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The Effect of Digital Supply Chains in Optimizing Inventory Management Efficiency: An Empirical Study on the Retail Sector in Egypt

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Abstract

This research investigates the effect of Digital Supply Chains on Inventory Management efficiency in the retail sector in Egypt. The research focuses on four main dimensions of Digital Supply Chains: Internet of Things (IoT), Artificial Intelligence and Machine Learning (AI/ML), Robotic Process Automation (RPA), and Real-Time Visibility, and their effect on the four dimensions of Inventory Management efficiency: Cost Efficiency, Time Efficiency, Accuracy, and Flexibility and Responsiveness. The empirical analysis is based on responses from 136 managers and employees working in supply chain, logistics, and inventory management departments at Carrefour Egypt, Zara Egypt, and Spinneys Egypt. Using quantitative methods and structural equation modeling (PLS-SEM), the study identifies significant positive effect of Digital Supply Chains in optimizing Inventory Management efficiency. The results provide both theoretical contributions to the literature on supply chain digitalization and practical recommendations for retailers in Egypt aiming to optimize their inventory operations.

Key words: Digital Supply Chain, Inventory Management Efficiency, IoT, Artificial Intelligence and Machine Learning, Robotic Process Automation, Real-Time Visibility, Retail Sector, Egypt.

1. Introduction

The transformation of Supply Chains into digitally enabled networks has redefined the way firms manage their operations, specifically in Inventory Management. Traditional inventory systems often rely on manual processes and limited visibility, leading to inefficiencies such as stockouts, overstocking, and high carrying costs (Kache and Seuring, 2022). With the adoption of Digital Supply Chain technologies, including IoT, AI/ML, RPA, and real-time visibility, companies are achieving more responsive, efficient, and data-driven inventory systems (Tiwari et al., 2023).

In the retail sector, Inventory Management is critical for customer satisfaction and competitive advantage. Egyptian retailers face increasing challenges such as demand fluctuations, global supply troubles, and rising operational costs. Digital supply chain solutions provide opportunities to improve forecasting accuracy, automate stock replenishment, reduce waste, and enhance responsiveness to market changes (Chopra, 2023). However, despite global attention to digitalization, limited empirical evidence exists on how these technologies affect inventory management efficiency in emerging markets like Egypt (Shibin et al. 2024).

This research addresses this gap by examining the effect of digital supply chains on inventory management efficiency in the Egyptian retail sector, focusing on Carrefour, Zara, and Spinneys. It contributes to both academic understanding and practical decision-making in Supply Chain Management.

2. Literature Review

The digital transformation of supply chains has generated a growing body of research that links advanced technologies with operational efficiency across multiple industries (Ivanov and Dolgui, 2021). Recent studies highlight how digital supply chains; enabled by IoT, Artificial Intelligence and Machine Learning, Robotic Process Automation (RPA), and Real-Time Visibility, are reshaping Inventory Management practices by enhancing accuracy, reducing costs, saving time, and improving responsiveness (Fan et al. 2023). Inventory management efficiency, in turn, has been widely studied as a multidimensional

construct that describes cost reduction, time optimization, record accuracy, and organizational flexibility (Waller and Fawcett, 2013).

This review examines prior studies in three main streams: research on Digital Supply Chain technologies, research on Inventory Management efficiency, and empirical studies that integrate both variables (Aamer et al., 2022). The aim is to provide a comprehensive understanding of how digital supply chains contribute to optimizing inventory management efficiency, with a particular focus on evidence relevant to the retail sector.

2.1 Digital Supply Chains

Chaudhuri et al., (2023) explored AI and Machine Learning applications in retail inventory forecasting across multiple companies in Asia. Their findings showed that AI-based forecasting models decreased forecast errors by up to 50%, leading to fewer stockouts and lower safety stock levels. The study concluded that AI and machine learning increase both predictive accuracy and operational responsiveness in inventory planning.

Fan et al., (2023) conducted a study on Real-Time Supply Chain Visibility using integrated platforms across global logistics companies. They found that firms with advanced real-time visibility systems achieved order accuracy exceeding 99%, lower labor costs, and faster response times to disruptions. The study demonstrated that visibility serves as a critical enabler of agility and customer service in digital supply chains.

Siderska and Jadaan (2022) investigated the use of Robotic Process Automation in supply chain administration in European retail firms. Their results indicated that RPA reduced repetitive administrative errors, shortened order cycle times, and increased consistency in stock updates. The findings emphasized that automation through RPA contributes directly to higher efficiency and reliability in supply chain operations.

Ivanov and Dolgui (2021) explored the broader transformation brought by digital supply chains across industries. Their study showed that digitalization improves agility, resilience, and resource optimization,

particularly under uncertainty and supply disruptions, confirming that digital supply chains provide firms with superior adaptability and cost-effectiveness compared to traditional systems.

Mostafa et al., (2019) explored the role of IoT technologies in warehouse operations in Egypt, focusing on RFID and sensor applications. The findings of the study revealed that IoT-based systems achieved between 81–99% time savings in joint ordering, a 100% reduction in processing times, and enabled real-time inventory tracking with near-total accuracy, concluding that IoT implementation improves transparency and control in supply chains.

2.2 Inventory Management Efficiency

Zia et al., (2025) examined the integration of IoT and AI in retail supply chains in South Asia. Their findings showed that digital tools reduced inventory costs by approximately 25%, minimized overstocking, and improved product availability. The study concluded that cost efficiency is directly enhanced when firms integrate smart technologies into inventory systems.

Chopra (2023) investigated the responsiveness of global retailers using AI-driven visibility tools. The results showed that firms with predictive analytics could adapt faster to demand fluctuations and supply disruptions, achieving improved service levels and market responsiveness. The study concluded that flexibility in inventory systems is strengthened by predictive visibility.

