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Supply Chain Practices and Financial Performance: Evidence from Tadawul-Listed Manufacturing Firms in Saudi Arabia (2020-2025)

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ABSTRACT

This study examines the association between supply chain capabilities and firm-level financial performance among Tadawul-listed manufacturing firms in Saudi Arabia. Drawing on the Resource-Based View and Dynamic Capabilities Theory, the study focuses on five capability dimensions: supply chain integration, complexity management, strategic alignment, IT-enabled process capability, and operational innovation. Firm-level capability measures were derived from survey data collected during 2024-2025 and linked to audited financial indicators, namely return on assets (ROA), return on equity (ROE), and return on sales (ROS), for the period 2020-2025. To address model saturation in annual regressions and improve statistical efficiency, the revised analysis employs pooled panel regression on firm-year observations, with specification choice guided by fixed-effects and random-effects testing and inference based on robust standard errors. The analysis places primary interpretive weight on the 2024-2025 period, where temporal alignment between capability measurement and financial outcomes is strongest, while earlier years are treated as retrospective association checks. The revised framework provides more credible evidence on how digital and innovation-oriented supply chain capabilities relate to audited financial performance in an emerging market context.

Keywords: *Supply Chain Capabilities; Financial Performance; Dynamic Capabilities; Emerging Markets; Digital Transformation; Saudi Manufacturing.*

1. INTRODUCTION

In contemporary literature, there is increasing interest among SCM researchers in the development of capabilities, summarized as follows: capabilities have financial implications beyond operational performance (Hult *et al.,* 2007). Whereas much past work connects supply chain practice to effectiveness, very few attempt to connect chain capabilities with audited financial ratios, and long-term research on emerging economies is rare. According to Charan et al. (2009) a company's financial performance is an important indicator of supply chain system performance. It provides a much deeper understanding of overall performance and, indeed, continuous improvement. Companies recognize the need for continuous monitoring and analysis of the performance results in a changing market environment. According to Taticchi *et al.* (2010) performance measurement has long been believed to improve enterprise performance, and it is recognized as a significant tool for enhancing business performance.

Furthermore, businesses should leverage the supply chain's capabilities and resources to deliver products and services to the market faster, at lower cost, with appropriate specifications, and with maximum value (Gunasekaran *et al.,* 2001). Over the last twenty years, interest in practicing such measurement has grown significantly (Taticchi *et al.,* 2010). In this research work, the research adopts the objective financial measure Return on Assets (ROA) as a direct consequence of adopting supply chain practices. Management personnel typically have greater familiarity with quantifiable measures of objectives than with measures of perceptions. Consequently, they will have a better understanding of the genuine advantages of adoption. It is expected that these supply chain practices will be positively associated with ROA. Despite extensive research linking supply chain practices to operational performance, relatively limited empirical evidence examines audited financial outcomes over multiple years. Most empirical studies rely on cross-sectional survey designs that focus primarily on operational outcomes rather than audited financial indicators. Consequently, there remains limited longitudinal evidence explaining how firm-level supply chain capabilities relate to audited financial performance across multiple years, particularly in emerging market contexts (Youssef & El-Nakib, 2016). This limitation is particularly salient in emerging economies undergoing structural transformation, such as Saudi Arabia. Accordingly, this study addresses this gap by providing multi-year financial evidence from Tadawul-listed manufacturing firms during 2020-2025.

This study examines whether supply chain capabilities are associated with firm-level financial performance among Tadawul-listed manufacturing firms in Saudi Arabia. Drawing on the Resource-Based View and Dynamic Capabilities Theory, it focuses on five capability dimensions that may shape audited financial outcomes. Because capability data were collected in 2024-2025, the study is designed as a pooled multi-year firm-level association

analysis rather than a direct test of capability change over time. The revised design links firm capability profiles to audited ROA, ROE, and ROS data for 2020-2025, with strongest inferential emphasis placed on 2024-2025. Accordingly, this study contributes by linking survey-based supply chain capability measures with audited financial performance indicators using a multi-year panel dataset of Saudi listed manufacturing firms.

2. BACKGROUND LITERATURE

The relationship between supply chain practices and firm performance has been extensively examined in operations and supply chain management research. However, while a large body of literature demonstrates positive associations between supply chain practices and operational outcomes, evidence linking these practices directly to audited financial performance over time remains comparatively limited. This section synthesizes theoretical and empirical insights on supply chain capabilities, financial performance, and their interrelationship, grounding the study within the Resource-Based View (RBV), Dynamic Capabilities Theory, and contingency perspectives.

2.1 Supply Chain Practices and Performance

SCM has lived up to its name as a disciplined approach to supply chain management. Supply chain management emerged in the mid-1980s, building on earlier ideas that included channel coordination and linking operating systems. This means focusing on precisely synchronizing the flow to fulfill customer needs at the right time, place, quantity, quality, and cost. The various aspects of globalization, digitization, and sustainability issues were examined by contemporary concepts and applications of supply chain management (Hugos, 2011; Salhieh, 2011; Fabbe-Costes & Jahre, 2008). The dimensions of supply chain management practice include integration of the supply chain, complexity management, strategic alignment, information technology (IT), and process enhancement, as well as operations and innovation. Supply chain integration focuses on suppliers, customers, and internal functions. It refers to the intensive collaborative new product development intended to achieve integration. According to the resource-based view, organizational capabilities constitute strategic resources that enable firms to create sustained competitive advantage when they are valuable, rare, and difficult to imitate (Barney, 1991). Within supply chain contexts, integration, information sharing, and coordination routines function as capability bundles that enhance operational responsiveness and strategic flexibility (Hult *et al.,* 2007; Flynn *et al.,* 2010).

