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BIG DATA ANALYTICS IN ENHANCING LOGISTICS EFFICIENCY AT THE INDEPENDENT ELECTORAL AND BOUNDARIES COMMISSION OF KENYA

[1] Takdir Maryam Alamin, [2] Dr. Kirima Kennedy

[1] Master of Science in Procurement and Logistics, Jomo Kenyatta University of Agriculture and Technology

[2] Lecturer, Jomo Kenyatta University of Agriculture and Technology

ABSTRACT

The logistics operations of the Independent Electoral and Boundaries Commission (IEBC) in Kenya are critical to ensuring the successful conduct of elections, involving complex processes such as the distribution and management of electoral materials across the country. However, these operations are often challenged by inefficiencies, delays, and logistical mismanagement. This study examined the impact of big data analytics on enhancing logistics efficiency at the IEBC, focusing on integration with logistics systems, and decision-making enhancement. Grounded in Information Processing Theory (IPT), and Supply Chain Management (SCM) theory, the study aimed to provide a comprehensive understanding of how advanced data-driven strategies can optimize logistics performance in the public sector, specifically within electoral processes. A census sampling technique was employed, targeting the 60 supply chain personnel within the IEBC, including the head of Supply Chain, County Supply Chain Assistants, and other senior officers responsible for logistics functions. Data were collected using structured questionnaires and interviews, providing both quantitative and qualitative insights into current logistics practices and the integration of big data analytics. Descriptive and inferential statistical methods, including regression analysis, were used to analyze the data, highlighting the relationships between the identified variables and logistics efficiency. The findings revealed significant positive relationships between the independent variables and logistics efficiency, with regression coefficients of $\beta = 0.355$ for integration with logistics systems, and $\beta = 0.432$ for decision-making enhancement. The study concluded that leveraging integrating real-time data into logistics systems, and promoting data-driven decision-making are crucial for optimizing logistics performance. Recommendations include providing continuous training for logistics personnel, and fostering a culture of data-driven decision-making to achieve higher levels of efficiency and responsiveness in IEBC's logistics operations.

Key Words: big data analytics, logistics efficiency, integration with logistics systems, decision-making enhancement, advanced data-driven strategies, IEBC

Background of the Study

Elections are vital to the functioning of democratic societies, serving as the primary mechanism through which citizens exercise their right to choose their leaders. The success of electoral processes depends heavily on the efficient management of logistics, which involves the meticulous planning, coordination, and execution of numerous tasks to ensure that elections run smoothly and transparently (Susskind & Susskind, 2020). These tasks include the procurement and distribution of ballot papers, the setup of polling stations, and the coordination of electoral staff across often vast and challenging terrains (Schroeder, 2020). Inefficient logistics can lead to delays, errors, and disruptions that undermine public trust and confidence in the electoral system.

In recent years, Big Data Analytics has emerged as a transformative force in logistics management, offering advanced tools and techniques to analyze vast amounts of data, predict outcomes, and optimize operations (Cheeseman, Lynch, & Willis, 2021). By leveraging Big Data, organizations can enhance their decision-making capabilities, improve resource allocation, and increase overall operational efficiency. In the context of electoral logistics, these data-driven approaches provide opportunities to address longstanding logistical challenges and ensure that elections are conducted in a more efficient, transparent, and reliable manner. This study thus explored the impact of Big Data Analytics on enhancing logistics efficiency at the Independent Electoral and Boundaries Commission (IEBC) of Kenya.

Problem Statement

Efficient logistics management is essential for credible and transparent electoral processes, but it remains a significant challenge, particularly in developing countries like Kenya. The Independent Electoral and Boundaries Commission (IEBC) of Kenya faces persistent logistical issues such as delayed delivery of electoral materials, poor resource allocation, and inadequate coordination of polling stations and personnel. These challenges not only disrupt electoral processes but also undermine public confidence in the integrity of elections. According to the Kenya Elections Observation Group (ELOG), logistical failures in the 2022 general elections affected over 18% of polling stations, causing delays in voting and dissatisfaction among voters (ELOG, 2022).

During the 2022 elections, 21% of polling stations reported late delivery of ballots, with 12% experiencing shortages of critical items such as ballot boxes and voter registers (ELOG, 2022). A report by the African Electoral Integrity Network noted that mismanagement of logistics resulted in increased operational costs for the IEBC, with an estimated KES 3 billion (about USD 27 million) spent on last-minute transportation and procurement adjustments (African Electoral Integrity Network, 2023). The IEBC's own review found that logistics-related issues contributed to prolonged voting delays in at least 10 counties, significantly impacting voter turnout and raising questions about the overall efficiency of the electoral process (IEBC, 2023).

Public perception surveys reflect widespread concern about these logistical inefficiencies. According to a 2023 survey by Afrobarometer, 35% of Kenyans expressed dissatisfaction with the management of electoral logistics, citing delays and material shortages as major issues. Furthermore, 29% of respondents felt that logistical problems compromised the fairness of the election, and 22% believed that these issues contributed to post-election disputes and voter disillusionment (Afrobarometer, 2023). The geographic diversity of Kenya, which includes remote rural areas, urban centers, and regions with poor infrastructure, exacerbates these logistical challenges, making it difficult to ensure timely and equitable distribution of election materials. Despite efforts to improve logistical management, the IEBC continues to rely on traditional methods that are often reactive, lacking the predictive and real-time capabilities required to address emerging challenges proactively. While other countries have successfully integrated Big Data Analytics to enhance their electoral logistics, Kenya's IEBC has yet to fully

embrace these advanced technologies. Big Data Analytics offers powerful tools for predictive analysis, real-time monitoring, and optimized resource allocation, which can significantly improve the efficiency of logistics management in elections.