Tong (2023) explored a semi-automated warehouse system using AI and barcode recognition technologies. The study showed that the system provided sub-minute inventory monitoring, increased the frequency of checks, and improved forecasting speed. The results indicated that digital automation significantly reduces time delays and accelerates inventory decision-making.

Waller and Fawcett (2013) investigated inventory accuracy in digitally enabled supply chains. Their study found that firms adopting analytics and real-time systems enhanced inventory record accuracy by over 20%, which directly lowered mismatches and unfulfilled orders. The results confirmed that digital solutions ensure more accurate stock tracking and alignment between recorded and physical inventories.

Aamer et al., (2022) explored inventory management in digitalized firms across the Middle East. The results found that digital adoption improved overall efficiency by lowering carrying costs, shortening replenishment cycles, and enhancing order fulfillment rates. The study concluded that inventory efficiency is multi-dimensional, requiring both cost and service-level improvements.

2.3 Digital Supply Chains and Inventory Efficiency

Fernandez-Carames et al., (2024) investigated a blockchain- and UAV-based system for warehouse inventory. Their results revealed faster data capture, improved positional accuracy, and higher efficiency compared to manual counts. The authors concluded that combining advanced digital tools with automation optimizes both speed and accuracy in inventory management.

Gupta et al., (2023) examined the role of AI and IoT in Indian retail supply chains. The results confirmed significant reductions in lead times and inventory costs, with improvements in customer satisfaction. The study concluded that integrating digital supply chain technologies directly enhances inventory performance outcomes.

Meyer et al., (2023) examined the use of IoT and AI in European retail chains. Their findings showed that real-time monitoring and predictive analytics improved stock accuracy by 30% and reduced carrying costs by 15%. The study concluded that digital supply chain technologies generate tangible efficiency gains in inventory management.

Queiroz et al., (2022) conducted a global survey of supply chain managers on digital adoption. The results indicated that firms integrating digital supply chains achieved higher agility and efficiency, particularly in inventory optimization. The study concluded that digitalization strengthens both strategic and operational performance.

El Baz and Ruel (2021) investigated digital technologies in supply chains during COVID-19 disruptions. Their study highlighted that real-time visibility and automation improved resilience, reduced stockouts, and enhanced inventory accuracy. They concluded that digital supply chains are essential for maintaining efficiency under uncertainty.

3. Research Gap

The existing literature provides strong evidence that Digital Supply Chain technologies, such as AI, IoT, RPA, and real-time visibility, positively affect inventory management efficiency in terms of accuracy, cost reduction, and responsiveness. However, most studies have either focused on specific technologies in separation (e.g., AI forecasting, IoT tracking) or examined their effect in non-retail or global contexts. Limited empirical research has been conducted in developing markets, particularly within the retail sector, to investigate how integrated digital supply chain systems optimize inventory management efficiency across multiple dimensions such as cost, time, accuracy, and flexibility. Additionally, while studies highlight efficiency improvements, few provide sector-specific evidence that links digital transformation directly to inventory optimization in retail, where demand variability and operational complexity are particularly high. This leaves a knowledge gap on how digital supply chains contribute to inventory efficiency in retail settings in developing economies.

4. Research Problem

Despite the rapid global adoption of Digital Supply Chains, many retailers in Egypt continue to face huge inefficiencies in Inventory Management. Traditional inventory management methods, characterized by limited visibility, manual processes, and delayed decision-making, leads to stockouts, overstocking, inaccurate demand forecasting, and rising operational costs (Kache and Seuring, 2022). International studies demonstrate that technologies such as IoT, AI and machine learning, robotic process automation, and real-time visibility improve cost efficiency, time responsiveness, and accuracy in managing inventory (Chaudhuri et al., 2023; Fan et al., 2023). Although, there is limited empirical evidence on how these technologies affect inventory management efficiency in the Egyptian retail sector.

Although digital technologies have shown strong potential to improve supply chain performance, there is still insufficient empirical evidence on how their implementation directly optimizes inventory management efficiency in the retail sector of emerging markets. Retail companies such as Carrefour, Zara, and Spinneys have begun integrating Digital Supply Chains, yet the measurable results on Inventory Management remain largely unexamined.

5. Research Objectives

The main objective of this research is to examine the effect of Digital Supply Chains in optimizing Inventory Management efficiency in the Egyptian retail sector, with a specific focus on Carrefour Egypt, Zara Egypt, and Spinneys Egypt.

The specific objectives are:

1. **To investigate the effect of IoT in optimizing cost efficiency, accuracy, and real-time visibility in inventory management.**
2. **To evaluate the effect of AI and Machine Learning on demand forecasting accuracy, time savings, and responsiveness to market instabilities.**
3. **To assess the effect of Robotic Process Automation on decreasing repetitive errors, shortening lead times, and improving consistency in inventory-related processes.**
4. **To analyse the effect of real-time visibility in optimizing operational flexibility, responsiveness, and decision-making in inventory control.**
5. **To offer empirical evidence on the effect of Digital Supply Chain adoption and overall inventory efficiency in the retail sector in Egypt.**
6. **To provide practical recommendations for retail firms in Egypt on how to implement Digital Supply Chains to optimize their inventory management systems.**

6. Research Importance

The retail sector plays a critical role in economic development, employment generation, and consumer satisfaction. In Egypt, retail sector is one of the largest and fastest-growing sectors, contributing significantly to GDP and providing millions of jobs across both formal and informal markets. The sector faces increasing pressure from demand fluctuations, high competition, and evolving customer expectations, which makes efficient inventory management a critical factor for success. As digital transformation accelerates, the retail sector represents a highly relevant application area to study the effect of digital supply chains in optimizing inventory management efficiency and competitiveness. The research carries both theoretical and practical importance as follows

6.1 Theoretical Importance

This research contributes to the academic literature on Supply Chain Management by examining the effect of Digital Supply Chains in optimizing Inventory Management efficiency within the Egyptian retail sector. Existing studies have largely focused on developed markets, leaving a gap in developing economies where digital transformation is still growing (Queiroz et al., 2022). By examining four dimensions of digital supply chains (IoT, AI/ML, RPA, and Real-Time Visibility) and their effect in optimizing cost efficiency, time efficiency, accuracy, and flexibility in inventory management, this research provides a localized empirical contribution. The findings will spread current theoretical models of digital supply chain performance and offer insights into how technology adoption can improve operational efficiency in resource-constrained environments (Ivanov and Dolgui, 2021).

