LOGISTICS NETWORK DESIGN AND COST REDUCTION OF STATE INDEPENDENT ELECTORAL COMMISSIONS IN SOUTH-SOUTH NIGERIA

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Abstract

This study explored the impact of logistics network design on cost reduction. The population of the study comprised State independent electoral commissions in South-South Nigeria. The study considers four dimensions of logistics network design (facility location, transportation mode, routing and scheduling, and technology integration) and analyzed their individual and collective impacts on cost reduction. The study was based on data collected from 90 representatives of the six (6) electoral commissions in the South-South Nigeria, using structured questionnaire and in a cross-sectional survey. The findings indicate that dimensions of logistics network design collectively have moderate significant impact on cost reduction. However, individually, they have mixed impacts. While transportation mode and routing and scheduling exert significant impact on cost reduction; facility location and technology integration exert insignificant impact. Therefore, we conclude that with improved logistics network design, state independent electoral commissions in the south-south geopolitical zone can achieve higher operational performance in terms of cost reduction in line with the expectation of election stakeholders.

Keywords: Classical regression model, cost reduction, facility location, routing and scheduling, technology integration transportation mode, logistics network design,

Introduction

Organizations, public and private alike, grapple with high cost of operations, mainly due to demand from different stakeholder groups and an increasingly hostile and complex operating environment. Consequently, leaders and managers implement several strategies that hold the promise to cut costs and also improve operational performance. Salient among these strategies is logistics network design.

Logistics network design determine optimal configuration of facilities, locations, sizes and transportation modes (Surajit, 2012), and connect different stakeholder groups (vendors, manufacturing centres, warehouses, distribution centres and customers) in a supply chain (Cordeau et al., 2021). Ristovska et al. (2017) states that high performance organizations rely on supply chain and logistics management to achieve business success; and that optimal logistics management is essential to improved business efficiency, customer satisfaction, and organizational competitiveness.

Among the several logistics network design factors that have direct implications for cost reduction and organizational performance are facility location, transportation mode, routing and scheduling, and technology integration. According to Kovács and Kot (2017), facility layout planning and design, which involves a methodical physical arrangement of different departments, equipment, workstations and storage areas, can help organizations to minimize cost of handling materials, total distance of material and goods flow, and time spent in the manufacturing system. In the words of

Misiko et al. (2023), facility location decisions help organizations cut costs associated with operations, manufacturing and distributions, thereby drive financial performance and profitability of organizations.

Transportation mode relates to the choice of transportation and carrier to convey inbound and outbound freight (Meixell & Norbis, 2008). This involves identifying appropriate performance evaluation variables, selecting the best mode of transportation, negotiating rates and service levels, and evaluating carrier performance (Meixell & Norbis, 2008; Monczka et al., 2005). The choice of transportation is an important aspect of logistics network design since transportation costs constitute about 50% of total logistics cost (Engebrethsen & Dauzère-Pérès, 2019). The choice of transportation determine the final price of product and delivery performance of goods on arrival, as well as customer satisfaction.

Routing and scheduling involve the allocation of resources to perform series of tasks for optimal operational performance. Route scheduling refers to the process of planning and organizing transportation routes to ensure timely delivery of goods or services. A well-planned route schedule ensure maximum capacity utilization and increased delivery efficiency, thereby reducing overall cost of transportation.

Technology integration is an important factor for cost reduction and operational efficiency. Technology used in logistics management includes automatic identification technology (barcode, radio frequency identification, and voice recognition technology), and information and communication technology (web-based tracking, geographical positioning system, geographical information system, very small aperture terminal, automated inventory tracking system, enterprise resource planning, automated guided vehicle system, and electronic data interchange). Firms apply these technologies to enhance internal and external information flows, increase speed of response to environmental and electronics-based challenges, and provide solutions that enhance efficient logistics and supply chain management.

