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A STUDY ON THE OPERATIONAL CHANGES IN SUPPLY CHAIN MANAGEMENT SUCCEDING ADOPTION OF INTERNET OF THINGS

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ABSTRACT

This study was undertaken to evaluate the operational changes in Supply Chain Management (SCM) following the adoption of Internet of Things (IoT) technology. In today's highly competitive business environment, organizations are increasingly adopting IoT solutions to improve efficiency, visibility, coordination, and decision-making across supply chain operations. The main objective of the research was to understand how IoT adoption has influenced various operational aspects of supply chain management, including inventory control, logistics management, real-time tracking, forecasting accuracy, process automation, and overall operational performance. The study was based on primary data collected from 31 supply chain managers from different sectors and organizations through a structured questionnaire. Their responses provided valuable practical insights regarding the implementation and impact of IoT in supply chain operations. The findings of the study indicate that IoT adoption has brought significant positive changes in supply chain processes. Real-time monitoring and tracking have improved operational visibility, while better data availability has enhanced planning and decision-making. Respondents also reported improvements in inventory management, faster response times, reduced operational delays, and increased coordination among supply chain partners. Organizations are planning to adopt digital technologies in supply chain management and managers seeking to improve operational performance through adopting IoT applications.

Keywords: Supply Chain Management (SCM), Internet of Things (IoT), operational efficiency, Technical Efficiency, Risk Management

INTRODUCTION

Supply chain management (SCM) is undergoing a significant transformation as organizations increasingly adopt advanced technologies to remain competitive in a fast-changing business environment. The term Internet of Things (IoT) was first introduced by MIT in the late 1990s. It broadly refers to a network of devices and sensors that are interconnected, allowing objects to be monitored, controlled, and optimized through wired, wireless, or hybrid communication systems. Unlike the traditional internet, which primarily connects people and information, IoT focuses on connecting physical and virtual "things." It is considered an integral part of the future internet, forming a dynamic and global network infrastructure with self-configuring capabilities. Among these technologies, the Internet of Things (IoT) has emerged as a powerful tool, enabling real-time data collection, enhanced visibility, and improved coordination across supply chain activities. From tracking inventory and monitoring shipments to optimizing routes and predicting maintenance needs, IoT is reshaping traditional supply chain operations. In this context, organizations are experiencing notable changes in key operational areas such as speed of operations, inventory accuracy, cost efficiency, and overall decision-making processes. While the potential benefits of IoT adoption are widely discussed, there is a growing need to systematically evaluate how these technologies are influencing actual operational performance within supply chains. This study **Kache, F., & Seuring, S. (2017)**[1] aims to assess the operational changes in supply chain management following the adoption of IoT. By comparing performance indicators before and after implementation, the research seeks to provide a deeper understanding of how IoT contributes to efficiency, responsiveness, and overall supply chain effectiveness. The findings of this study are expected to offer valuable insights for organizations considering or currently implementing IoT in their supply chain operations.

Traditionally, supply chains relied on manual processes and limited visibility, often resulting in inefficiencies, delays, and higher operational costs. However, the integration of IoT technologies has significantly improved these processes by enabling real-time tracking, predictive analytics, and automation. IoT supports machine-driven decision-making with minimal human intervention and enhances accuracy and speed in supply chain operations **Zhou, W., & Piramuthu, S. (2015)**[2]. One of the most important contributions of IoT to supply chain management is enhanced visibility. Organizations can track inventory levels, shipment locations, equipment performance, and environmental conditions at every stage of the supply chain. This transparency helps managers identify bottlenecks, prevent stockouts, reduce wastage, and ensure timely deliveries. For example, temperature-sensitive goods such as pharmaceuticals and food products can be monitored continuously during storage and transportation, reducing quality risks and ensuring compliance with safety standards. Real-time shipment tracking also improves customer communication by providing accurate delivery updates.