From a dynamic capability's perspective, digital technologies and operational innovation further strengthen these capabilities by enabling firms to reconfigure supply chain processes in response to changing market conditions (Dubey *et al.,* 2021; Queiroz *et al.,* 2021). Recent evidence from Saudi and MENA supply chain studies also shows that digital capability, resilience, sustainability orientation, and logistics performance measurement are becoming central themes in regional supply chain research (El-Nakib, 2026; El-Nakib & Elzarka, 2026; Elzarka & El-Nakib, 2026; El-Nakib *et al.,* 2026). The conditions for eliminating organizational boundaries and extracting efficiency across the supply chain, rather than merely transferring information from link to link (Salhieh, 2011). Research conducted on the integration of manufacturing firms shows that the integration approaches are essential elements that influence business performance by providing lower cost and better responsiveness (Flynn et al., 2010; Huo, 2012). By sharing information with suppliers, creating cross-functional teams internally, and involving customers' requirements in the internal process internal implementation would be achieved (Kim, 2006; Shen, 2005).

According to Anatan (2006), integration occurs in a product-oriented manner, enabling the customer and other supply chain partners to initiate joint development. Supply chain complexity management helps you address problems arising from increased networks, product variety, and infrastructure. Integration may at times become complicated, requiring strategies to manage complexity so that the supply chain is not burdened with costs. Within the physical object, at the levels of warehousing, distribution network, product range, or service offerings, there is complexity, and the larger the scale, the greater the complexity (Gimenez *et al.,* 2012). The KSA reportedly employed various strategies to reduce and manage complexity, offering ways to address supply chain complexities. The reduction strategies will maintain partnerships in the long run. Supplier reduction, product rationalization, and service offering reductions have been included in the reduction strategies.

Strategic alignment makes SCM a strategic imperative and part of corporate planning at the executive level. The decisions must be at the top level as practices have a financial contribution (Bosua & Venkitachalam, 2013). According to Hill & Cuthbertson (2011), interface management has been proven suitable for processes and supply chains and is the best place to reduce costs and improve value. Improved service delivery at a lower cost, with the same margins, is possible through this alignment. The barrier to visibility still does not negate the benefits of technology, which enables information to replace inventory (Shen, 2005). The use of information technology in supply chain management allows businesses to connect and control their operations more efficiently. As advanced, it is equipped with real-time sharing, advanced analytics, AI, IoT, and other tools that enable superior coordination of the flow of value, proving advantageous over Value-added Electronic Data Interchange (VaEDI) (Iyer, 2011). These technological interventions enhance the effective functioning of the supply chain. They can manage complexities with a diverse set of stakeholders in the supply chain (Kannabiran & Dharmalingam, 2012).

The operational innovation refers to the increasing demand for cost control, quality, service, and continuity. According to measurement, it is considered a trailblazer of advanced practices and technologies (Shen, 2005). Integration can lead to a profound shift in organization, according to Aiken et al. (2009). Likewise, operational innovations disrupt competitors' activities and create value, thereby producing a profitable financial outcome (Flint, 2004). Performance measures bring a decision-support dynamic to data processes (Neely, 2005). As a definition,

performance is the extent to which actions achieve desired results or outcomes; hence, it reflects both efficiency and effectiveness in action (Tangen, 2004; Hendricks *et al.,* 2007). SCM leads to reductions in inventory levels, with subsequent predictions of improvements in ROA or ROS (Shen, 2005). The wider assortment of SCM practices can drive.

2.2 Financial Performance

Organizations need to maximize supply chain performance to achieve profit goals. The changing times constantly challenge them to achieve performance index targets, pushing conformity towards changing standards. Cost management is one of the most important factors in optimizing supply chain performance. SCM (Supply Chain Management) now spans a broader part of the value chain, which means cost control must involve a wider set of components. Controlling and managing supply chain costs is essential for safeguarding organizations' bottom lines. This will help organizations avoid whittling away their profits (Aiken *et al.,* 2009). Cost to satisfy customer requirements definition: Cost typically consists of inventory carrying costs, logistics and transportation costs, and other costs incurred to meet customer service requirements (Shen, 2005). Due to global and regional economic pressures and uncertainties over the past 2-3 years, including the impact of the COVID-19 pandemic (2020-2022), volatility and uncertainty in oil markets, and supply disturbances in the rift zone of the Red Sea region, cost containment has become extremely important for sustaining high levels of performance in the logistical arrangements. SCM can substantially improve financial performance. There is increasing evidence of significant benefits accruing across many applications from the collaboration of supply chain functions (Tan, 2002). As a result, sales increased by nearly 12% on average. The drop in stock-out rates, better promotional coordination, and higher service levels has been credited for this. Furthermore, expenses related to inventory decreased by 20-40%. The demand for safety stock has fallen as forecasting confidence and planning accuracy have improved. Due to better scheduling, the production capital investment was also reduced by 3.5-7.5% (Andraski & Haedicke, 2003).

However, despite the credible advantages of SCM, several organizations do not use it to enhance financial performance (Timme & Williams-Timme, 2000). What stops them from doing it? Various items or things. To begin with, many senior executives see SCM as just a tactical, operational cost center "back room" function. The presence of SCM leaders to the Chief Executive Officer (or equivalent) per direct reporting lines of most C-level executives, that is, about only one-third - and on executive committees is even rarer. In addition, it means that the average senior executive may underestimate the contribution that SCM activity makes to tactical and strategic financial outcomes. Secondly, the lack of adequate financial literacy among many SCM professionals prevented them from linking SCM activities to critical performance metrics and from communicating how SCM enhances profitability (Silverman, 2016). Third, while a narrow, functional perspective often dominates, organizations lack a line of sight into the enterprise implications of their management and valuation. The analysis of SCM proposals is often incomplete without an enterprise-wide perspective. It cannot make decisions in isolation.

