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INFLUENCE OF RURAL ROAD NETWORKS ON SUPPLY CHAIN PERFORMANCE IN LAU LOCAL GOVERNMENT AREA

Ebagu Cornelius Odey

Department of Business Administration

Federal University Wukari

ebaguc@fuwukari.edu.ng

Abstract

This study examined the influence of rural road networks on supply chain performance in Lau Local Government Area, Taraba State, Nigeria. Specifically, the study investigated the effects of road infrastructure quality, road connectivity, road accessibility, travel time reliability, road maintenance effectiveness, and transport cost efficiency on supply chain performance. A quantitative approach employing a cross-sectional survey research design was adopted. The study population comprised 180 farmers, agricultural produce marketers, transport operators, agro-input dealers, produce aggregators, and cooperative society executives, from which a sample of 120 respondents was selected using stratified random sampling. Primary data were collected through a structured questionnaire, whose validity and reliability were established through expert review and Cronbach's Alpha coefficient, respectively. Data were analysed using descriptive statistics and Multiple Linear Regression Analysis with SPSS Version 27 at a 5% significance level. The findings revealed that rural road networks significantly influenced supply chain performance ($R = 0.752$; $R^2 = 0.566$; $F = 24.583$; $p < 0.05$). Transport cost efficiency and road maintenance effectiveness had significant positive effects, while road infrastructure quality and travel time reliability had significant negative effects. However, road connectivity and road accessibility had no significant influence. The study concluded that improving rural road maintenance and reducing transport costs are essential for enhancing agricultural supply chain performance in the study area.

Keywords: Rural Road Networks; Supply Chain Performance; Road Infrastructure Quality; Transport Cost Efficiency; Lau Local Government Area.

Introduction

Transportation infrastructure is widely acknowledged as a fundamental driver of economic growth, trade facilitation, and supply chain competitiveness across developed and developing economies. In developed countries, well-developed road networks support efficient logistics operations by reducing transportation costs, improving delivery reliability, enhancing market accessibility, and strengthening supply chain resilience. These benefits have enabled agricultural and manufacturing sectors to achieve greater operational efficiency and competitiveness through seamless movement of goods across production and distribution networks (World Bank, 2024). Consequently, continuous investment in road infrastructure remains a strategic priority for sustaining economic development and efficient supply chain systems.

The importance of rural road networks is particularly evident in agricultural supply chains, where the movement of farm inputs, harvested products, and processed commodities depends predominantly on road transportation. Efficient rural roads facilitate timely deliveries, reduce travel time, minimize post-harvest losses, and improve market access for farmers and agribusinesses. Conversely, poor road conditions increase transportation costs, delay deliveries, constrain market integration, and reduce overall supply chain performance (World Bank, 2024). Thus, the quality and functionality of rural road infrastructure significantly influence logistics efficiency and agricultural productivity.

In Sub-Saharan Africa, agriculture remains the backbone of many national economies, yet inadequate rural transport infrastructure continues to hinder agricultural

supply chains. Poor road conditions, limited connectivity, seasonal inaccessibility, and inadequate maintenance increase logistics costs and restrict access to markets. Mikou et al. (2019) observed that improved rural accessibility enhances market participation and economic inclusion, while Nakamura, Bundervoet, and Nuru (2021) found that investments in rural roads improve agricultural commercialization, household welfare, and resilience by reducing transportation constraints. Despite these gains, infrastructure deficiencies remain widespread across the region, limiting the efficiency and competitiveness of agricultural value chains.

Nigeria possesses considerable agricultural resources, but the performance of its agricultural supply chains is constrained by inadequate rural road infrastructure. Although investments have been made in transport development, many rural feeder roads remain poorly maintained and become impassable during the rainy season, resulting in prolonged travel times, high vehicle operating costs, reduced market accessibility, and increased post-harvest losses. The World Bank (2024) reported that improvements under the Nigeria Rural Access and Mobility Project enhanced rural connectivity, reduced transportation costs, and improved farmers' access to markets. However, rural infrastructure challenges remain particularly evident in many agricultural communities, including those in Taraba State.

Lau Local Government Area is an important agricultural zone in Taraba State, where farming is a major source of livelihood. The movement of agricultural inputs and produce depends largely on rural road networks linking farms with markets, storage facilities, and processing centres. This study conceptualizes rural road networks through six dimensions: road infrastructure quality, road connectivity, road accessibility, travel time reliability, road maintenance effectiveness, and transport cost efficiency. These dimensions are expected to influence supply chain performance through improved delivery reliability, logistics efficiency, market responsiveness, inventory movement, and customer satisfaction. Although previous studies have examined road infrastructure in relation to agricultural productivity and rural development, limited empirical evidence has investigated the combined influence of these six dimensions on supply chain performance in rural agricultural settings in Nigeria. This study therefore seeks to fill this gap by examining the influence of rural road networks on supply chain performance in Lau Local Government Area, Taraba State, Nigeria.

