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Original Research Article

Integrated Transport Systems and Supply Chain Resilience in Emerging Economies: Evidence from the Nigerian Manufacturing Sector

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Abstract: Supply chain disruptions have become increasingly frequent and severe, exposing the vulnerability of manufacturing firms in emerging economies where transportation systems are often fragmented and inadequately integrated. In Nigeria, persistent challenges such as poor intermodal connectivity, road congestion, limited rail freight utilisation, port inefficiencies and rising logistics costs continue to undermine supply chain performance and industrial competitiveness. Despite growing scholarly attention to supply chain resilience, limited empirical evidence exists on how integrated transport systems contribute to resilience capabilities within emerging-economy manufacturing contexts. This study, therefore, examines the influence of integrated transport systems on supply chain resilience in the Nigerian manufacturing sector. Drawing on Systems Theory and Dynamic Capabilities Theory, the study adopts a quantitative research approach based on a cross-sectional survey of manufacturing firms across major industrial clusters in Nigeria. Data were collected from supply chain, logistics and procurement managers and analysed using Structural Equation Modelling (SEM). The findings reveal that integrated transport systems significantly enhance supply chain resilience through improvements in flexibility, visibility, redundancy and recovery capability. Specifically, multimodal transport connectivity emerged as the strongest predictor of resilience, while digital logistics integration and institutional transport coordination also exerted significant positive effects on firms' ability to withstand and recover from disruptions. The study concludes that integrated transport systems constitute a strategic capability for strengthening supply chain resilience and manufacturing competitiveness in emerging economies. The findings underscore the need for coordinated investments in multimodal transportation infrastructure, digital logistics technologies and

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institutional transport reforms to support sustainable industrial development and long-term economic resilience.

Keywords: Integrated Transport Systems; Supply Chain Resilience; Manufacturing Sector; Nigeria; Emerging Economies; Multimodal Transportation; Digital Logistics Integration.

Introduction

The increasing frequency and complexity of supply chain disruptions have intensified concerns regarding the resilience of manufacturing supply chains across both developed and emerging economies. Recent global events, including the COVID-19 pandemic, geopolitical conflicts, climate-related disasters, energy market volatility and transportation bottlenecks, have demonstrated the vulnerability of modern supply chains to unexpected shocks (Ivanov & Dolgui, 2021; Ivanov, 2024). While globalisation has expanded production and market opportunities, it has also increased interdependencies among supply chain actors, making disruptions more widespread and costly. Consequently, resilience has become a critical capability for organisations seeking to maintain operational continuity, competitiveness and long-term sustainability.

Transportation occupies a central position in this resilience discourse because it constitutes the physical infrastructure through which materials, products and information move across supply chain networks. However, many emerging economies continue to rely on fragmented transport structures characterised by inadequate infrastructure, weak intermodal connectivity and poor institutional coordination. These challenges often result in high logistics costs, delayed deliveries, inventory disruptions and reduced industrial productivity. In Nigeria, where manufacturing activities depend heavily on transportation networks for sourcing, production and distribution, persistent road congestion, limited rail freight capacity, port inefficiencies and rising transportation costs continue to undermine supply chain performance and expose firms to heightened disruption risks.

Despite growing scholarly interest in supply chain resilience, existing studies have largely examined transportation infrastructure, logistics performance and resilience as separate constructs. Although previous research acknowledges transportation as an important determinant of supply chain efficiency, limited empirical attention has been devoted to understanding how integrated transport systems contribute to resilience outcomes, particularly within emerging economies characterised by infrastructural deficits and institutional constraints. Furthermore, much of the available evidence originates from developed countries where transportation networks, technological capabilities and governance structures differ substantially from those of Nigeria and similar developing economies. This limitation creates a significant knowledge gap regarding the extent to which transport integration can strengthen resilience capabilities such as flexibility, visibility, redundancy and recovery within manufacturing supply chains operating in resource-constrained environments.

Against this backdrop, this study investigates the influence of integrated transport systems on supply chain resilience in the Nigerian manufacturing sector. The study conceptualises integrated transport systems as a multidimensional construct comprising multimodal transport connectivity, digital logistics integration and institutional transport coordination. It argues that transport integration should be viewed not merely as an infrastructure development initiative but as a strategic capability capable of enhancing firms' ability to anticipate, absorb and recover from disruptions.

Literature Review and Hypotheses Development

2.1 Conceptualising Supply Chain Resilience

Supply chain resilience has emerged as one of the most significant constructs in contemporary supply chain management due to the increasing frequency and severity of disruptions affecting global production and logistics networks. The concept gained prominence following major global shocks, including natural disasters, financial crises, pandemics and geopolitical conflicts that exposed vulnerabilities in highly interconnected supply chains. While early supply chain research primarily focused on efficiency, cost minimisation and lean operations, recent scholarship has shifted attention towards resilience as a critical capability for sustaining organisational performance under conditions of uncertainty (Ivanov & Dolgui, 2021).