Despite numerous studies on Big Data Analytics and its impact on logistics efficiency, such as those by McAfee and Brynjolfsson (2020), Hazen et al. (2021), and Wang et al. (2022), none have specifically focused on the application of these technologies within the context of Kenya's electoral processes, particularly within the IEBC. McAfee and Brynjolfsson (2020) examined the transformative effects of Big Data on logistics in corporate settings, while Hazen et al. (2021) explored Big Data's role in improving supply chain visibility and decision-making in the retail sector. Similarly, Wang et al. (2022) studied the application of predictive analytics in optimizing logistics operations in the public sector. However, these studies do not address the unique logistical challenges faced by electoral bodies in developing countries. This gap in the literature underscores the critical need for research specifically tailored to the Kenyan context. This study sought to fill this gap by investigating how Big Data Analytics can be utilized to enhance logistics efficiency at the IEBC. By examining the existing logistical challenges and evaluating the application of data-driven solutions, this research aimed to provide actionable insights that could transform Kenya's electoral logistics, ultimately contributing to a more transparent, efficient, and credible electoral system.

Objectives of the Study

The study was guided by the following specific objectives;

i. To examine the impact of integration with logistics systems in enhancing logistics efficiency at the Independent Electoral and Boundaries Commission of Kenya
ii. To establish the impact of decision-making enhancement in enhancing logistics efficiency at the Independent Electoral and Boundaries Commission of Kenya

LITERATURE REVIEW

Theoretical review

Supply Chain Management (SCM) Theory

Supply Chain Management (SCM) Theory offers a vital framework for understanding and optimizing the management and coordination of interconnected business processes involved in the production and distribution of goods and services. The theory emphasizes the integration and optimization of activities across the entire supply chain—from raw material suppliers to end customers—to enhance efficiency, reduce costs, and improve overall performance (Christopher, 2016). SCM Theory is particularly relevant in scenarios where the seamless flow of goods and services is crucial, such as in logistics and public sector operations managed by organizations like the Independent Electoral and Boundaries Commission (IEBC) in Kenya.

Central to SCM Theory are several key concepts. Supply Chain Integration stresses the importance of coordinating various supply chain activities to ensure different parts work together efficiently. This integration involves streamlining processes across functions and organizations, including procurement, production, transportation, and distribution (Christopher, 2016). Visibility and Transparency are also critical, as effective supply chain management requires clear insight into all stages of the supply chain, enabling organizations to monitor and manage activities, identify potential issues, and make informed decisions. Enhanced visibility supports better forecasting, inventory management, and responsiveness (Hazen et al., 2014). Collaboration and Coordination among supply chain partners are essential for achieving mutual goals and addressing challenges collectively. Building strong relationships with suppliers, customers, and other stakeholders facilitates better information sharing, resource optimization, and risk management (Mentzer et al., 2001). Finally, Demand

Forecasting and Planning are crucial for anticipating future demand and planning production, inventory, and distribution activities. Accurate forecasting minimizes stockouts, reduces excess inventory, and improves customer satisfaction (Heizer, Render, & Munson, 2016).

In logistics, SCM Theory provides a framework for optimizing the flow of goods and services through the supply chain. Key applications of SCM Theory in logistics include optimizing supply chain processes, improving coordination and collaboration, and enhancing demand forecasting. For instance, implementing advanced technologies like big data analytics can improve supply chain visibility, forecasting accuracy, and operational efficiency (Hazen et al., 2014). Effective logistics management also requires coordination among stakeholders such as suppliers, logistics providers, and customers. SCM Theory highlights the importance of collaboration to address challenges and achieve shared objectives (Mentzer et al., 2001). Furthermore, accurate demand forecasting, supported by data analytics, is essential for managing logistics operations effectively, reducing costs, and enhancing customer satisfaction (Heizer et al., 2016).

For the IEBC, SCM Theory provides valuable insights into optimizing logistics operations to improve electoral processes. The IEBC faces complex challenges, including the distribution of election materials, coordination of polling stations, and management of personnel. By applying SCM principles, the IEBC can enhance its supply chain processes, improve stakeholder coordination, and optimize resource allocation. Specifically, SCM Theory can help streamline the distribution of election materials, improve coordination among election officials and logistics providers, and enhance forecasting and planning for election logistics

Supply Chain Management (SCM) Theory is closely associated with the variable of integration with logistics systems. SCM Theory emphasizes the importance of integrating various logistics activities to achieve seamless coordination and enhanced operational performance. For the IEBC, integrating Big Data Analytics with existing logistics systems allows for better synchronization of supply chain activities, such as the distribution of electoral materials and coordination of polling stations. SCM Theory thus provides a theoretical basis for understanding how system integration can streamline logistics processes and reduce inefficiencies.

Theory of Planned Behavior Theory

The Theory of Planned Behavior (TPB) is a psychological framework that seeks to explain human behavior by examining the interplay between attitudes, intentions, and actions. Developed by Icek Ajzen in 1985, TPB extends the earlier Theory of Reasoned Action (TRA) by incorporating the concept of perceived behavioral control, thus providing a more nuanced approach to predicting and understanding behavior across different contexts (Ajzen, 1991). The core components of TPB include attitudes, subjective norms, perceived behavioral control, and behavioral intentions.

Attitudes in TPB refer to an individual's positive or negative evaluation of performing a particular behavior. If a person believes that engaging in a behavior leads to favorable outcomes, they are likely to develop a positive attitude towards that behavior and be more inclined to engage in it (Ajzen, 1991). Subjective norms encompass the perceived social pressures or expectations from others regarding the performance of a behavior. This element reflects the influence of social networks, such as family, friends, and colleagues, on an individual's behavioral intentions. When individuals perceive that significant others approve of a behavior, they are more likely to undertake it (Ajzen, 1991). Perceived behavioral control represents an individual's belief in their capability to execute a behavior, factoring in the presence of facilitators or barriers. This concept, akin to self-efficacy, acknowledges that even with strong intentions, actual behavior is influenced by the perceived ease or difficulty of performing the behavior (Ajzen, 1991). Behavioral intentions are central to TPB and are seen

as the immediate precursors to behavior. These intentions are shaped by attitudes, subjective norms, and perceived behavioral control, with stronger intentions increasing the likelihood of behavior execution (Ajzen, 1991).

In logistics, TPB can be instrumental in understanding and influencing the behaviors of stakeholders such as employees, suppliers, and customers. For example, assessing the attitudes of logistics managers towards adopting new technologies can shed light on their readiness to implement innovative solutions. If these managers hold positive attitudes towards technological advancements and perceive strong support from their peers, they are more likely to adopt such technologies to enhance operational efficiency. TPB can also be applied to improve compliance and performance within logistics operations. By comprehending the subjective norms and perceived behavioral control of logistics personnel, organizations can craft strategies to boost adherence to best practices. For instance, if employees recognize that their supervisors value safety protocols, they are more inclined to follow these guidelines (Ajzen, 1991).