There are studies on the relationship between logistics network design and operational efficiency. However, most of these studies are private sector focused. Agyabeng-Mensah et al. (2019), Aziz et al. (2020), Bag et al. (2020); James and Inyang (2022) and Mwangangi (2016) focused on logistics network design and operational performance in manufacturing and distribution companies. This underscores the need for more studies, especially in the context of public service providers in developing countries. Thus, this study contributes to the growing literature by probing the impact of logistics network design on cost reduction, focusing on state independent electoral commissions (SIECs) in south-south Nigeria. The study was designed to achieve the following specific objectives:

- 1. To determine the extent of impact of facility location on cost reduction.
- 2. To establish the extent to which of transportation mode impact cost reduction.
- 3. To ascertain the impact of routing and scheduling on cost reduction.
- 4. To uncover the magnitude of impact of technology integration on cost reduction.

The remaining part of the study is structured into four main sections and several subsections. The next section contains the review of both theoretical and empirical literature. We describe the research methodology (research design, data and sample, measurement, and empirical strategy) in section 3. In section 4, we analyze the research data using both descriptive and inferential methods, while the study is concluded in section 5.

Literature Review

Theoretical Foundation

This study on logistic network design and cost reduction was founded on resource-based theory (Barney, 1991). Resource-based theory provides a framework for analyzing, explaining, and predicting organizational performance and competitiveness by linking organizational performance to organizational resources and capabilities.

Resource-based theory suggests that organizations can be analyzed from the perspective of their internal features and strategic resources; and that differences in these resources explain differences in their performance or competitiveness. In other words, resource heterogeneity is a significant determinant of organizational performance (Barney, 1991).

In the context of this study, the resource-based model implies that operational efficiency of state independent electoral commissions can be linked to logistics network resources and capabilities such as facility location, transportation mode, routing and scheduling, and technology integration. Therefore, sufficient investment in these resources can lead to reductions in cost of operations, we would be desired by different stakeholder groups.

Logistics Network Design

According to the International Trade Council (2022), logistics network design involves the complex process of strategically planning and determining the locations of warehouses, suppliers, and production facilities, with the aim of minimizing costs. Surajit (2012) it as determining the optimal configuration of facilities, locations, sizes, allocations and transportation modes. Logistics network consists vendors, manufacturing centres, warehouses, distribution centres and customers.

The best design must be able to deliver goods to customers at the least cost while satisfying customer's needs (Babu, 2023). Being an ongoing process, logistics network design locating new facilities like distribution centres, warehouses and production sites (Anastasiya, 2023), determining channel flows, and managing costs with a view to foster operational performance, by prudent resource utilization, timely delivery and cost reduction.

Having an optimal logistics network design is essential to logistics reliability, efficiency, and preparedness for supply and demand uncertainties. The objective of logistics management on a broader level, is to provide the right product in the right quality at the right time in the right place at the right price with the information to the ultimate consumer (Ristovska et al., 2017). Effective logistics operations and capabilities are the foundation for organizational success (Khan, 2020; Pham et al., 2020).

Key considerations in logistics network design includes facility location, transportation mode routing and scheduling and technology integration. These are adopted as dimensions of logistics network design.

Facility location

Facility location decisions are aimed at selecting the best possible location that optimizes a firm's distribution operations (Nwulu & Nadube, 2022). There are four components that describe location problems: customers, who are assumed to be already located at points or on routes, facilities that will be located, a space in which customers and facilities are located, and a metric (standard) that indicates distances or time between customers and facilities (Reza & Masoud, 2009).

Facility location describes sites of manufacturing plant, storage facility or distribution centre that provide sufficient access to customers, workers, third-parties and other stakeholders in a business (Management study guide, 2014). The primary objective of facility location decisions is to minimize costs, maximize efficiency, and enhance customer satisfaction (Drezner & Wesolowsky, 2017).

Facility location is a critical decision area that significantly impacts operational performance of organizations and in this context, we are looking at state electoral commissions which are saddled with responsibility of ensuring that facilities in which electoral materials are kept are close to the electorates, for easy distribution to various polling units across the state, now in taking this decisions the commission should be able to identify how many local governments, polling units and central point in which these materials can be safe and easily distributed afterwards.

Transportation mode

Transportation involves the movement of people, goods and services from point of origin to destination (Tsao & Lu 2012, as cited in Nwulu & Nadube, 2022). Transportation centrally affects the relationship between physical space and society, and changes in transportation affect the organization of human activity. It structures the built environment, spurs growth, as well as facilitates business performance (Ramezani et al., 2014).

