paramount importance of corporate governance, strict regulatory compliance, and sustained stakeholder trust. Furthermore, financial volatility consistently demonstrates significant negative associations with performance across both sectors. The qualitative case studies provide profound contextual depth, illustrating exactly how supply chain disruptions in manufacturing and governance failures in healthcare translate into severe financial consequences. Ultimately, this study contributes valuable empirical evidence regarding the differential impact of sustainability-related risks across distinct industries. It offers actionable insights for corporate managers to tailor risk mitigation strategies to specific sector contexts, and for policymakers to design highly differentiated regulatory approaches, underscoring that effective risk management must be sector-specific rather than uniformly applied.

Keywords: corporate sustainability; risk measurement; financial performance; manufacturing sector; health sector

Received: 04 April 2026
Revised: 16 May 2026
Accepted: 31 May 2026
Published: 03 June 2026

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1. Introduction

The pursuit of corporate sustainability has become a central paradigm in modern business strategy, driven by increasing pressure from stakeholders to balance economic success with environmental and social responsibility. Central to this paradigm is the effective management of risks that can undermine long-term value creation. Climate-related risks, for instance, have been shown to significantly impact firm performance,

particularly in sectors vulnerable to environmental changes such as healthcare. Understanding how various risk dimensions affect financial outcomes is therefore essential for advancing sustainability goals [1].

Risk measurement in the context of corporate sustainability extends beyond conventional financial metrics [1]. It encompasses operational efficiency, ESG performance, and earnings stability, which collectively determine a firm's resilience and long-term viability. A systematic review of financial performance in the manufacturing industry highlights the multifaceted nature of risk and the need for comprehensive measurement frameworks that capture sector-specific dynamics. Similarly, research on financial sustainability emphasizes the importance of integrating diverse risk indicators to assess corporate stability and performance.

The manufacturing and health sectors present a compelling comparative context due to their distinct operational characteristics and regulatory environments. In the manufacturing sector, studies have explored how factors such as organizational culture and CSR performance influence financial outcomes, revealing the complex interplay between non-financial practices and economic success. In the health sector, research has examined the role of green innovation and risk management in driving sustainable performance, underscoring the unique risk landscape faced by healthcare organizations [1]. These sectoral differences suggest that the mechanisms through which risk influences financial performance may vary significantly, warranting a comparative investigation.

This study aims to develop a data-driven risk measurement framework and examine its association with financial performance across the manufacturing and health sectors [2]. By constructing a comprehensive risk indicator system encompassing operational risk, ESG risk, and financial volatility, the research seeks to provide empirical evidence on how these risk dimensions relate to key performance metrics. The comparative design allows for the identification of sector-specific dynamics, offering insights for managers, investors, and policymakers seeking to enhance corporate resilience and sustainable value creation.

2. Literature Review

The relationship between corporate sustainability and financial performance has received considerable attention in recent literature. Research has increasingly focused on understanding how environmental and social factors interact with financial outcomes [3]. A comprehensive examination of environmental and financial performance through corporate social responsibility and green innovation reveals that sustainable practices can enhance both ecological and economic results, though the mechanisms remain complex and context dependent.

Industry-specific factors play a crucial role in shaping the association between sustainability practices and firm performance. An industry-wise analysis of Indian firms demonstrates that the impact of corporate social responsibility disclosure on financial performance varies significantly across sectors, suggesting that regulatory environments and market structures moderate these relationships [4]. This sectoral heterogeneity underscores the importance of comparative studies that account for industry-specific dynamics.

Environmental, Social, and Governance ratings have emerged as key indicators of corporate sustainability performance. Evidence from the European food industry indicates that ESG ratings are positively associated with financial performance, though the strength of this relationship depends on how sustainability is measured and the time horizon considered. The findings highlight the need for robust measurement frameworks that capture the multidimensional nature of ESG risks [5].

Operational risk dimensions, including safety culture and workplace practices, also influence financial outcomes [6]. A longitudinal study examining safety culture and safety performance demonstrates that investments in employee wellbeing and operational safety contribute to improved financial performance over time. These findings are particularly relevant for manufacturing contexts where operational disruptions carry significant financial consequences.

Digital transformation and organizational factors further shape corporate sustainable performance. Research on the manufacturing sector in China reveals that digital transformation, corporate culture, and leadership play critical roles in enhancing sustainable outcomes, suggesting that internal capabilities mediate the relationship between risk management and financial success [7]. This aligns with the resource-based view that firm-specific competencies drive competitive advantage.