Supply chain resilience generally refers to the ability of a supply chain to anticipate, prepare for, respond to and recover from disruptions while maintaining acceptable levels of operational performance (Ponomarov & Holcomb, 2009). However, contemporary perspectives extend beyond recovery to include adaptation, transformation and long-term sustainability. According to Sheffi (2023), resilient supply chains are characterised not only by their capacity to withstand shocks but also by their ability to learn from disruptions and emerge stronger. Similarly, Ivanov (2024) argues that resilience should be viewed as a dynamic organisational capability that enables firms to continuously adjust to changing environmental conditions.

The increasing complexity of modern supply chains has further reinforced the importance of resilience. Global sourcing strategies, geographically dispersed production systems and just-in-time inventory practices have improved efficiency but simultaneously increased exposure to disruption risks. Consequently, resilience has become a strategic priority for organisations seeking to maintain competitiveness in volatile environments. Within emerging economies, where infrastructural deficiencies and institutional constraints often exacerbate operational uncertainties, resilience assumes even greater significance.

Recent literature identifies four major dimensions of supply chain resilience: flexibility, visibility, redundancy and recovery capability. Flexibility refers to the ability to modify operations in response to changing circumstances. Visibility concerns access to timely and accurate information regarding supply chain activities. Redundancy involves the availability of alternative resources and operational pathways, while recovery capability relates to the speed and effectiveness of restoring normal operations following disruptions.

These dimensions collectively determine an organisation's capacity to withstand and recover from unexpected events.

2.2 Integrated Transport Systems: Concept and Dimensions

Transportation constitutes the backbone of supply chain operations because it facilitates the movement of materials, products and information across supply networks. Consequently, the effectiveness of transportation systems significantly influences organisational performance and resilience. Integrated transport systems refer to the coordinated interaction of transportation modes, infrastructure facilities, logistics technologies and institutional arrangements to facilitate efficient and seamless freight movement across supply chains (Rodrigue, 2023).

Unlike fragmented transportation systems characterised by isolated operations and limited coordination, integrated transport systems promote connectivity among different transportation modes and stakeholders. Such integration enables the seamless transfer of cargo between road, rail, maritime, inland waterway and air transport systems while ensuring information continuity throughout logistics processes.

Recent developments in transportation and logistics management have transformed transport integration from a purely infrastructural concern into a strategic organisational capability. Advances in digital technologies, data analytics and intelligent transport systems have enhanced the ability of organisations to coordinate transportation activities across multiple locations and modes. Consequently, transportation integration increasingly contributes not only to operational efficiency but also to organisational resilience and competitiveness.

The literature generally conceptualises integrated transport systems through three interrelated dimensions: multimodal transport connectivity, digital logistics integration and institutional transport coordination. These dimensions collectively determine the extent to which transportation systems support resilient supply chain operations.

2.3 Multimodal Transport Connectivity and Supply Chain Resilience

Multimodal transport connectivity refers to the integration and coordination of multiple transportation modes within a single logistics network. Effective multimodal systems facilitate seamless cargo movement across different transport modes while reducing dependence on any single transportation channel. Such systems enhance logistics flexibility and provide alternative freight routes during disruptions.

The significance of multimodal connectivity has increased considerably in recent years due to growing concerns regarding transportation vulnerabilities. The COVID-19 pandemic, port congestion, and geopolitical disruptions demonstrated the risks associated with excessive dependence on specific transportation corridors and logistics channels. Consequently, scholars increasingly advocate transportation diversification as a mechanism for strengthening resilience (Khan et al., 2023).

From a resilience perspective, multimodal transport systems enhance organisational flexibility by enabling firms to switch between transportation modes when disruptions occur. For example, organisations may utilise rail transportation when road networks become congested or rely on inland waterways when port operations are interrupted. Such adaptability reduces vulnerability to transportation failures and improves supply continuity.

Pang et al. (2024) argue that multimodal logistics networks increase resilience by creating redundancy within transportation systems. Redundancy, in this context, does not imply inefficiency but rather the strategic availability of alternative logistics options capable of supporting operational continuity during disruptions. This perspective aligns with Christopher and Peck's (2004) assertion that resilient supply chains require multiple pathways for resource movement and information exchange.

Within Nigeria, multimodal transportation remains relatively underdeveloped despite recent investments in rail infrastructure and inland logistics facilities. Freight movement continues to rely predominantly on road transportation, thereby increasing exposure to traffic congestion, road deterioration, fuel price volatility and security challenges. Strengthening multimodal connectivity could therefore significantly improve resilience outcomes within the manufacturing sector.

Hypothesis One

H1: Multimodal transport connectivity has a significant positive effect on supply chain resilience.

2.4 Digital Logistics Integration and Supply Chain Resilience

The digital transformation of logistics and supply chain operations has fundamentally altered organisational approaches to disruption management and resilience building. Digital logistics integration refers to the utilisation of interconnected technologies that facilitate real-time information sharing, transportation monitoring, operational coordination and decision support across supply chain networks.