Statement of the Problem

Efficient rural road networks are essential for agricultural supply chains because they facilitate the timely movement of farm inputs to producers and agricultural products to markets. However, many rural roads in Lau Local Government Area, Taraba State, Nigeria are characterized by poor road conditions, inadequate maintenance, weak connectivity, seasonal inaccessibility, unreliable travel times, and high transportation costs. These challenges increase logistics costs, delay product deliveries, contribute to post-harvest losses, limit market access, and reduce the overall performance of agricultural supply chains. Consequently, farmers, transporters, and traders experience lower productivity, reduced profitability, and constrained participation in regional markets despite government investments in rural road infrastructure.

From a theoretical perspective, studies based on Accessibility Theory, the Resource-Based View, and Transaction Cost Economics acknowledge the importance of transport infrastructure in enhancing organizational performance. However, they provide limited explanation of how specific dimensions of rural road networks jointly influence supply chain performance in rural agricultural settings.

Empirically, previous studies have largely focused on the relationship between road infrastructure and agricultural productivity, market accessibility, or rural development, with limited attention to supply chain performance. In addition, findings remain inconsistent across different geographical contexts, while evidence from rural communities in northeastern Nigeria is scarce. Few studies have simultaneously examined road infrastructure quality, road connectivity, road accessibility, travel time reliability, road maintenance effectiveness, and transport cost efficiency as predictors of supply chain performance using multiple regression analysis. This study addresses these gaps by examining the influence of these dimensions on supply chain performance in Lau Local Government Area, Taraba State, Nigeria.

Research Objectives

1. To examine the influence of road infrastructure quality on supply chain performance in Lau Local Government Area, Taraba State.
2. To determine the influence of road connectivity on supply chain performance in Lau Local Government Area, Taraba State.

3. To assess the influence of road accessibility on supply chain performance in Lau Local Government Area, Taraba State.
4. To investigate the influence of travel time reliability on supply chain performance in Lau Local Government Area, Taraba State.
5. To examine the influence of road maintenance effectiveness on supply chain performance in Lau Local Government Area, Taraba State.
6. To determine the influence of transport cost efficiency on supply chain performance in Lau Local Government Area, Taraba State.

Research Hypotheses

Null Hypotheses

H_{01}: Road infrastructure quality has no significant influence on supply chain performance in Lau Local Government Area, Taraba State.

H_{02}: Road connectivity has no significant influence on supply chain performance in Lau Local Government Area, Taraba State.

H_{03}: Road accessibility has no significant influence on supply chain performance in Lau Local Government Area, Taraba State.

H_{04}: Travel time reliability has no significant influence on supply chain performance in Lau Local Government Area, Taraba State.

H_{05}: Road maintenance effectiveness has no significant influence on supply chain performance in Lau Local Government Area, Taraba State.

H_{06}: Transport cost efficiency has no significant influence on supply chain performance in Lau Local Government Area, Taraba State.

LITERATURE REVIEW

Conceptual Framework

Rural Road Networks

Rural road networks refer to the interconnected system of roads that provide access between rural settlements, agricultural production areas, markets, processing centres, and essential social services. They constitute a critical component of transport infrastructure because they facilitate the movement of agricultural inputs, farm produce, labour, and information, thereby promoting rural development and economic integration. Mikou, Rozenberg, Koks, Fox, and Peralta Quiros (2019) defined rural road networks as all-season transport links that improve rural accessibility by connecting populations to economic opportunities and public services. Similarly, the World Bank (2024) argued that efficient rural road networks enhance agricultural commercialization, reduce transportation costs, and strengthen supply chain resilience through improved market connectivity. In contrast, Nakamura, Bundervoet, and Nuru (2021) emphasized that the benefits of rural roads extend beyond accessibility, demonstrating that improved road networks increase household welfare, stimulate agricultural productivity, and enhance resilience to economic shocks. While these studies consistently acknowledge the developmental role of rural roads, they differ in emphasis, with some focusing on accessibility and others highlighting broader socioeconomic outcomes. Collectively, the literature suggests that well-developed rural road networks enhance logistics efficiency, market responsiveness, and supply chain performance. This conceptualization is particularly relevant to the present study, which examines how rural road networks influence supply chain performance in Lau Local Government Area, Taraba State, Nigeria.

Road Infrastructure Quality

Road infrastructure quality refers to the physical condition, structural adequacy, and operational efficiency of road facilities that support the safe and reliable movement of people and goods. It encompasses characteristics such as pavement condition, road width, drainage systems, bridge integrity, signage, and overall road durability. High-quality road infrastructure reduces vehicle operating costs, shortens travel time, improves road safety, and enhances the efficiency of logistics and supply chain operations. Mikou, Rozenberg, Koks, Fox, and Peralta Quiros (2019) argued that improvements in road infrastructure quality significantly enhance rural accessibility by connecting agricultural communities to markets and essential services. Similarly, Nakamura, Bundervoet, and Nuru (2020) found that investments in quality rural roads improved agricultural commercialization, household welfare, and resilience by reducing transport constraints in Ethiopia. At a broader level, the World Bank (2024) maintained that resilient road infrastructure strengthens supply chain performance by facilitating efficient freight movement, reducing transport disruptions, and improving market integration. Although these studies consistently demonstrate the economic value of quality road infrastructure, they differ in emphasis, with Mikou et al. (2019) focusing on accessibility, Nakamura et al. (2020) highlighting socioeconomic outcomes, and the World Bank (2024)

emphasizing logistics resilience. These perspectives collectively suggest that road infrastructure quality is a fundamental determinant of supply chain performance. Therefore, this study examines how road infrastructure quality influences supply chain performance in Lau Local Government Area, Taraba State, Nigeria.