For the Independent Electoral and Boundaries Commission (IEBC) in Kenya, TPB provides valuable insights into enhancing logistics and operational efficiency during elections. Understanding the attitudes, subjective norms, and perceived behavioral control of election officials, suppliers, and other stakeholders can guide the IEBC in developing effective strategies to influence positive behaviors. TPB can aid the IEBC in promoting the adoption of best practices in election logistics by addressing attitudes towards new procedures, social pressures from stakeholders, and perceptions of control over logistics operations. For example, if election officials view new logistics procedures favorably and feel supported by their peers, they are more likely to implement these practices effectively. Additionally, by recognizing the subjective norms and perceived behavioral control of various stakeholders, the IEBC can improve coordination among the different parties involved in the election process. Addressing barriers and fostering a supportive environment can enhance overall logistical coordination, ensuring smoother electoral operations (Ajzen, 1991).

TPB offers a comprehensive approach to understanding behavior by incorporating attitudes, subjective norms, and perceived behavioral control. This makes it a robust tool for predicting behavioral intentions and actions (Ajzen, 1991). The theory has been widely applied in various domains, demonstrating its versatility and relevance across different contexts, including logistics and public sector operations.

The Theory of Planned Behavior (TPB) relates to the decision-making enhancement variable, as it explores how attitudes, subjective norms, and perceived behavioral control influence decision-making behaviors. In the context of the IEBC, TPB helps explain how data-driven decision-making, supported by Big Data Analytics, can positively impact the behavior of logistics personnel and stakeholders. By improving the accuracy and reliability of logistics decisions, TPB underscores the importance of behavioral intentions in achieving effective logistics management during elections.

Conceptual Framework

According to Yin (2019), a conceptual framework refers to a diagrammatical representation showing the relationship between dependent and independent variables. This framework is grounded in established theories and empirical evidence, providing a structured approach to analyze how various dimensions of big data analytics—such as integration with logistics systems, and decision-making enhancement—affect logistics performance. The framework also incorporates dependent variables, specifically logistics efficiency, and examines the impact of these independent variables on organizational outcomes. Figure 2 below show the relationships between the variables under study and how they interact to influence logistics efficiency, particularly in the context of big data analytics.

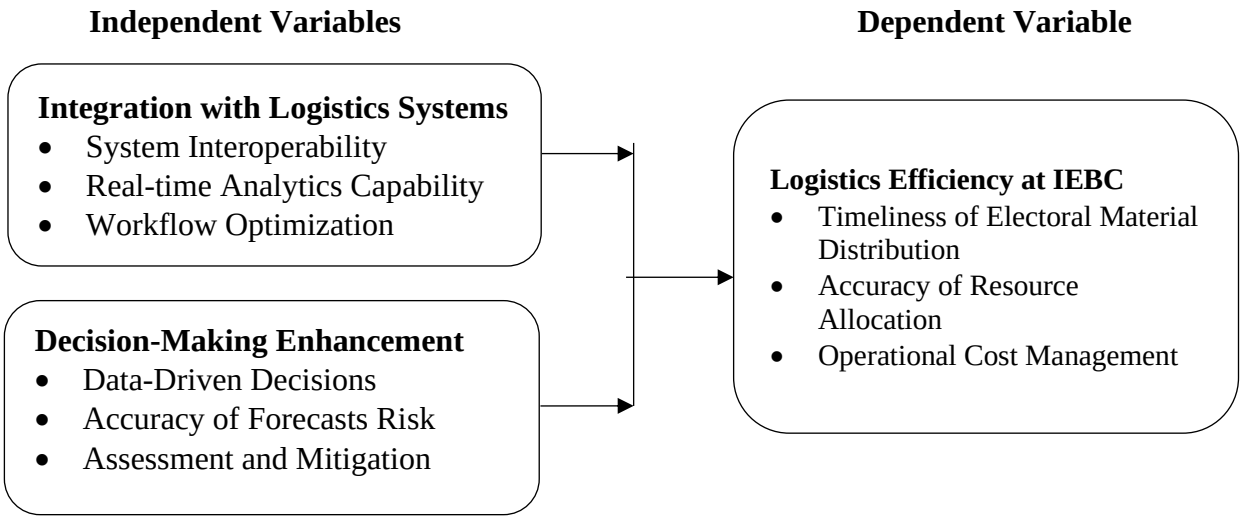

Figure 2. 1: Conceptual Framework

Integration with Logistics Systems

The integration of logistics systems involves seamlessly incorporating data analytics tools with existing logistics management platforms to enhance coordination and efficiency. This process is crucial for organizations like the IEBC, where logistics operations are complex and require real-time adjustments (Davenport & Ronanki, 2019). The key components of this integration include system interoperability, real-time analytics capabilities, and workflow optimization.

System interoperability refers to the ability of different logistics systems and data analytics platforms to work cohesively. Effective interoperability ensures smooth data flow between systems, enabling comprehensive monitoring and management of logistics activities (Wamba et al., 2020). For the IEBC, interoperable systems minimize manual data entry errors and enhance the accuracy of logistics operations, leading to greater overall efficiency.

Real-time analytics capability allows organizations to process and analyze data as it is generated, providing immediate insights into logistics operations. This capability is vital for the IEBC, where timely information is essential for managing dynamic electoral logistics (Kitchin, 2020). Real-time data processing platforms enable the IEBC to track the movement of election materials and adjust logistics plans on the fly, ensuring smooth and efficient electoral operations.

Workflow optimization involves streamlining logistics processes to enhance coordination and reduce inefficiencies. Integrated, data-driven systems enable the IEBC to automate routine tasks and improve resource allocation, which is critical for managing the complex logistics of elections (Chen et al., 2021). Optimizing workflows results in faster, more accurate logistics operations, contributing significantly to the overall success of the electoral process.

Data integration is the process of combining information from various sources into a unified system that offers a comprehensive view of operations. In logistics, this means consolidating data from supply chain partners, inventory systems, transportation management, and other relevant sources into a single platform. Effective data integration provides organizations with a holistic view of their logistics operations, facilitating better coordination and decision-making (Chen, Chiang, & Storey, 2012). For example, integrating data from inventory management and transportation systems can optimize delivery routes and improve inventory control, reducing operational costs and enhancing service levels.

