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The Role of the Digital Supply Chain in Improving Operational Efficiency and Achieving Economic Growth: A case Study of Delivery Companies in Mosul

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Abstract

This study examines the role of Digital Supply Chain Management (DSCM) on operational efficiency and economic growth within delivery companies operating in Mosul. Driven by rapid digitalization and the increasing need for resilient logistics systems, the research analyzes how six DSCM dimensions—Information and System Integration, Traceability and Transparency, Big Data Analytics and AI, Internet of Things (IoT), Cloud Platforms and Collaboration, and Resilience and Responsiveness—shape firm-level performance. A structured questionnaire administered to employees across three major delivery firms, and statistical analyses conducted using correlation tests, multiple regression, Variance Inflation Factor (VIF) diagnostics, and interaction analysis.

Results reveal strong and significant correlations between all DSCM dimensions and operational efficiency, while regression outcomes indicate that Information and System Integration is the only dimension with a unique significant effect, highlighting its foundational role. Multicollinearity and interaction effects further demonstrate that DSCM functions as an integrated system rather than independent components. Beyond operational outcomes, the study shows that DSCM contributes to broader economic development through productivity gains, reduced transaction costs, expansion of e-commerce, employment generation, and strengthened value chains. The findings underscore the strategic role of digital technologies in enhancing firm competitiveness and supporting sustainable economic recovery in Mosul. Implications for managerial practice and policy development also presented.

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Introduction

Over the past decade, global supply chains have undergone profound transformations driven by the Fourth Industrial Revolution and accelerated digitalization. Digital technologies have become pivotal in strengthening supply chain resilience, enhancing operational efficiency, and supporting sustainability-oriented practices. Tools such as big data analytics, block chain, artificial intelligence (AI), digital twins, and the Internet of Things (IoT) have redefined the management of information and physical flows, offering firms new capabilities for prediction, integration, and real-time control.

Early studies highlight the role of big data analytics in enabling predictive insights into demand and supply variations, thereby improving decision-making

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accuracy and efficiency (Wang et al., 2016). Subsequent research has shown that digital analytics capabilities serve as essential mediators that enhance agility and resilience and translate digital adoption into operational performance gains (Bahrami et al., 2022; Gopal et al., 2024). Similarly, Zhao et al. (2023) emphasize that digitalization goes beyond efficiency improvements to reinforce adaptability and responsiveness in volatile environments—a trend reinforced by the operational challenges observed during the COVID-19 pandemic (Spieske & Birkel, 2021; Ning et al., 2023).

Block chain technologies contribute to improved transparency and traceability, particularly in sensitive industries such as food and healthcare (Agi & Shahzad, 2022; Sahoo et al., 2024). Digital twins further expand predictive capabilities and real-time simulation, offering firms a competitive advantage in navigating uncertainty (Wang et al., 2022; Le & Fan, 2024). Despite the broad literature base, research gaps remain, particularly regarding the integration of multiple digital technologies within unified data-governance frameworks and the assessment of long-term sustainable returns on digital investment (Wu et al., 2025).

With the proliferation of modern technologies—RFID, IoT, cloud computing, AI, and 3D printing—traditional supply chain approaches have become insufficient for meeting the rapidly evolving requirements of contemporary industries. Consequently, digital supply chain management (DSCM) has emerged as a critical field within both academic and industrial research (Agrawal & Narain, 2018; Büyüközkan & Göçer, 2018; Garay-Rondero et al., 2020). Recent studies have explored multiple dimensions of DSCM, including dynamic capabilities (Queiroz et al., 2021), data-driven innovation (Nica, 2019), security and trust (Zhang et al., 2019), and resilience during global disruptions (Ivanov, 2021) .

Research Problem

Despite the global shift toward digitalized supply chains, delivery companies in developing cities—such as Mosul—continue to face operational obstacles, including limited information integration, high operational costs, weak resilience to disruptions, and suboptimal resource utilization. Moreover, empirical research exploring the relationship between DSCM adoption and operational efficiency in the delivery sector remains scarce.

Thus, the research problem can expressed through the following central question:

"To what extent do the dimensions of digital supply chain management (DSCM) contribute to enhancing the operational efficiency of delivery companies in Mosul and their economic growth?"