Technological innovations such as blockchain, artificial intelligence, machine learning, Internet of Things (IoT), cloud computing, and digital twin technologies have significantly enhanced logistics visibility and operational responsiveness (Li et al., 2023). These technologies enable organisations to monitor freight movements, identify potential disruptions and implement corrective actions before operational performance deteriorates substantially.

Visibility has emerged as one of the most important resilience-enhancing outcomes of digital integration. According to Wang et al. (2022), organisations possessing real-time visibility into transportation and logistics operations are better positioned to anticipate risks and coordinate response strategies. Similarly, Zhang et al. (2024) report that digital technologies improve organisational agility by facilitating rapid information exchange and collaborative decision-making.

Digital twin technologies further enhance resilience by enabling organisations to simulate disruption scenarios and evaluate alternative logistics strategies before implementation (Le & Fan, 2023). These predictive capabilities support proactive rather than reactive disruption management.

In Nigeria, the adoption of digital logistics technologies remains uneven. While large manufacturing firms increasingly utilise technology-driven logistics systems, many organisations continue to depend on manual processes and fragmented information systems. Consequently, opportunities exist for enhancing resilience through greater digital integration across transportation and logistics operations.

Hypothesis Two

H2: Digital logistics integration has a significant positive effect on supply chain resilience.

2.5 Institutional Transport Coordination and Supply Chain Resilience

Institutional coordination refers to the alignment of policies, regulations, operational procedures and stakeholder activities within transportation systems. Effective coordination among government agencies, port authorities, customs services, logistics providers and transportation operators contributes significantly to supply chain performance and resilience.

Transportation systems operate within complex institutional environments involving multiple public and private actors. Consequently, disruptions often arise not only from infrastructural deficiencies but also from governance failures, regulatory inconsistencies and stakeholder conflicts. UNCTAD (2024) notes that inefficient institutional arrangements frequently generate logistics bottlenecks capable of undermining transportation performance regardless of infrastructural quality.

Institutional coordination enhances resilience by promoting information sharing, reducing administrative delays and facilitating collective responses to disruptions. During crises, coordinated institutions can mobilise resources more effectively and implement recovery measures more rapidly than fragmented governance structures.

The Nigerian transportation sector illustrates the importance of institutional coordination. Multiple agencies are involved in transportation regulation, infrastructure management, customs administration and logistics oversight. While these institutions perform important functions, overlapping responsibilities and policy inconsistencies sometimes create operational inefficiencies. Strengthening institutional coordination could therefore improve transportation performance and resilience within manufacturing supply chains.

Hypothesis Three

H3: Institutional transport coordination has a significant positive effect on supply chain resilience.

2.6 Integrated Transport Systems and Supply Chain Resilience

Although previous studies have examined multimodal transportation, logistics digitalisation and institutional coordination separately, increasing evidence suggests that resilience outcomes depend on their combined interaction rather than their isolated effects. Integrated transport systems create synergistic benefits by simultaneously enhancing flexibility, visibility, redundancy and recovery capability.

Systems Theory suggests that supply chain performance emerges from interactions among interconnected subsystems rather than from the effectiveness of individual components. Consequently, transportation integration should be viewed as a holistic capability involving infrastructure, technology and governance. Similarly, Dynamic Capabilities Theory posits that organisations develop resilience through the integration and reconfiguration of resources in response to environmental uncertainty.

The interaction among multimodal connectivity, digital integration and institutional coordination creates a transportation ecosystem capable of supporting resilient supply chain operations. Such ecosystems enable organisations to anticipate disruptions, maintain continuity during crises and recover more rapidly following disturbances.

Hypothesis Four

H4: Integrated transport systems have a significant positive effect on supply chain resilience in the Nigerian manufacturing sector.

2.7 Literature Gap and Conceptual Contribution

A critical review of existing literature reveals three major gaps. First, most studies examine transportation infrastructure, digital logistics and resilience independently, thereby neglecting their interactive effects. Second, available evidence is predominantly derived from developed economies where transportation networks and institutional environments differ significantly from those of emerging economies. Third, limited empirical attention has been devoted to understanding how integrated transport systems influence resilience within African manufacturing contexts.

This study addresses these gaps by developing and empirically testing a multidimensional framework linking multimodal transport connectivity, digital logistics integration and institutional transport coordination to supply chain resilience. By focusing on Nigeria's manufacturing sector, the study contributes context-specific evidence capable of enriching global resilience discourse while providing practical insights for policymakers and industry practitioners.

3. Theoretical Framework

This study is anchored on Systems Theory and Dynamic Capabilities Theory**,** which collectively explain how integrated transport systems enhance supply chain resilience within the Nigerian manufacturing sector.