Road Connectivity

Road connectivity refers to the extent to which road networks provide continuous, direct, and efficient links between production areas, markets, processing centres, storage facilities, and other economic destinations. It reflects the degree to which roads facilitate uninterrupted movement within and across regions, thereby reducing travel barriers and enhancing logistics efficiency. Effective road connectivity enables agricultural producers and supply chain actors to transport inputs and outputs efficiently, improve market access, and strengthen value chain integration. Mikou, Rozenberg, Koks, Fox, and Peralta Quiros (2019) argued that improved road connectivity enhances rural accessibility by linking isolated communities to markets, schools, healthcare facilities, and economic opportunities. Similarly, Nakamura, Bundervoet, and Nuru (2020) found that enhanced rural road connectivity increased agricultural commercialization, reduced transport constraints, and improved household welfare in Ethiopia. From a logistics perspective, the World Bank (2024) maintained that well-connected road networks improve freight mobility, reduce transport disruptions, and strengthen supply chain resilience by facilitating timely movement of goods across production and distribution channels. Although these studies consistently recognize the importance of road connectivity, they differ in emphasis, with Mikou et al. (2019) focusing on accessibility, Nakamura et al. (2020) highlighting socioeconomic impacts, and the World Bank (2024) emphasizing logistics performance. Collectively, the literature indicates that road connectivity is a critical determinant of supply chain performance. Accordingly, this study examines how road connectivity influences supply chain performance in Lau Local Government Area, Taraba State, Nigeria.

Road Accessibility

Road accessibility refers to the ease with which people, goods, and services can reach desired destinations through an effective road transport network. It reflects the ability of road infrastructure to provide reliable, safe, and year-round access to farms, markets, processing centres, storage facilities, and social services. High road accessibility reduces travel time and transport costs while improving the movement of agricultural inputs and outputs, thereby enhancing supply chain efficiency. Mikou, Rozenberg, Koks, Fox, and Peralta Quiros (2019) argued that improved rural road accessibility promotes economic inclusion by connecting remote communities with markets and essential public services. Likewise, Nakamura, Bundervoet, and Nuru (2020) found that increased accessibility through improved rural roads enhanced agricultural commercialization, strengthened household resilience, and reduced poverty by facilitating market participation. Similarly, the World Bank (2024) emphasized that accessible road networks improve logistics efficiency, reduce delivery delays, and enhance the resilience of agricultural supply chains. While Mikou et al. (2019) primarily emphasized accessibility as a measure of rural connectivity, Nakamura et al. (2020) highlighted its contribution to socioeconomic development, whereas the World Bank (2024) focused on its logistics and supply chain implications. These complementary perspectives demonstrate that road accessibility is a fundamental determinant of efficient supply chain performance. Therefore, this study investigates the influence of road accessibility on supply chain performance in Lau Local Government Area, Taraba State, Nigeria.

Travel Time Reliability

Travel time reliability refers to the consistency and predictability of the time required to travel between origin and destination under normal operating conditions. Unlike travel time itself, which measures the duration of a trip, travel time reliability reflects the extent to which actual travel times correspond with expected travel times. Reliable travel times enable transport operators, suppliers, and customers to plan logistics activities efficiently, improve delivery schedules, reduce inventory costs, and enhance customer satisfaction. Chen, Shao, and Machemehl (2020) argued that travel time reliability is a key indicator of transport network performance because it minimizes uncertainty in freight movement and improves operational efficiency. Similarly, The World Bank (2024) emphasized that reliable transport systems enhance supply chain resilience by reducing delays, facilitating timely deliveries, and strengthening market connectivity. In addition, Mikou, Rozenberg, Koks, Fox, and Peralta Quiros (2019) maintained that dependable travel times improve accessibility to markets and essential services, particularly in rural areas where transport disruptions are common. Although these studies consistently recognize the importance of travel time reliability, they differ in emphasis, with Chen et al. (2020) focusing on logistics efficiency, Mikou et al. (2019) emphasizing rural accessibility, and the World Bank (2024) highlighting

supply chain resilience. Collectively, the literature suggests that reliable travel times are essential for improving supply chain performance. Consequently, this study examines the influence of travel time reliability on supply chain performance in Lau Local Government Area, Taraba State, Nigeria.