Research Importance

The growing demand for delivery services in Mosul, combined with rising operational costs and heightened expectations for service quality, underscores the need for digital transformation in the delivery sector. Implementing DSCM practices can strengthen transparency, improve resource allocation, enhance productivity, and increase a firm's ability to respond to disruptions.

The value of this research lies in its attempt to empirically, link digital supply chain adoption with operational efficiency, focusing on its future benefits within a context that has received limited scholarly attention. The study further contributes by offering insights relevant to competitive advantage and sustainable performance in delivery companies.

Research Objectives

1. Identify the measurable dimensions of the digital supply chain applicable to delivery companies.
2. Analyze the impact of adopting DSCM dimensions on the operational efficiency of delivery companies in Mosul.
3. Evaluate the levels of operational efficiency across dimensions such as time, resource utilization, quality, productivity, flexibility, and financial performance.
4. Eventually, the role of those dimensions and effects, as well as levels of operational efficiency, in achieving the expansion and growth of supply chains, and achieving economic growth for delivery companies.
5. Propose recommendations to enhance operational efficiency through digital integration.

Beyond its operational and technological importance, Digital Supply Chain Management (DSCM) carries broader economic implications that are particularly relevant for emerging and post-conflict urban environments such as Mosul. As global economies increasingly rely on digital infrastructure to enhance productivity, reduce transaction costs, and support market integration, DSCM becomes a strategic mechanism through which firms contribute not only to their own performance but also to wider economic revitalization. The transformation of supply chains through digitalization fosters innovation, strengthens local value creation, expands service-sector activities, and enhances economic resilience—factors that are fundamental to sustainable growth. Therefore, examining DSCM within delivery companies in Mosul provides an opportunity to understand not only its operational effects but also its potential to stimulate economic development in the city.

1. Theoretical Framework

Here we start with the research model and hypotheses development. Based on the theoretical framework, a conceptual model developed to illustrate the logical relationships among the study variables (Figure 1). The

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model examines the association between DSCM dimensions and operational efficiency, as well as the direct effects of these dimensions on performance outcomes.

Hypotheses of Correlation (H1)

- **H1: There is a significant correlation between the digital supply chain (DSC) and operational efficiency.**

H1-1: Information and System Integration correlates with operational efficiency.

H1-2: Traceability and Transparency correlate with operational efficiency.

H1-3: Big Data Analytics and AI correlate with operational efficiency.

H1-4: IoT and Automation correlate with operational efficiency.

H1-5: Cloud Platforms and Collaboration correlate with operational efficiency.

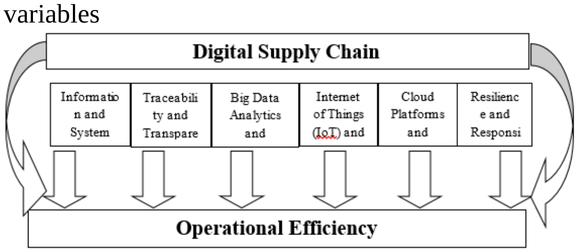
H1-6: Resilience and Responsiveness correlate with operational efficiency and growth.

Hypotheses of Effect (H2)

- **H2: Digital supply chain dimensions have a statistically significant effect on operational efficiency**.

H2-1 through H2-6 correspond to the effect of each DSCM dimension on operational efficiency.

Figure 1: the logical relationships among the study variables



Data Collection Methods

The theoretical component of the research relied on scholarly books, theses, and peer-reviewed articles. The empirical component based on a structured questionnaire using a five-point Likert scale, administered to managers and employees across three delivery companies (Al-Barq, Al-Fayhaa Express, and Al-Salihin Group for International Transportation). The questionnaire method enabled the researchers to capture detailed insights regarding operational mechanisms and the systemic characteristics of the studied environment.

