The Effect of Ai-Route Optimization on Supply Chain Performance among Large Supermarkets in Nairobi City County, Kenya

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ABSTRACT

Supermarkets increasingly face logistical challenges such as fluctuating demand patterns, rising distribution costs, and the need for timely and efficient product delivery. Artificial Intelligence (AI) has emerged as a critical tool for improving logistics decision-making, particularly through route optimization systems that enhance delivery speed, reduce transportation costs, and improve overall supply chain responsiveness. This study examined the effect of AI-Route Optimization on supply chain performance among large supermarkets in Nairobi City County, Kenya. The study was grounded in the Hybrid Intelligence Model, Triple Triangle Constraint Theory, and Technology Acceptance Theory to explain the integration and influence of AI technologies on supply chain outcomes. A descriptive research design was adopted, targeting employees working in the supply chain departments of 10 large supermarkets within Nairobi City County. A sample of 70 respondents was drawn from this population, and data were collected using structured questionnaires. Reliability was tested through a pretest involving seven respondents from selected Naivas branches in Kiambu County. Descriptive statistics, including means and standard deviations, were used to summarize the data, while inferential statistics such as correlation and regression analysis were applied to determine the relationship between AI-route optimization and supply chain performance using SPSS version 30. The findings indicated that AI-Route Optimization had a statistically significant effect on supply chain performance ($M = 3.57$, $SD = 0.43$), with the regression model showing strong explanatory power ($R^2 = 0.79$) and statistical significance ($F = 222.015$, $\rho < 0.01$). The study concluded that AI-driven route optimization positively enhances supply chain performance by improving delivery efficiency, minimizing transport costs, and strengthening service reliability. The study recommends that supermarket supply chain managers invest in advanced AI-based routing tools, integrate real-time data sources such as GPS and traffic feeds, and enhance staff capacity to effectively utilize these systems. Further research is recommended in other geographical contexts to compare the role of AI-route optimization across different retail and logistics environments.

INTRODUCTION

In today's highly competitive retail environment, supply chain performance has become a core driver of organizational success, influencing delivery reliability, customer satisfaction, and overall operational efficiency (Kalaitzi et al., 2019). Over the years, supply chains have evolved from basic production–distribution systems into sophisticated, technology-supported networks that require advanced tools to manage growing complexity (Alomar, 2022). The emergence of Artificial Intelligence (AI) has accelerated this transformation by enabling firms to leverage data-driven insights, real-time analytics, and intelligent decision-making to streamline supply chain operations (Zong & Guan, 2024).

AI has been particularly influential in enhancing logistics activities such as transportation and distribution, which are central to ensuring timely product availability in supermarkets (Muthuswamy & Ali, 2023). As global and local retail markets become more dynamic, large supermarkets face increasing pressure to improve delivery accuracy, minimize lead times, and reduce operational costs (Hove-Sibanda et al., 2021). Traditional routing practices often struggle with challenges such as traffic congestion, unpredictable travel times, fuel inefficiencies, and limited visibility across delivery routes, which undermine overall supply chain performance (Kazim, 2018).

AI-based route optimization has emerged as a transformative solution to these challenges. By integrating real-time traffic data, historical route patterns, and delivery constraints, AI systems can recommend the most efficient delivery paths, thereby improving fleet utilization, reducing transportation costs, and enhancing delivery reliability (Helo et al., 2022). Studies have demonstrated that AI-driven routing tools significantly enhance logistics efficiency, though results vary across contexts due to differences in technological readiness and infrastructure quality (Oosthuizen et al., 2021).