Road Maintenance Effectiveness

Road maintenance effectiveness refers to the extent to which routine, periodic, and emergency maintenance activities preserve the functional condition, safety, and serviceability of road infrastructure over time. Effective maintenance minimizes road deterioration, extends pavement life, and ensures uninterrupted mobility for passengers and freight. In agricultural supply chains, well-maintained roads reduce vehicle operating costs, improve travel time reliability, lower post-harvest losses, and facilitate timely delivery of farm inputs and produce. Mikou, Rozenberg, Koks, Fox, and Peralta Quiros (2019) argued that sustained investment in road maintenance improves rural accessibility and enhances connectivity between farming communities and markets. Similarly, Nakamura, Bundervoet, and Nuru (2020) found that maintaining rural roads contributes to increased agricultural commercialization and household welfare by reducing transport constraints and improving year-round market access. From a broader infrastructure perspective, the World Bank (2024) emphasized that effective road maintenance strengthens transport resilience, reduces disruptions caused by deteriorating infrastructure, and improves logistics performance. While Mikou et al. (2019) primarily focused on accessibility outcomes, Nakamura et al. (2020) highlighted socioeconomic benefits, whereas the World Bank (2024) underscored operational efficiency and supply chain resilience. Collectively, these perspectives indicate that effective road maintenance is fundamental to sustainable transport systems and efficient supply chains. Therefore, this study examines the influence of road maintenance effectiveness on supply chain performance in Lau Local Government Area, Taraba State, Nigeria.

Transport Cost Efficiency

Transport cost efficiency refers to the ability of a transport system to move goods and services at the lowest possible cost while maintaining the required level of service quality, reliability, and timeliness. It reflects the optimization of transport resources by minimizing vehicle operating costs, fuel consumption, maintenance expenses, handling costs, and transit delays. In agricultural supply chains, transport cost efficiency is critical because it directly influences product pricing, market competitiveness, profitability, and customer satisfaction. Nakamura, Bundervoet, and Nuru (2020) found that improvements in rural road infrastructure significantly reduced transportation costs, enhanced agricultural commercialization, and increased household welfare by improving access to markets. Similarly, Mikou, Rozenberg, Koks, Fox, and Peralta Quiros (2019) argued that investments in rural road infrastructure reduce travel costs and improve accessibility, thereby promoting economic inclusion and market participation. The World Bank (2024) further emphasized that efficient transport systems lower logistics costs, strengthen supply chain resilience, and facilitate the timely movement of goods across production and distribution networks. Although these studies consistently acknowledge the importance of transport cost efficiency, they differ in emphasis, with Nakamura et al. (2020) focusing on rural livelihoods, Mikou et al. (2019) emphasizing accessibility, and the World Bank (2024) highlighting logistics performance. Collectively, the literature suggests that transport cost efficiency is a vital determinant of supply chain performance. Accordingly, this study examines the influence of transport cost efficiency on supply chain performance in Lau Local Government Area, Taraba State, Nigeria.

Supply Chain Performance

Supply chain performance refers to the ability of a supply chain to efficiently and effectively coordinate the flow of materials, information, and financial resources from suppliers to final customers while achieving organizational and customer objectives. It is commonly assessed using indicators such as delivery reliability, order fulfilment, logistics efficiency, inventory management, responsiveness, cost efficiency, flexibility, and customer satisfaction. Ivanov and Dolgui (2020) argued that supply chain performance reflects the capability of supply chains to maintain operational efficiency and resilience despite disruptions through effective coordination and resource utilization. Similarly, Kamble, Gunasekaran, and Gawankar (2020) maintained that superior supply chain performance depends on the integration of logistics processes, information sharing, and infrastructure that enhances responsiveness and operational efficiency. From a development perspective, the World Bank (2023) emphasized that efficient transport and logistics systems improve supply chain performance by reducing transit delays, lowering logistics costs, and strengthening market connectivity. Although these studies consistently recognize supply chain performance as a multidimensional construct, Ivanov and Dolgui (2020) emphasized resilience,

Kamble et al. (2020) focused on integration and operational efficiency, whereas the World Bank (2023) highlighted transport infrastructure and logistics competitiveness. Collectively, the literature indicates that efficient supply chain performance depends on reliable transport systems and coordinated logistics activities. Therefore, this study examines how rural road network dimensions influence supply chain performance in Lau Local Government Area, Taraba State, Nigeria.

Theoretical Framework

This study is anchored on the Accessibility Theory propounded by Walter G. Hansen (1959). The theory explains that accessibility is determined by the ease with which people, goods, and services can reach desired destinations through an efficient transport network. Hansen (1959) argued that improved transport infrastructure enhances access to markets, production centres, and social services by reducing travel time, transportation costs, and spatial barriers. Consequently, areas with better accessibility are more likely to experience increased economic activities, efficient logistics operations, and improved organizational performance.

Accessibility Theory is highly relevant to this study because it explains how rural road networks facilitate the movement of agricultural inputs and outputs across the supply chain. The theory suggests that road infrastructure quality, road connectivity, road accessibility, travel time reliability, road maintenance effectiveness, and transport cost efficiency collectively influence the efficiency of logistics operations and the performance of supply chains. Improved road infrastructure enables farmers, transporters, processors, and marketers to move goods more efficiently, reduce delivery delays, minimize post-harvest losses, and improve market responsiveness.

The theory is considered appropriate for this study because it provides a direct explanation of the relationship between the independent variable (rural road networks) and the dependent variable (supply chain performance). In the context of Lau Local Government Area, Taraba State, Nigeria, where agriculture depends heavily on road transportation, Accessibility Theory offers a sound basis for examining how improvements in rural road infrastructure can enhance logistics efficiency, strengthen market integration, and improve overall supply chain performance. Therefore, the theory provides the most suitable framework for explaining the relationship investigated in this study.