Statistical Analysis Methods

After data collection, the Statistical Package for the Social Sciences (SPSS) used to perform the necessary analyses. The following statistical tools employed:

1. Descriptive statistics (frequencies, percentages, means, standard deviations).
2. Pearson correlation coefficient to measure the strength and direction of relationships.
3. Multiple regression analysis to determine the effect of DSCM dimensions on operational efficiency.
4. F-test to assess the overall significance of the regression model.
5. T-test to evaluate the significance of individual predictors.
6. R^2 to determine the proportion of variance in the dependent variable explained by the independent variables.

With the rapid acceleration of technological advancements, organizations increasingly rely on digitalization to address operational challenges and enhance supply chain performance. Over the past two decades, digital supply chain management (DSCM) has emerged as a central theme in academic literature. Christopher (2000) argued that competition no longer takes place between individual firms but rather among entire supply chains, emphasizing the strategic importance of effective supply chain integration.

Early contributions, such as Butner (2010), underscored the necessity of investing in advanced technologies to transform traditional supply chains into intelligent and adaptive systems capable of meeting emerging market requirements. Wu et al. (2016) further characterized DSCM by six core attributes: interconnectivity, intelligence, automation, integration, innovation, and physical-digital alignment.

Agrawal and Narain (2018) provided an extensive review of the evolution of DSCM, highlighting its role in integrating cross-functional processes and enhancing overall supply chain effectiveness. Complementary perspectives by Büyüközkan and Göçer (2018) emphasized the contribution of DSCM to sustainability, recommending future research linking digitalization with the circular economy.

Industry 4.0 developments have significantly influenced supply chain dynamics. Hofmann and Rüsch (2017) pointed out that digitization represents a transformative force in logistics and supply chain operations. Similarly, Ivanov et al. (2018) demonstrated that digital tools play a vital role in risk management by enhancing flexibility and mitigating volatility.

Blockchain applications also gained increasing attention. Saberi et al. (2019) showed that blockchain contributes to strengthening trust and transparency across supply chains. Likewise, Nica (2019) highlighted the role of data-driven innovation in enhancing operational effectiveness within digital supply chains.

More recent studies, including (Wang et al. 2023), confirmed that digital transformation has become a strategic priority for organizations—particularly in light of the disruptions associated with the COVID-19 pandemic, which revealed an urgent need for resilience, agility, and rapid reconfiguration within supply chains.

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Digital supply chain management builds on technologies such as e-procurement, automation systems, digital distribution, and advanced after-sales services. These technologies significantly influence efficiency, competitiveness, and overall performance (Nica, 2019; Wamba et al., 2020). Because traditional supply chains often lack the agility and adaptability required in dynamic environments, digital transformation increasingly adopted to create fully integrated, data-driven supply networks (Ivanov, 2021; Zhang et al., 2024). Initiatives such as Industry 4.0 and Made in China 2025 have accelerated the global diffusion of DSCM practices (Lasi et al., 2014; Zhong et al., 2017).

Although DSCM is a relatively new concept, literature frequently uses overlapping terms such as:

1. Smart Supply Chain Management (Wu et al., 2016)
2. Intelligent Supply Chain Management (Yan et al., 2014)
3. Supply Chain 4.0 (Alicke, 2017)

Drawing from Butner (2010) and Wu et al. (2016), DSCM can described as a technologically enhanced supply chain characterized by instrumentation, interconnectivity, intelligence, automation, integration, and innovation.

Concept of Digital Supply Chain Management (DSCM)

DSCM refers to the integration of advanced digital technologies, including IoT, Big Data Analytics (BDA), Artificial Intelligence (AI), cloud computing, and blockchain, into conventional supply chain operations to enhance visibility, integration, and real-time decision-making. According to Büyüközkan and Göçer (2018), DSCM provides a framework that transforms traditional linear supply chains into intelligent, interconnected networks driven by real-time data.

Garay-Rondero et al. (2020) describe DSCM as an extension of traditional supply chain systems, adding a technological layer that supports collaboration, real-time tracking, and adaptation. (Queiroz et al. 2021) further argue that DSCM is not merely a set of digital tools but a dynamic capability that enables firms to respond to rapidly changing environments.