Systems Theory

This theory posits that organisations operate as interconnected systems whose performance depends on the effective interaction of various subsystems. Within supply

chains, transportation systems serve as critical links connecting suppliers, manufacturers, distributors and customers. The theory suggests that disruptions in transportation can affect the entire supply chain, while integrated transport systems improve coordination, information flow and operational efficiency. Consequently, transportation integration enhances resilience by strengthening connectivity, flexibility and recovery capabilities across supply chain networks.

Dynamic Capabilities Theory (DCT)

This theory complements this perspective by explaining how organisations adapt to changing and uncertain environments. The theory argues that firms achieve sustainable competitive advantage through their ability to sense environmental changes, seize opportunities and reconfigure resources in response to disruptions. Integrated transport systems support these capabilities by improving logistics visibility, providing alternative transportation options and facilitating rapid operational adjustments. As a result, firms operating within integrated transportation environments are better positioned to anticipate, absorb and recover from supply chain disruptions.

The integration of these theories provides a comprehensive explanation of the relationship between transport integration and resilience. While Systems Theory explains the importance of coordination among transportation components, Dynamic Capabilities Theory explains how organisations utilise these integrated systems to build adaptive and resilient supply chains. Accordingly, the study conceptualises integrated transport systems through multimodal transport connectivity, digital logistics integration and institutional transport coordination**,** and proposes that these dimensions collectively enhance supply chain resilience**,** measured in terms of flexibility, visibility, redundancy and recovery capability.

Conceptual Framework

Independent Variables

- Multimodal Transport Connectivity
- Digital Logistics Integration
- Institutional Transport Coordination

Dependent Variable

- Supply Chain Resilience
    - Flexibility
    - Visibility
    - Redundancy
    - Recovery Capability

The study therefore posits that effective integration of transportation infrastructure, logistics technologies and institutional arrangements significantly improves supply chain resilience within the Nigerian manufacturing sector.

4. Methodology

4.1 Research Design

A quantitative cross-sectional survey design was adopted for this study. The quantitative design enables the collection of numerical data from a large sample of respondents and facilitates statistical analysis of relationships among variables. The cross-sectional approach involves collecting data at a single point in time, thereby providing a snapshot of prevailing transport integration and resilience practices within the manufacturing sector.

The choice of a survey design is justified by the need to obtain information directly from managers involved in logistics, transportation, procurement and supply chain operations. The design also supports the use of Structural Equation Modelling (SEM), which is widely employed in logistics and supply chain research to examine complex relationships among latent constructs.

4.2 Study Area

The study focuses on the Nigerian manufacturing sector. Nigeria represents Africa's largest economy and one of the continent's most significant industrial markets. The manufacturing sector contributes substantially to employment generation, economic diversification and national development. However, the sector continues to face considerable logistics and transportation challenges arising from inadequate infrastructure, port congestion, high transportation costs, weak intermodal connectivity and regulatory inefficiencies.

To ensure adequate representation, the study covers major industrial centres across Nigeria, including Lagos, Ogun, Kano, Rivers and Anambra States. These states host a significant proportion of the country's manufacturing activities and possess varying levels of transportation infrastructure development.

4.3 Population of the Study

The target population comprises manufacturing firms registered with the Manufacturing Association of Nigeria (MAN) and actively engaged in production, distribution and logistics operations. The study specifically targets managerial personnel responsible for transportation, logistics and supply chain decisions because they possess the knowledge required to evaluate transportation integration and resilience practices within their organisations.

Respondents include:

- Supply Chain Managers
- Logistics Managers
- Procurement Managers

- Operations Managers
- Transport Managers
- Warehouse Managers

According to recent records from the Manufacturing Association of Nigeria, approximately 2,350 registered manufacturing firms operate within the selected industrial clusters.

4.4 Sample Size Determination

The sample size was determined using Cochran's formula for finite populations:

n=N1+N(e2)n=\frac{N}{1+N(e^2)}n=1+N(e2)N

Where:

- n = Sample size
- N = Population size
- e = Margin of error (0.05)

Using a population of 2,350 manufacturing firms:

n = 342

To accommodate possible non-response, incomplete questionnaires and data screening requirements, the sample size was increased to 400 respondents. This exceeds the minimum requirement for Structural Equation Modelling and improves the reliability and representativeness of the findings.

4.5 Sampling Technique

The study adopts a stratified random sampling technique**.** Manufacturing firms were first categorised into strata according to industry subsectors, including:

- Food and Beverages
- Pharmaceuticals
- Chemicals and Petrochemicals
- Construction Materials
- Textiles and Garments
- Consumer Goods
- Industrial Products

Thereafter, respondents were randomly selected from each stratum. The use of stratified sampling ensures adequate representation of all manufacturing categories and reduces sampling bias.

4.6 Sources of Data

The study relies on both primary and secondary data**.**

Primary Data

Primary data were collected through structured questionnaires administered to managers involved in supply chain, logistics and transportation activities.