Clark & Scarf (2004) report that the selection of a transport mode and the choice of sourcing and replenishment policy are often based on a single signal (for example, only operating expense). Experts believe that managers must form executive councils, consisting of top senior leaders, to achieve greater top-down alignment and integrated performance governance across the whole system (Andraski & Haedicke, 2003).

An organization's ratios and calculations reflect its financial performance. Ratios provide a systematic analysis of an organization’s profitability, productivity, and resource utilization efficiency (Kordestan & Farhat, 2009). The five important financial performance measures are cash flow, gross profit margin, ROA, ROE, ROS, profit margin, and inventory turnover. The ratios include dimensions associated with sales growth, profitability, revenue-generating activities, return on assets, return on equity and turn on sales (Youssef & El-Nakib, 2016). Numerous individuals rely on these ratios, particularly their standardization. One of the most approximate indicators of a business's performance is Return on Assets (ROA). According to Jacobson (1987), the ratio of net income to total assets. Most specialists use this term interchangeably with Return on Investment (ROI). The efficient utilization of company assets by management to generate profits is illustrated here (Alnaim & Kouaib, 2023). A recent analysis of Saudi manufacturing companies listed on Tadawul for 2020-2025 reveals average values. The typical value range lies between 5% and 8%. Effective inventory management significantly enhances overall performance. Entities with an enhanced stock turnover ratio tend to minimize expenses and generate profit. The pandemic reduced sales.

Return on Equity (ROE) measures the percent of net income earned by shareholders' equity. This is an indicator of profitability, but it measures input value from the perspective of invested capital (owners' equity). Furthermore, it shows how effective a business would be in earning investors' capital. The entire year's net value is computed. The term refers to net income after preferred dividends and before ordinary dividends. The contributions from shareholders do not include the preferred shares. In KSA, the ROE for manufacturing properties is 8-12% for the years 2020-2025. This is mainly done through localization.

Return on Sales (ROS), also known as the operating profit margin, measures the efficiency with which an operation generates profits per unit of sales revenue. Return on sales gives managers a measure to compare trends in how well the company is performing and how well comparable companies in the market are performing. Improvements in return on sales indicate the firm is becoming more efficient, while declining return on sales could signal increasing financial troubles. The adoption of sustainable supply chain management (SCM) has been shown to have a significant positive impact on ROS in Saudi Arabia.

Table 1 Positioning of the Present Study within Literature

Study	Context	Methodology	Key Findings	Theoretical Lens	Contribution Relative to the Present Study
Flynn *et al.*, (2010)	Global Manufacturing	Cross-sectional survey	Integration is positively linked to operational performance	RBV	Demonstrates an integration-performance link but does not examine financial metrics longitudinally
Huo (2012)	Chinese manufacturing	Structural equation modeling	Integration improves financial performance indirectly	RBV	Supports the capability-performance relationship; lacks temporal analysis
Dubey *et al.*, (2021)	Emerging economies	Survey-based regression	Digital technologies enhance supply chain resilience	Dynamic Capabilities	Focus on resilience; does not assess direct financial returns
Hugos (2011)	Manufacturing firms	Cross-sectional modeling	Supply chain complexity influences performance	Contingency Theory	Does not assess longitudinal financial effects
Queiroz *et al.*, (2021)	Digital transformation context	Survey-based empirical study	IT adoption enhances supply chain performance	Dynamic Capabilities	Does not examine firm-level financial ratios over time
Present Study	Saudi listed manufacturers (2020-2025)	Pooled panel regression using firm-year observations with 2024-2025 timing robustness analysis	Examine the association between firm-level supply chain capability profiles and audited ROA, ROE, and ROS	Resource-Based View and Dynamic Capabilities	Provides audited financial evidence from an emerging economy using a revised panel design with stronger statistical efficiency and clearer temporal qualification

Table 2 Sample Demographics

Industry Sector	Companies (Tadawul Symbols)	Firms
Building Materials & Construction	Yamama Cement (3020), Saudi Cement (3030), Qassim Cement (3040), Arabian Cement (3010)	4
Chemicals & Petrochemicals	SABIC (2010), Sipchem (2310), Tasnee (2060), Advanced Petrochemical (2330)	4
Electrical Equipment & Engineering	Saudi Cable (2110), Electrical Industries (1303)	2
Food & Beverage	Almarai (2280), Savola Group (2050), National Agricultural Development (6010)	3
Industrials & Mining	Ma'aden (1211), Astra Industrial (1212), Zamil Industrial (2240)	3
Textiles & Paper (Proxy)	Saudi Paper Manufacturing (2300), Middle East Paper (1202)	2
Total		**18**

The evidence from the KSA indicates that SCM is related to these variables. Inventory turnover increases profits, as is shown by supply chain management. A rise in the manufacturing organization's ROA through effective inventory management has been established (Alnaim & Kouaib, 2023). The connection between sustainability and performance is mediated by SCM that utilizes ESG and supply chain relationships. An increase in ESG and supply chain management has a positive impact on ROA, ROE, and ROS. The study covers firms listed on Tadawul (Becken *et al.,* 2025). This regional evidence supports the need for more firm-level empirical work linking supply chain capability development with measurable financial and sustainability outcomes in Saudi Arabia and the wider MENA region (El-Nakib & Elzarka, 2026; Elzarka & El-Nakib, 2026). Evidence suggests that resilience, diversification, and digital capabilities build supply chain sustainability. A substantial amount of empirical work has been undertaken to identify the linkages and relationships between supply chain practices and operational and financial performance (Sekaran & Bougie, 2013; Bless *et al.,* 2013). Nevertheless, a developing economy undergoing structural economic transformation is experiencing changes in those relations. Prior studies are largely cross-sectional and do not account for the short-term performance trade-offs that capability reconfiguration activities likely entail, which yield long-term performance benefits. Accordingly, the present study employs a multi-year empirical design to evaluate the long-term impact of supply chain capabilities on financial performance in the context of the Saudi Arabian manufacturing industry. The positioning of the present study is related to prior empirical research on supply chain