Empirical Review

In advanced economies, rural road networks have been shown to stabilize supply chains and reduce volatility. Lambert, Schoeneman, and Brienen (2025) investigated the relationship between road networks and food price volatility in the United States. Using national datasets, they found that rural road infrastructure significantly reduced transportation bottlenecks, thereby stabilizing food supply chains and ensuring timely delivery of agricultural products. Regression modelling and volatility analysis confirmed that improved rural connectivity reduces supply chain disruptions and price fluctuations.

In Bangladesh, Ahmed and Yusuf (2018) employed a difference-in-difference (DiD) approach using household survey data. Their study revealed that rural road improvements increased household income by 15% and reduced poverty by 10%. These results highlight how road networks enhance supply chain performance by reducing delivery times and improving access to urban markets.

In Indonesia, Zulham et al. (2025) examined 228 villages using balanced panel data from 2011 to 2021. Applying the multinomial logit (mlogit) model, they found that 27% of villages shifted their primary income sources due to road improvements, while 17% transitioned into brackish water aquaculture. Their findings illustrate how rural road networks facilitate structural changes in village economies, enabling diversification and strengthening supply chains by connecting producers to new industries.

Within Nigeria, several studies confirm the transformative role of rural roads in supply chain performance. Jamiu, Araoye, and Ademola (2024) analyzed secondary data from 1990 to 2023 using the ARDL model. They reported that a 1% increase in capital expenditure on rural roads resulted in a 0.523% rise in household income, while poverty levels declined significantly. Bounds testing, Granger causality, and variance decomposition validated these findings, underscoring rural roads as a critical driver of supply chain efficiency.

In Bauchi State, Adamu and Kawugana (2025) adopted a mixed-method approach, collecting data from farmers, traders, transport operators, and government officials. Their study confirmed that rural road construction reduced transportation costs, improved access to agricultural inputs, and enhanced market connectivity. Chi-square and regression analysis demonstrated significant relationships between road infrastructure and

agricultural productivity, while thematic analysis emphasized improved welfare and reduced poverty.

Further evidence from Nwafor et al. (2020) showed that improved road networks in Northern Nigeria reduced travel times and increased both income and consumption levels. Similarly, Adeola and Fakorede (2023) reported a 30% decline in poverty rates in Southwestern Nigeria following rural road improvements, though they cautioned that poor maintenance often eroded long-term benefits.

Methodology

This study adopted a quantitative research approach using a cross-sectional survey research design to examine the influence of rural road networks on supply chain performance in Lau Local Government Area of Taraba State, Nigeria. The design was considered appropriate because it facilitates the collection of data at a single point in time and enables the testing of relationships between the independent and dependent variables using inferential statistics.

The study was conducted in Lau Local Government Area, where agriculture is the dominant economic activity and rural roads constitute the principal means of transporting agricultural inputs and outputs. The target population comprised 180 respondents, including farmers, agricultural produce marketers, transport operators, agro-input dealers, produce aggregators, and cooperative society executives. A sample of 120 respondents was selected using a stratified random sampling technique to ensure proportionate representation of all respondent categories.

Primary data were collected through a structured questionnaire designed on a five-point Likert scale, ranging from Strongly Disagree (1) to Strongly Agree (5). The independent variable, rural road networks, was measured using six dimensions: road infrastructure quality, road connectivity, road accessibility, travel time reliability, road maintenance effectiveness, and transport cost efficiency, while the dependent variable was supply chain performance.

A pilot study involving 20 respondents from a neighbouring community with similar characteristics was conducted to assess the clarity and suitability of the questionnaire. The instrument's validity was established through face and content validity by experts in Logistics and Supply Chain Management, Transportation Studies, and Research Methodology. Reliability was determined using Cronbach's Alpha, with coefficients of 0.70 and above indicating acceptable internal consistency.

Data were coded and analysed using SPSS Version 27. Descriptive statistics, including frequencies, percentages, means, and standard deviations, were used to summarize the data, while the hypotheses were tested using Multiple Linear Regression Analysis at a 5% level of significance ($\alpha = 0.05$). The regression model evaluated the influence of the six dimensions of rural road networks on supply chain performance using R^2, Adjusted R^2, ANOVA, standardized beta coefficients (β), t-values, and p-values. Hypotheses were rejected where $p < 0.05$ and retained where $p > 0.05$.

The multiple regression model estimated in this study is specified as:

$$\text{SCP} = \beta_0 + \beta_1\text{RIQ} + \beta_2\text{RC} + \beta_3\text{RA} + \beta_4\text{TTR} + \beta_5\text{RME} + \beta_6\text{TCE} + \varepsilon$$

where:

SCP represents Supply Chain Performance

RIQ denotes Road Infrastructure Quality

RC represents Road Connectivity

RA denotes Road Accessibility

TTR represents Travel Time Reliability

RME denotes Road Maintenance Effectiveness

TCE represents Transport Cost Efficiency

β_0 is the intercept

β_1–β_6 are the regression coefficients of the explanatory variables

ε is the stochastic error term.