IoT also contributes to operational efficiency and cost reduction. Automated data capture reduces manual errors and saves time in routine administrative tasks. Predictive maintenance systems help identify equipment issues before breakdowns occur, thereby reducing downtime and repair costs. Real-time route optimization lowers transportation expenses and fuel consumption by identifying efficient delivery paths. Smart inventory systems maintain optimal stock levels, reducing carrying costs, avoiding overstocking, and minimizing shortages. These benefits collectively improve organizational productivity and profitability. Despite the increasing adoption of IoT in supply chain management, there remains a need to critically evaluate its actual impact on operational performance. While several studies highlight the potential benefits of IoT, there is limited empirical evidence on how it transforms day-to-day supply chain activities and decision-making processes. This indicates a research gap in understanding the extent to which IoT adoption leads to measurable operational improvements in supply chains **Ben Daya et al.. (2019)**[3].

Although previous studies have pointed out the theoretical benefits of IoT, we still need practical evidence of its effects on everyday supply chain operations. Much of the existing literature focuses on ideas, technological abilities, or case studies. Fewer studies have looked at the operational changes' organizations experience after they implement IoT technologies. This creates a gap in understanding the real outcomes of IoT adoption in various industries.

REVIEW OF LITERATURE

Sargam Bahl (2018)[4] investigated the role of Internet of Things (IoT) in improving supply chain management effectiveness through an empirical study. The study found that IoT significantly enhances real-time tracking, inventory management, route optimization, predictive maintenance, collab-oration among supply chain partners, and quality control. The findings showed that technologies such as tags, sensors, and smart devices help organizations reduce costs, improve delivery performance. **Ben-Daya et al. (2019)**[5] in their paper titled "Internet of Things and Supply Chain Management: A Literature Review," take a broad look at how IoT is being used and studied in supply chain management. They explain the basic idea of IoT, the technologies behind it, and how it is applied across different supply chain activities.

Rejeb et al. (2020)[6] in their paper titled "Internet of Things Research in Supply Chain Management and Logistics: A Bibliometric Analysis," take a closer look at how research on IoT in supply chains and logistics has developed over time. **Tharaka de Vass (2021)**[7] in "IoT in Supply Chain Management: Opportunities and Challenges for Businesses in Early Industry 4.0 Con-text," explains how IoT is shaping supply chain operations. Based on interviews with managers in the Australian retail sector, the study shows that IoT improves the visibility of goods, simplifies data collection, and enhances communication between partners, leading to better decision-making. **Biswas et al.(2023)**[8] , in their paper titled "Critical Success Fac-tors for 5G Technology Adaptation in Supply Chains," explore what is needed for supply chains to successfully adopt 5G technology in a rapidly digitalizing environment. The study highlights that simply in-troducing 5G is not enough; organizations must also focus on building the right ecosystem around it. **Udeh et al. (2024)**[9] looked at how the Internet of Things (IoT) helps improve transparency and efficiency in supply chains. The study explains that IoT allows real-time tracking of goods and smooth data flow, which gives better visibility at every stage of the supply chain. **Radhakrishnan, G. V. (2025)**[10] explored the role of Internet of Things (IoT) in improving efficiency and transparency within supply chain management. The study highlighted that IoT technologies enable real-time tracking, monitoring, and management of goods and assets, thereby increasing operational visibility and response speed.

PROBLEM IDENTIFICATION

Despite the growing recognition of IoT as a transformative technology in supply chain management, critical gaps remain in the existing literature. Traditional supply chains continue to face significant operational challenges, including inventory inaccuracies, process delays, limited real-time visibility, and suboptimal stock management, all of which undermine organisational efficiency and competitiveness. WhilE IoT has been widely proposed as a solution to these challenges, empirical evidence quantitatively demonstrating how IoT adoption actually changes supply chain operations remains scarce. Furthermore, the factors that drive IoT adoption in supply chain con-texts are not yet well understood. In particular, the combined influence of Performance Impact, Employee Readiness, Risk Management, and Compatibility on adoption decisions has not been comprehensively examined within a single empirical framework.

This study therefore seeks to address these gaps by empirically examining the key determinants of IoT adoption and quantitatively assessing the operational changes in supply chain performance following its implementation. In doing so, the study aims to provide meaningful insights into both the challenges and opportunities associated with IoT adoption, contributing to a deeper understanding of how IoT can enhance efficiency and competitiveness in supply chain management and informing organisations on effective implementation strategies **Rejeb, A et al. (2019)**[11].

SCOPE OF THE STUDY

This study focuses on evaluating the operational changes in supply chain management following the adoption of Internet of Things (IoT) technologies. The analysis is cantered on key operational dimensions such as efficiency, speed, accuracy, visibility, and coordination.