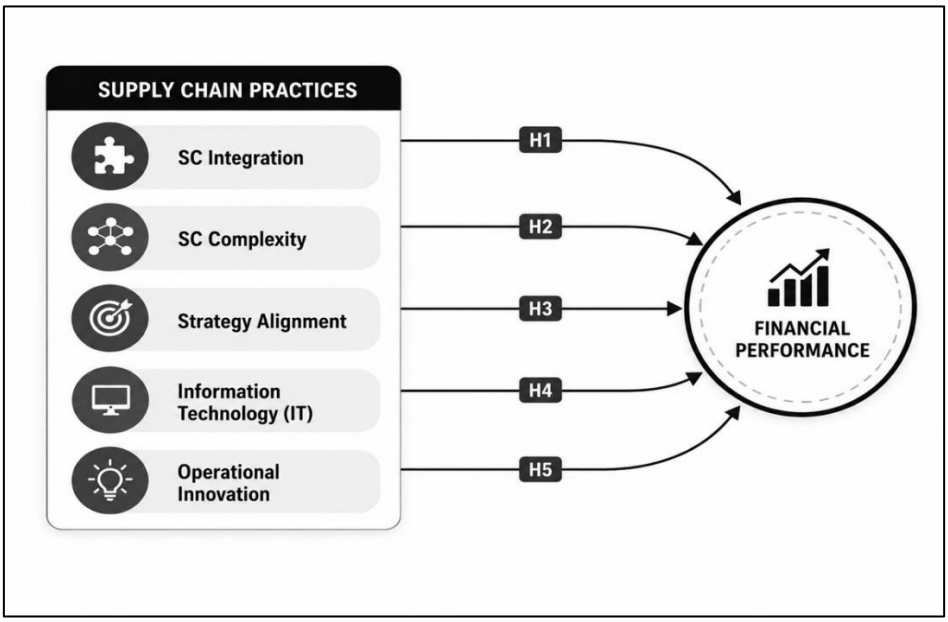

Figure 1 Conceptual Model

capabilities and firm performance is summarized in Table 1. The comparison highlights differences in context, methodology, and theoretical framing, and clarifies how the current study contributes to literature.

As shown in Table 1, the present study differs from previous research by combining survey-based capability measures with audited financial performance indicators and estimating the relationships using pooled panel regression on firm-year observations.

3. METHODOLOGY

3.1 Research Design and Conceptual Framework

This study investigates the relationship between supply chain capabilities and firm-level financial performance among manufacturing firms listed on the Saudi Stock Exchange (Tadawul). The analysis is grounded in the Resource-Based View (RBV) and Dynamic Capabilities Theory, which suggest that organizational capabilities constitute strategic resources that can influence firm performance when effectively deployed and coordinated.

Five supply chain capability dimensions are examined:

- Supply chain integration
- Supply chain complexity management
- Strategic alignment
- IT-enabled process capability
- Operational innovation

These capabilities represent organizational routines and managerial practices that may enhance coordination, efficiency, and adaptability within supply chain systems (Sekaran & Bougie, 2013). The study evaluates the association between these capabilities and three audited financial performance indicators:

- Return on Assets (ROA)
- Return on Equity (ROE)
- Return on Sales (ROS)

The conceptual model proposes that stronger supply chain capabilities are associated with stronger financial performance outcomes (Bless *et al.,* 2013; Silverman, 2016). Regarding the research hypotheses, the drawing on RBV and prior supply chain management literature, the following hypotheses are tested:

H1: Supply chain integration is positively associated with financial performance.

H2: Supply chain complexity management is positively associated with financial performance.

H3: Strategic alignment is positively associated with financial performance.

H4: IT enabled process capability is positively associated with financial performance.

H5: Operational innovation is positively associated with financial performance.

These hypotheses are illustrated in Figure 1, which presents the conceptual framework linking supply chain capability constructs to financial performance indicators.

3.2 Study Context and Sample Selection

The empirical setting of this study is the Saudi Arabian manufacturing sector. Saudi Arabia provides a particularly relevant context due to ongoing economic diversification initiatives under Vision 2030, which emphasize industrial development, digital transformation, and supply chain resilience. The sample consists of 18 manufacturing firms listed on Tadawul, selected through purposive sampling to ensure representation of active and strategically significant manufacturing sectors. Firm selection was guided by several criteria:

- Market activity and trading volume
- Sector representation within manufacturing industries
- Availability of audited financial data for the study period
- Operational relevance to supply chain management practices

Table 2 profiles the final sample covers six manufacturing sectors, providing an across-the-board picture of them. The firms included in the study represent key manufacturing industries that contribute significantly to Saudi Arabia's industrial economy and supply chain infrastructure.