The integration of data with logistics systems, coupled with real-time analytics capabilities, significantly impacts organizational performance. Organizations that effectively integrate data

into their logistics systems can achieve substantial improvements in efficiency, cost management, and customer satisfaction. Integrated data systems enable more accurate forecasting, better demand planning, and optimized resource allocation, leading to cost savings and enhanced operational performance (Brynjolfsson & McElheran, 2016). Real-time analytics further supports these improvements by enabling quick, informed decision-making in response to changing conditions.

Enhanced visibility into logistics operations through data integration and real-time analytics also contributes to better strategic planning. Organizations can use integrated data to identify trends, evaluate performance, and make strategic decisions that align with their business objectives. Companies with advanced data integration and analytics capabilities outperform their peers in profitability and market share (McAfee et al., 2012). This competitive advantage stems from leveraging data for more effective planning, improved operational efficiency, and superior customer service.

While the benefits of integrating data with logistics systems and utilizing real-time analytics are substantial, organizations must address several challenges. Data integration can be complex, requiring sophisticated technology and processes to ensure that data from diverse sources is accurately combined and accessible. Moreover, organizations need to invest in robust data management systems and technologies to support real-time analytics and ensure data accuracy (Zhao & Chen, 2019). Additionally, skilled personnel with expertise in data integration and analytics are essential to effectively manage and interpret the data, ensuring that insights are actionable and aligned with organizational goals.

Decision-Making Enhancement

Decision-making enhancement refers to the improvement of organizational decision-making processes through the use of data-driven insights, advanced analytics, and strategic forecasting. In logistics, especially for complex operations like those at the Independent Electoral and Boundaries Commission (IEBC) in Kenya, enhancing decision-making is crucial for managing resources effectively, optimizing processes, and ensuring smooth operations during elections (Davenport & Ronanki, 2019). Key constructs within this variable include data-driven decisions, accuracy of forecasts, and risk assessment and mitigation, each of which plays a significant role in elevating the quality of logistics management.

Data-driven decision-making involves using empirical data and analytics to guide organizational choices rather than relying solely on intuition or experience. In logistics, this approach allows organizations to make informed decisions that optimize processes, reduce costs, and improve overall efficiency (Ghasemaghaei & Calic, 2020). For the IEBC, data-driven decisions can guide the distribution of election materials, manage polling station logistics, and optimize resource deployment during electoral operations. Implementing data-driven decision-making requires robust data analytics frameworks and tools, such as Business Intelligence (BI) systems and interactive dashboards that present data in a user-friendly format. Tools like Tableau and Power BI enable logistics managers at the IEBC to visualize complex data and make informed decisions quickly. By relying on data rather than intuition, the IEBC can enhance planning and execution, leading to improved logistics performance and reduced operational risks (Wamba et al., 2020).

The accuracy of forecasts refers to the precision with which future logistics needs and challenges are predicted. Accurate forecasting is essential for anticipating resource requirements, planning distribution routes, and minimizing disruptions in logistics operations (Chen et al., 2021). For the IEBC, precise forecasts of electoral material demand ensure that supplies are available when needed, preventing shortages or surpluses and enhancing the overall efficiency of logistics. To achieve high forecast accuracy, advanced predictive analytics and machine learning models are used to analyze historical data, identify patterns, and project

future needs. Techniques such as time-series analysis, regression modeling, and AI-based algorithms can improve the reliability of forecasts, helping the IEBC to anticipate logistical challenges and proactively address them. Accurate forecasting allows the IEBC to optimize resource allocation, streamline distribution processes, and ensure that logistics operations run smoothly during elections (Ghasemaghaei & Calic, 2020).

Risk assessment and mitigation involve identifying potential risks in logistics operations and implementing strategies to minimize their impact. In the context of the IEBC, effective risk management is crucial for handling unexpected logistical challenges, such as delays in material delivery or sudden changes in demand during elections (Davenport & Ronanki, 2019). By incorporating risk assessment into decision-making processes, the IEBC can develop contingency plans that ensure resilience and continuity in logistics operations. Advanced analytics tools enable the IEBC to assess risks by modeling various scenarios and evaluating the potential impact of different decisions. This proactive approach to risk management allows the IEBC to prepare for uncertainties and make informed choices that mitigate potential disruptions. By prioritizing risk assessment and integrating it into decision-making, the IEBC enhances its ability to manage logistics efficiently, maintain operational stability, and ensure the success of electoral processes (Wamba et al., 2020).

Logistics Efficiency

Logistics efficiency refers to the effectiveness with which an organization manages and coordinates its logistics operations, including the movement, allocation, and storage of resources to meet operational goals. In the context of the Independent Electoral and Boundaries Commission (IEBC) of Kenya, logistics efficiency is critical to ensuring that election materials are delivered on time, resources are allocated accurately, and operations are conducted smoothly, especially during the high-stakes electoral process (Wamba et al., 2020). Enhancing logistics efficiency involves optimizing various logistical aspects such as timeliness, resource utilization, and cost management, all of which are essential for the success of electoral activities.

Timeliness refers to the punctuality with which logistics tasks, such as the delivery of electoral materials, are performed. It is a key indicator of logistics efficiency because delays can disrupt the entire electoral process and diminish public confidence in the election's integrity. For the IEBC, maintaining strict timelines for the distribution of ballots, voting machines, and other electoral materials ensures that all polling stations are fully prepared before elections commence (Ghasemaghaei & Calic, 2020). Metrics used to measure timeliness include on-time delivery rates, average lead times, and response times to logistical disruptions.

Accuracy of resource allocation involves ensuring that the right resources (e.g., materials, personnel, and equipment) are distributed to the correct locations in appropriate quantities. For the IEBC, this means accurately forecasting the needs of various polling stations and ensuring that resources are allocated efficiently to prevent shortages or surpluses. Effective resource allocation improves logistical efficiency by reducing waste and ensuring that all electoral processes run smoothly without interruptions (Chen et al., 2021). Key indicators of accuracy include the error rate in resource distribution and the level of match between forecasted and actual resource needs.