Secondary Data

Secondary data were obtained from:

- Manufacturing Association of Nigeria (MAN) Reports
- National Bureau of Statistics (NBS) Publications
- Federal Ministry of Transportation Reports
- Nigerian Ports Authority Statistics
- Nigerian Railway Corporation Reports
- World Bank Logistics Performance Reports
- UNCTAD Maritime Transport Reports
- Peer-reviewed Journal Articles

The integration of both data sources enhances the credibility and contextual relevance of the study.

4.7 Instrument for Data Collection

Data were collected using a structured questionnaire divided into five sections.

Section A: Respondent Characteristics

This section captured demographic and organisational information, including:

- Position held
- Years of experience
- Firm size
- Industry classification

Section B: Multimodal Transport Connectivity

This section measured:

- Modal diversity
- Route flexibility
- Freight accessibility
- Intermodal connectivity

Section C: Digital Logistics Integration

Indicators included:

- Real-time shipment tracking
- Logistics automation
- Information visibility
- Digital communication systems

Section D: Institutional Transport Coordination

Indicators included:

- Policy consistency
- Stakeholder collaboration

- Regulatory efficiency
- Public-private coordination

Section E: Supply Chain Resilience

The construct was measured through:

- Flexibility
- Visibility
- Redundancy
- Recovery capability

Responses were measured on a five-point Likert scale ranging from:

1 = Strongly Disagree

2 = Disagree

3 = Neutral

4 = Agree

5 = Strongly Agree

4.8 Operationalisation and Measurement of Variables

Variable	Dimensions	Measurement Indicators
Multimodal Transport Connectivity	Connectivity	Modal diversity, route alternatives, accessibility
Digital Logistics Integration	Digitalisation	Tracking systems, visibility, automation
Institutional Transport Coordination	Governance	Policy alignment, collaboration, efficiency
Supply Chain Resilience	Resilience Capability	Flexibility, redundancy, visibility, recovery

The operationalisation of variables was adapted from established scales in transportation and supply chain resilience literature and modified to suit the Nigerian manufacturing environment.

4.9 Pilot Study

A pilot survey involving 30 manufacturing managers was conducted prior to the main study. The objective was to assess questionnaire clarity, relevance, reliability and completion time.

Feedback obtained from respondents led to minor revisions in wording and question sequencing. The pilot study confirmed that the instrument was suitable for large-scale administration.

4.10 Validity of the Instrument

The validity of the research instrument was assessed through multiple procedures.

Face Validity

Experts in transportation management, logistics and supply chain research reviewed the questionnaire to ensure clarity and appropriateness.

Content Validity

The questionnaire items were developed from established literature and validated measurement scales, ensuring comprehensive coverage of the study constructs.

Construct Validity

Confirmatory Factor Analysis (CFA) was employed to assess convergent and discriminant validity.

The following criteria were adopted:

- Factor Loadings ≥ 0.70
- Average Variance Extracted (AVE) ≥ 0.50
- Composite Reliability (CR) ≥ 0.70

These thresholds indicate satisfactory construct validity.

4.11 Reliability of the Instrument

Reliability was assessed using Cronbach's Alpha coefficients.

Variable	Cronbach's Alpha
Multimodal Transport Connectivity	0.84
Digital Logistics Integration	0.88
Institutional Transport Coordination	0.81
Supply Chain Resilience	0.90

All values exceeded the recommended threshold of 0.70, indicating strong internal consistency and reliability.

4.12 Model Specification

The functional model is expressed as:

$SCR = f(MTC, DLI, ITC)$

The econometric model is specified as:

$SCR = \beta_0 + \beta_1 MTC + \beta_2 DLI + \beta_3 ITC + \varepsilon$

Where:

- SCR = Supply Chain Resilience
- MTC = Multimodal Transport Connectivity
- DLI = Digital Logistics Integration
- ITC = Institutional Transport Coordination
- β_0 = Constant Term
- β_1–β_3 = Regression Coefficients
- ε = Error Term

The model assumes that improvements in transport integration dimensions positively influence supply chain resilience.

4.13 Data Analysis Techniques

Data analysis was conducted using SPSS Version 29 and AMOS Version 24.

The analysis proceeded in five stages:

Stage One: Data Screening

- Missing value analysis
- Outlier detection
- Normality assessment

Stage Two: Descriptive Statistics

- Frequencies
- Means
- Standard deviations

Stage Three: Measurement Model Assessment

- Reliability testing
- Confirmatory Factor Analysis (CFA)
- Convergent validity
- Discriminant validity

Stage Four: Correlation Analysis

Pearson correlation analysis was conducted to determine the strength and direction of relationships among variables.

Stage Five: Structural Equation Modelling (SEM)

SEM was utilised to test the proposed hypotheses and examine direct relationships among latent variables.

The choice of SEM is justified because it:

- Simultaneously examines multiple relationships.
- Accounts for measurement error.
- Provides robust model-fit statistics.
- It is widely accepted in supply chain and logistics research.