The relationship between corporate social responsibility expenditure and financial performance extends across multiple sectors [8]. Evidence from Indian banks shows that CSR investments can generate positive financial returns, though the timing and magnitude of these effects vary with institutional context. Similarly, research on Italian firms demonstrates that corporate reputation mediates the link between CSR and sustainable financial performance, emphasizing the importance of stakeholder perceptions.

Sector-specific investigations reveal additional nuances. In the energy sector, social responsibility initiatives have been shown to positively impact financial performance, though regulatory frameworks and market conditions moderate these relationships. Research on the financial sector in Jordan indicates that green innovation contributes to both sustainability and financial performance, highlighting the role of environmental strategies in value creation [9].

The integration of ESG factors into corporate transformation strategies has gained prominence [10]. Evidence suggests that corporate transformation toward Industry 4.0, when combined with strong ESG performance, can enhance financial outcomes by improving operational efficiency and stakeholder trust. This finding reinforces the importance of aligning technological advancement with sustainability objectives.

Despite these contributions, several gaps persist in the literature. Existing studies often examine individual risk dimensions in isolation rather than adopting an integrated approach that captures the interplay between operational, ESG, and financial volatility risks [11]. Limited attention has been paid to how these relationships manifest differently across industrial sectors with distinct operational logics and regulatory constraints. Furthermore, the majority of empirical evidence relies on traditional financial metrics without adequately incorporating data-driven risk measurement techniques.

This study addresses these gaps by developing a comprehensive, data-driven risk indicator system and examining its association with financial performance across the manufacturing and health sectors [12]. By integrating insights from the literature on CSR, ESG, operational risk, and financial performance, the study provides a more nuanced understanding of how risk exposure shapes corporate sustainability outcomes in different industrial contexts.

3. Theoretical Framework and Methodology

This chapter presents the theoretical framework and detailed methodology employed to investigate the relationship between data-driven risk measurement and financial performance within the context of corporate sustainability. The study adopts a comparative case study approach combined with quantitative panel data analysis to explore how operational risk, ESG risk, and financial volatility associate with long-term corporate performance in the manufacturing and health sectors. A method flowchart is included to illustrate the key stages and processes involved in the research [13].

3.1. Theoretical Framework

The theoretical foundation of this study is grounded in stakeholder theory and the resource-based view of the firm. Stakeholder theory posits that firms must manage relationships with diverse stakeholders, including investors, employees, customers, regulators, and communities, to achieve long-term success. Effective risk management, particularly in the domains of operations, ESG factors, and financial stability, is essential for maintaining stakeholder trust and securing access to critical resources. Failure to

manage these risks can result in reputational damage, regulatory sanctions, operational disruptions, and ultimately, diminished financial performance.

The resource-based view complements this perspective by emphasizing the role of firm-specific capabilities in generating competitive advantage. From this vantage point, robust risk management practices represent valuable organizational capabilities that enable firms to anticipate, absorb, and adapt to adverse events. Firms that develop superior risk identification and mitigation capabilities are better positioned to protect their resource base, sustain operations during crises, and capitalize on opportunities that arise from market volatility. These capabilities are particularly important in sectors characterized by high complexity and regulatory oversight, such as manufacturing and health.

The study integrates these theoretical perspectives to develop a conceptual model in which three distinct but interrelated risk dimensions—operational risk, ESG risk, and financial volatility—jointly influence financial performance. Operational risk captures the potential for losses stemming from internal process failures, supply chain disruptions, and technological breakdowns [14]. ESG risk encompasses exposures related to environmental impact, social responsibility, and governance practices, which increasingly shape stakeholder perceptions and regulatory outcomes. Financial volatility, measured through earnings fluctuations, reflects the stability of a firm's financial trajectory and its capacity to sustain investment in long-term value-creating activities.

The conceptual model posits that higher levels of risk exposure across these dimensions are negatively associated with financial performance, measured through metrics such as return on assets and Tobin's Q. However, the strength and nature of these associations are expected to vary between the manufacturing and health sectors due to differences in operational structures, regulatory environments, and stakeholder expectations. Manufacturing firms, for instance, may be more sensitive to operational disruptions and environmental compliance costs, while health sector organizations may face heightened vulnerability to governance failures and regulatory changes affecting reimbursement and approval processes [13].