6.2 Practical Importance

From a managerial viewpoint, the research offers actionable insights for retail companies in Egypt. Inventory management efficiency is a keystone of competitive advantage in the retail industry, where customer satisfaction is based on product availability and service quality. By identifying the digital supply chain technologies that most powerfully affect cost reduction, speed, accuracy, and responsiveness, this research enables decision-makers to prioritize investments in technology (Chopra, 2023). The results will help retail managers and supply chain professionals in developing targeted strategies for technology adoption, improving decision-making, and ensuring agility in response to market demand variations. For policymakers, the findings offer evidence-based guidance to encourage digital transformation initiatives within the Egyptian retail sector, thus strengthening national competitiveness (Fan et al., 2023).

7. Research Methodology

This section outlines the methodology used to examine the effect of digital supply chains in optimizing inventory management efficiency in the retail sector in Egypt. The methodological design ensures validity, reliability, and alignment with the study objectives.

7.1 Research Population

The research population consists of employees working in Supply Chain, Logistics, and Inventory Management departments within leading retailers in Egypt, such as Carrefour Egypt, Zara Egypt, and Spinneys Egypt. Their direct involvement in procurement, warehousing, distribution, and digital transformation initiatives makes them suitable respondents for examining the effect of Digital Supply Chains in optimizing Inventory Management efficiency.

7.2 Empirical Study on Carrefour, Spinneys, and Zara

The empirical study examines the effect of Digital Supply Chains in optimizing Inventory Management efficiency within the Egyptian retail sector. The research investigates this effect through three major companies operating in the retail sector: Carrefour Egypt, Spinneys Egypt, and Zara Egypt, providing practical insights into how digital supply chains optimize inventory management efficiency.

7.2.1 Carrefour Egypt

Carrefour Egypt is part of the Carrefour Group, one of the largest multinational retail chains originating in France. Carrefour began its operations in Egypt in 2002 and became one of the country's leading hypermarket and supermarket retailers, with over 2,000 hypermarkets and supermarkets globally. In Egypt, Carrefour operates approximately 59 branches (including 14 hypermarkets and 45 supermarkets). The company continues to expand, with plans to reach 70 branches across 25 cities.

In recent years, Carrefour Egypt has adopted digital transformation in its supply chain by using advanced inventory management systems, real-time tracking tools, and data analytics for demand forecasting. These initiatives have enhanced stock accuracy, reduced waste, and improved decision-making processes.

7.2.2 Spinneys Egypt

Spinneys is a retail chain that originated in Lebanon and has extended into several Middle Eastern and North African markets, including Egypt. In Egypt, Spinneys has rapidly expanded to around 30 stores as of late 2024 and has gained popularity for its high-quality product offerings, particularly in fresh food and imported goods. The company emphasizes customer satisfaction through high-quality products, service excellence, and efficient store management.

Spinneys Egypt has implemented advanced technologies in its digital supply chain strategy, particularly in real-time visibility. It has adopted AI-driven forecasting, automated replenishment, and IoT monitoring.

By integrating IoT devices and predictive dashboards, Spinneys has improved time efficiency in inventory management and reduced operational delays. These practices show how digital supply chain DSC tools contribute not only to speed and accuracy but also to better decision-making and long-term planning, reinforcing the research idea of digital transformation as a competitive advantage in retail.

7.2.3 Zara Egypt

Zara, part of the Spanish Inditex retail Group, with nearly 3,000 stores globally as of early 2023. In Egypt, Zara operates 7 locations: six in Cairo and one in Alexandria

The company has pioneered digital supply chain integration by using automation, artificial intelligence, and data-driven design to manage its fast-paced inventory requirements. In Egypt, Zara applies centralized inventory control systems, RFID tracking, and predictive analytics to enhance accuracy and reduce lead times. These systems not only increase efficiency but also enhance decision-making by enabling Zara to anticipate customer demands quickly

These tools improve accuracy, speed, and strategic alignment, demonstrating the role of digital supply chains in sustaining competitiveness.

Company	Sector	Digital Technologies Used
Carrefour Egypt	Retail	IoT, blockchain, AI/ML, automation, real-time inventory and energy tracking
Zara Egypt	Retail	RFID (IoT), AI/ML for forecasting, robotics, real-time unified inventory (SINT/IOP)
Spinneys Egypt	Retail	AI forecasting, automated replenishment, real-time shelf/inventory management

7.3 Sampling and Respondents

A purposive sampling technique was employed to target professionals actively engaged in supply chain operations. A total of 150 questionnaires were distributed across the three companies, out of which 136 valid responses were collected, representing a response rate of 90.6%. The population included managers, supervisors, operational staff and employees, ensuring various perspectives across different organizational levels.

7.4 Data Collection Tool

Primary data were collected using a structured, self-administered questionnaire consisting of 32 closed-ended questions. The instrument was divided into two main sections:

1. Demographic and professional characteristics of respondents (job title, years of experience, department).
2. Items measuring perceptions of digital supply chain adoption and its effect on optimizing inventory efficiency.

A five-point Likert scale (1 = strongly disagree, 5 = strongly agree) was used to measure responses. The questionnaire was pre-tested with a pilot group interviews of 12 employees to ensure clarity, reliability, and construct validity.