OBJECTIVES OF THE STUDY

- To investigate how IoT adoption in supply chain management is affected by performance impact.
- To evaluate how employee readiness affects supply chain operations' adoption of IoT technologies.
- To measure the operational changes in supply chain performance specifically in terms of speed of operations, inventory accuracy, real-time tracking, process delays, operational productivity, stockouts, and overstocking — before and after IoT adoption.

RESEARCH METHODOLOGY

The study adopts a descriptive research approach, and primary data has been collected using a structured questionnaire. The respondents consist of supply chain professionals working at top-level, middle-level, and operational-level management across various organizations. This ensures a comprehensive understanding of IoT adoption from different managerial perspectives. The sampling is based on convenience sampling, considering accessibility and availability of respondents. The study includes organizations from sectors such as logistics, manufacturing, and services, depending on the responses obtained. The geographical scope is limited to the selected sample, which may include organizations operating at local, national, and global levels. The analysis is carried out using statistical tools to evaluate the im-pact of IoT adoption on supply chain operations. The study data consists of responses from 31 supply chain professionals working at top, middle, and operational management levels. Respondents belong to various functional areas such as procurement, operations, logistics, and IT, across industries where IoT has been adopted or is actively used.

LIMITATIONS OF THE STUDY

The study is restricted to operational aspects and does not cover in-depth financial, technical, or strategic implementation issues related to IoT. Therefore, the findings cannot be generalized beyond the selected sample. the sample size comprising 31 respondents due to time constraint, although it is sufficient for the non-parametric statistical methodologies employed, re-mains comparatively modest. The study is limited to the data collected during the specified time period and reflects the perceptions of the respondents at the time of the survey.

DATA ANALYSIS

This diverse sample provides multiple perspective on IoT adoption in supply chain management. The data is used to analyze the relationship between IoT adoption determinants and their impact on supply chain performance.

Table 1: Respondents by Management Level

Level	Frequency	Percent (%)
Operational Level	5	16.1
Middle Management	16	51.6
Top Management	10	32.3
Total	**31**	**100.0**

Source: Primary Data Analysis

The majority of respondents belong to Middle Management (51.6%), followed by Top Management (32.3%) and Operational Level (16.1%). This indicates balanced representation from different managerial levels in the study.

The analysis is based on 31 valid responses. All items were measured on a five-point Likert scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree). The mean score reflects the central tendency of responses, while the standard deviation indicates the degree of variability among respondents.

Table 2: Descriptive Statistics – IoT Perception Items (*N* = 31)

Item	Min	Max	Mean	SD
Performance Impact (PI)				
IoT improves operational efficiency	1	5	4.10	1.08
IoT provides better control over SCM operations	1	5	4.00	1.13
IoT implementation significantly enhances productivity	1	5	3.87	1.09
IoT benefits visible in day-to-day operations	1	5	3.68	0.94
IoT results and outcomes can be easily demonstrated	1	5	3.71	1.01
Employee Readiness (ER)				
IoT systems are user-friendly and easy to understand	1	5	3.13	0.99
Employees comfortable and confident using IoT systems	1	5	3.19	1.11
Employees possess necessary technical proficiency	1	5	3.26	1.00
Risk Management (RM)				

IoT involves manageable data security and privacy risks	1	5	3.32	1.11
Potential operational risks of IoT are well-controlled	1	5	3.23	1.12
IoT Adoption (ADO)				
IoT aligns well with current business processes	1	5	3.39	0.99
IoT widely implemented and integrated across departments	1	5	3.26	1.06
IoT used regularly for real-time monitoring and tracking	1	5	3.84	1.00
Note: SD = Standard Deviation. Scale: 1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree.				

Source: Primary Data Analysis

Among the Performance Impact items, IoT improves operational efficiency recorded the highest mean score (M = 4.10, SD = 1.08), indicating strong agreement among respondents that IoT enhances operational efficiency compared to previous systems. This was closely followed by IoT provides better control over supply chain operations (M = 4.00, SD = 1.13) and IoT is used regularly for real-time monitoring and tracking (M = 3.84, SD = 1.00), both reflecting positive perceptions of IoT's functional value. IoT benefits visible in day-to-day operations recorded the lowest mean within the Performance Impact group (M = 3.68, SD = 0.94), suggesting that while respondents generally agree, a portion are yet to observe clear operational benefits on a daily basis.