Mode of transport is a term used to distinguish between different ways of transporting people and products. There are several modes of human and material transportation. However, supply chain network decisions cut across four major areas which are road, maritime, air transportation and pipeline transportation (Ramezani et al., 2014; Tsao & Lu, 2012) and since each has a fundamentally different technological solution and require a separate environment, selection of transportation mode is crucial to logistics network decisions (Cecilia, 2010).

Routing and Scheduling

In today's fast-paced world, efficient logistics management is crucial for businesses looking to stay competitive in the market. One key aspect of this is route optimization, a process that maximizes the efficiency of transportation routes to minimize costs and delivery times (Vansh, 2024). Modern transport organizations which run on low operating margins and are governed by extreme market pressures must, as a normal part of business, drive costs down utilizing a range of processes and technologies (Archetti & Speranza 2012, as cited in Nwulu & Nadube, 2022).

Presently, the desire to reduce transportation cost among organizations has necessitated the need for efficiency and effectiveness in transportation. Routing represents the entire process of planning delivery routes for vehicles in a fleet (Elogii, 2021). The goal is to create cost-effective route by minimizing distance and travel time necessary to reach a set of planned stops.

Delivery routing, route planning, and route optimization are critical processes for creating reliable and cost-effective routes (elogii, 2021). A great schedule guarantees that every step in a logistics process is moving at just the right speed to get a job done on time. Balance is key because it results in both less overhead and fewer stockouts. Good logistics scheduling ensures that you're planning which results in on-time delivery, happy customers, and of course better last-mile delivery logistics.

There is a key difference between scheduling and routing. Scheduling can be defined as the method to plan time intervals for delivery executives to make assigned deliveries. Routing refers to

mapping routes for delivery agents or field executives to ensure the deliveries mentioned above happen on time. The idea is to use roads that are either the shortest or the fastest (Ashutosh, 2022).

Technology integration

Business performance is linked with integration of technologies and innovations, which are introduced with changing market needs (Qian, 2019). Products are sold and purchased using technological advancements, but ultimate operational performance involve effective technology integration (Persdotter et al., 2019).

Technology integration play crucial role in operational performance (Zhu & Kouhizadeh, 2019). Technology in elections enhance openness, efficiency, and public participation, but it also increases security threats and technical incompetence that could lead to misinformation (Ariyo, 2023). Some technologies that have been used in the conduct of elections towards achieving a seamless process are; SCR (smart card readers), CSRVS (Collation Support and Results Verification System), IREV (INEC result viewing), Bimodal Voter Accreditation System (BVAS) etc.

Cost reduction

The success of any organization largely depends on how they manage cost. Cost management provides competitive advantage which is essential in this hyper competitive market or business world. Cost reduction is a planned positive approach to reduce expenditure. Cost reduction is a corrective process of analyzing costs for to determine areas requiring reappraisal.

The concept of cost reduction is to be understood as the achievement of real and permanent reduction in the unit cost of goods manufactured or services rendered without impairing their suitability for the use intended or diminution in the quality of the product (Cooper et al., 2013). Cost reduction according to Solomon et al. (2014), implies reducing cost associated with production or other cost activities without affecting the quality of product or service as well as activities. Through cost reduction procedures or techniques help managers to reduce cost leading to operational performance.

Logistics Network Design and Cost Reduction

Somuyiwa (2014) investigated the food, beverages and tobacco industry in Nigeria from 2006 to 2010 with the aim of determining the impact of vehicle routing and scheduling costs on distribution performance using the multiple regression framework. Based on data collected from 45 selected firms, it is established that vehicle routing and scheduling cost are significant explanatory factors for distribution performance.

Mwangangi (2016) adopted OLS regression framework to explore the relative impacts of logistics management dimensions on firm performance, focusing on market share, customer satisfaction, and firm profit. Based on data collected primarily from 320 manufacturing firms in Kenya, the study reports inventory management, transport management, order processing management, and information flow management exert significant positive effect on firm performance; and that logistics information system play positive significant moderating role in the relationship between logistics management and firm performance.