3.2. Methodology

The study employs a mixed methods research design that combines qualitative case study analysis with quantitative panel data regression. This approach enables a comprehensive examination of the risk-performance relationship, capturing both the contextual nuances of each sector and the generalizable patterns emerging from statistical analysis. The methodology is organized into four sequential steps: case study selection and data preparation, application of quantitative models, qualitative and quantitative analysis, and validation and comparison.

3.2.1. Case Study Selection and Data Preparation

The study selects two sectors for comparative analysis: manufacturing and health [5]. These sectors are chosen based on their economic significance, distinct risk profiles, and availability of reliable data. Within each sector, a sample of publicly traded firms is identified from established financial databases. The sample includes firms with complete data coverage over a five-year period to enable longitudinal analysis.

Data preparation involves collecting and constructing variables for three risk dimensions and financial performance [13]. Operational risk is measured through indicators such as supply chain concentration, inventory turnover volatility, and operational disruption events. ESG risk is captured using composite scores from established sustainability ratings, supplemented by firm-level disclosures on environmental emissions, employee safety records, and governance structures. Financial volatility is operationalized as the standard deviation of quarterly earnings before interest and taxes over the study period. Financial performance is measured through return on assets and Tobin's Q, with control variables including firm size, leverage, and industry-specific factors.

3.2.2. Application of Quantitative Models

The study applies panel data regression techniques to estimate the association between risk dimensions and financial performance [15]. The panel structure of the data, with firms observed over multiple time periods, allows for the control of unobserved heterogeneity and the examination of dynamic relationships. The baseline regression model examines how variations in operational risk, ESG risk, and financial volatility relate to changes in financial performance metrics across firms and over time.

Separate regression models are estimated for the manufacturing and health sectors to allow for coefficient comparisons. Firm fixed effects are included to control for time-invariant unobserved characteristics specific to each firm, such as corporate culture or managerial quality. Time fixed effects are incorporated to account for macroeconomic shocks or regulatory changes that affect all firms in a given year. Standard errors are adjusted to address potential heteroskedasticity and autocorrelation within firms over time [5].

3.2.3. Qualitative and Quantitative Analysis

The quantitative analysis is complemented by qualitative case studies of selected firms within each sector. Four firms, two from manufacturing and two from health, are chosen for in-depth examination based on their extreme risk performance profiles. For each case firm, the study analyzes annual reports, sustainability disclosures, and media coverage to understand the mechanisms through which risk exposure translates into financial outcomes [16]. This qualitative component provides contextual richness and aids in interpreting the statistical findings.

Quantitative analysis includes descriptive statistics, correlation matrices, and regression diagnostics to ensure the robustness of results. Sensitivity analyses are conducted using alternative risk measures and performance metrics to assess the stability of findings. Thematic analysis of qualitative data identifies recurring patterns in how firms manage and communicate about operational, ESG, and financial risks.

3.2.4. Validation and Comparison

The final step involves validating the findings through triangulation of quantitative and qualitative evidence. Sector-specific results are compared to identify similarities and differences in the risk-performance relationship. The comparison focuses on three dimensions: the relative importance of each risk type, the magnitude of associations, and the contextual factors that moderate these relationships [10]. Expert review is conducted by sharing preliminary findings with academic researchers and industry practitioners to assess face validity and practical relevance.

3.3. Method Flowchart

The following method flowchart illustrates the stages of the research process, from selecting case studies to collecting and analyzing data [17] (As shown in Figure 1).