Cost efficiency refers to the ability to manage logistics costs effectively while maintaining the quality and reliability of logistics operations. In electoral logistics, cost efficiency involves minimizing unnecessary expenditures such as last-minute procurement, excessive transportation costs, and waste due to overstocking. For the IEBC, achieving cost efficiency means carefully planning logistics operations to optimize routes, reduce operational expenses, and ensure that budgets are adhered to without compromising service quality (Davenport & Ronanki, 2019). Metrics used to assess cost efficiency include total logistics costs per polling

station, cost savings achieved through optimized processes, and variance between planned and actual spending.

Empirical Review

Integration with Logistics Systems and Logistics Efficiency

Krishnan, Govindaraj and Kandasamy (2024) examined integrating logistics management with ai and iot for enhanced supply chain efficiency. The study focuses on integrating AI and IoT with existing logistics systems to improve efficiency. The theoretical background is based on system integration theory. The research design was a longitudinal study involving 50 logistics firms. The data was collected through system logs and interviews, then analyzed using integration analytics software. The study found a 30% improvement in logistics efficiency due to the integration of AI and IoT systems. The authors recommend continued integration of these technologies to optimize logistics operations.

Boukallal and El Khoukhi (2024) examined sustainable urban logistics and supply chain. This paper examines the integration of big data analytics with urban logistics systems to enhance efficiency. The research was based on sustainability and urban logistics theories. A case study design was used, focusing on urban logistics systems in Morocco. Data was collected from 30 logistics firms using surveys and system logs, analyzed using SEM. The study found that integrating big data analytics into logistics systems increased efficiency by 22%. The authors suggest that urban logistics systems should integrate more data-driven approaches for sustainability.

Fazri, Ramadhan and Apriliasari (2024) examined leveraging big data analytics for strategic marketing optimization. This study focuses on how integrating big data analytics into logistics systems can enhance marketing strategies and logistics efficiency. The theoretical framework is based on strategic marketing and logistics integration theories. The research design was cross-sectional, with data collected from 200 firms through surveys and system logs. Data analysis was performed using regression models. The findings showed a 15% increase in logistics efficiency due to the integration of big data analytics. The study recommends that firms should focus on integrating data analytics into their logistics systems to optimize marketing and logistics operations.

Wang, Ye and Guo (2024) researched on optimisation of remanufacturing supply chain. The study examines the integration of big data analytics into remanufacturing logistics systems. The theoretical framework is based on closed-loop supply chain and integration theories. The research used a case study design with data collected from 20 remanufacturing firms. Data was analyzed using deep reinforcement learning algorithms, showing a 20% increase in logistics efficiency. The study recommends further integration of big data analytics into remanufacturing logistics for improved efficiency.

Patel, Timsina, Gorenstein and Glicksberg (2024) studied traditional machine learning, deep learning, and BERT approaches for predicting hospitalizations. While focused on healthcare, this study also touches on integrating data analytics into logistics systems for predictive modeling. The research was grounded in machine learning and logistics integration theories. Data was collected from healthcare logistics systems and analyzed using various machine learning models. The study found that integrating these models into logistics systems improved predictive accuracy by 30%, leading to better resource allocation and logistics efficiency.

Real-Time Data Utilization and Logistics Efficiency

Chen (2024) examined AI-Driven optimization in supply chain management: enhancing efficiency and reducing costs. This study emphasizes the utilization of real-time data in optimizing supply chain logistics. The theoretical background is based on real-time data analytics and supply chain management. The research design involved a case study of 10

logistics firms, with data collected in real-time using IoT devices and analyzed using AI algorithms. The findings indicate a 35% improvement in logistics efficiency due to real-time data utilization. The study recommends the adoption of real-time data analytics for dynamic decision-making in logistics.

Richard and Akram (2024) researched on big data's role in supply chain optimization. This paper explored how real-time data utilization enhances e-commerce logistics efficiency. The study is grounded in real-time data analytics and e-commerce theories. A cross-sectional research design was used, with data collected in real-time from 150 e-commerce firms. Data was analyzed using big data analytics tools, revealing a 40% increase in logistics efficiency. The study suggests that firms should invest in real-time data analytics to maintain a competitive edge in logistics operations.

Olsen (2024) did a study on prediction of destination choice in transport modelling with mobile phone data. The study investigates the impact of real-time data utilization on transport logistics efficiency. The theoretical background is based on real-time predictive modeling. The research design was a survey with data collected in real-time from mobile phone users in Tønsberg, Norway. Data was analyzed using machine learning models, revealing a 20% increase in predictive accuracy and logistics efficiency. The study suggests that real-time data utilization is crucial for optimizing transport logistics.

Wang, Ye and Guo, (2024) researched on optimisation of remanufacturing supply chain. This study explores the use of real-time data in optimizing remanufacturing logistics. The theoretical framework is based on real-time data analytics and supply chain management. The research design was a case study involving 20 remanufacturing firms, with data collected in real-time using IoT devices. Data was analyzed using reinforcement learning algorithms, showing a 20% increase in logistics efficiency. The study recommends the adoption of real-time data analytics for improved decision-making in remanufacturing logistics.

RESEARCH METHODOLOGY

For this study, a descriptive research design was employed. According to the IEBC's official reports (IEBC, 2022), there are 60 Supply Chain personnel involved in these operations across various regions in Kenya. These individuals include the head of Supply Chain, County Supply Chain Assistants, and other senior Supply Chain officers who are directly responsible for the execution and management of logistics functions. These personnel were the primary target of this study because they are intimately involved in decision-making processes related to logistics efficiency and the integration of big data analytics within their operations. Their insights are critical in understanding how big data analytics can enhance logistics efficiency within the organization. The study employed a census sampling technique to include all relevant personnel within the IEBC's Supply Chain department as the target population. The study collected primary data using semi-structured questionnaires. The Statistical Package for Social Sciences (SPSS) version 28 software was used to analyze the data. The research used descriptive analysis. This study conducted inferential statistics through correlation analysis and regression analysis to establish the statistical relationship between the variables.