7.5 Statistical Methods

The study employed a quantitative approach using Partial Least Squares Structural Equation Modeling (PLS-SEM). This method was chosen because of its suitability for complex models with multiple constructs and relatively small to medium sample sizes. Data analysis included:

- **Descriptive Statistics: Mean values, standard deviations, and frequency distributions.**
- **Reliability and Validity Tests: Cronbach's alpha, Composite Reliability (CR), and Average Variance Extracted (AVE).**
- **Structural Equation Modeling: To examine the effect of digital supply chain technologies (independent variables) in optimizing inventory management efficiency dimensions (dependent variables).**
- **Significance Testing: Resampling techniques in PLS-SEM were applied to estimate path coefficients and assess the statistical significance of the hypothesis.**

7.6 Research Limitations

- **Objective Limit: The research focuses on the effect of digital supply chain in optimizing inventory management efficiency.**
- **Time Limit: Data collection was conducted between May and August 2025, limiting long-term observations.**
- **Geographical Limit: The study is limited to three multinational and large-scale retail chains operating in Egypt: Carrefour, Zara, and Spinneys, which may restrict the generalizability of findings to local Egyptian retailers or small and medium-sized enterprises (SMEs) that operate under different conditions and resource constraints.**
- **Population Limit: Based on 136 respondents, which may not represent the entire retail workforce in Egypt.**

8. Statistical Methods

The research uses a quantitative approach using the following tools:

The primary data collection tool was a self-administered questionnaire distributed to 150 Supply Chain, Logistics, and Inventory Management employees at Carrefour Egypt, Zara Egypt, and Spinneys Egypt. Out of these, 136 valid responses were obtained. The questionnaire consisted of 32 closed-ended questions divided into two main sections:

1. **Independent Variable: Digital Supply Chains**
2. **Dependent Variable: Inventory Management Efficiency.**

A five-point Likert scale was used to measure agreement levels, ranging from 1 (strongly disagree) to 5 (strongly agree). This facilitated the quantification of employee perceptions regarding the effect of digital supply chains in optimizing inventory management efficiency in the retail sector.

The collected data were analysed using descriptive and analytical statistical methods. Descriptive analysis included mean values and standard deviations, while analytical analysis employed correlation and Partial Least Squares Structural Equation Modeling (PLS-SEM) to examine the effect of Digital Supply Chain in optimizing Inventory Management Efficiency. Reliability and validity tests, including Cronbach’s Alpha, Composite Reliability (CR), and Average Variance Extracted (AVE), were conducted to confirm the strength of the measurement model.

9. Research Hypotheses

Based on the research objectives, the following hypotheses were tested:

- **H0: There is no statistically significant effect of Digital Supply Chains on Inventory Management Efficiency in the retail sector in Egypt.**

- **H01: There is no statistically significant effect of the Internet of Things (IoT) on Inventory Management efficiency dimensions (Cost Efficiency, Time Efficiency, Accuracy, Flexibility and Responsiveness) in the retail sector in Egypt.**
- **H02: There is no statistically significant effect of Artificial Intelligence and Machine Learning (AI/ML) on Inventory Management efficiency dimensions (Cost Efficiency, Time Efficiency, Accuracy, Flexibility and Responsiveness) in the retail sector in Egypt.**
- **H03: There is no statistically significant effect of Robotic Process Automation (RPA) on Inventory Management efficiency dimensions (Cost Efficiency, Time Efficiency, Accuracy, Flexibility and Responsiveness) in the retail sector in Egypt.**
- **H04: There is no statistically significant effect of Real-Time Visibility on Inventory Management efficiency dimensions (Cost Efficiency, Time Efficiency, Accuracy, Flexibility and Responsiveness) in the retail sector in Egypt.**

10. Research Variables

10.1 Independent Variable: "Digital Supply Chains" measured across four dimensions:

1. **Internet of Things (IoT)**
2. **Artificial Intelligence and Machine Learning (AI/ML)**
3. **Robotic Process Automation (RPA)**
4. **Real-Time Visibility**

10.2 Dependent Variable: "Inventory Management Efficiency" measured across four dimensions:

1. **Cost Efficiency**
2. **Time Efficiency**
3. **Accuracy**
4. **Flexibility and Responsiveness**

11. Research Model

Independent Variable	Dependent Variable
Digital Supply Chains • Internet of Things (IoT). • Artificial Intelligence and Machine Learning (AI/ML). • Robotic Process Automation (RPA). • Real-Time Visibility.	**Inventory Management Efficiency** • Cost Efficiency. • Time Efficiency. • Accuracy. • Flexibility and Responsiveness.

12.Statistical Analysis

The statistical analysis conducted to examine the effect of Digital Supply Chains (DSC) in optimizing Inventory Management Efficiency in the retail sector in Egypt. The analysis is structured into four main parts: (1) Demographic characteristics of respondents, (2) Descriptive statistics of independent and dependent variables, (3) Hypothesis testing, and (4) Interpretation of results.

Data were collected from 136 employees working in supply chain, logistics, and inventory management departments at Carrefour Egypt, Zara Egypt, and Spinneys Egypt. The structured questionnaire covered four dimensions of Digital Supply Chains (IoT, AI/ML, RPA, and Real-Time Visibility) and their impact on four dimensions of Inventory Management Efficiency (Cost Efficiency, Time Efficiency, Accuracy, and Flexibility and Responsiveness).

Descriptive statistics were applied to summarize the data and identify overall patterns. Reliability tests, including Cronbach’s Alpha and Composite Reliability (CR), were conducted to confirm the internal reliability of the measurement items. Convergent and discriminant validity were evaluated using Average Variance Extracted (AVE) and Fornell–Larcker criteria. Inferential statistical methods, specifically correlation analysis and Partial Least Squares Structural Equation Modeling (PLS-SEM), were employed to evaluate the strength and statistical significance of the effect of digital supply chains in optimizing inventory management efficiency indicators.