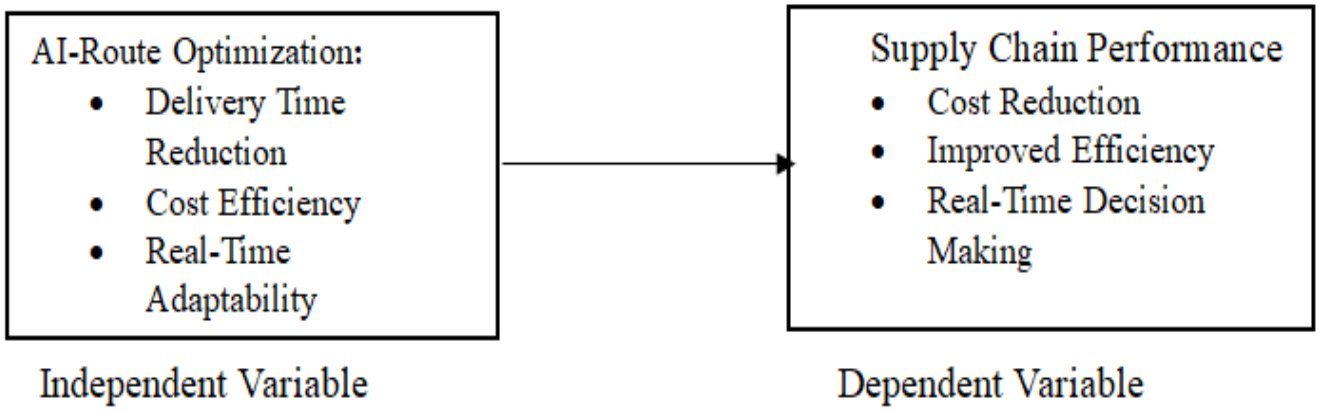
Despite growing global adoption, empirical research on AI-route optimization within the Kenyan retail sector remains limited. While large supermarkets in Nairobi continue to expand their distribution networks, little is known about the extent to which AI-enabled routing systems have been implemented or the magnitude of their impact on supply chain performance (Charles et al., 2021). This gap highlights the need for context-specific evidence on how AI-driven routing influences transportation efficiency, delivery reliability, and overall supply chain outcomes. Therefore, this study examined the effect of AI-Route Optimization on supply chain performance among large supermarkets in Nairobi City County, Kenya, generating insights that are essential for retailers, policymakers, and technology providers seeking to strengthen logistics capabilities within the supermarket sector.

Research Hypothesis

AI-Route optimization has no statistically significant effect on supply chain performance among large supermarkets in Nairobi city county, Kenya.

Conceptual Framework

According to Burns and Burns (2013), a conceptual framework is a tool that researchers use to direct a research project's studies, plans, practices, thinking, and execution. The complete study process is reflected in it (Kivunja, 2018). According to Kivunja (2018), it is a diagrammatic flow chart that illustrates or explains the connections between the elements and variables that have been recognized as pertinent to the study. The main purpose of the conceptual framework is to assist researchers in connecting their goals with the body of existing literature.



Source: Researcher (2025)

Figure 1: Conceptual Framework

LITERATURE REVIEW

Theoretical Literature Review

The Technology Acceptance Theory (TAT), developed by Fred Davis in 1989, explains how individuals adopt and use new technologies based on two primary perceptions: perceived usefulness and perceived ease of use. According to the model, users are more willing to embrace a technology when they believe it will enhance their performance and when it is simple to operate (Ammenwerth, 2019). These perceptions shape a user's attitude, intention, and actual behavior toward adopting a technological innovation.

TAT has been widely applied in understanding technology adoption across various sectors, including artificial intelligence. As AI tools increasingly support forecasting, decision-making, and automation, users' acceptance depends largely on their belief that such systems are beneficial and user-friendly (Unal & Uzun, 2021). However, scholars note that while the model offers a strong foundation for analyzing technology adoption, it has limitations. It focuses primarily on individual perceptions and does not sufficiently account for broader influences such as organizational culture, social pressure, infrastructure readiness, or financial barriers (Kim & Wang, 2021; Dutot et al., 2019). These omissions highlight the need for contextual considerations when applying TAT in complex organizational settings.

Despite these limitations, TAT remains relevant in studies examining technological integration within supply chains. Effective implementation of AI tools, including route optimization systems, depends on employees' willingness to interact with and trust the technology (Liu et al., 2022). When users perceive AI-driven routing platforms as beneficial, reliable, and easy to use, adoption rates rise, leading to improvements in operational efficiency, reduced costs, and better decision-making.

In the context of this study, TAT provides a valuable lens for understanding how perceptions of AI-route optimization influence its acceptance and subsequent impact on supply chain performance. The theory helps explain how the independent variable (AI-route optimization) aligns with user behavior and ultimately influences the dependent variable (supply chain performance) within large supermarkets.

Empirical Literature Review

Studies across different countries consistently show that AI-route optimization enhances supply chain performance, though the extent varies by context and industry. In the USA, Vaka (2024) found that AI improved delivery efficiency and customer satisfaction among e-commerce firms, though the study's geographical and sectoral focus limits its applicability to Kenyan supermarkets. Similarly, Khadem et al. (2023) reported that AI improved efficiency and route decision-making in India's manufacturing sector, but with a modest explanatory power ($R^2 = 0.052$), indicating the need for further sector-specific research.