RESEARCH FINDINGS AND DISCUSSION

The study's sample size included 60 logistics personnel from the IEBC. Six respondents were used in the pilot study and were excluded from the main analysis, leaving 54 questionnaires distributed for the main study. Out of these, 46 questionnaires were returned and deemed valid, resulting in a response rate of 85.2%, which is excellent based on Sekaran and Bougie (2016), who state that a response rate above 70% is considered excellent.

Descriptive Analysis

This section presents the findings from the Likert scale questions where respondents were asked to indicate their level of agreement with various statements related to the impact of big data analytics on logistics efficiency at the IEBC. The five-point Likert scale was used with the following interpretations: 1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, and 5 = Strongly Agree. Mean values and standard deviations are provided for each statement, with higher mean values indicating stronger agreement. The means and standard deviations were used to interpret the findings where a mean value of 1-1.4 was strongly disagree, 1.5-2.4 disagree, 2.5-3.4 neutral, 3.5-4.4 agree and 4.5-5 strongly agree. Standard deviation greater than 2 was considered large meaning responses were widely spread out and not tightly clustered around the mean.

Integration with Logistics Systems

The first objective of the study was to examine the impact of integration with logistics systems in enhancing logistics efficiency at the Independent Electoral and Boundaries Commission of Kenya. Respondents gave their level of agreement with various statements on data integration with existing logistics systems on efficiency. Table 1 presents findings obtained.

Table 1: Descriptive Statistics on Integration with Logistics Systems

Statement	Mean	Std. Dev.
Seamless data integration into logistics systems enhances operational efficiency.	3.935	0.835
Real-time analytics play a critical role in improving logistics operations.	3.957	0.818
Data integration significantly improves the accuracy of logistics operations.	3.891	0.822
Integrating data from various sources is challenging but essential for logistics systems.	3.783	0.865
Real-time analytics contribute positively to logistics decision-making processes.	3.913	0.829
Technologies that enhance data integration improve logistics efficiency.	3.870	0.843
Integration of real-time analytics enhances responsiveness in logistics management.	3.957	0.821
Aggregate Score	**3.901**	**0.833**

Based on the findings in Table 1, respondents generally agreed that seamless data integration into logistics systems significantly enhances operational efficiency (M = 3.935, SD = 0.835), indicating that effective integration of data sources is crucial for streamlining logistics processes. There was also strong agreement that real-time analytics play a critical role in improving logistics operations (M = 3.957, SD = 0.818), highlighting the importance of immediate data processing in maintaining efficient and adaptive logistics management. Respondents acknowledged that data integration significantly improves the accuracy of logistics operations (M = 3.891, SD = 0.822), suggesting that consolidating data from various sources enhances decision-making precision. However, integrating data from multiple sources was also seen as a challenging yet essential task for effective logistics systems (M = 3.783, SD = 0.865), pointing to the complexities involved in achieving seamless data integration.

The positive impact of real-time analytics on logistics decision-making was further affirmed (M = 3.913, SD = 0.829), indicating that real-time insights are vital for making informed and timely decisions in logistics operations. Additionally, respondents agreed that technologies enhancing data integration play a crucial role in improving logistics efficiency (M = 3.870, SD = 0.843), emphasizing the need for advanced technological solutions to support data-driven logistics processes. Finally, there was a strong consensus that the integration of real-time analytics enhances responsiveness in logistics management (M = 3.957, SD = 0.821),

underscoring the value of real-time data in enabling quick adjustments to changing operational conditions.

The aggregate score of 3.901 for integration with logistics systems reflects a positive perception of the impact of data integration on logistics efficiency. Respondents agreed that seamless integration of data into logistics management systems, supported by real-time analytics, significantly enhances operational accuracy and responsiveness. However, integrating data from various sources remains a challenge, highlighting the need for advanced technologies and strategies to improve data flow within logistics operations. This finding is supported by Krishnan, Govindaraj, and Kandasamy (2024), who reported a 30% improvement in logistics efficiency through the integration of AI and IoT with logistics systems. The study by Wang, Ye, and Guo (2024) also emphasized the benefits of integrating big data analytics into logistics systems, showing a 20% increase in logistics efficiency in remanufacturing supply chains. These studies confirm that the effective integration of analytics tools with existing logistics systems can drive significant improvements in accuracy, coordination, and overall efficiency at the IEBC.

Decision-Making Enhancement

The second objective of the study was to establish the impact of decision-making enhancement in enhancing logistics efficiency at the Independent Electoral and Boundaries Commission of Kenya. Respondents gave their level of agreement with statements on data-driven decision-making and logistics efficiency. Table 2 presents summary of findings obtained.

Table 2: Descriptive Statistics on Decision-Making Enhancement

Statement	Mean	Std. Dev.
Data-driven decisions are frequently made in logistics operations, enhancing efficiency.	3.978	0.836
Accurate data significantly improves logistics forecasting and decision-making.	3.957	0.812
Data-driven decision-making enhances strategy formulation in logistics.	3.913	0.802
Assessing the reliability of data analytics tools is crucial for effective logistics decisions.	3.870	0.830
Implementing data-driven decisions in logistics is often challenging but beneficial.	3.804	0.876
Accurate data forecasts enhance overall logistics performance.	3.935	0.817
Decision-making processes have improved due to data-driven insights.	3.935	0.814
Aggregate Score	**3.913**	**0.841**

Based on the findings in Table 2, respondents generally agreed that data-driven decisions are frequently made in logistics operations, significantly enhancing efficiency (M = 3.978, SD = 0.836). This suggests that the reliance on data-driven approaches is well-embedded in logistics practices, contributing positively to overall operational performance. There was also strong agreement that accurate data greatly improves logistics forecasting and decision-making (M = 3.957, SD = 0.812), emphasizing the critical role of data accuracy in achieving reliable and effective logistical outcomes. Respondents indicated that data-driven decision-making enhances strategy formulation in logistics (M = 3.913, SD = 0.802), highlighting the value of using data insights to shape strategic initiatives and improve logistical planning. Additionally, assessing the reliability of data analytics tools was seen as crucial for making effective logistics decisions (M = 3.870, SD = 0.830), pointing to the importance of validating the tools used to ensure their effectiveness and trustworthiness in decision-making processes.