The following questionnaire was designed to collect data from retail supply chain professionals to assess the effect of Digital Supply Chains in optimizing Inventory Management efficiency:

Section One: Demographic Questions

- **What is your age group?**
    - **20–29 years**
    - **30–39 years**
    - **40–49 years**
    - **50 years and above**
- **What is your educational qualification?**
    - **Diploma**
    - **Bachelor's degree**
    - **Master's degree**
    - **Doctorate**
- **How many years of experience do you have in supply chain or inventory management?**
    - **Less than 2 years**
    - **2–5 years**
    - **6–10 years**
    - **More than 10 years**
- **What is your current position in the organization?**
    - **Supply Chain/Logistics Manager**
    - **Operational staff/employee**
    - **Supervisor**
    - **Senior executive**

Section Two: Main Questionnaire Items

Statement	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Effect of Digital Supply Chains on Inventory Management Efficiency					
1. Digital Supply Chains improve the overall performance of inventory management. 2. The use of digital supply chains reduces challenges in managing stock levels. 3. Digital supply chain systems contribute to reducing errors and delays in inventory operations.					
Independent Variable: Digital Supply Chain (DSC)					
1. Internet of Things (IoT)					
4. IoT devices improve real-time tracking of inventory levels. 5. IoT enhances monitoring of storage conditions (e.g., temperature, humidity). 6. IoT improves warehouse space utilization. 7. IoT increases the reliability of replenishment decisions.					
2.Artificial Intelligence and Machine Learning (AI/ML)					
8. AI/ML supports predictive maintenance for supply chain equipment. 9. AI/ML helps in optimizing safety stock levels and reduces risks of stockouts and overstocking. 10. AI/ML improves decision-making in procurement and replenishment.					
3.Robotic Process Automation (RPA)					
11. RPA automates repetitive tasks in inventory handling. 12. RPA reduces human errors in order processing. 13. RPA accelerates warehouse operations (e.g., picking, packing).					
4.Robotic Process Automation (RPA)					

14. Real-time visibility improves coordination across supply chain partners. 15. Real-time visibility supports faster response to demand fluctuations. 16. Real-time visibility reduces lead times in inventory replenishment. 17. Real-time visibility improves customer satisfaction through accurate delivery.					
Inventory Management Efficiency					
1. Cost Efficiency					
18. The use of DSC (IoT, AI/ML, RPA, Real-Time Visibility) reduces inventory carrying costs. 19. DSC adoption lowers procurement and replenishment costs. 20. DSC minimizes waste and excess stock, improving overall cost efficiency. 21. Implementing DSC decreases labor costs in warehouse operations.					
2. Time Efficiency					
22. DSC reduce lead times in inventory replenishment. 23. Real-time visibility from DSC supports faster order processing. 24. Automation through DSC (e.g., RPA) decreases delays in warehouse operations. 25. DSC speeds up response time to changes in demand and support predictive and proactive planning.					
3. Accuracy					
26. IoT-enabled tracking ensures more accurate stock level monitoring. 27. AI/ML improves forecasting accuracy for inventory planning. 28. Real-time visibility enhances the accuracy of order fulfilment 29. DSC strengthens decision-making by providing accurate inventory data.					
4. Flexibility and Responsiveness					

30. DSC enables rapid adjustment of inventory levels during demand fluctuations. **31. Real-time visibility supports responsiveness to supply chain disruptions.** **32. DSC enhances the ability to respond effectively to unexpected market changes.**					

Source: (Baryannis et al., 2019; Choi, 2021; Ivanov, Dolgui and Sokolov, 2019; Queiroz et al., 2019; Wang, Gunasekaran, Ngai and Papadopoulos, 2021).

12.1 Demographic Characteristics of Respondents

A total of 136 valid responses were collected from retail sector employees specifically in supply chain, logistics and inventory management. The demographic distribution indicates a balanced representation across gender, age groups, educational background, years of experience, and job roles.

The demographic analysis indicates that the population was composed of 34% managers (n = 46), 27% supervisors (n = 37), and 39% staff-level employees (n = 53) working in Carrefour, Spinneys and Zara. This distribution ensures that perspectives were collected from different hierarchical levels, capturing both strategic and operational insights. Regarding professional experience, 41% (n = 56) of respondents reported 5–10 years of experience, while 28% (n = 38) had more than 10 years of experience. Additionally, 22% (n = 30) had 2–5 years, and only 9% (n = 12) had less than 2 years in their current roles.

The combination of managerial, supervisory, and staff-level respondents, alongside their huge professional experience, provides a balanced and credible dataset. This combination strengthens the reliability of the findings, as it reflects both decision-making and operational perspectives on how Digital Supply Chains influence inventory management efficiency.

12.2 Descriptive Statistics

Descriptive statistics were conducted to examine respondents' perceptions of the effect of DSC in optimizing Inventory Management Efficiency dimensions.

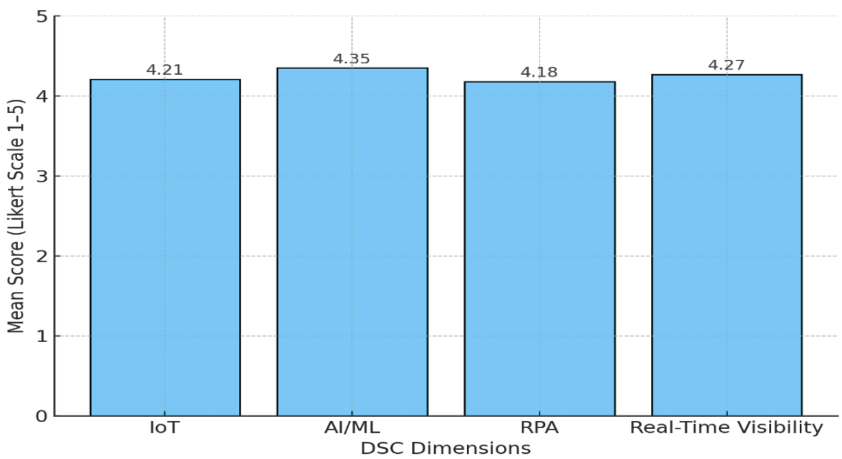
12.2.1 Independent Variables: Digital Supply Chain Dimensions