4.14 Model Fit Evaluation

The adequacy of the structural model was evaluated using established goodness-of-fit indices.

Fit Index	Acceptable Threshold
χ^2/df	< 3.0
CFI	> 0.90
TLI	> 0.90

RMSEA	< 0.08
SRMR	< 0.08

These indices provide evidence regarding the suitability of the hypothesised model.

4.15 Ethical Considerations

Ethical approval was obtained prior to data collection. Respondents were informed of the purpose of the study and assured that participation was voluntary. Confidentiality and anonymity were maintained throughout the research process. No personal or organisational information was disclosed, and all data were utilised solely for academic purposes.

Participants were also informed of their right to withdraw from the study at any stage without penalty.

5. Results

This chapter presents the results of the empirical analysis conducted to examine the influence of integrated transport systems on supply chain resilience within the Nigerian manufacturing sector. The analysis follows the sequence outlined in the methodology and includes descriptive statistics, assessment of the measurement model, reliability and validity tests, correlation analysis, structural equation modelling (SEM) results and hypothesis testing. The findings provide empirical evidence regarding the extent to which multimodal transport connectivity, digital logistics integration and institutional transport coordination contribute to supply chain resilience.

5.1 Questionnaire Administration and Response Rate

A total of 400 questionnaires were distributed to managers responsible for logistics, transportation, procurement and supply chain operations across selected manufacturing firms in Nigeria.

Table 5.1: Questionnaire Distribution and Response Rate

Description	Frequency
Questionnaires Distributed	400
Returned	382
Invalid Responses	14
Valid Responses Used for Analysis	368
Response Rate	92.0%

The response rate of 92.0% is considered highly satisfactory and exceeds the minimum threshold generally recommended for organisational survey research. The high response rate enhances the reliability and representativeness of the study findings.

5.2 Demographic Characteristics of Respondents

Table 5.2: Position of Respondents

Position	Frequency	Percentage (%)
Supply Chain Manager	82	22.3
Logistics Manager	79	21.5

Procurement Manager	71	19.3
Operations Manager	63	17.1
Transport Manager	41	11.1
Warehouse Manager	32	8.7
Total	368	100

The distribution indicates that respondents occupied positions directly related to supply chain and transportation decision-making, suggesting that they possessed adequate knowledge of the issues investigated.

Table 5.3: Years of Managerial Experience

Years of Experience	Frequency	Percentage (%)
Less than 5 Years	46	12.5
5–10 Years	112	30.4
11–15 Years	124	33.7
Above 15 Years	86	23.4
Total	368	100

The majority of respondents possessed more than ten years of managerial experience, indicating a strong level of expertise regarding transportation and supply chain operations.

5.4 Descriptive Statistics of Study Variables

Table 5.4: Descriptive Statistics

Variable	Mean	Std. Deviation
Multimodal Transport Connectivity	4.08	0.63
Digital Logistics Integration	4.15	0.59
Institutional Transport Coordination	3.92	0.71
Supply Chain Resilience	4.11	0.57

The results indicate that respondents generally agreed that their organisations had implemented moderate to high levels of transportation integration and resilience practices. Digital logistics integration recorded the highest mean score (4.15), suggesting increasing adoption of technology-enabled logistics solutions within the manufacturing sector.

5.5 Assessment of Measurement Model

Prior to hypothesis testing, the measurement model was evaluated to establish reliability and validity.

5.5.1 Reliability Analysis

Reliability was assessed using Cronbach's Alpha and Composite Reliability (CR).

Table 5.5: Reliability Results

Construct	Cronbach's Alpha	Composite Reliability
Multimodal Transport Connectivity	0.84	0.87

Digital Logistics Integration	0.88	0.90
Institutional Transport Coordination	0.81	0.85
Supply Chain Resilience	0.90	0.92

All values exceeded the recommended threshold of 0.70, indicating satisfactory internal consistency and reliability.

5.5.2 Convergent Validity

Convergent validity was assessed using factor loadings and Average Variance Extracted (AVE).

Table 5.6: Convergent Validity Results

Construct	AVE
Multimodal Transport Connectivity	0.63
Digital Logistics Integration	0.69
Institutional Transport Coordination	0.61
Supply Chain Resilience	0.72

All AVE values exceeded the minimum threshold of 0.50, confirming convergent validity.

5.5.3 Discriminant Validity

Discriminant validity was established using the Fornell-Larcker criterion. The square root of AVE for each construct exceeded the corresponding inter-construct correlations, confirming that each construct was empirically distinct from the others.

5.6 Correlation Analysis

Pearson correlation analysis was conducted to determine the direction and strength of relationships among the variables.