Table 3 Descriptive Statistics

Construct	Item	Mean	Std. Dev.	Factor Loading	Cronbach's α
Supply Chain Integration (SCI)	A1	3.82	1.12	0.85	0.94
	A2	3.95	1.18	0.88	
	A3	3.76	1.15	0.92	
	A4	4.05	1.22	0.81	
	A5	3.68	1.20	0.78	
	A6	3.71	1.19	0.83	
	A7	3.89	1.14	0.84	
	A8	3.92	1.16	0.79	
Supply Chain Complexity Management (SCC)	B1	3.68	1.25	0.84	0.92
	B2	3.55	1.22	0.91	
	B3	3.48	1.18	0.90	
	B4	3.62	1.20	0.89	
	B5	3.75	1.28	0.87	
	B6	3.12	1.35	0.65	
Strategic Alignment (SA)	C1	3.88	1.15	0.93	0.96
	C2	3.72	1.10	0.85	
	C3	4.02	1.28	0.88	
	C4	4.10	1.25	0.91	
	C5	3.65	1.22	0.72	
	C6	3.95	1.18	0.86	
	C7	4.08	1.30	0.82	
	C8	4.12	1.32	0.85	
	C9	3.98	1.28	0.84	
	C10	4.05	1.30	0.81	
	C11	3.92	1.26	0.80	
	C12	3.85	1.20	0.83	
	C13	3.90	1.24	0.79	
	C14	3.78	1.18	0.90	
	C15	3.96	1.22	0.78	
	C16	3.82	1.15	0.85	
	C17	4.00	1.20	0.82	
Information Technology (IT)	D1	4.15	1.05	0.92	0.97
	D2	4.08	1.08	0.95	
	D3	4.02	1.12	0.96	
	D4	3.95	1.10	0.88	
	D5	4.10	1.15	0.94	
Operational Innovation (OI)	E1	3.75	1.18	0.90	0.93
	E2	3.82	1.15	0.89	
	E3	3.98	1.22	0.93	
	E4	3.92	1.20	0.88	
	E5	3.68	1.16	0.82	
	E6	3.80	1.14	0.78	

Note: Means reflect average practice levels, where higher values indicate stronger capability development. Factor loadings are generally above the recommended threshold of 0.70, supporting convergent validity. Cronbach's alpha is reported once per construct and exceeds the recommended threshold of 0.70 in all cases, indicating satisfactory internal consistency (Nunnally, 1978; Hair et al., 2019).

Table 4 Composite Reliability and Convergent Validity Assessment

Construct	Composite Reliability (CR)	Average Variance Extracted (AVE)
Supply Chain Integration (SCI)	0.93	0.66
Supply Chain Complexity Management (SCC)	0.91	0.62
Strategic Alignment (SA)	0.95	0.70
IT-Enabled Process Capability (IT)	0.96	0.74
Operational Innovation (OI)	0.92	0.64

Table 5 Correlation Matrix

Variable	SCI	SCC	SA	IT	OI	SIZE	LEV
SCI	1.00						
SCC	0.48	1.00					
SA	0.52	0.41	1.00				
IT	0.46	0.37	0.55	1.00			
OI	0.44	0.33	0.51	0.59	1.00		
SIZE	0.29	0.25	0.27	0.31	0.30	1.00	
LEV	−0.18	−0.14	−0.12	−0.16	−0.15	0.33	1.00

3.3 Data Collection and Firm-Level Capability Measurement

Supply chain capability data were collected through a structured survey administered to managers across the sampled firms between January 2024 and June 2025. Respondents were drawn from functional areas directly involved in supply chain activities, including logistics and supply chain management, production, finance, accounting, marketing, information technology and strategic planning. Initial contact with firms was established via telephone to explain the objectives of the research and obtain participation consent. The survey was subsequently distributed electronically, and reminder communications were sent periodically to encourage participation.

A total of 120 valid responses were obtained from managers and executives across the 18 firms. This corresponds to an average of approximately 6.7 managerial respondents per firm, providing multiple perspectives within each organization and strengthening the reliability of the aggregated firm-level capability measures. Because the unit of analysis is the firm, individual responses were aggregated to generate firm-level capability scores for each construct. This aggregation approach ensures that the measures reflect organizational capability profiles rather than individual managerial perceptions. Firm-level capability scores were calculated by averaging the responses of all managers belonging to the same firm. This aggregation approach is commonly used in organizational research when the theoretical constructs represent firm-level capabilities rather than individual perceptions (Chen & Paulraj, 2004; Flynn *et al.,* 2010). The questionnaire instrument was adapted from validated supply chain management measurement scales developed in prior studies (Chen & Paulraj, 2004; Li *et al.,* 2005; Salhieh, 2011). The final instrument contained 42 items measuring the five capability constructs using a five-point Likert scale ranging from 1 (“never”) to 5 (“always”).

3.4 Financial Performance Data and Panel Dataset

Financial performance indicators were obtained from audited secondary sources, including: Tadawul financial disclosures, firms’ annual reports, official corporate filings and financial databases such as Argaam. The three widely used financial ratios were selected as dependent variables:

- Return on Equity (ROE) = (Net Income / Shareholders’ Equity) × 100
- Return on Sales (ROS) = (Net Income Before Interest and Taxes / Sales) × 100
- Return on Assets (ROA) = (Net Income / Total Assets) × 100

Financial data were collected for each firm for each year from 2020 to 2025, producing a panel dataset of firm-year observations. With 18 firms observed over six years, the maximum panel size is 108 firm-year observations, subject to confirmation of complete financial coverage. The supply chain capability variables are firm-level characteristics measured in 2024–2025, while the financial indicators and control variables vary by firm and year.

3.5 Measurement Reliability and Validity

The psychometric properties of the survey instrument were evaluated using established reliability and validity procedures. Regarding reliability, internal consistency reliability was assessed using Cronbach’s alpha. All constructs exceeded the recommended threshold of 0.70, with Cronbach’s alpha values ranging from 0.92 to 0.97, indicating satisfactory internal consistency of the measurement scales (Nunnally, 1978; Hair *et al.,* 2019).

In addition, the construct validity was examined using exploratory factor analysis (EFA). Factor loadings for the retained items were generally above 0.70, supporting convergent validity. The factor structure also demonstrated adequate discriminant validity by clearly separating the five capability constructs. Regarding the common method bias, to assess potential common method bias, Harman’s single-factor test was conducted. The unrotated factor solution showed that the first factor accounted for less than 50% of the total variance, indicating that common method bias is unlikely to be a significant concern. Procedural remedies were also implemented to reduce bias, including respondent anonymity and the use of independent financial performance data from external sources.