Importance of the Digital Supply Chain

Recent research highlights several areas in which DSCM drives significant operational value:

1. Improving Operational Efficiency:
2. Automation and analytical capabilities reduce operational costs, optimize resource use, **and increase process accuracy (He et al., 2024).**
3. Enhancing Transparency and Traceability: **Blockchain and similar technologies strengthen trust and ensure secure information exchange across the supply chain (Saberi et al., 2019).**
4. Increasing Flexibility and Resilience: **Digital capabilities enhance responsiveness to emergencies, disruptions, and demand fluctuations (Zhao et al., 2023).**
5. Enabling Innovation in Service Delivery: **Digital integration supports faster, customized, and higher-quality service delivery, strengthening competitiveness and extension (Ivanov et al., 2018).**
6. Supporting Sustainability and Competitiveness: **DSCM reduces waste, improves inventory control, and enhances resource management efficiency (Kache & Seuring, 2017).**

Dimensions of the Digital Supply Chain (DSC)

Recent literature classifies DSCM into multiple dimensions that influence performance:

1. Information and System Integration (ISI)

Refers to the digital integration of internal and external systems, enabling real-time information flows across sales, warehousing, logistics, and distribution (Büyüközkan & Göçer, 2018).

2. Traceability and Transparency (Blockchain-Based Systems)

Enhance trust through secure, auditable, and tamper-proof information records (Saberi et al., 2019).

3. Big Data Analytics and Artificial Intelligence

Enable predictive modeling, demand forecasting, and data-driven decision-making, thus reducing waste and improving operational outcomes (Kache & Seuring, 2017).

4. Internet of Things (IoT) and Automation

Facilitate real-time tracking of vehicles and shipments, improving monitoring accuracy and process automation (Ivanov et al., 2018).

5. Cloud Platforms and Collaboration

Support scalable, integrated infrastructures that enhance cooperation among supply chain partners (Garay-Rondero et al., 2020).

6. Resilience and Responsiveness

Strengthen the supply chain's ability to handle crises, disruptions, and unexpected fluctuations (Zhao et al., 2023).

2. Methodology

2.1 Concept and Dimensions of Operational Efficiency

Operational efficiency refers to an organization's ability to maximize productivity while minimizing time, cost, effort, and waste in transforming inputs into high-quality outputs. Empirical studies emphasize that digital transformation significantly enhances

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operational and logistics efficiency by improving information flow and reducing cost and time (He et al., 2024).

Operational efficiency commonly assessed across six dimensions:

1. Time Performance: Measured through delivery times, processing speed, and adherence to schedules (Lee et al., 2023).
2. Resource Utilization Efficiency: Involves optimal use of vehicles, labor, inventory, and energy to minimize operational costs (Subramanian et al., 2020).
3. Service Quality and Accuracy: Reflected in error rates, return rates, customer satisfaction, and quality consistency (Kache & Seuring, 2017).
4. Flexibility and Responsiveness: Determines the organization's ability to adapt to crises, unforeseen events, and demand variability (Zhao et al., 2023).
5. Productivity: Measured by output levels per worker, vehicle, or process unit (Gopal et al., 2024).
6. Financial Efficiency: Includes operating cost per order, profit margins, and return on operating assets (He et al., 2024).

2.2Hypothesis Testing

This section examines the strength and significance of correlation and effect relationships between the dimensions of DSCM and operational efficiency, in line with the study's hypotheses.

Study Sample Description:

The work distributed 80 questionnaires to the research sample individuals as shown in tables (1,2).

Table(1): Describe study sample characters

Descriptive Information	Category	Count	Percentage
Sex	Male	66	82.5
	Female	14	17.5
	Total	80	
Age Group	25 and below	28	35.0
	26–34	24	30.0
	35–44	7	8.8
	45 and above	21	26.3
	Total	80	
Job Title	Logistics Manager	4	5.0
	IT Department	8	10.0
	Administrative Employee	34	42.5
	Operations Manager	14	17.5
	Driver	20	25.0
	Total	80	
Experience years (Tenure)	Less than (1) year	18	22.5
	1–3 years	53	66.3
	4–6 years	9	11.3
	Total	80	

Source: Prepared by researcher's work.