In contrast, the Employee Readiness items recorded comparatively lower mean scores. IoT systems are user-friendly returned the lowest mean across all perception items (M = 3.13, SD = 0.99), indicating un-certainty about the ease of use of IoT platforms. Similarly, employees comfortable using IoT systems (M = 3.19, SD = 1.11) and employees possess necessary technical proficiency (M = 3.26, SD = 1.00) suggest that workforce readiness remains a moderate concern among respondents.

The Risk Management items also returned moderate mean scores, with IoT involves manageable data security risks (M = 3.32, SD = 1.11) and operational risks are well-controlled (M = 3.23, SD = 1.12), reflecting a cautiously neutral stance on risk management. The relatively higher standard deviations in these items indicate divided opinions among respondents regarding the adequacy of existing risk controls. Overall, the descriptive results suggest that respondents hold a more favorable view of IoT's operational performance benefits than its usability and risk management dimensions.

Table 3: Descriptive Statistics – Pre and Post IoT Operational Metrics ($N = 31$)

Metric	Before IoT				After IoT			
	Min	**Max**	**Mean**	**SD**	**Min**	**Max**	**Mean**	**SD**
Speed of Operations	1	5	2.87	1.15	2	5	4.03	0.71
Inventory Accuracy	1	5	2.61	1.02	2	5	4.16	0.86
Real-Time Tracking	1	5	2.68	1.35	3	5	4.29	0.74
Process Delays	1	5	2.58	1.09	2	5	3.87	0.67

Operational Productivity	1	5	2.84	1.07	2	5	4.00	0.68
Stockouts	1	5	2.55	1.03	2	5	3.97	0.71
Overstock	1	5	2.58	1.06	2	5	3.87	0.81
SD = Standard Deviation. Higher scores indicate better performance for all metrics except Process Delays, Stockouts, and Overstock, where higher scores reflect reduced occurrences.								

Source: Primary Data Analysis

A clear and consistent pattern of improvement is observed across all seven operational metrics following IoT adoption. Prior to IoT implementation, all metrics recorded below-average mean scores ranging from 2.55 to 2.87, reflecting respondents' perception of relatively poor operational performance before IoT. After IoT adoption, all seven metrics recorded substantially higher mean scores, ranging from 3.87 to 4.29, indicating a marked improvement across all dimensions of supply chain performance.

Real-time tracking capability recorded the highest post IoT mean (M = 4.29, SD = 0.74), suggesting that IoT's most immediate and widely recognized benefit is its ability to enable real-time visibility across sup-ply chain operations. Inventory Accuracy also showed a notable improvement, rising from a pre IoT mean of 2.61 to a post IoT mean of 4.16, representing the largest absolute gain among all metrics. Speed of Operations improved from 2.87 to 4.03, and Operational Productivity increased from 2.84 to 4.00, further confirming IoT's positive influence on core supply chain functions. Equally significant is the reduction in standard deviations observed across all metrics after IoT adoption. For instance, the standard deviation for Real-Time Tracking dropped from 1.35 (before IoT) to 0.74 (after IoT), and Process Delays reduced from 1.09 to 0.67. This consistent narrowing of variability indicates that IoT implementation not only improved average performance levels but also produced more uniform and consistent outcomes across the respondent organizations, reducing the disparity in operational experiences. These descriptive findings provide a strong preliminary basis for the hypothesis testing that follows.

Table 4: Results of Wilcoxon Signed-Rank Test

Hypothesis	**Z**	**Sig. (2-tailed)**	**Decision**
H1: Speed of Operations (After − Before)	−4.083	< 0.001	Supported
H2: Inventory Accuracy (After − Before)	−4.188	< 0.001	Supported
H3: Real-Time Tracking (After − Before)	−4.214	< 0.001	Supported
H4: Process Delays (After − Before)	−4.059	< 0.001	Supported
H5: Operational Productivity (After − Be-fore)	−4.085	< 0.001	Supported
H6: Stockouts (After − Before)	−4.491	< 0.001	Supported
H7: Overstock (After − Before)	−4.311	< 0.001	Supported
Note: Z values are based on negative ranks, indicating higher scores after IoT adoption. Sig. < 0.05 indicates a statistically significant difference. N = 31.			