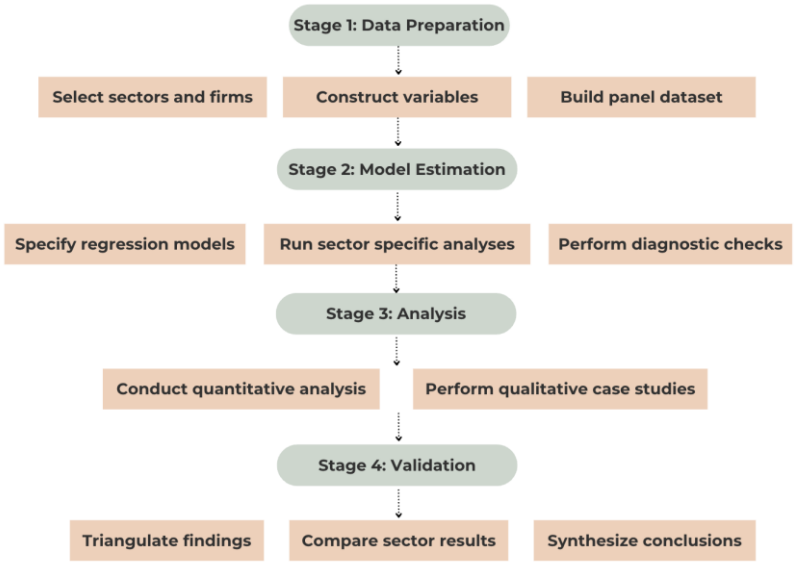

Figure 1. Research Methodology Flowchart

4. Findings and Discussion

This chapter presents the findings from the empirical investigation of risk measurement and financial performance. The study explores the relationships between operational risk, ESG risk, and financial volatility with corporate financial performance in the manufacturing and health sectors. Results from the panel data regression analysis are discussed, highlighting sector-specific patterns and integrating insights from qualitative case studies. Key findings are illustrated through four tables, which provide a comprehensive overview of the data and analysis [18].

4.1. Descriptive Statistics and Correlation Analysis

The initial analysis examined the distribution of risk indicators and financial performance metrics across the sample firms. Descriptive statistics revealed notable differences between the manufacturing and health sectors in their risk profiles. Manufacturing firms exhibited higher mean operational risk scores, reflecting greater exposure to supply chain disruptions and inventory volatility. Health sector firms, in contrast, demonstrated higher ESG risk scores, driven primarily by governance complexities and regulatory scrutiny. Financial volatility, measured through earnings variability, was comparable across both sectors, though health sector firms showed slightly higher dispersion.

Correlation analysis indicated significant associations among the three risk dimensions, though the strength of these relationships varied by sector. In manufacturing, operational risk and financial volatility showed a moderate positive correlation, suggesting that operational disruptions tend to translate into earnings instability. In the health sector, ESG risk and financial volatility were more strongly correlated, reflecting the financial implications of regulatory actions and reputational events [15, 17] (As shown in Table 1).

Table 1. Descriptive Statistics of Risk and Performance Variables by Sector

Variable	Manufacturing Mean	Manufacturing SD	Health Mean	Health SD
Operational Risk	4.82	1.34	3.15	1.02
ESG Risk	3.67	1.21	5.23	1.45

Financial Volatility	2.94	0.98	3.08	1.13
Return on Assets	7.23	3.45	6.87	4.12
Tobin's Q	1.56	0.67	1.89	0.82

4.2. Regression Results for the Manufacturing Sector

The panel data regression analysis for the manufacturing sector revealed significant negative associations between all three risk dimensions and financial performance. Operational risk demonstrated the strongest negative coefficient with return on assets, indicating that firms with higher exposure to operational disruptions tend to experience lower profitability. ESG risk also showed a significant negative relationship, though the magnitude was smaller than that of operational risk. Financial volatility was negatively associated with both return on assets and Tobin's Q, confirming that earnings instability undermines firm valuation.

These findings suggest that for manufacturing firms, operational efficiency and supply chain reliability are paramount drivers of financial performance. The significant role of operational risk reflects the asset-intensive nature of manufacturing, where production disruptions directly impact revenue generation and cost structures (As shown in Table 2).

Table 2. Regression Results for Manufacturing Sector

Variable	Return on Assets	Tobin's Q
Operational Risk	-1.24***	-0.18***
ESG Risk	-0.67**	-0.09*
Financial Volatility	-0.93***	-0.14**
Firm Size	0.45*	0.08
Leverage	-0.38	-0.11*
Adjusted R squared	0.42	0.36

Note: *** p < 0.01, ** p < 0.05, * p < 0.1

4.3. Regression Results for the Health Sector

The regression results for the health sector presented a different pattern. ESG risk emerged as the strongest negative predictor of financial performance, with coefficients substantially larger than those observed in manufacturing. Operational risk showed a weaker and sometimes insignificant association with performance metrics, reflecting the different operational logic of health sector organizations where regulatory compliance and governance matter more than physical production efficiency. Financial volatility remained a significant negative predictor, consistent with its role as a fundamental risk indicator across sectors.

These results highlight the distinctive risk landscape of the health sector [7]. Regulatory approvals, patient safety incidents, and governance failures carry substantial financial consequences, often exceeding the impact of operational disruptions that might dominate in manufacturing contexts (As shown in Table 3).