Table (2). Compatible with the average and elastic deflection for each period (DSCM and EFF)

Item	arithmetic mean	standard deviation	% deal (4-5)	% neutral (3)	% difference (1-2)
DSCM_1	2.91	0.97	27.5%	40.0%	32.5%
DSCM_10	2.99	1.08	33.8%	36.2%	30.0%
DSCM_11	3.00	1.06	35.0%	31.2%	33.8%
DSCM_12	2.94	1.02	30.0%	30.0%	40.0%
DSCM_13	2.95	1.10	28.7%	36.2%	35.0%
DSCM_14	2.95	0.97	23.8%	45.0%	31.2%
DSCM_15	2.99	1.01	33.8%	32.5%	33.8%
DSCM_16	3.02	1.02	30.0%	38.8%	31.2%
DSCM_17	2.98	1.14	28.7%	36.2%	35.0%

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DSCM_18	3.00	1.04	30.0%	33.8%	36.2%
DSCM_19	2.94	1.04	27.5%	38.8%	33.8%
DSCM_2	2.85	0.94	28.7%	32.5%	38.8%
DSCM_20	3.02	1.06	32.5%	31.2%	36.2%
DSCM_21	3.04	0.97	33.8%	36.2%	30.0%
DSCM_22	3.14	1.03	37.5%	31.2%	31.2%
DSCM_23	3.05	1.10	33.8%	32.5%	33.8%
DSCM_3	2.83	1.02	26.2%	36.2%	37.5%
DSCM_4	2.85	0.99	28.7%	30.0%	41.2%
DSCM_5	2.89	0.87	23.8%	38.8%	37.5%
DSCM_6	2.81	0.93	23.8%	37.5%	38.8%
DSCM_7	2.84	0.92	26.2%	36.2%	37.5%
DSCM_8	3.01	1.02	33.8%	37.5%	28.7%
DSCM_9	2.85	1.02	28.7%	32.5%	38.8%
DSCM_Cloud	2.98	0.97	17.5%	12.5%	22.5%
DSCM_InfoSys	2.86	0.90	17.5%	6.2%	23.8%
DSCM_IoT	2.96	0.94	17.5%	10.0%	16.2%
DSCM_Resilience	3.06	0.95	23.8%	10.0%	17.5%
DSCM_Trace	2.85	0.82	16.2%	12.5%	26.2%
DSCM_total	2.95	0.77	10.0%	2.5%	12.5%
EFF_1	2.85	1.14	25.0%	37.5%	37.5%
EFF_10	2.99	1.12	36.2%	28.7%	35.0%
EFF_11	3.00	1.09	35.0%	35.0%	30.0%
EFF_12	3.09	1.12	37.5%	32.5%	30.0%
EFF_13	2.98	1.07	31.2%	40.0%	28.7%
EFF_14	2.98	1.15	33.8%	33.8%	32.5%
EFF_15	3.01	1.16	41.2%	30.0%	28.7%
EFF_16	3.05	1.12	36.2%	31.2%	32.5%
EFF_17	3.06	1.16	36.2%	33.8%	30.0%
EFF_18	3.12	1.18	38.8%	31.2%	30.0%
EFF_2	2.98	1.16	35.0%	31.2%	33.8%
EFF_3	2.91	1.14	35.0%	27.5%	37.5%
EFF_4	2.83	1.10	27.5%	33.8%	38.8%
EFF_5	2.94	1.16	31.2%	30.0%	38.8%
EFF_6	2.92	1.19	32.5%	27.5%	40.0%
EFF_7	2.89	1.11	31.2%	32.5%	36.2%
EFF_8	3.08	1.10	36.2%	32.5%	31.2%
EFF_9	3.08	1.12	38.8%	27.5%	33.8%
EFF_Financial	3.08	1.08	28.7%	11.2%	17.5%
EFF_Flex	3.02	1.03	25.0%	6.2%	17.5%
EFF_Productivity	2.99	1.06	26.2%	18.8%	21.2%
EFF_Resource	2.90	1.09	22.5%	13.8%	30.0%
EFF_ServiceQ	3.01	1.05	25.0%	10.0%	22.5%
EFF_TimePerf	2.91	1.07	23.8%	16.2%	27.5%
EFF_total	2.99	0.93	12.5%	2.5%	16.2%

Source: Prepared by researcher's work.