In Pakistan, Modgil et al. (2022) demonstrated that AI strengthens supply chain resilience through improved visibility and last-mile delivery, although the study did not analyze specific AI tools such as route optimization. Experimental findings by Hassouna et al. (2022) in Egypt showed that AI-based systems identified optimal transportation routes that minimized cost and time ($F = 1.38$, $\rho < 0.05$). However, this research was limited to the transport industry rather than retail.

Existing studies agree that AI contributes positively to logistics efficiency, but they reveal contextual, methodological, and geographical gaps. Most research has focused on manufacturing, transport, or e-commerce sectors outside Africa. The current study seeks to address these gaps by examining AI-Route Optimization and supply chain performance in large supermarkets in Nairobi City County, Kenya.

RESEARCH METHODOLOGY

The study adopted a descriptive research design, which was appropriate for examining how AI-enabled route optimization influenced supply chain performance among supermarkets in Nairobi City County. The target population consisted of logistics, procurement, and operations personnel drawn from major supermarket chains operating within the county. A census approach was used for supermarkets, while purposive sampling was applied to select respondents directly involved in logistics decision-making.

Primary data were collected using structured questionnaires, which contained both closed-ended and Likert-scale items aligned with the study variables. The instrument's reliability was confirmed through Cronbach's alpha, where all constructs exceeded the acceptable threshold. Validity was ensured through expert review and piloting. Data were analyzed using descriptive statistics, including means, frequencies, and standard deviations, to summarize the characteristics of the variables. Inferential analysis, specifically regression analysis, was used to determine the effect of AI-enabled route optimization on supply chain performance. Ethical considerations

including informed consent, confidentiality, and voluntary participation were also strictly observed throughout the research process.

Data Processing and Analysis

To examine the relationship between AI-Route Optimization and supply chain performance, correlation analysis was first employed to determine the strength and direction of the association between the independent and dependent variables. Following this, regression analysis was conducted to assess the predictive influence of AI-Route Optimization on supply chain performance. The regression model used in the study was specified as:

$$Y = \beta_0 + \beta_1 X_1 + \epsilon$$

In this model, Yrepresents the dependent variable, supply chain performance, while X_1denotes the independent variable, AI-Route Optimization. The coefficient $\beta_0$represents the intercept, $\beta_1$measures the magnitude and direction of the effect of AI-Route Optimization on supply chain performance, and ϵcaptures the random error term. This approach enabled the study to quantify the impact of AI-based route optimization on the operational efficiency, delivery reliability, and overall performance of large supermarket supply chains in Nairobi City County.

RESEARCH FINDINGS

The study assessed the impact of AI-Route Optimization on supply chain performance in large supermarkets in Nairobi City County. Data collected from 61 respondents, representing supply chain managers, supervisors, and officers, revealed that AI-Route Optimization significantly influenced supply chain performance, particularly in delivery reliability, cost efficiency, and operational effectiveness.

Demographics and Familiarity with AI

The majority of respondents were male (68.9%) and aged between 41–50 years (65.6%), indicating a mature workforce with substantial professional experience. Most respondents held at least a bachelor's degree (59%) or postgraduate qualification (31.1%), suggesting strong educational backgrounds suited to adopting AI technologies. In terms of work experience, 36.1% had 6–10 years, and 26.2% had 11–15 years of experience, reflecting considerable exposure to supermarket operations and supply chain practices. The mix of managers, supervisors, and officers provided diverse perspectives on the use of AI in routing and logistics.

Impact of AI-Route Optimization

Analysis of AI-Route Optimization indicated that respondents strongly agreed that AI tools enhanced delivery efficiency, reduced operational costs, and improved real-time decision-making in route planning. Descriptive statistics showed a high mean score (M = 3.57, SD = 0.43), reflecting general consensus on the positive impact of AI-route tools. Regression analysis confirmed that AI-Route Optimization had a statistically significant effect on supply chain performance ($R^2 = 0.79$, $F = 222.015$, $\rho < 0.01$).

Table 1: AI-Route Optimization and Supply Chain Performance

Variable	Number of Items	Mean	SD	R^2	F	Significance (ρ)
AI-Route Optimization	15	3.57	0.43	0.79	222.02	<0.01

Source: Primary Data (2025)

The findings indicate that AI-Route Optimization significantly contributed to improved supply chain performance in large supermarkets by enabling more efficient delivery routes, reducing transport costs, and enhancing the reliability of product distribution. This supports the integration of AI-based routing systems as a strategic tool for optimizing logistics operations in the Kenyan retail sector.