Table 3. Regression Results for Health Sector

Variable	Return on Assets	Tobin's Q
Operational Risk	-0.43	-0.06
ESG Risk	-1.56***	-0.24***
Financial Volatility	-0.87**	-0.15**

Firm Size	0.62*	0.12*
Leverage	-0.51	-0.09
Adjusted R squared	0.45	0.41

Note: *** p < 0.01, ** p < 0.05, * p < 0.1

4.4. Qualitative Case Study Insights

The qualitative case studies provided contextual depth to the statistical findings [14]. In the manufacturing sector, the two selected firms illustrated how operational risk materializes through supply chain disruptions and production downtime. One firm had experienced significant financial losses following a supplier failure, consistent with the strong operational risk coefficient in the regression analysis. The firm's subsequent investments in supply chain diversification and inventory buffering demonstrated the principle that risk management capabilities can be developed to protect performance.

In the health sector, the case studies revealed the mechanisms through which ESG risk affects financial outcomes. One pharmaceutical firm faced substantial reputational damage and regulatory fines following governance lapses in clinical trial reporting [11]. The financial impact extended beyond immediate penalties to include delayed product approvals and reduced investor confidence. This pattern aligned with the regression finding that ESG risk dominates other risk dimensions in the health sector.

The case studies also revealed sector-specific risk management practices. Manufacturing firms emphasized operational resilience through technological investments and supplier relationships. Health sector organizations prioritized regulatory compliance, ethical governance, and stakeholder communication as primary risk mitigation strategies. These qualitative insights reinforce the quantitative findings and illustrate the contextual nature of the risk-performance relationship (As shown in Table 4).

Table 4. Summary of Qualitative Case Study Findings

Sector	Firm	Primary Risk Exposure	Financial Impact	Risk Management Response
Manufacturing	Firm A	Supply chain disruption	12% revenue decline	Supplier diversification
Manufacturing	Firm B	Production downtime	8% margin reduction	Automation investments
Health	Firm C	Clinical trial governance	Regulatory fines, delayed approvals	Enhanced compliance protocols
Health	Firm D	Patient safety incident	Reputational damage, litigation	Safety culture transformation

4.5. Discussion

The findings from this study reveal important sector-specific dynamics in the relationship between risk and financial performance. The manufacturing sector is primarily sensitive to operational risk, reflecting the centrality of production processes and supply chains to value creation. The health sector, by contrast, is most vulnerable to ESG risk, particularly governance failures and regulatory actions that can disrupt operations and damage stakeholder trust.

These sectoral differences have important implications for corporate sustainability. In manufacturing, sustainability initiatives that enhance operational efficiency and supply

chain resilience may yield the greatest financial benefits. In health, investments in governance structures, ethical practices, and regulatory compliance are likely to be more consequential for long-term performance [10]. Financial volatility, however, emerges as a consistently negative factor across both sectors, underscoring the universal importance of earnings stability for corporate sustainability.

The integration of quantitative and qualitative evidence strengthens confidence in these conclusions. The regression results establish generalizable patterns, while the case studies illuminate the mechanisms through which risk translates into performance outcomes [13]. Together, they suggest that effective risk management must be tailored to sector-specific contexts, rather than applied uniformly across industries.

5. Conclusion

This study investigated the relationship between data-driven risk measurement and financial performance across the manufacturing and health sectors. By constructing a risk indicator system encompassing operational risk, ESG risk, and financial volatility, the research examined how risk exposure influences corporate sustainability outcomes.

The findings reveal distinct sector-specific patterns. In manufacturing, operational risk emerged as the strongest negative predictor of financial performance. In the health sector, ESG risk dominated as the primary risk factor. Financial volatility consistently showed negative associations with performance across both sectors.

These results have clear implications. Managers should tailor risk strategies to sector contexts: manufacturing firms should prioritize operational resilience, while health organizations should focus on governance and compliance. Investors can use these insights for sector-specific risk assessment. Policymakers should consider differential regulatory approaches.

The study contributes empirical evidence on how sustainability-related risks differentially impact industries. Limitations include reliance on publicly available data, a five-year panel, and potential subjectivity in ESG measurement. Future research should extend the analysis to longer time horizons, additional sectors, and more granular risk measures.

In conclusion, risk is not monolithic but multidimensional, with financial implications that depend critically on sector context. Recognizing these differences enables firms to better protect and enhance long-term performance.

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