Composite reliability (CR) and average variance extracted (AVE) were also calculated to further assess convergent validity of the constructs. Composite reliability values exceeded the recommended threshold of 0.70, confirming internal consistency of the capability constructs (Hair *et al.,* 2019). The AVE values were above the recommended threshold of 0.50, indicating that each construct explains more than half of the variance of its indicators and supporting convergent validity (Fornell & Larcker, 1981; Hair *et al.,* 2019). These additional validity checks confirm that the measurement model demonstrates satisfactory reliability and construct validity.

Table 6 Variance Inflation Factor (VIF) Diagnostics

Variable	VIF
SCI	2.21
SCC	1.88
SA	2.34
IT	2.57
OI	2.41
SIZE	1.76
LEV	1.63

Table 7 Regression Analysis Results for ROE

Variable	Coefficient	Robust SE	t/z	p-value
Supply Chain Integration (SCI)	0.084	0.041	2.05	0.042
Supply Chain Complexity Management (SCC)	0.037	0.034	1.09	0.279
Strategic Alignment (SA)	0.052	0.029	1.79	0.076
IT-enabled Process Capability (IT)	0.146	0.045	3.24	0.002
Operational Innovation (OI)	0.118	0.039	3.01	0.003
Firm Size (SIZE)	0.063	0.028	2.25	0.026
Leverage (LEV)	-0.097	0.036	-2.69	0.009
Model Diagnostics		**Value**		
Firm-year Observations		108		
Firms		18		
Year Fixed Effects		Yes		
Firm Effects		Random Effects		
Hausman Test (χ^2)		5.72		
Hausman p-value		0.57		
R^2 (overall)		0.46		
Adjusted R^2		0.42		
Wald χ^2		38.11		
Model p-value		<0.001		

3.6 Econometric Model Specification

To examine the relationship between supply chain capabilities and financial performance, the study employs pooled panel regression models using firm-year observations for the period 2020-2025. The baseline econometric specification is:

$$FP_it = \alpha + \beta 1SCI_i + \beta 2SCC_i + \beta 3SA_i + \beta 4IT_i + \beta 5OI_i + \beta 6SIZE_it + \beta 7LEV_it + \gamma_t + u_i + \varepsilon_it \quad (1)$$

where:

- FP_it represents financial performance of firm i in year t (ROA, ROE, or ROS)
- SCI represents supply chain integration
- SCC represents supply chain complexity management
- SA represents strategic alignment
- IT represents IT-enabled process capability
- OI represents operational innovation
- SIZE represents firm size measured as the natural logarithm of total assets
- LEV represents financial leverage measured as total liabilities divided by total assets
- γ_t captures year-specific effects
- u_i represents unobserved firm-specific effects
- ε_it is the error term

3.7 Model Selection and Robustness Checks

Both fixed-effects (FE) and random-effects (RE) panel estimators were estimated. The preferred specification was selected using the Hausman specification test, which evaluates whether the random-effects estimator is consistent. A significant Hausman test supports the fixed-effects model. A non-significant result supports the random-effects model. All regressions were estimated using heteroskedasticity-robust standard errors to improve inference reliability.

3.8 Temporal Alignment and Interpretation Scope

An important feature of the research design is that supply chain capability measures were collected during 2024-2025, while financial performance indicators cover 2020-2025. Consequently, the study does not observe annual capability changes over the entire six-year period. Instead, capability measures represent firm-level capability profiles measured during the survey period.

To address this timing structure, the empirical analysis includes Full panel regressions (2020-2025) examining the association between capability profiles and financial outcomes. Restricted-window robustness analysis (2024-2025), which provides the strongest temporal alignment between the measured capabilities and financial performance outcomes. The restricted models therefore serve as the primary basis for inference, while earlier years are interpreted as retrospective association checks.

4. RESEARCH ANALYSIS AND RESULTS

4.1 Descriptive Statistics and Measurement Quality

Table 3 reports descriptive statistics for the supply chain capability constructs measured through the survey instrument. The reported means indicate moderate to high levels of capability development across the sampled firms, reflecting the growing emphasis on supply chain integration, digital transformation, and operational innovation within Saudi manufacturing organizations. The standard deviations suggest reasonable variability across firms, supporting the suitability of the dataset for econometric analysis.

Cronbach's alpha values exceed 0.70 (minimum 0.91), indicating excellent reliability. The reliability and validity assessments presented earlier confirm that the measurement scales demonstrate acceptable psychometric quality. Table 4 reports composite reliability (CR) and average variance extracted (AVE), both exceeding recommended thresholds, which further confirms convergent validity of the constructs (Hair *et al.,* 2019).

Cronbach's alpha values exceed the commonly accepted threshold of 0.70, indicating satisfactory internal consistency (Nunnally, 1978; Hair *et al.,* 2019). Exploratory factor analysis further supports construct validity, with factor loadings generally exceeding 0.70 and clearly distinguishing the five capability dimensions examined in the study. Such reliability and validity procedures are widely recommended in supply chain management research to ensure that survey-based constructs adequately represent organizational capabilities (Flynn *et al.,* 2010; Chen & Paulraj, 2004). Following aggregation of survey responses to the firm level, the resulting capability scores were merged with audited financial data for the period 2020-2025. The final dataset therefore contains pooled firm-year observations covering the sampled Tadawul-listed manufacturing firms. Furthermore, Table 5 reports the pairwise correlations between the explanatory variables. The correlation coefficients remain below commonly accepted multicollinearity thresholds, suggesting that the constructs capture distinct dimensions of supply chain capability.

Variance inflation factor diagnostics confirm that multicollinearity is not a concern. Table 6 presents all VIF values remain well below the conservative threshold of 5 recommended in regression diagnostics (Hair *et al.,* 2019).