Descriptive Statistics: AI-Route Optimization and Supply Chain Performance

The study assessed the impact of AI-Route Optimization on supply chain performance in large supermarkets in Nairobi City County across three dimensions: delivery time reduction, cost efficiency, and real-time adaptability. The respondents' feedback was analyzed using mean scores and standard deviations to determine the level of agreement on each indicator.

Table: Descriptive Statistics for AI-Route Optimization

Dimension	Mean	Standard Deviation (SD)	Interpretation
Delivery Time Reduction	3.66	0.43	Agreed – AI reduces delivery time by optimizing routes
Cost Efficiency	3.73	0.73	Agreed – AI improves cost efficiency through route planning and resource optimization
Real-Time Adaptability	3.32	0.69	Neutral – AI provides some adaptability but respondents were less certain about effectiveness in unexpected situations
Overall Average	3.57	0.62	Agreed – AI-Route Optimization positively influences supply chain performance

Source: Primary Data (2025)

The findings indicate that AI-Route Optimization had a notable positive effect on supply chain performance, particularly in reducing delivery time and enhancing cost efficiency. Delivery time reduction had the highest agreement among respondents, confirming that AI-enabled route planning significantly streamlines operations. Cost efficiency also showed strong positive effects, reflecting savings in fuel, travel time, and driver productivity. Real-time adaptability received a slightly lower mean, suggesting that while AI contributes to flexibility in dynamic conditions, respondents perceived some limitations in its ability to handle unexpected disruptions fully. The descriptive statistics confirm that AI-Route Optimization is an effective tool for improving key aspects of supply chain performance in large supermarkets in Nairobi City County.

Correlation Analysis: AI-Route Optimization and Supply Chain Performance

The study examined the relationship between AI-Route Optimization and various dimensions of supply chain performance, including cost reduction, improved efficiency, and real-time decision-making. Pearson correlation coefficients were computed, and the results are presented below:

Table 2: AI-Route Optimization and Supply Chain Performance

Variables	AI-Route Optimization	Cost Reduction	Improved Efficiency	Real-Time Decision Making
AI-Route Optimization	1	0.877**	0.802**	0.818**
Cost Reduction	0.877**	1	0.946**	0.646**
Improved Efficiency	0.802**	0.946**	1	0.757**
Real-Time Decision Making	0.818**	0.646**	0.757**	1

Source: Primary Data (2025)

The findings show strong positive correlations between AI-Route Optimization and all measured dimensions of supply chain performance. AI-Route Optimization exhibited the highest correlation with cost reduction (r = 0.877), followed by real-time decision-making (r = 0.818) and improved efficiency (r = 0.802). All correlations are statistically significant at the 0.01 level, indicating that as AI-Route Optimization improves, key aspects of supply chain performance such as cost efficiency, operational efficiency, and timely decision-making also improve.

This confirms that implementing AI-based route optimization significantly contributes to enhancing overall supply chain performance in large supermarkets in Nairobi City County.

Regression Analysis: AI-Route Optimization and Supply Chain Performance

The study examined the effect of AI-Route Optimization on supply chain performance among large supermarkets in Nairobi City County using a simple linear regression model expressed as:

$$Y = \beta_0 + \beta_1 X_3 + \epsilon$$

Where Yrepresents supply chain performance, X_3denotes AI-Route Optimization, $\beta_0$is the regression intercept, $\beta_1$is the coefficient of AI-Route Optimization, and ϵrepresents the error term.

Model Summary

The regression model (Table 38) showed a strong relationship between AI-Route Optimization and supply chain performance. The coefficient of determination (Adjusted $R^2 = 0.786$) indicated that approximately 78.6% of the variation in supply chain performance was explained by AI-Route Optimization, while the remaining 21.4% was attributed to other unmeasured factors. The standard error of the estimate was 0.271, indicating a reasonably good fit.

Table 3: Model Summary

Model	R	R^2	Adjusted R^2	Std. Error of Estimate
1	0.889	0.79	0.786	0.27081

Source: Primary Data (2025)

ANOVA

The ANOVA results (Table 39) confirmed the model's overall significance, with **$F(1, 59) = 222.015$, $p < 0.01$**, indicating that AI-Route Optimization is a significant predictor of supply chain performance. This demonstrates that the regression model is suitable for understanding and predicting changes in supply chain performance based on AI-route optimization.