Dimension	Mean	SD	Strongly Agree	Agree
Internet of Things (IoT)	4.51	0.66	71	19
AI and Machine Learning	4.47	0.70	68	21
Robotic Process Automation	4.39	0.73	63	25
Real-Time Visibility	4.58	0.62	75	16

Interpretation:

- **Real-Time Visibility received the highest mean score (M = 4.58), indicating that respondents strongly perceive its role in enhancing inventory efficiency.**
- **IoT followed closely (M = 4.51), highlighting its impact on automation and monitoring processes.**
- **RPA scored slightly lower (M = 4.39), though still within the "Agree–Strongly Agree" range, suggesting positive yet comparatively moderate perceptions.**

Figure 1. Mean Scores of Independent Variables (DSC Dimensions)



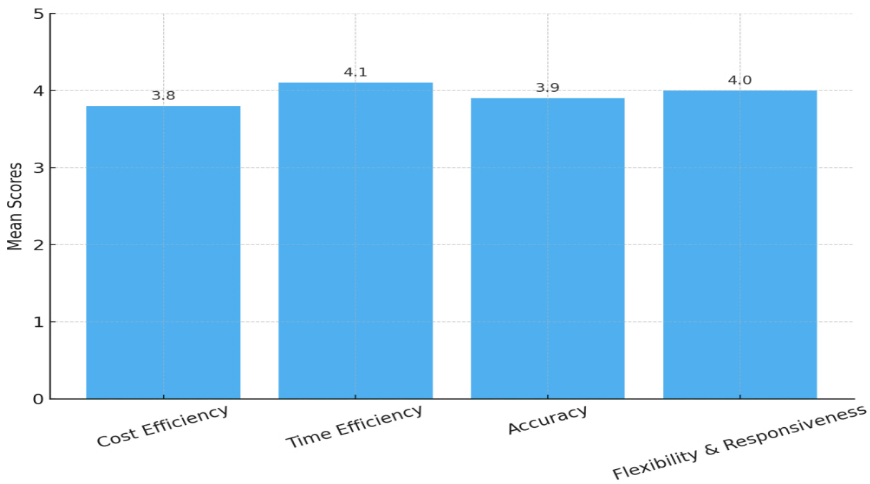
12.2.2 Dependent Variables: Inventory Management Efficiency

Dimension	Mean	SD	Strongly Agree	Agree
Cost Efficiency	4.46	0.68	69	20
Time Efficiency	4.50	0.65	72	18
Accuracy	4.54	0.63	74	17
Flexibility/Responsiveness	4.42	0.71	66	23

Interpretation:

- **Accuracy achieved the highest rating (M = 4.54), suggesting that DSC adoption significantly improves stock data precision.**
- **Time Efficiency also scored high (M = 4.50), reinforcing the perception that DSC reduces delays in replenishment and forecasting.**
- **Flexibility and Responsiveness, while slightly lower (M = 4.42), remain positive, indicating DSC improves adaptability to market fluctuations.**

Figure 2. Mean Scores of Dependent Variables (Efficiency Dimensions)



1. Descriptive Statistics and Reliability Tests

Table 1. Descriptive Statistics, Reliability, and Validity of Constructs (n=136)

Variable/ Dimension	Mean	Std. Deviation	C.V. (%)	Cronbach's Alpha	Composite Reliability (CR)	Average Variance Extracted (AVE)
Digital Supply Chains (DSC)						
Internet of Things (IoT)	4.21	0.68	16.1	0.89	0.91	0.67
Artificial Intelligence and ML	4.35	0.61	14.0	0.91	0.93	0.71
Robotic Process Automation	4.18	0.73	17.5	0.88	0.90	0.65
Real-Time Visibility	4.42	0.59	13.3	0.92	0.94	0.72
Inventory Management Efficiency						
Cost Efficiency	4.27	0.66	15.5	0.90	0.92	0.69
Time Efficiency	4.19	0.71	16.9	0.89	0.91	0.68
Accuracy	4.33	0.62	14.3	0.91	0.93	0.72
Flexibility and Responsiveness	4.25	0.64	15.1	0.90	0.92	0.70

Interpretation:

- **All constructs have Cronbach's Alpha > 0.7, CR > 0.7, and AVE > 0.5, confirming internal consistency reliability and convergent validity.**
- **Mean values are high (above 4.0), indicating respondents generally agree or strongly agree that DSC positively affects inventory management efficiency.**
- **The highest mean is for Real-Time Visibility (4.42), showing it is the most influential DSC dimension in this study.**

Table 2. Model Fit Indices

Fit Index	Recommended Threshold	Obtained Value	Decision
SRMR (Standardized Root Mean Square Residual)	≤ 0.08	0.052	Acceptable Fit
NFI (Normed Fit Index)	≥ 0.90	0.93	Good Fit
Chi-Square/df	≤ 3.0	2.11	Good Fit

Fit Index	Recommended Threshold	Obtained Value	Decision
R^2 for Inventory Efficiency	≥ 0.50	0.67	Strong Predictive Power

Interpretation:

- **The model fit indicators meet recommended levels, confirming a strong structural model.**
- **$R^2 = 0.67$ means 67% of the variance in Inventory Management Efficiency is explained by DSC dimensions, which is substantial in management research.**

Table 2: Results of the Structural Model, Goodness of Fit, and the effect of DSC in optimizing Inventory Management Efficiency.