Test of Hypotheses

The hypotheses formulated for this study were tested using Multiple Linear Regression Analysis with the aid of the Statistical Package for the Social Sciences (SPSS) Version 27 at a 5% level of significance ($\alpha = 0.05$). Multiple regression analysis was considered appropriate because it enables the simultaneous examination of the influence of the six dimensions of rural road networks such as road infrastructure quality, road connectivity, road accessibility, travel time reliability, road maintenance effectiveness, and transport cost efficiency on supply chain performance. The decision to accept or reject each hypothesis was based on the standardized beta coefficient (β), t-value, and probability (p-value). The null hypothesis was rejected where the p-value was less than 0.05, indicating a statistically significant relationship, and accepted where the p-value was greater than 0.05, indicating no statistically significant relationship between the variables.

Table 1: MODEL SUMMARY INFLUENCE OF RURAL ROAD NETWORKS ON SUPPLY CHAIN PERFORMANCE IN LAU LOCAL GOVERNMENT AREA

					Change Statistics					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	F Change	df1	df2	Sig. F Change	Durbin-Watson
1	.752[a]	.566	.543	.69878	.566	24.583	6	113	.000	1.985

a. Predictors: (Constant), Transport Cost Efficiency, Road Maintenance Effectiveness, Travel Time Reliability, Road Infrastructure Quality, Road Connectivity, Road Accessibility

b. Dependent Variable: Supply Chain Performance

Source: Field work, 2025

Table 1 presents the model summary for the multiple regression analysis examining the influence of rural road networks on supply chain performance in Lau Local Government Area, Taraba State. The multiple correlation coefficient (R = 0.752) indicates a strong positive relationship between the six dimensions of rural road networks and supply chain performance. The coefficient of determination ($R^2 = 0.566$) shows that 56.6% of the variation in supply chain performance is jointly explained by road infrastructure quality, road connectivity, road accessibility, travel time reliability, road maintenance effectiveness, and transport cost efficiency, while the remaining 43.4% is explained by other factors outside the model. The Adjusted R^2 of 0.543 confirms that the model remains robust after adjusting for the number of predictors. The overall regression model is statistically significant ($F = 24.583$; $p = 0.000 < 0.05$), indicating that the independent variables significantly predict supply chain performance. Furthermore, the Durbin–Watson statistic of 1.985 indicates the absence of autocorrelation, confirming the reliability and fitness of the regression model.

Table 2: ANOVA ON INFLUENCE OF RURAL ROAD NETWORKS ON SUPPLY CHAIN PERFORMANCE IN LAU LOCAL GOVERNMENT AREA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	72.022	6	12.004	24.583	.000[b]

	Residual	55.178	113	.488		
	Total	127.200	119			

a. Dependent Variable: Supply Chain Performance

b. Predictors: (Constant), Transport Cost Efficiency, Road Maintenance Effectiveness, Travel Time Reliability, Road Infrastructure Quality, Road Connectivity, Road Accessibility

Source: Field work, 2025

Table 2 presents the Analysis of Variance (ANOVA) results for the multiple regression model examining the influence of rural road networks on supply chain performance in Lau Local Government Area, Taraba State. The results indicate that the regression model is statistically significant, with an F-value of 24.583 and a p-value of 0.000, which is less than the 0.05 level of significance. This implies that the six dimensions of rural road networks such as road infrastructure quality, road connectivity, road accessibility, travel time reliability, road maintenance effectiveness, and transport cost efficiency jointly exert a significant influence on supply chain performance. The regression sum of squares (72.022) is greater than the residual sum of squares (55.178), indicating that the model explains a substantial proportion of the variation in the dependent variable. Consequently, the null hypothesis that rural road networks have no significant influence on supply chain performance is rejected, while the alternative hypothesis is accepted. This confirms that the overall regression model is statistically fit and suitable for predicting supply chain performance.

Table 3: COEFFICIENTS ON INFLUENCE OF RURAL ROAD NETWORKS ON SUPPLY CHAIN PERFORMANCE IN LAU LOCAL GOVERNMENT AREA

		Unstandardized Coefficients		Standardized Coefficients			95.0% Confidence Interval for B		Correlations			Collinearity Statistics	
Model		B	Std. Error	Beta	t	Sig.	Lower Bound	Upper Bound	Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	2.722	.863		3.155	.002	1.013	4.432					
	Road Infrastructure Quality	-1.010	.181	-.488	-5.590	.000	-1.368	-.652	-.215	-.465	-.346	.504	1.986
	Road Connectivity	.086	.146	.042	.590	.556	-.203	.375	.194	.055	.037	.767	1.304
	Road Accessibility	-.200	.198	-.097	-1.011	.314	-.592	.192	.020	-.095	-.063	.420	2.383
	Travel Time Reliability	-.198	.066	-.214	-3.012	.003	-.327	-.068	-.096	-.273	-.187	.758	1.319
	Road Maintenance Effectiveness	.400	.066	.427	6.013	.000	.268	.531	.356	.492	.373	.760	1.316
	Transport Cost Efficiency	1.321	.157	.609	8.441	.000	1.011	1.632	.464	.622	.523	.738	1.355