Table 4: ANOVA

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	16.282	1	16.282	222.015	0.000
Residual	4.327	59	0.073		
Total	20.609	60			

Source: Primary Data (2025)

Regression Coefficients

The coefficient analysis (Table 40) revealed that AI-Route Optimization had a positive and statistically significant effect on supply chain performance ($\beta = 1.202$, $t = 14.9$, $p < 0.01$). The regression intercept was -0.574, which is not statistically significant at the 1% level ($p = 0.053$).

Table 5: Regression Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-0.574	0.291		-1.973	0.053
	AI-Route Optimization	1.202	0.081	0.889	14.9	0
a Dependent Variable: Supply Chain Performance						

Source: Primary Data (2025)

The resulting regression equation is:

$$Y = -0.574 + 1.202X_3 + \epsilon$$

The results indicate that for every one-unit increase in AI-Route Optimization, supply chain performance is expected to increase by 1.202 units, holding other factors constant. The null hypothesis (Ho3), which stated that AI-Route Optimization has no statistically significant effect on supply chain performance, was therefore rejected. This finding aligns with previous studies, such as Bello et al. (2024), which found that AI-driven route optimization improves efficiency, reduces operational costs, enhances delivery reliability, and strengthens supply chain resilience.

AI-Route Optimization significantly enhances supply chain performance in large supermarkets in Nairobi City County. The results underscore the importance of integrating AI-driven routing systems into logistics management to improve operational efficiency, reduce costs, and optimize delivery processes.

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Summary

The study examined the effect of AI-Route Optimization on supply chain performance among large supermarkets in Nairobi City County, Kenya, focusing on delivery time reduction, cost efficiency, and real-time adaptability. The correlation analysis indicated a strong positive relationship between AI-Route Optimization and supply chain performance, suggesting that improvements in route optimization enhance operational outcomes. Regression analysis confirmed this relationship, with a significant coefficient estimate of $\beta = 1.202$ ($p = 0.000 < 0.01$). This demonstrates that AI-Route Optimization significantly contributes to the improvement of supply chain performance, explaining a substantial portion of the variation in performance among the supermarkets studied.

Conclusion

The findings of the study show that AI-Route Optimization positively and significantly affects supply chain performance in large supermarkets in Nairobi City County. By dynamically optimizing delivery routes, supermarkets achieved reductions in delivery times, enhanced cost efficiency, and improved real-time decision-

making. The results confirm that adopting AI-driven route optimization strengthens overall supply chain efficiency, reliability, and resilience, enabling supermarkets to meet customer demands more effectively.

Recommendation

To fully leverage the benefits of AI-Route Optimization, supply chain managers should prioritize the selection of AI platforms that provide real-time visibility of routes, improve delivery reliability, and reduce operational costs through fuel and maintenance savings. They should invest in robust data infrastructure and skilled personnel to ensure the effective implementation and maintenance of AI systems. Integration of AI tools with existing supply chain execution systems is crucial to enable accurate, real-time decision-making. Managers should also promote collaboration across departments to align AI solutions with strategic business objectives. Furthermore, it is essential to maintain enabling systems, including reliable hardware, software, and internet connectivity, to allow supermarkets to adapt to changing operational demands without compromising supply chain performance.

Statement Of The Problem

Efficient route planning was essential for supermarkets to achieve timely and cost-effective deliveries, yet large supermarkets in Nairobi City County continued to experience transport inefficiencies such as fuel wastage, delays, unreliable delivery times, and high logistics costs. Although AI-based route optimization had proven effective in improving distribution efficiency in global retail supply chains, evidence from previous studies remained mixed, with some reporting significant performance gains while others noted high integration costs and limited effectiveness. In Kenya, existing research had largely concentrated on general technology adoption in supply chains, leaving minimal empirical evidence on the use and impact of AI-route optimization in the retail sector. It was unclear whether supermarkets in Nairobi used AI-driven routing tools, how effectively they had been applied, and the extent to which they influenced supply chain performance outcomes such as delivery reliability, cost efficiency, and service responsiveness. This gap in contextualized knowledge formed the basis of the study, which sought to assess the effect of AI-Route Optimization on supply chain performance among large supermarkets in Nairobi City County, Kenya.

Objective Of The Study

The purpose of the study was to examine the effect of AI-Route Optimization on supply chain performance among large supermarkets in Nairobi City County, Kenya.

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