Source: Primary Data Analysis

The Wilcoxon Signed-Rank test was conducted to assess whether IoT adoption led to a statistically significant improvement in supply chain operational performance. This non-parametric test was selected as the appropriate alternative to the paired samples t-test, given that

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the normality test confirmed non-normal distributions for all seven pairs of before-and-after operational performance variables. The test compares paired observations — in this case, respondents' perceptions of operational performance before and after IoT adoption — and evaluates whether the differences are statistically significant. A p-value below 0.05 was considered sufficient to reject the null hypothesis. The results are presented in Table 4.

The results of the Wilcoxon Signed-Rank test revealed statistically significant differences between the before and after IoT adoption scores across all seven operational performance dimensions. All Z values were based on negative ranks, confirming that post-adoption scores were consistently higher than pre-adoption scores across all dimensions tested.

• H1: Speed of Operations --- A statistically significant improvement was observed in the speed of operations following IoT adoption ($Z = -4.083$, $p < 0.001$), indicating that IoT implementation contributed to faster operational processes in the supply chain. H1 is therefore supported.

• H2: Inventory Accuracy — IoT adoption led to a significant improvement in inventory accuracy ($Z = -4.188$, $p < 0.001$), suggesting that IoT enabled tracking and monitoring systems enhanced the precision of inventory management. H2 is therefore supported.

• H3: Real-Time Tracking — A significant improvement in real-time tracking capability was recorded after IoT adoption ($Z = -4.214$, $p < 0.001$), reflecting that IoT technologies considerably strengthened the ability to monitor and track supply chain operations in real time. H3 is therefore supported.

• H4: Process Delays — The reduction in process delays was found to be statistically significant following IoT adoption ($Z = -4.059$, $p < 0.001$), confirming that IoT integration contributed to smoother and more efficient operational workflows. H4 is therefore supported.

• H5: Operational Productivity — A significant improvement in overall operational productivity was observed after IoT adoption ($Z = -4.085$, $p < 0.001$), indicating that IoT-enabled processes enhanced the overall efficiency and output of supply chain operations. H5 is therefore supported.

• H6: Stockouts — IoT adoption led to a significant reduction in stockouts ($Z = -4.491$, $p < 0.001$), recording the highest ab-solute Z value among all seven dimensions, suggesting that IoT had the most pronounced impact on minimizing stock shortages. H6 is therefore supported.

• H7: Overstock — A statistically significant reduction in over-stocking was observed following IoT adoption ($Z = -4.311$, $p < 0.001$), confirming that IoT-based inventory monitoring helped organizations better balance their stock levels. H7 is therefore supported.

Overall, all seven hypotheses (H1–H7) were supported, confirming that IoT adoption leads to statistically significant improvements across all examined supply chain operational performance dimensions. The consistently high absolute Z values and p-values below 0.001 across all dimensions reflect the strong and reliable impact of IoT adoption on supply chain performance. Notably, Stockouts recorded the highest Z value ($Z = -4.491$), suggesting that IoT had the most significant influence on reducing stock shortages, while Process Delays recorded the lowest Z value ($Z = -4.059$), though still highly significant.

CONCLUSION

This study investigated the determinants of IoT adoption and its sub-sequent impact on supply chain operational performance within the context of logistics and supply chain management. With respect to the adoption of IoT, the results confirm that Performance Impact, Employee Readiness, Risk Management, and Compatibility are each significant positive predictor of IoT adoption. With respect to operational outcomes, the pre- and post-IoT com-parisons reveal statistically significant improvements across all seven dimensions of supply chain performance, including speed of operations, inventory accuracy, real-time tracking, process delay reduction, overall productivity, stockout reduction, and overstock reduction. IoT adoption does not merely yield marginal gains but rather drives substantial and measurable transformation in supply chain operations.

In conclusion, this study contributes to the growing body of evidence affirming the transformative potential of IoT in supply chain management. The convergence of strong adoption predictors and significant post-adoption improvements across multiple operational dimensions positions IoT not merely as an emerging technology, but as a strategic imperative for organizations seeking to enhance efficiency, resilience, and competitiveness in an increasingly data-driven global marketplace.

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