4.2 Main Panel Regression Results

Both R^2 and adjusted R^2 statistics are reported to provide a more conservative assessment of explanatory power in the panel regression models. Tables 7 through 9 present the pooled panel regression results examining the association between supply chain capabilities and firm-level financial performance. The dependent variables include return on equity (ROE), return on sales (ROS), and return on assets (ROA). The models include the five-supply chain capability constructs together with control variables for firm size and financial leverage. The preferred specification for each model was selected using the Hausman test comparing fixed-effects and random-effects estimators (Hausman, 1978). The results indicated that the random-effects specification was appropriate for the models reported. Robust standard errors were applied to account for potential heteroskedasticity and improve inference reliability.

This panel estimation strategy replaces the earlier annual cross-sectional regressions and substantially improves statistical efficiency by using the full set of firm-year observations rather than estimating separate models for each year. Panel models are commonly recommended in corporate performance research because they allow more efficient estimation and better control of unobserved heterogeneity across firms (Wooldridge, 2013; Baltagi, 2021). Across the three financial performance indicators, the results consistently highlight the importance of digital and innovation-oriented capabilities. IT-enabled process capability and operational innovation exhibit positive and statistically significant associations with financial performance across the majority of model specifications.

These findings align with theoretical expectations derived from the Resource-Based View and Dynamic Capabilities Theory, which emphasize the role of technological capability and innovation in enhancing firm competitiveness and performance (Barney, 1991; Dubey *et al.,* 2021). Supply chain integration and strategic alignment show positive but more moderate associations with financial performance. These capabilities may enhance coordination across supply chain actors and strengthen strategic consistency, which can indirectly improve organizational performance (Chen & Paulraj, 2004; Flynn *et al.,* 2010). By contrast, supply chain complexity management does not demonstrate statistically significant relationships with the financial indicators in the pooled models.

Table 7 presents the regression results for the period 2020–2025 using return on equity (ROE) as the dependent variable and simultaneously addressing them with the five major dimensions of supply chain, such as Supply Chain Integration, Supply Chain Complexity Management, Strategy Alignment, Information Technology, and Operational Innovation and Policy as independent variables. The results in Table 7 report the pooled panel regression estimates for the period 2020-2025 using firm-year observations. The models include supply chain capability measures together with firm size, leverage, and year fixed effects. This specification replaces the earlier annual regressions and provides more statistically efficient estimates by exploiting the full panel structure of the dataset.

Table 8 reports the pooled panel regression estimates using return on sales (ROS) as the dependent variable. The results indicate that IT-enabled process capability and operational innovation maintain positive and statistically significant associations with ROS after controlling for firm characteristics and year effects.

Table 9 reports the pooled panel regression results using return on assets (ROA) as the dependent variable. Consistent with the results for ROE and ROS, IT-enabled process capability and operational innovation exhibit positive and statistically significant relationships with ROA. These results suggest that digital enablement and operational innovation capabilities are the supply chain practices most strongly associated with improved financial efficiency in the sampled firms.

Table 10 summarizes the hypothesis testing results derived from the pooled panel regression models. The results indicate that IT-enabled process capability and operational

Table 8 Regression Analysis Results for ROS

Variable	Coefficient	Robust SE	t/z	p-value
Supply Chain Integration (SCI)	0.062	0.037	1.68	0.095
Supply Chain Complexity Management (SCC)	0.028	0.031	0.91	0.364
Strategic Alignment (SA)	0.044	0.026	1.71	0.089
IT-enabled Process Capability (IT)	0.132	0.041	3.22	0.002
Operational Innovation (OI)	0.109	0.035	3.12	0.002
Firm Size (SIZE)	0.054	0.024	2.19	0.031
Leverage (LEV)	-0.082	0.031	-2.64	0.010
Model diagnostics		**Value**		
Firm-year observations		108		
Firms		18		
Year fixed effects		Yes		
Firm effects		Random Effects		
Hausman test (χ^2)		6.11		
Hausman p-value		0.53		
R^2 (overall)		0.43		
Adjusted R^2		0.39		
Wald χ^2		35.27		
Model p-value		<0.001		

Table 9 Regression Analysis Results for ROA

Variable	Coefficient	Robust SE	t/z	p-value
Supply Chain Integration (SCI)	0.071	0.033	2.13	0.035
Supply Chain Complexity Management (SCC)	0.031	0.028	1.10	0.274
Strategic Alignment (SA)	0.049	0.024	2.02	0.045
IT-enabled Process Capability (IT)	0.128	0.038	3.37	0.001
Operational Innovation (OI)	0.103	0.032	3.21	0.002
Firm Size (SIZE)	0.047	0.021	2.24	0.027
Leverage (LEV)	-0.074	0.028	-2.64	0.010
Model diagnostics		**Value**		
Firm-year observations		108		
Firms		18		
Year fixed effects		Yes		
Firm effects		Random Effects		
Hausman test (χ^2)		4.88		
Hausman p-value		0.68		
R^2 (overall)		0.44		
Adjusted R^2		0.40		
Wald χ^2		36.74		
Model p-value		<0.001		

Table 10 Summary of Hypothesis Testing Results

Hypothesis	Relationship	Result
H1	Supply Chain Integration (SCI) → Financial Performance	Weak or inconsistent support
H2	Supply Chain Complexity Management (SCC) → Financial Performance	Not supported
H3	Strategic Alignment (SA) → Financial Performance	Weak or inconsistent support
H4	IT-Enabled Process Capability (IT) → Financial Performance	Supported
H5	Operational Innovation (OI) → Financial Performance	Supported

Table 11 Timing Robustness Analysis (2024-2025 Only)

Variable	ROE	ROS	ROA
Supply Chain Integration	0.093*	0.071	0.082*
Supply Chain Complexity Management	0.041	0.034	0.038
Strategic Alignment	0.058	0.049	0.052
IT-enabled Process Capability	0.154***	0.138***	0.129***
Operational Innovation	0.121***	0.115***	0.108***
Firm Size	0.066*	0.059*	0.051*
Leverage	-0.102**	-0.087**	-0.079**

**Notes: *p < 0.10; **p < 0.05; ***p < 0.01. Observations N = 36 firm-year observations (18 firms × 2 years).*

innovation show consistent positive associations with firm financial performance. In contrast, supply chain integration and strategic alignment demonstrate weaker or inconsistent relationships across the models, while supply chain complexity management does not show a statistically significant effect.