2.3 Description of the Study Sample

80 questionnaires were distributed among respondents from different functional units across the participating delivery companies. Table (1) presents demographic and occupational characteristics, including gender, age groups, job titles, and years of experience.

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Descriptive Statistics for DSCM and Operational Efficiency

Table (2) reports the arithmetic means, standard deviations, and response distributions for all DSCM and operational efficiency items. The results indicate moderate levels of adoption and efficiency, with variations across the measured dimensions.

Table (3) presents aggregated mean scores, coefficients of variation (CV), and Cronbach's alpha values for the six DSCM dimensions and the six operational efficiency dimensions. All Cronbach's alpha values exceeded accepted reliability thresholds, confirming the internal consistency of the measurement scales.

2.4 Correlation Analysis between DSCM Dimensions and Operational Efficiency

Pearson correlation coefficients calculated to examine the relationships between the six dimensions of Digital Supply Chain Management (DSCM) and overall operational efficiency (EFF_total). As shown in **Table (3)**, all dimensions exhibit statistically significant positive correlations with operational efficiency at ($\alpha \leq 0.05$). Correlation Coefficients between DSCM Dimensions and Operational Efficiency Table (4). Stratkle after DSCM intensity and (6) efficiency intensity in Table (5).

Table (3). Correlation Coefficients Between DSCM Dimensions and Operational Efficiency

Dimension	r	p-value	Interpretation
InfoSys	0.613	0.000	Significant positive correlation
Traceability	0.529	0.000	Significant positive correlation
BDA & AI	0.565	0.000	Significant positive correlation
IoT	0.529	0.000	Significant positive correlation
Cloud	0.510	0.000	Significant positive correlation
Resilience	0.557	0.000	Significant positive correlation

These findings indicate that increased adoption of DSCM practices is associated with higher levels of operational efficiency among delivery companies in Mosul.

Table (4): Stratkle after (4) DSCM intensity and (6) efficiency intensity Table

Item	arithmetic mean	standard deviation	% Agreement (average > = 4)	CV (%)	Cronbach's Alpha (subscale)
DSCM – InfoSys	2.86	0.90	17.5%	31.35	0.934
DSCM – Trace	2.85	0.82	16.2%	28.81	0.888
DSCM - BDA_AI	2.96	0.97	21.2%	32.73	0.945
DSCM – IoT	2.96	0.94	17.5%	31.75	0.934
DSCM – Cloud	2.98	0.97	17.5%	32.58	0.938
DSCM – Resilience	3.06	0.95	23.8%	30.86	0.929
EFF – TimePerf	2.91	1.07	23.8%	36.64	0.925
EFF – Resource	2.90	1.09	22.5%	37.74	0.946
EFF – ServiceQ	3.01	1.05	25.0%	34.74	0.936
EFF – Flex	3.02	1.03	25.0%	33.99	0.918
EFF – Productivity	2.99	1.06	26.2%	35.57	0.938
EFF – Financial	3.08	1.08	28.7%	35.10	0.927

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Source: Prepared by researcher's work.

Table (3): Correlation coefficients: Each dimension of the DSCM with operational efficiency (EFF_total) Table (5).

Item	R	p-value	sincere
InfoSys	0.613	0.000	moral
Trace	0.529	0.000	moral
BDA_AI	0.565	0.000	moral
IoT	0.529	0.000	moral
Cloud	0.510	0.000	moral
Resilience	0.557	0.000	moral

Source: Prepared by researchers

2.5 Multiple Regression Analysis

To test the effect of the six DSCM dimensions on operational efficiency, a multiple linear regression model estimated. The model yielded statistically significant results, as shown below:

- **R^2 = 0.458**, Adjusted R^2 = 0.414
- **F = 10.294**, p = 0.000

This confirms that the DSCM dimensions collectively explain approximately **41.4%** of the variance in operational efficiency.