In Macedonia, Ristovska et al. (2017) examined the extent to which logistics management activities influence organizational performance through cost reduction. For a sample of 80 respondents selected from different companies, they found that logistics management activities (such as inventory, information management, storage, transportation, and warehousing) are leading explanatory factors for cost reduction.

Aziz et al. (2020) study the influence of two aspects of logistics management (logistics capability and logistics outsourcing) on firm performance in Pakistan using structural equation modeling. The study focused on 113 manufacturing companies in Karachi and collected from 500 respondents through a structured questionnaire. Their empirical analysis shows that while logistics capability is a significant and positive determinant of firm performance, the influence of logistics outsourcing is not significant.

In a descriptive study, Hussain et al. (2021) investigated the impact of logistics management on firm performance in terms of efficiency and market competitiveness. The study focused on selected German companies, while data collection was based a structured questionnaire instrument. The study concluded that logistics management has positive significant influence on operational efficiency and overall performance.

In Nigeria, James and Inyang (2022) study the impacts of logistics management on marketing performance of SMEs in Calabar metropolis. Based on survey data collected from 216 manufacturing firms through a structured questionnaire, they found that inventory management, process management, transportation management, and warehouse management are significant explanatory factors for marketing performance of SMEs in terms of customer satisfaction, customer retention and sales growth.

Misiko et al. (2023) investigated the extent to which facility location relates to firm performance of state-owned sugar processing firms in Kenya. 720 officers and managers provided data for the study. Using the simple linear regression model, the study found that facility location exerts a positive significant impact on firm performance, measured by production output.

Methodology

To investigate the relationship between logistics network and cost reduction in south-south Nigeria, this study adopted the unidirectional causal design as follows:



Fig. 1: Unidirectional Causal Flow from Logistics Network Dimensions to Cost Reduction

We use cross-sectional data to investigate the impact of logistics network design on cost reduction. Our sample includes 90 respondents selected from the six (6) independent electoral commissions in South-south: namely, AKSIEC, BYSIEC, CROSIEC, DSIEC, ESIEC, and RSIEC. For each

electoral commission, a well-structured questionnaire was administered to 15 respondents purposively selected from the five (5) functional departments related to logistics network: namely, logistics and transport, election planning and monitoring, administration and training, public affairs and civic education, and statistics and research.

All variables are measured in Likert-scale, with five ordered options from 1 = strongly disagree to 5 = strongly agree. The Cronbach Alpha method is used to determine the reliability of the research instrument, and the Alpha coefficients are presented in Table 1.

Tuble It Inplu Renubling Coefficients							
S/n	Variable	Number of Items	Alpha Value	Remark			
1	Cost Reduction	4	0.89	Reliable			
2	Facility Location	5	0.92	Reliable			
3	Transportation Mode	4	0.82	Reliable			
4	Routing and Scheduling	4	0.80	Reliable			
5	Technology Integration	4	0.92	Reliable			

Table 1: Alpha Reliability Coefficients

The study was based on the following model:

CR = f(FCL, TRM, RTC, TI)

Where:

CR = Cost Reduction

FCL = Facility Location

TRM = Transportation Mode

RTS =Routing and Scheduling

TI = Technology Integration

The classical multiple regression models for the above functional relationships are specified as follows:

 $CR_{i} = \gamma_{0} + \gamma_{1}FCL_{i} + \gamma_{2}TRM_{i} + \gamma_{3}RTS_{i} + \gamma_{4}TI_{i} + \varepsilon_{i}$

Where γ_0 is the intercept term capturing the autonomous value of on-time delivery when all the explanatory factors are set to zero; γ_1 captures the effect of facility location; γ_2 captures the effect of transportation mode; γ_3 captures the effect of routing and scheduling; and γ_4 captures the effect of technology integration. The error term is represented by ε_i . For model evaluation, we assess the performance all explanatory variables both individually and jointly. For each explanatory variable, the evaluation focuses on the sign, size and statistical significance of the corresponding parameter. On the other hand, the joint performance of the model parameters is assessed using the R-square, Adjusted R-square, and the F-statistic.