a. Dependent Variable: Supply Chain Performance

Source: Field work, 2025

Table 3 presents the regression coefficients showing the individual influence of each dimension of rural road networks on supply chain performance in Lau Local Government Area. The results indicate that Road Infrastructure Quality has a significant negative influence on supply chain performance (β = -0.488, t = -5.590, $p < 0.001$), while Travel Time Reliability also has a significant negative effect (β = -0.214, t = -3.012, p = 0.003). In contrast, Road Maintenance Effectiveness (β = 0.427, t = 6.013, $p < 0.001$) and Transport Cost Efficiency (β = 0.609, t = 8.441, $p < 0.001$) exert significant positive influences on supply chain performance, with transport cost efficiency emerging as the strongest predictor. However, Road Connectivity (β = 0.042, p = 0.556) and Road Accessibility (β = -0.097, p = 0.314) do not significantly influence supply chain performance. Furthermore, the tolerance values (0.420–0.767) and VIF values (1.304–2.383) indicate the absence of multicollinearity, confirming the reliability of the regression estimates.

Table 4: COEFFICIENT CORRELATIONS ON INFLUENCE OF RURAL ROAD NETWORKS ON SUPPLY CHAIN PERFORMANCE IN LAU LOCAL GOVERNMENT AREA

Model		Transport Cost Efficiency	Road Maintenance Effectiveness	Travel Time Reliability	Road Infrastructure Quality	Road Connectivity	Road Accessibility
1 Correlations	Transport Cost Efficiency	1.000	.088	.120	-.038	-.192	-.301
	Road Maintenance Effectiveness	.088	1.000	-.169	.137	-.228	-.320
	Travel Time Reliability	.120	-.169	1.000	.338	.177	-.329
	Road Infrastructure Quality	-.038	.137	.338	1.000	-.110	-.597
	Road Connectivity	-.192	-.228	.177	-.110	1.000	-.075
	Road Accessibility	-.301	-.320	-.329	-.597	-.075	1.000
Covariances	Transport Cost Efficiency	.025	.001	.001	-.001	-.004	-.009
	Road Maintenance Effectiveness	.001	.004	-.001	.002	-.002	-.004
	Travel Time Reliability	.001	-.001	.004	.004	.002	-.004
	Road Infrastructure Quality	-.001	.002	.004	.033	-.003	-.021
	Road Connectivity	-.004	-.002	.002	-.003	.021	-.002

	Road Accessibility	-.009	-.004	-.004	-.021	-.002	.039

a. Dependent Variable: Supply Chain Performance

Source: Field work, 2025

Table 4 presents the coefficient correlations among the independent variables included in the regression model. The results indicate generally weak to moderate correlations, suggesting that the predictor variables are sufficiently distinct and do not exhibit serious multicollinearity. The highest positive correlation is observed between Travel Time Reliability and Road Infrastructure Quality (r = 0.338), indicating a modest positive association. Conversely, the strongest negative correlation exists between Road Infrastructure Quality and Road Accessibility (r = -0.597), implying an inverse relationship between these variables. Other correlations, such as between Transport Cost Efficiency and Road Maintenance Effectiveness (r = 0.088) and between Road Connectivity and Road Accessibility (r = -0.075), are relatively weak. The covariance values are also small, indicating minimal shared variance among the predictors. Overall, the coefficient correlation matrix confirms that the independent variables are not highly correlated, supporting the stability of the regression coefficients and reinforcing the reliability of the multiple regression model used to explain supply chain performance in Lau Local Government Area.

Discussion of Findings

The findings of this study revealed that rural road networks significantly influence supply chain performance in Lau Local Government Area, Taraba State, Nigeria. Specifically, transport cost efficiency and road maintenance effectiveness exerted significant positive effects on supply chain performance, whereas road infrastructure quality and travel time reliability had significant negative effects. Conversely, road connectivity and road accessibility did not significantly influence supply chain performance. These findings partly agree with and partly differ from previous empirical studies.

The significant positive effect of transport cost efficiency is consistent with the findings of Adu, Dorasamy, and Keelson (2023), who reported that efficient road transport infrastructure significantly enhanced supply chain performance among beverage manufacturing firms in Ghana through improved logistics operations and road safety compliance. Similarly, Adu, Dorasamy, and Keelson (2024) found that road transport infrastructure positively influenced supply chain asset management in manufacturing firms, emphasizing that efficient transport systems improve operational performance and resource utilization. These findings support the present study by demonstrating that reducing transport costs enhances supply chain efficiency across different sectors and geographical contexts.

The positive influence of road maintenance effectiveness also agrees with the findings of Nakamura, Bundervoet, and Nuru (2020), who established that improved maintenance of rural roads in Ethiopia enhanced year-round market accessibility, reduced transport constraints, and increased agricultural commercialization and household welfare. Likewise, the World Bank (2023) emphasized that maintaining transport infrastructure reduces logistics disruptions, improves delivery reliability, and strengthens supply chain competitiveness. These studies reinforce the present finding that maintaining rural roads is essential for improving agricultural supply chain performance.