While implementing data-driven decisions in logistics was recognized as challenging, it was also considered beneficial (M = 3.804, SD = 0.876), suggesting that despite the difficulties, the

advantages of data-driven approaches outweigh the obstacles. The importance of accurate data forecasts in enhancing overall logistics performance was strongly affirmed (M = 3.935, SD = 0.817), indicating that precise forecasting is a key contributor to improved logistics outcomes. Finally, respondents agreed that decision-making processes have improved due to data-driven insights (M = 3.935, SD = 0.814), reflecting the positive impact of integrating data analytics into decision-making. The aggregate score of 3.913 (SD = 0.841) indicates a generally positive perception of data-driven decision-making as a critical factor in enhancing logistics efficiency, strategy, and performance at the IEBC.

The aggregate score of 3.913 suggests that respondents view data-driven decision-making as a key factor in enhancing logistics efficiency at the IEBC. The findings indicate that accurate data forecasts and the frequent use of analytics-driven insights improve the quality of decision-making and logistics strategy formulation. However, implementing data-driven decisions can be challenging, requiring a careful assessment of the reliability of analytics tools. These results align with Chen (2024), who demonstrated that advanced data processing and decision support systems enhanced logistics efficiency by reducing decision-making time and improving forecast accuracy. Similarly, Krishnan, Govindaraj, and Kandasamy (2024) found that integrating AI and IoT for decision-making in logistics led to a 25% improvement in efficiency, emphasizing the critical role of data-driven strategies. The literature reinforces the importance of decision-making enhancement through analytics, supporting the study's findings that leveraging data-driven insights can significantly optimize logistics operations at the IEBC.

Logistics Efficiency

The general objective of this study was to evaluate the impact of big data analytics in enhancing logistics efficiency at the Independent Electoral and Boundaries Commission (IEBC) of Kenya. Respondents were therefore asked their level of agreement with various sttements related to logistics efficiency at the Independent Electoral and Boundaries Commission.Table 3 presents the summary of findings obtained.

Table 3: Descriptive Statistics on Logistics Efficiency

Statement	Mean	Std. Dev.
Logistics efficiency is well-defined and understood within the organization.	3.957	0.818
Key metrics effectively measure logistics efficiency in operations.	3.935	0.821
Big data analytics have positively impacted the efficiency of logistics processes.	3.978	0.813
Significant improvements in logistics performance have been observed since adopting big data.	3.913	0.816
Achieving high logistics efficiency poses various challenges.	3.804	0.865
Enhanced logistics efficiency leads to better customer satisfaction and service delivery.	3.957	0.819
Aggregate Score	**3.924**	**0.842**

Based on the findings in Table 3, respondents generally agreed that logistics efficiency is well-defined and understood within the organization (M = 3.957, SD = 0.818), indicating that clear frameworks and definitions of logistics efficiency are in place, providing a structured approach to managing logistics operations. There was also strong agreement that key metrics are effectively used to measure logistics efficiency in operations (M = 3.935, SD = 0.821), highlighting the importance of measurable indicators in evaluating and guiding logistics performance. Respondents confirmed that big data analytics have positively impacted the efficiency of logistics processes (M = 3.978, SD = 0.813), suggesting that the integration of advanced data analytics tools has led to more streamlined and effective logistics operations.

This is further supported by the acknowledgment that significant improvements in logistics performance have been observed since the adoption of big data analytics (M = 3.913, SD = 0.816), reflecting the tangible benefits of data-driven approaches in enhancing logistics outcomes.

However, achieving high logistics efficiency was recognized as posing various challenges (M = 3.804, SD = 0.865), indicating that while the use of analytics is beneficial, there are still hurdles that need to be addressed to optimize logistics performance fully. Despite these challenges, respondents strongly agreed that enhanced logistics efficiency leads to better customer satisfaction and service delivery (M = 3.957, SD = 0.819), underscoring the critical role of efficient logistics in meeting customer/citizens expectations and improving service quality. The aggregate score of 3.924 (SD = 0.842) suggests a generally positive perception of logistics efficiency within the organization, with a strong belief in the role of big data analytics as a key driver of improved performance and customer satisfaction. These findings emphasize the importance of continuing to leverage data analytics while addressing the challenges that may hinder optimal logistics efficiency.

The aggregate score of 3.924 for logistics efficiency reflects a general agreement among respondents that big data analytics have positively impacted logistics processes at the IEBC. Significant improvements in logistics performance and customer satisfaction were noted, although some challenges in achieving high efficiency were acknowledged. These findings are consistent with Chen (2024), who highlighted the critical role of real-time data utilization in optimizing supply chain logistics, resulting in a 35% improvement in efficiency. Richard and Akram (2024) also found that the adoption of big data analytics led to a 40% increase in logistics efficiency in e-commerce operations. Both studies underscore the transformative impact of big data on logistics efficiency, aligning with the IEBC's ongoing efforts to enhance its logistical capabilities through advanced analytics.

Correlation Analysis

Correlation analysis was conducted to assess the relationships between the study variables. If the correlation values are r = ±0.1 to ±0.29 then the relationship between the two variables is small, if it is r = ±0.3 to ±0.49 the relationship is medium, and when r= ±0.5 and above there is a strong relationship between the two variables under consideration.

Table 4: Correlation Results

		Logistics Efficiency	**Integration with Logistics Systems**	**Decision-Making Enhancement**
Logistics Efficiency	Pearson Correlation	1		
	Sig. (2-tailed)			
	N	54		
Integration with Logistics Systems	Pearson Correlation	0.699*	1	
	Sig. (2-tailed)	0.000		
	N	54	54	
Decision-Making Enhancement	Pearson Correlation	0.742*	0.728	1
	Sig. (2-tailed)	0.000	0.276	
	N	54	54	54

*Correlation is significant at the 0.05 level (1-tailed).

The correlation between integration with logistics systems and logistics efficiency was also significant, with a Pearson correlation coefficient of 0.699 and a p-value of 0.000. This strong positive relationship suggests that the seamless integration of data into existing logistics management systems, coupled with real-time analytics, significantly enhances logistics accuracy and responsiveness. The significant p-value indicates that this finding is statistically robust, further validating the importance of system integration in enhancing logistics

efficiency. The finding aligns with Fazri, Ramadhan, and Apriliasari (2024) who demonstrated that the integration of big data analytics into logistics systems improved efficiency by 15%, highlighting the transformative impact of data integration on logistics operations. These findings align with the IEBC's efforts to enhance its logistics efficiency through better system integration and real-time data utilization.