Table (4). Regression Coefficients

Variable	B	Std. Error	t	p-value	95% CI
Constant	0.642	0.320	2.007	0.048	[0.005, 1.280]
Infosys	0.314	0.141	2.232	0.029	[0.034, 0.594]
Traceability	0.036	0.154	0.231	0.818	[-0.271, 0.342]
BDA & AI	0.168	0.135	1.243	0.218	[-0.102, 0.438]
IoT	0.080	0.128	0.630	0.530	[-0.174, 0.335]
Cloud	0.003	0.130	0.026	0.979	[-0.255, 0.262]
Resilience	0.195	0.123	1.590	0.116	[-0.049, 0.440]

Interpretation

Only **Information and System Integration (InfoSys)** has a statistically significant unique effect on operational efficiency (p = 0.029).

The remaining five dimensions, while important in the correlation analysis, do not show significant individual effects when included together in the regression model. This discrepancy explained through multicollinearity.

Reliability Analysis

Cronbach's alpha values for both scales demonstrate excellent internal consistency:

- **DSCM total: α = 0.967**
- **EFF total: α = 0.971**

All sub-dimensions also exceeded accepted reliability thresholds (α > 0.88), confirming the robustness of the measurement instruments.

3. Results and Analysis

3.1 Hypotheses Testing

3.2 Correlation Hypotheses (H1)

The analysis confirmed strong, statistically significant correlations between the overall DSCM construct and operational efficiency. Hence:

1. **Main Hypothesis H1: Accepted.**
2. **Sub-Hypotheses H1-1 to H1-6: All Accepted.**

This indicates that each DSCM dimension is positively associated with operational efficiency.

3.3Effect Hypotheses (H2)

1. **Main Hypothesis H2: Accepted.**
The six DSCM dimensions collectively have a significant effect on operational efficiency.
2. **Sub-Hypotheses H2-1 to H2-6:**
H2-1 (Infosys): Accepted
H2-2 to H2-6: Rejected (No significant unique effect after accounting for multicollinearity)

This means Information and System Integration is the only dimension with a distinct contribution in the presence of other predictors.

3.4 Multicollinearity and Robustness Analysis

Variance Inflation Factor (VIF)

High VIF values (ranging from 3.91 to 5.41) indicate **substantial multicollinearity** among DSCM dimensions. This means the dimensions are strongly interrelated and often implemented jointly, complicating the isolation of individual effects.

Practical implication: DSCM dimensions work as an integrated system rather than independent variables.

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Principal Component Analysis (PCA)

To handle multicollinearity, PCA generated two uncorrelated components explaining **82.9%** of DSCM variance.

Regression results using PC1 and PC2:

R^2 = 0.432, F = 29.45, p = 0.000

Both components were statistically significant predictors.

Interaction Effects

Interaction terms revealed additional insights:

1. Infosys × Resilience → significant
2. BDA/AI × IoT → significant
3. Cloud × Traceability → significant

These results suggest that DSCM dimensions reinforce each other and perform better when jointly implemented.

4. Economic Implications and Contributions to Growth

Digital Supply Chain Management (DSCM) extends its value far beyond operational optimization and represents a strategic foundation for stimulating economic growth—particularly in emerging or recovering urban economies such as Mosul. The empirical findings of this study, which show a strong positive relationship between DSCM adoption and operational efficiency, are consistent with theoretical perspectives in growth economics that link productivity improvement, technological progress, and market efficiency with macroeconomic expansion (Solow, 1956; Romer, 1990).

4.1 Productivity and Total Factor Productivity (TFP) Enhancement

Economic growth models emphasize productivity as a fundamental driver of long-term expansion. Digital integration—such as real-time information systems, automation, and data analytics—raises Total Factor Productivity by improving the efficiency of capital, labor, and logistical assets.
Within delivery companies, improved routing algorithms, integrated information systems, and reduced idle time lead to higher output per worker and per vehicle, contributing to firm-level and sector-level productivity gains. According to Porter and Heppelmann (2015), digitally enabled operations create a "smart productivity frontier" that expands the economic value added.

4.2 Market Efficiency and Reduced Transaction Costs

DSCM reduces transaction costs associated with information asymmetry, delays, and coordination barriers. Coase (1937) and Williamson (1985) argued that lower transaction costs lead to more efficient markets and broader participation.