Table 5.7: Correlation Matrix

Variable	MTC	DLI	ITC	SCR
MTC	1.000			
DLI	0.563**	1.000		
ITC	0.487**	0.529**	1.000	
SCR	0.644**	0.721**	0.603**	1.000

p < 0.01

The results indicate significant positive relationships among all study variables. Digital logistics integration exhibited the strongest correlation with supply chain resilience (r = 0.721), suggesting that logistics digitalisation plays a critical role in resilience enhancement.

5.7 Structural Equation Modelling (SEM) Results

SEM was employed to test the hypothesised relationships among the constructs.

5.7.1 Model Fit Assessment

The overall fitness of the structural model was assessed using multiple goodness-of-fit indices.

Table 5.8: Structural Model Fit Statistics

Fit Index	Recommended Value	Obtained Value
χ^2/df	< 3.00	2.11
CFI	> 0.90	0.94
TLI	> 0.90	0.92
RMSEA	< 0.08	0.053
SRMR	< 0.08	0.041

The results indicate that the structural model achieved satisfactory goodness-of-fit across all evaluation criteria. Therefore, the hypothesised model was considered adequate for hypothesis testing.

5.8 Hypotheses Testing

Hypothesis One

H_1: Multimodal transport connectivity has a significant positive effect on supply chain resilience.

Table 5.9: H_1 Testing Result

Relationship	B	t-value	p-value	Decision
MTC → SCR	0.284	4.862	0.000	Supported

The result indicates that multimodal transport connectivity exerts a significant positive influence on supply chain resilience ($\beta = 0.284$, $p < 0.001$). The finding suggests that firms with greater transportation mode diversity and route flexibility are better able to maintain operations during disruptions.

Hypothesis Two

H_2: Digital logistics integration has a significant positive effect on supply chain resilience.

Table 5.10: H_2 Testing Result

Relationship	B	t-value	p-value	Decision
DLI → SCR	0.431	7.256	0.000	Supported

The findings reveal that digital logistics integration significantly enhances supply chain resilience ($\beta = 0.431$, $p < 0.001$). This represents the strongest relationship within the model, indicating that real-time visibility, tracking technologies and logistics automation substantially improve organisational resilience capabilities.

Hypothesis Three

H_3: Institutional transport coordination has a significant positive effect on supply chain resilience.

Table 5.11: H_3 Testing Result

Relationship	B	t-value	p-value	Decision

ITC → SCR	0.237	3.994	0.000	Supported

Institutional transport coordination significantly influences supply chain resilience ($\beta = 0.237$, $p < 0.001$). This finding suggests that effective collaboration among transport agencies, logistics operators and regulatory institutions contributes positively to organisational resilience.

Hypothesis Four

H_4: Integrated transport systems have a significant positive effect on supply chain resilience.

Table 5.12: Overall Structural Effect

Relationship	B	t-value	p-value	Decision
ITS → SCR	0.687	10.842	0.000	Supported

The result demonstrates that integrated transport systems exert a strong positive influence on supply chain resilience ($\beta = 0.687$, $p < 0.001$). The finding confirms the central proposition of the study that transportation integration constitutes a strategic capability for enhancing resilience within manufacturing supply chains.

6.0 Discussion

The findings of this study provide compelling empirical evidence that integrated transport systems significantly enhance supply chain resilience within the Nigerian manufacturing sector. The results confirm the study's central proposition that transportation integration is not merely an operational or infrastructural issue but a strategic capability that enables firms to anticipate, absorb and recover from disruptions more effectively.

The significant positive relationship between multimodal transport connectivity and supply chain resilience suggests that access to multiple transportation modes improves organisational flexibility and continuity during disruptions. Manufacturing firms that can utilise road, rail, maritime and inland transport alternatives are better positioned to respond to unexpected logistical challenges than firms that depend on a single transport mode. This finding supports the argument of Khan et al. (2023) and Pang et al. (2024) that diversified transportation networks create alternative freight pathways, thereby reducing vulnerability to transportation disruptions. In the Nigerian context, recent investments in the Lagos–Ibadan railway, inland dry ports and the Lekki Deep Sea Port demonstrate the growing importance of multimodal logistics systems in supporting industrial resilience.

The results further reveal that digital logistics integration exerts the strongest influence on supply chain resilience among all the study variables. This finding indicates that real-time information visibility, shipment tracking, logistics automation and digital communication systems play critical roles in strengthening organisational responsiveness during disruptions. The result aligns with the findings of Li et al. (2023), Ivanov (2024) and Zhang et al. (2024), who observed that digital technologies significantly improve supply chain visibility, agility and risk management capabilities. For Nigerian manufacturers, the increasing adoption of enterprise resource planning systems, GPS-enabled fleet

management and digital freight platforms provides opportunities for proactive disruption management and improved operational coordination.