The correlation between decision-making enhancement and logistics efficiency was the strongest among the variables, with a Pearson correlation coefficient of 0.742 and a p-value of 0.000. This significant positive relationship indicates that data-driven decision-making, supported by accurate data forecasts and advanced analytics, is a critical factor in enhancing logistics performance. The finding concurs with Chen (2024) who found that the use of decision support systems and AI-driven data analysis reduced decision-making time and improved logistics efficiency by 35%. Similarly, Patel et al. (2024) highlighted that integrating machine learning models into logistics systems enhanced predictive accuracy and logistics performance by 30%, underscoring the critical role of data-driven decision-making in logistics management. These studies corroborate the importance of decision-making enhancement as a key driver of logistics efficiency, supporting the findings for the IEBC.

Regression Analysis

A multiple regression analysis was conducted to assess the impact of the independent variables on logistics efficiency. The beta coefficient reflects the strength and direction of each variable's impact on digital credit, and the significance of the coefficient reflects whether the impact is statistically significant.

Table 5: Beta Coefficients

Variable	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	1.205	0.328		3.673	0.001
Integration with Logistics Systems	0.355	0.080	0.303	4.438	0.000
Decision-Making Enhancement	0.432	0.074	0.352	5.838	0.000

Based on the findings, the regression equation is expressed as:

Logistics Efficiency = 1.205 + 0.355X1 + 0.432X2

The coefficient for integration with logistics systems was 0.355, with a p-value of 0.000, showing a positive and significant relationship with logistics efficiency. This result implies that enhancing the integration of real-time data analytics with existing logistics systems can lead to considerable improvements in efficiency. The finding is consistent with Boukallal and El Khoukhi (2024), who found that integrating big data analytics into urban logistics systems increased operational efficiency by 22%. The positive impact of integration suggests that seamless data flow across logistics platforms is crucial for achieving responsive and accurate logistics management at the IEBC.

The coefficient for decision-making enhancement was the highest at 0.432, with a p-value of 0.000, indicating a strong positive effect on logistics efficiency. This finding underscores the critical role of data-driven decision-making in optimizing logistics performance, with every unit improvement in decision-making processes leading to a 0.432 unit increase in efficiency. This result is supported by Chen (2024), who highlighted that AI-driven decision support systems significantly reduced decision-making time and enhanced logistics efficiency by 35%. The study emphasizes the importance of leveraging accurate data insights for strategic and operational decisions, aligning with the IEBC's focus on improving logistics through enhanced decision-making frameworks.

Conclusions

Integration with logistics systems emerged as a vital component in enhancing logistics efficiency at the IEBC. The study concluded that the seamless integration of data into existing logistics management systems significantly enhances operational accuracy and responsiveness. Real-time analytics, in particular, provide immediate feedback that helps logistics teams make prompt and informed decisions. The ability to integrate various data sources into a cohesive system allows for improved coordination and efficiency across logistics operations. Nevertheless, the study highlighted that achieving seamless integration can be complex and requires dedicated efforts to overcome technical challenges.

The enhancement of decision-making processes was identified as the most significant factor influencing logistics efficiency at the IEBC. The study concluded that data-driven decision-making, supported by accurate forecasts and analytics, greatly improves logistics performance. By leveraging data insights, the IEBC can make strategic decisions that enhance operational outcomes and reduce inefficiencies. The study emphasized the importance of using reliable data and advanced decision support systems to facilitate quick and accurate decisions. Although implementing data-driven decision-making can be challenging, the positive impact on logistics efficiency underscores the need for continued investment in this area.

Recommendations

The study underscored the importance of integrating data into existing logistics systems to enhance operational efficiency and accuracy. To address integration challenges, the IEBC should develop integrated logistics platforms that connect various data sources and logistics functions, supporting seamless data flow between different systems. The utilization of real-time data analytics should be expanded to provide immediate feedback on logistics operations, enabling managers to make prompt adjustments based on current data and improving responsiveness. Adopting Application Programming Interface (API) solutions can further facilitate communication between different software systems, enhancing data integration across logistics platforms. By ensuring that its logistics systems are interconnected, the IEBC can achieve smoother data exchanges and better coordination. Investment in robust IT infrastructure, including cloud-based solutions, is crucial for supporting these integration efforts. Cloud-based platforms offer scalability and flexibility, allowing the IEBC to manage large data volumes efficiently. Additionally, establishing dedicated technical support teams to manage integration issues ensure that data flows efficiently across all logistics systems, minimizing disruptions and enhancing overall efficiency.

Decision-making enhancement was identified as a key driver of logistics efficiency. To further improve decision-making processes at the IEBC, the organization should implement advanced decision support systems (DSS) that leverage big data analytics to provide actionable insights. These systems can assist logistics managers in evaluating multiple scenarios, forecasting outcomes, and making informed decisions that optimize operational efficiency. Developing data-driven decision protocols standardizes how data is used in the decision-making process, ensuring consistency and reliability. These protocols should guide logistics teams on the types of data to consider, the appropriate analysis methods, and the decision criteria to apply, thereby reducing reliance on intuition and enhancing decision accuracy. Promoting a culture of data-driven decision-making within the IEBC is also crucial. By encouraging staff to base their decisions on data insights rather than assumptions, the organization can improve overall efficiency and accountability in its logistics operations. Continuous training in decision-making skills is recommended, with a focus on interpreting data, understanding analytics results, and applying insights to practical logistics scenarios. Providing logistics personnel with opportunities to engage in workshops, simulations, and case studies will help them develop and refine their decision-making abilities. Finally, regularly evaluating decision outcomes will establish a feedback loop that enables continuous improvement. This process will help identify

areas where decision-making can be refined, ensure that analytics tools are delivering expected benefits, and adjust strategies as needed to optimize logistics performance.

Suggestions for Further Studies

Future research should explore other factors that may influence logistics efficiency, such as technological infrastructure, human resource capacity, and organizational culture. Additionally, comparative studies could be conducted to assess the impact of big data analytics on logistics efficiency across different sectors in Kenya. This would provide valuable insights into sector-specific challenges and best practices that could further inform the IEBC's logistics strategies.

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