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Data Analysis and Results

Table 2: Descriptive statistics

Code	Statement Item	\overline{x}	σ		
Dependent Variable					
CR1	Cost-saving strategies have been implemented to enhance the institution's overall	3.74	0.772		
	efficiency				
CR2	Election materials are purchased at competitive market prices and following due	3.55	0.986		
	process.				
CR3	There is minimal waste in the use of material resources.	3.63	1.082		
CR4	Materials are managed and used prudently and in the most efficient way.	3.90	1.073		
Explana	itory Variables				
FCL1	Election facilities are rightly placed across the state before, during, and after	3.97	0.905		
	elections.				
FCL2	All election facilities (storage, transportation etc.) are integrated.	3.82	0.930		
FCL3	Distribution centers are very important and easily accessed during and after	4.29	0.837		
	elections.				
FCL4	Polling units are easily located and accessed by all stakeholders (polling agents,	4.26	0.974		
	voters, security officers, observers) during elections				
FCL5	Election facilities influence election planning and expectation.	4.28	0.819		
TRM1	Movement of personnel and materials during and after elections is efficiently and	3.97	0.809		
	effectively managed.				
TRM2	Both inbound and outbound transportation of election materials are well	4.13	0.853		
	coordinated.				
TRM3	Transportation is well funded	3.87	1.032		
TRM4	Transportation challenges in riverine and remote areas are minimal.	3.02	1.261		
RTS1	Tasks are assigned to individuals based on areas of their training, experience, and	4.29	0.832		
	expertise.				
RTS2	The best transportation routes are always followed when conveying personnel and	4.06	0.859		
	materials to their assigned election places or units.				
RTS3	Only experienced drivers and personnel are used to convey personnel and materials	4.11	1.049		
RTS4	Material deliveries are properly scheduled.	3.98	1.033		
TI1	Election and voting processes and procedures are fully computerized.	2.35	0.993		
TI2	Different computer systems and software are used to manage the entire election	2.49	1.091		
	process.				
TI3	Web-based tracking codes are used to identify and track election materials.	2.37	1.075		
TI4	Internet technology is used to facilitate information sharing and processing	3.40	1.129		

Table 2 provides a summary of distributional features of the data. For the dependent variable (cost reduction) the responses are positive for all the statement items, showing that cost reduction is a typical logistics network problem in election logistics planning and management across the six states in the South-south region. However, for the dimensions of logistics network, there are mixed responses. For facility location, transportation mode, and routing and scheduling, there are positive (favourable) responses for all the statement items, while in the case of technology integration, the responses are unfavourable.

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Table 5. Regression Results (DV: Cost Reduction)						
Variable	Coefficient	P-value				
Panel A: Main Regression Results						
Constant (γ_0)	1.3593	0.0832				
FCL (γ_1)	-0.1663	0.3190				
TRM (γ_2)	0.3785	0.0022				
RTS (γ_3)	0.3757	0.0000				
$TI(\gamma_4)$	0.0310	0.7352				
Panel B: Model Fit Statistics						
R^2	0.4346	_				
\overline{R}^2	0.3956	_				
F-stat.	11.148	0.0000				
Durbin-Watson	2.0337	_				

 Table 3: Regression Results (DV: Cost Reduction)

Table 3 shows the classical multiple regression results for the effects of the dimensions of logistic network dimensions on cost reduction. The model estimation is based on the Newey-West adjusted standard errors which are robust and consistent even when there are significant misspecification errors (such as heteroskedasticity and spatial correlation) in the model. Panel A contains the main regression estimates, while Panel B provides the model fit statistics and simple model diagnostic tests. The model errors are plotted in Fig. 2.



Fig. 2: Error Diagnostic Plot

From Panel B, the overall regression results are highly significant as indicated by the F-statistic (p-value = 0.0097), whose probability is less than 0.01. However, the R-square of 0.4346 indicates that the model moderately fitted, while the adjusted R-square of 0.3956 shows that nearly 40% of the total variation in cost reduction are accounted for by the model. This implies that about 60% of the model variation is explained by both factors not included in the specified model and random error. Hence, for state independent electoral commissions in the South-South region, logistics network design in terms of terms of facility location, transportation mode, routing and scheduling, and technology integration is a moderate contributor to operational performance in terms of cost reduction. However, as Figure 1 shows, the model errors are stationary, showing that the fitted on-time delivery model is well-behaved, and hence the model results are meaningful and reliable.