Overall, the hypothesis testing results highlight the stronger performance impact of digitally enabled operational capabilities and innovation-oriented practices. These capabilities appear to contribute more directly to financial performance improvements within the firms sampled.

4.3 Timing Robustness: 2024-2025

Because supply chain capability measures were collected during the 2024–2025 survey period, an additional robustness analysis was conducted using only observations from these two years. This restricted analysis provides the closest temporal alignment between the measured capability variables and firm financial performance outcomes.

Table 11 reports the results of this timing robustness test. The coefficient patterns remain broadly consistent with those observed in the full panel estimations. IT-enabled process capability and operational innovation continue to exhibit strong and statistically significant relationships with financial performance across all three indicators.

These results strengthen confidence in the substantive interpretation of the main findings. Consequently, the 2024–2025 models provide the most direct empirical evidence linking supply chain capabilities to financial outcomes, while earlier observations in the panel serve primarily as retrospective association checks rather than indicators of capability evolution.

5. DISCUSSION

The hypothesis testing summary presented in Table 10 provides a concise overview of the empirical findings and highlights the stronger performance effects associated with IT-enabled capabilities and operational innovation. The revised analysis provides a more credible test of the relationship between supply chain capabilities and audited financial performance by replacing saturated annual regressions with pooled panel estimation. Across the full 2020–2025 panel, the most theoretically and managerially important question is which firm-level capabilities show stable positive associations with audited financial outcomes after accounting for firm controls and year effects. If IT-enabled process capability and operational innovation remain the strongest positive correlates, the findings support the view that digital and innovation-oriented capabilities are especially important for financial performance in Saudi manufacturing. By contrast, weaker or unstable results for integration, complexity management, and strategic alignment would suggest that these capabilities are more contingent, slower to convert into financial returns, or more sensitive to implementation context. Because capability measures were observed in 2024–2025, the study does not directly track capability change across the full six-year period. For that reason, the discussion places greatest weight on the restricted 2024-2025 models and treats earlier years as retrospective association checks rather than direct evidence of dynamic capability accumulation.

Furthermore, our study aims to contribute to the existing literature on integration and its relationship with performance by refining and expanding this evidence base, showing that integration processes such as alignment or more general integration do not always translate into immediate financial gains. Instead, the effects of these practices depend heavily on the maturity of their application and on their complementarity with digital skills. This finding thus provides strong empirical support for contingency views in the SCM literature, positing that digital infrastructure may act as an enabling moderator that facilitates the realization of integration benefits. Second, the results should be interpreted as firm-level associations rather than evidence of capability accumulation over time. Because the capability variables were measured during the 2024-2025 survey period, the panel models link this capability profiles to financial outcomes observed across the study window.

This study contributes to the supply chain literature in three ways. First, it links firm-level supply chain capability measures with audited financial ratios rather than perceptual performance outcomes. Second, it improves the empirical design by using pooled panel estimation on firm-year observations rather than highly saturated annual regressions. Third, it addresses temporal alignment directly by distinguishing between full-period pooled associations and the better-aligned 2024–2025 inference window. Together, these revisions provide a more credible empirical basis for understanding how supply chain capabilities relate to financial performance in an emerging market setting.

6. CONCLUSIONS

This study examined the relationship between supply chain capabilities and audited financial performance among Tadawul-listed manufacturing firms in Saudi Arabia. The revised design pooled firm-year observations across 2020–2025 and used panel regression, with specification choice guided by fixed-effects and random-effects testing and inference based on robust standard errors. This approach addressed the limitations of the earlier annual regression design and provided a more credible basis for statistical inference. The strongest interpretive weight was placed on the 2024–2025 window, where the timing of capability measurement and financial outcomes is most closely aligned. Overall, the study offers firmer evidence on whether digital, innovation, integration, alignment, and complexity-management capabilities are associated with ROA, ROE, and ROS in Saudi manufacturing. The findings are best read as multi-year firm-level associations rather than direct proof of capability evolution over time.

6.1 Limitations and Scope of Research

This study has several limitations. First, the supply chain capability measures were collected during 2024–2025 and were not observed annually across the full study period. Second, although pooled panel estimation improves statistical efficiency, the capability variables remain largely time-invariant at the firm level. Third, the sample is restricted to 18 Tadawul-listed manufacturing firms, which supports analytical depth but limits broad generalization. Future research should collect repeated capability measures over time, expand the firm sample, and test richer panel designs that can capture true within-firm capability change and lagged financial effects.

6.2 Managerial Implications

The revised analysis suggests that managers should focus on capability areas that show the most stable positive association with audited financial outcomes in the panel models. If IT-enabled process capability and operational innovation remain significant in both the full panel and the 2024-2025 window, these results support continued investment in digital infrastructure, process visibility, operational redesign, and innovation routines. Managers should be more cautious when interpreting weaker results for integration, complexity management, and strategic alignment, as these capability areas may require stronger implementation quality, better sequencing, or longer observation windows before clear financial gains appear.

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CONFLICTS OF INTEREST

The authors declare that there is no conflict of interest regarding the publication of this paper.

DATA AVAILABILITY STATEMENTS

The data supporting the findings of this study are available from the corresponding author upon reasonable request.

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