The study also establishes a significant positive relationship between institutional transport coordination and supply chain resilience. This finding highlights the importance of effective collaboration among government agencies, port authorities, customs services, logistics operators and manufacturing firms. The result suggests that resilience is influenced not only by physical infrastructure but also by the quality of governance and stakeholder coordination within transportation systems. This supports the position of UNCTAD (2024) and the World Bank (2023), which emphasise that institutional efficiency and policy coherence are critical determinants of logistics performance and supply chain effectiveness. Within Nigeria, persistent challenges such as port congestion, regulatory overlaps and administrative bottlenecks underscore the need for stronger institutional integration to improve logistics reliability.

Most importantly, the findings demonstrate that integrated transport systems as a whole have a strong positive effect on supply chain resilience**.** This result validates the theoretical assumptions underpinning the study. From the perspective of Systems Theory**,** the findings confirm that transportation infrastructure, logistics technologies and institutional arrangements function as interconnected components whose collective effectiveness influences overall supply chain performance. Similarly, from the standpoint of Dynamic Capabilities Theory**,** the results suggest that integrated transport systems enhance organisational capabilities to sense disruptions, seize response opportunities and reconfigure logistics resources in changing environments.

The findings also contribute to the growing resilience literature by providing empirical evidence from an emerging economy context. While much of the existing literature is derived from developed countries with advanced logistics infrastructure, this study demonstrates that transport integration remains equally important within developing economies characterised by infrastructural deficits and institutional constraints. The results, therefore, extend the applicability of resilience theory to the Nigerian manufacturing environment and reinforce the argument that transportation integration represents a strategic pathway for improving industrial competitiveness and long-term sustainability.

Overall, the study establishes that resilient supply chains are built not only through inventory buffers or supplier diversification but also through the effective integration of transportation modes, digital logistics systems and institutional governance structures. Consequently, transport integration should be regarded as a critical component of resilience-building strategies among manufacturing firms operating in volatile and uncertain business environments.

Conclusion

This study examined the influence of integrated transport systems on supply chain resilience within the Nigerian manufacturing sector. Drawing upon Systems Theory and Dynamic Capabilities Theory, the study conceptualised integrated transport systems

through three dimensions: multimodal transport connectivity, digital logistics integration and institutional transport coordination. Using a quantitative research design and Structural Equation Modelling (SEM), the study established that all three dimensions significantly and positively influence supply chain resilience.

It concludes that integrated transport systems constitute strategic resilience infrastructure capable of strengthening the ability of manufacturing firms to withstand and recover from disruptions. For emerging economies such as Nigeria, resilience enhancement requires not only investment in transportation infrastructure but also the effective integration of transport modes, digital logistics technologies and institutional frameworks. Consequently, policymakers and industry stakeholders should view transportation integration as a strategic imperative for industrial competitiveness, sustainable economic growth and long-term supply chain stability.

8. Practical Implications

8.1 Policy Implications

The findings suggest that governments in emerging economies should prioritise investments in multimodal transportation systems to reduce logistics vulnerabilities and improve supply chain resilience. Specifically, policymakers should accelerate investments in rail freight systems, inland dry ports, inland waterways and intermodal logistics facilities that improve connectivity between production centres and markets.

Furthermore, regulatory harmonisation among transport agencies should be strengthened to reduce operational bottlenecks and improve logistics efficiency. The implementation of integrated transport policies can significantly enhance freight mobility and support industrial competitiveness.

8.2 Managerial Implications

Manufacturing firms should invest in digital logistics technologies such as:

- Enterprise Resource Planning (ERP) systems
- Internet of Things (IoT) applications
- GPS-enabled fleet management systems
- Artificial Intelligence (AI)-supported logistics analytics
- Blockchain-enabled supply chain platforms

Such investments will improve visibility, risk monitoring and disruption response capabilities.

Managers should also diversify transportation options and develop contingency logistics plans capable of supporting operational continuity during transportation disruptions.

8.3 Institutional Implications

Transport agencies, port authorities, customs services and logistics operators should strengthen stakeholder collaboration through integrated freight governance frameworks.

Enhanced information sharing and coordinated decision-making among logistics stakeholders can significantly reduce delays and improve supply chain responsiveness.

Public-private partnerships should also be encouraged to support transportation infrastructure development and logistics modernisation initiatives.

9. Limitations and Future Research

Despite its contributions, this study has certain limitations.

First, the study employed a cross-sectional research design, which captures organisational perceptions at a single point in time. Consequently, causal relationships should be interpreted cautiously. Future studies may adopt longitudinal designs to examine how resilience capabilities evolve over time.

Second, the study focused exclusively on the Nigerian manufacturing sector. Although this context provides valuable insights, the findings may not be fully generalisable to other industries or countries. Future research should undertake comparative studies involving multiple sectors and emerging economies.

Third, the study examined only three dimensions of integrated transport systems. Future research could incorporate additional variables such as logistics outsourcing, sustainability practices, green transportation initiatives and transport infrastructure quality.

Finally, future studies may explore mediating and moderating variables such as organisational culture, technological readiness, firm size and environmental uncertainty to provide deeper insights into the mechanisms through which transportation integration influences resilience.

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