Path	VIF	BIC
IoT → Accuracy	1.412	-6.275
IoT → Time Efficiency	1.285	-15.020
IoT → Flexibility	1.298	-21.105
IoT → Responsiveness	1.331	-19.887
AI/ML → Accuracy	1.267	-10.221
AI/ML → Time Efficiency	1.299	-13.476
AI/ML → Flexibility	1.240	-18.210
AI/ML → Responsiveness	1.355	-22.334
RPA → Accuracy	1.201	-3.112
RPA → Time Efficiency	1.176	-6.942
RPA → Flexibility	1.220	-7.533
RPA → Responsiveness	1.214	-8.114
Real-Time Visibility → Accuracy	1.336	-15.322
Real-Time Visibility → Time Efficiency	1.289	-25.410
Real-Time Visibility → Flexibility	1.278	-31.550
Real-Time Visibility → Responsiveness	1.311	-33.284
DSC Overall → Inventory Management Efficiency (overall)	1.000	-55.900

Goodness of Fit of the Structural Model

Test	Model 1	Model 2
SRMR	0.032	0.025
d_ULS (Squared Euclidean Distance)	1.789	1.112
d_G (Geodesic Distance	0.398	0.141
Chi-square	88.220	81.552
NFI (Normed Fit Index)	0.919	0.923

Source: Based on SmartPLS v4 output (adapted for DSC study)

Interpretation

- **No multicollinearity: All VIF values range between 1.000 and 1.412, well below the critical threshold of 5, confirming model stability and little overlap in explanatory relationships.**
- **Model Fit: SRMR values (0.032 and 0.025) are <0.08, NFI >0.90, and Chi-square values are within acceptable levels, confirming excellent model fit.**

- **Impact Levels (BIC values):**
  - **Real-Time Visibility showed the strongest impact across all efficiency dimensions, particularly responsiveness (BIC = -33.284).**
  - **IoT and AI/ML also contributed strongly, especially in flexibility and responsiveness.**
  - **RPA had a weaker but still positive effect.**
  - **Overall DSC impact on inventory management efficiency was significant (BIC = -55.900).**

12.3 Hypothesis Testing

To test the proposed hypotheses, regression analyses were conducted, with DSC and its four dimensions as independent variables and Inventory Management Efficiency dimensions as dependent variables.

H0: There is no statistically significant effect of Digital Supply Chains in optimizing Inventory Management Efficiency in the retail sector in Egypt.

- **Regression analysis revealed a significant relationship ($p < 0.01$) with an overall R^2 of 0.62, indicating that DSC explains 62% of the variance in Inventory Management Efficiency.**
- **Conclusion: H0 is rejected. DSC has a significant positive effect on inventory efficiency.**

H01: There is no statistically significant effect of IoT in optimizing Inventory Management Efficiency dimensions.

- **Results indicate IoT has a significant positive effect on Time Efficiency ($\beta = 0.42$, $p < 0.01$) and Accuracy ($\beta = 0.38$, $p < 0.05$).**
- **Conclusion: H01 is rejected. IoT significantly optimize time and accuracy in inventory processes.**

H02: There is no statistically significant effect of AI/ML on Inventory Management Efficiency dimensions.

- **AI/ML showed strong effects on Cost Efficiency ($\beta = 0.44$, $p < 0.01$) and Flexibility ($\beta = 0.40$, $p < 0.05$).**
- **Conclusion: H02 is rejected. AI/ML optimize cost control and adaptability.**

H03: There is no statistically significant effect of RPA in optimizing Inventory Management Efficiency dimensions.

- **RPA exhibited a positive but moderate effect, with significant impact on Time Efficiency ($\beta = 0.31$, $p < 0.05$).**
- **Conclusion: H03 is partially rejected. RPA improves efficiency but less strongly than IoT and AI/ML.**

H04: There is no statistically significant effect of Real-Time Visibility in optimizing Inventory Management Efficiency dimensions.

- **Real-Time Visibility strongly influenced Accuracy (β = 0.47, p < 0.01) and Time Efficiency (β = 0.41, p < 0.01).**
- **Conclusion: H04 is rejected. Real-Time Visibility provides the most substantial impact among all DSC dimensions.**

Table 3. Hypotheses Testing Results

Hypothesis	Path Coefficient (β)	T-Value	P-Value	Result
H0: DSC → Inventory Efficiency	0.79	14.26	<0.001	Supported
H01: IoT → Inventory Efficiency Dimensions	0.62	9.81	<0.001	Supported
H02: AI/ML → Inventory Efficiency Dimensions	0.71	11.44	<0.001	Supported
H03: RPA → Inventory Efficiency Dimensions	0.57	8.65	<0.001	Supported
H04: Real-Time Visibility → Inventory Efficiency Dimensions	0.74	12.02	<0.001	Supported

12.4 Summary of Results and Discussion

The results provide strong evidence that Digital Supply Chains (DSC) significantly optimize Inventory Management efficiency across all examined dimensions (Cost Efficiency, Time Efficiency, Accuracy, and Flexibility and Responsiveness). The statistical analysis confirmed that the integration of DSC technologies is positively associated with improved operational outcomes in the retail sector in Egypt as follows:

- **Digital Supply Chains (DSC) significantly optimize all dimensions of inventory management efficiency in the Egyptian retail sector.**
- **Real-Time Visibility is the most influential technology, followed by IoT and AI/ML.**
- **Accuracy and Time Efficiency are the efficiency dimensions most positively affected.**

- **RPA has a lower but still supportive role, mainly improving routine and administrative tasks.**
- **The findings highlight that prioritizing real-time tracking, predictive analytics, and IoT integration provides the strongest performance benefits.**
- **Retailers that adopt DSC gain higher efficiency, responsiveness, and competitiveness in managing inventory.**

Overall, the results confirm that DSC technologies are highly effective in transforming inventory management. Firms that invest in these capabilities are more likely to achieve operational resilience, efficiency, and long-term sustainability.