In the case of Mosul, digital delivery networks enhance market functioning by:

1. Reducing delivery costs
2. Improving price stability
3. Increasing transparency
4. Facilitating smoother movement of goods

This contributes to a more efficient urban economy, stimulating consumer spending and business activity.

4.3 Enabling E-commerce Expansion and Service-Sector Growth

Modern economic growth increasingly depends on service-sector dynamism. Reports by UNCTAD (2022) and McKinsey (2021) show that e-commerce growth is strongly tied to the maturity of digital logistics infrastructure.

By adopting DSCM, delivery companies become enablers of:

1. Digital marketplaces
2. SME participation in online retail
3. Financial technology (fintech) integration
4. Urban supply chain ecosystems

The growth of e-commerce adds directly to GDP through increased trade volume, job creation, and higher tax revenues.

4.4 Employment Creation and Workforce Upgrading

Although automation raises concerns globally, empirical studies in developing economies show that digitization often **reshapes** rather than reduces employment (Baldwin, 2019).

DSCM contributes to job creation in:

1. Digital logistics coordination
2. Data management and analytics
3. System administration
4. IoT maintenance
5. Customer experience and platform management

Moreover ‹technology adoption increases demand for skilled labor, supporting human capital development—one of the strongest predictors of long-term growth (Lucas, 1988).

4.5 Improving Economic Resilience and Reducing Shock Vulnerability

Economic resilience has become a key determinant of sustainable growth. Digital supply chains enhance resilience by:

1. Reducing vulnerability to disruptions
2. Enabling real-time rerouting and mitigation
3. Protecting inventory and ensuring availability of essential goods

Resilient supply chains stabilize broader economic activity and reduce systemic risks, particularly in post-conflict cities like Mosul.

4.6 Strengthening Local Value Chains and Multiplier Effects

By lowering costs and improving reliability, DSCM strengthens the integration of local suppliers, retailers, and service providers into value chains. Baldwin and Evenett (2020) highlight the importance of integrating

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domestic firms into digitally enabled supply networks to maximize national economic multipliers.

Potential multiplier effects in Mosul include:

1. Higher retail turnover
2. Growth in allied sectors (IT services, transportation, warehousing)
3. Increased investment in digital infrastructure
4. Greater local value-added and reduced economic leakages

Collectively, these mechanisms align DSCM with both short-term economic activation and long-term sustainable growth.

This work suggests considering the possibility of applying the results of this study by companies in Mosul and elsewhere, and benefiting from them, especially the recommendations in the fifth paragraph of the conclusion, to enhance operational efficiency through digital integration.

Comprehensive Conclusion

The empirical analysis provides strong evidence supporting the pivotal role of Digital Supply Chain Management in enhancing operational efficiency among delivery companies in Mosul. The findings can be summarized as follows:

1. **Strong Overall Relationship:** All DSCM dimensions exhibit significant positive correlations with operational efficiency.
2. **Collective Impact is Substantial:** DSCM dimensions jointly explain more than **41%** of the variance in operational efficiency.
3. **Integration is Crucial:** Multicollinearity and significant interaction effects confirm that DSCM components operate synergistically, not independently.
4. **Information and System Integration is the Key Driver:** It is the only dimension with a statistically significant standalone effect, underscoring its foundational role in enabling other technologies.
5. **Digital Synergy Enhances Efficiency:** Combinations such as (InfoSys × Resilience) and (BDA/AI × IoT) create a cumulative positive effect greater than individual contributions.

The findings of this study demonstrate that the benefits of DSCM extend beyond measurable improvements in operational efficiency. When viewed through the lens of economic development, digital supply chains act as catalysts for productivity enhancement, workforce upgrading, market expansion, and resilience building—particularly in rapidly transforming urban economies. In Mosul, where economic recovery and modernization are central priorities, the adoption of DSCM practices by delivery companies can accelerate the city's reintegration into regional markets and stimulate broader economic activity. By strengthening value chains, reducing inefficiencies, and supporting the growth of digital commerce, DSCM becomes not merely a managerial tool but a driver of long-term economic revival. As such, the study underscores the strategic importance of fostering digital capabilities within logistics and service firms as part of a holistic approach to sustainable economic growth.

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