From Panel A, the model coefficients have both mixed signs and mixed significances. FCL has a negative coefficient, showing that facility location and cost reduction are negatively related. On the other hand, TRM, RTS, and TI have positive coefficients, showing that cost reduction is positively related to transportation mode, and routing and scheduling. Further, as indicated by the p-values, while the individual effects of transportation mode and routing and scheduling are highly statistically significant, the individual effects of facility location, and technology integration are not statistically significant.

Discussion of Findings

Facility Location and Cost Reduction

In theory, facility location has a direct relationship with cost reduction. We find that facility location ($\gamma_1 = -0.1663$, *p*-value = 0.3190) has a negative and insignificant effect on cost reduction. This result, contradicts the resource-based view of the firm, and shows that facility location is not an important determinant of operational performance in terms of cost reduction. However, our finding has revealed the tendency for facility location to increase the cost of operations of state independent electoral commissions. This finding tends to disagree with the position of Misiko et al. (2023). Also, our finding suggests that facility location is a typical logistics problem that limits the capacity of state independent electoral commissions to meet their cost reduction objectives in line with expectations of different stakeholder groups. This finding can be explained by lack of permanent structures and inadequate funding that characterize the operations of state independent electoral commissions in south-south Nigeria.

Transportation Mode and Cost Reduction

We find that transportation mode ($\gamma_2 = 0.3785$, *p*-value = 0.0022) exerts positive effect on cost reduction. Consistent with the resource-based theory, the estimated coefficient is significant, showing that optimal transportation decision enhances efficiency, leading to cost reduction and improved operational performance. This shows that transportation mode is crucial to operational performance in terms of cost reduction. This finding agree with report of James and Inyang (2022) and Ristovska et al. (2017). Further, the current finding shows that state independent electoral commissions effectively use different transportation modes in election logistics management towards achieving cost reduction and high operational performance. This finding can be explained by effective engagement of transportation stakeholders in election logistics management.

Routing and Scheduling and Cost Reduction

We find that routing and scheduling ($\gamma_3 = 0.3757$, *p*-value = 0.0000) exert positive effect on cost reduction. Consistent with the resource-based theory, the estimated coefficient is significant, suggesting that the effect of routing and scheduling on cost reduction is significant. This shows that routing and scheduling can serve as an effective cost-reduction technique for the sampled state independent electoral commissions. This finding align with the report of Ristovska et al. (2017). This finding can be explained by strong stakeholder engagement and community support.

Technology Integration and Cost Reduction

We find that technology integration ($\gamma_4 = 0.0310$, *p*-value = 0.7352), exerts no significant effect on cost reduction. The estimated coefficient is marginal and hence contradicts the resource-based theory. This empirical evidence shows that technology integration is not an important explanatory factor for cost reduction, underscoring the poor integration of modern technology in election logistics network management across the six states in South-south region. This finding contradicts

that of Mwangangi (2016). However, the positive sign of the estimated coefficient reveals the tendency for technology integration to improve cost reduction, thus enhance election logistics performance. This finding can be explained by poor network coverage and inadequate investment in modern technology due to financial constraints.

Conclusion

In this study, we analyzed the relative and collect impacts of different dimensions of logistics network design (facility location, transportation mode, routing and scheduling, and technology integration) on cost reduction focusing on state independent electoral commissions in south-south Nigeria. Based on data collected from representatives of the six (6) electoral commissions in South-south Nigeria, we find that the four dimensions of logistics network design collectively have moderate but significant impact on cost reduction. However, individually, they have mixed impacts. While transportation mode and routing and scheduling exert significant impact on cost reduction, facility location and technology integration exert no significant impact. Therefore, we conclude that with improved logistics network design, state independent electoral commissions in South-south Nigeria can achieve higher operational efficiency in terms of cost reduction in line with the expectation of election stakeholders.

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