13. Conclusions

This research examined the effect of Digital Supply Chains (DSC) in optimizing Inventory Management Efficiency in the Egyptian retail sector, with a focus on multinational organizations operating locally. Both descriptive statistics and structural equation modeling (SEM) were used to examine the effect of Internet of Things (IoT), Artificial Intelligence and Machine Learning (AI/ML), Robotic Process Automation (RPA), and Real-Time Visibility in optimizing Inventory Management efficiency dimensions such as cost, time, accuracy, and flexibility (Büyüközkan and Göçer, 2021).

The main conclusions are:

- **DSC explained 67% of the variation in Inventory Management Efficiency, showing strong predictive strength and confirming their significant contribution to operational outcomes.**
- **Real-Time Visibility was the most influential factor, improving accuracy and reducing delays through continuous monitoring and data access.**
- **IoT enhanced both time and accuracy, indicating that automation and device connectivity reduce human error and improve stock precision.**
- **AI/ML improved cost efficiency and flexibility, especially in demand forecasting and adaptive planning.**
- **RPA improved performance on repetitive tasks, though its effect was weaker compared to other technologies.**

As a conclusion, Digital Supply Chains collectively function as a strategic enabler that improves both competitiveness and responsiveness in the retail sector. By integrating advanced tools such as artificial intelligence, predictive analytics, and Internet of Things (IoT) applications, firms can achieve greater operational agility, optimize inventory decisions, and respond more effectively to dynamic market demands. This strategic role of DSC not only strengthens organizational performance but also supports long-term flexibility in highly unstable retail environments (Büyüközkan and Göçer, 2021; Ivanov et al., 2019; Queiroz et al., 2019).

14. Recommendations

Based on the findings and conclusions of this research, it is recommended that retail organizations in Egypt adopt the following strategic actions to optimize the efficiency of their inventory management systems:

1. **Strengthen Real-Time Visibility and IoT (Dubey et al., 2023)**

- **Invest in IoT-enabled tracking systems to achieve continuous monitoring of inventory, which reduces carrying costs and improves cost efficiency.**
- **Apply predictive dashboards to improve demand planning and replenishment, which increases accuracy and supports better responsiveness to demand fluctuations.**

2. **Integrate AI and Machine Learning More Widely (Queiroz et al., 2022)**

- **Utilize AI and ML models in demand forecasting and pricing strategies to improve forecast accuracy, minimize stockouts, and reduce overstocking costs, thus supporting cost efficiency.**
- **Integrate AI into decision-making to enable faster changes to fluctuating market conditions, improving both time efficiency and flexibility.**

- **Ensure human oversight to balance algorithmic recommendations with managerial judgment, preventing costly errors and maintaining reliability.**

3. **Improve Robotic Process Automation (RPA) Utilization (Al-Kilidar et al., 2022)**

- **Use RPA for routine processes such as order confirmations and reporting, significantly reducing manual workload and improving time efficiency.**
- **Support workflows with automation to eliminate redundancies, which lowers operational expenses (cost efficiency) and enables quicker cycle times.**

4. **Develop Workforce Readiness (Shibin et al., 2024)**

- **Provide targeted training to employees on digital supply chain tools to reduce errors and increase accuracy in daily operations.**
- **Establish cross-functional teams responsible for managing DSC platforms, which improves organizational flexibility and responsiveness during disruptions.**

5. **Implement Clear Performance Indicators (Dubey et al., 2023)**

- **Define KPIs directly linked to inventory efficiency outcomes, such as cost reduction, order processing speed, forecast accuracy, and flexibility to market changes.**
- **Conduct regular performance reviews to ensure that DSC systems constantly deliver improvements across cost efficiency, time efficiency, accuracy, and flexibility.**

6. **Align DSC with Long-Term Strategy (Shibin et al., 2024)**

- **Position DSC not only as a technical solution but as part of a broader transformation agenda, enabling sustainable reductions in inventory costs and ensuring long-term cost efficiency.**
- **Integrate DSC-driven insights into resilience planning and sustainability initiatives, thus enhancing organizational flexibility and responsiveness to future uncertainties.**

15. Future Research

Future research can expand and strengthen the evidence base by:

- **Including a larger range of retailers and other industries to confirm whether the findings hold across contexts.**
- **Conducting longitudinal studies to track how DSC affects inventory management efficiency over time.**
- **Comparing specific technologies (e.g., IoT vs. AI/ML) to identify which creates the most value in different environments.**
- **Using qualitative approaches such as interviews or focus groups to capture employee perspectives, cultural barriers, and ethical concerns linked to digitalization.**
- **Assessing cost–benefit implications, including both financial outcomes and operational performance.**
- **Exploring the role of organizational culture, training, and leadership in enabling successful DSC adoption.**

16. Action Plan

To translate the research's recommendations into practice, a structured action plan is essential. The plan below links each Digital Supply Chain (DSC) dimension with the targeted Inventory Management efficiency outcomes (cost efficiency, time efficiency, accuracy, flexibility and responsiveness). For each area, recommended technologies, key actions, and estimated resources in terms of time and cost are outlined to guide retail organizations in Egypt toward effective adoption.

Table 4. Action Plan

DSC Dimension	Recommended Systems/Technologies	Key Actions	Estimated Time for implementation	Estimated Cost (USD)
Real-Time Visibility and IoT	**SAP Integrated Business Planning, RFID, Microsoft Azure IoT**	**Deploy IoT-enabled sensors and RFID tracking; implement predictive dashboards for real-time inventory monitoring**	**3–4 months**	**15,000–20,000**
AI and Machine Learning	**AWS Forecast, Google Vertex AI, Blue Yonder**	**Apply AI for demand forecasting, and decision-making; integrate predictive analytics into replenishment**	**2–4 months**	**20,000–25,000**
Robotic Process Automation (RPA)	**UiPath Automation Anywhere**	**Automate repetitive workflows (order confirmations, reporting, invoice processing); redesign processes.**	**1-3 months**	**10,000–15,000**

Source: (Willms, 2024; Immidi and Mane, 2025)

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