However, the significant negative effect of road infrastructure quality differs from most previous studies. Adu et al. (2023) reported a positive relationship between road transport infrastructure and supply chain performance in Ghana, while Mikou, Rozenberg, Koks, Fox, and Peralta Quiros (2019) argued that improved road infrastructure increases accessibility and market integration. The negative coefficient obtained in the present study may reflect the poor condition and inadequate maintenance of rural roads in Lau Local Government Area, where deteriorating infrastructure may increase vehicle operating costs and delay the movement of agricultural produce despite ongoing infrastructure investments. This suggests that infrastructure quality alone may not guarantee improved supply chain performance unless accompanied by effective maintenance and management practices.

Similarly, the finding that travel time reliability negatively influences supply chain performance contrasts with the general position in the transportation literature. Previous studies have consistently shown that predictable travel times improve logistics planning, delivery reliability, and customer satisfaction. The contrary result obtained in this study may be attributed to seasonal road conditions, flooding, and traffic

disruptions commonly experienced in rural communities, which reduce the reliability of transport services and adversely affect supply chain operations.

Furthermore, the insignificant effects of road connectivity and road accessibility differ from the conclusions of Mikou et al. (2019), who found that improved rural connectivity and accessibility significantly enhanced access to markets and economic opportunities. They also contrast with the findings of Nakamura et al. (2020), who demonstrated that improved accessibility contributed to agricultural commercialization and poverty reduction. The disparity may be explained by contextual differences between the study locations, variations in transport infrastructure development, and differences in the characteristics of agricultural supply chains in Lau Local Government Area compared with those examined in previous studies.

Overall, the findings of this study support the broader literature that rural road networks are important determinants of supply chain performance. However, they also demonstrate that the effects of individual road network dimensions vary according to local infrastructure conditions, institutional capacity, and the operational characteristics of rural supply chains. Consequently, the study contributes to the growing body of knowledge by providing empirical evidence from rural Nigeria and highlighting the need for policy interventions that prioritize road maintenance and transport cost reduction alongside infrastructure development.

Contribution to Knowledge

This study contributes to knowledge by providing empirical evidence on the influence of rural road networks on supply chain performance in Lau Local Government Area, Taraba State, Nigeria, a context that has received limited scholarly attention. Unlike previous studies that focused broadly on transport infrastructure, this research decomposes rural road networks into road infrastructure quality, road connectivity, road accessibility, travel time reliability, road maintenance effectiveness, and transport cost efficiency, thereby identifying the individual contribution of each dimension to supply chain performance. The findings enrich the literature by demonstrating that transport cost efficiency and road maintenance effectiveness are the strongest predictors of supply chain performance in rural agricultural settings. The study also provides evidence-based recommendations for policymakers and transport planners on improving rural road infrastructure to enhance logistics efficiency, agricultural market integration, and sustainable supply chain performance in developing economies.

Limitations of the Study

This study was limited to Lau Local Government Area of Taraba State, Nigeria; therefore, the findings may not be readily generalizable to other rural areas with different socioeconomic and transport characteristics. The study relied on cross-sectional survey data, which captured respondents' perceptions at a single point in time and could not establish changes over time or causal relationships. In addition, data were obtained through self-administered questionnaires, making the responses susceptible to respondent bias. Furthermore, the study focused on six dimensions of rural road networks and did not consider other factors, such as government transport policies, funding availability, climatic conditions, and technological innovations, which may also influence supply chain performance. Despite these limitations, the study provides valuable empirical evidence on rural road networks and supply chain performance.

Conclusion

This study examined the influence of rural road networks on supply chain performance in Lau Local Government Area of Taraba State, Nigeria, using six dimensions of rural road networks: road infrastructure quality, road connectivity, road accessibility, travel time reliability, road maintenance effectiveness, and transport cost efficiency. The findings revealed that rural road networks collectively exert a significant influence on supply chain performance. Specifically, transport cost efficiency and road maintenance effectiveness had significant positive effects on supply chain performance, indicating that lower transportation costs and effective maintenance of rural roads enhance logistics efficiency, reduce delays, and improve the movement of agricultural products. Conversely, road infrastructure quality and travel time reliability exhibited significant negative effects, suggesting that the existing condition of rural roads and unreliable travel times continue to constrain supply chain operations in the study area. Furthermore, road connectivity and road accessibility did not significantly influence supply chain performance, implying that the mere existence of road links and physical access may not necessarily translate into improved supply chain outcomes without adequate road quality and maintenance. Overall, the study concludes that improving the effectiveness and sustainability of rural road infrastructure, particularly through regular maintenance and transport cost reduction, is essential for enhancing agricultural supply chain performance and

promoting rural economic development in Lau Local Government Area.

Recommendations

Based on the findings of the study, the following recommendations are made:

1. **Road Infrastructure Quality:** Since road infrastructure quality exerted a significant negative influence on supply chain performance, the Federal, State, and Local Governments should prioritize the rehabilitation, upgrading, and reconstruction of deteriorated rural roads using durable construction standards to improve the movement of agricultural products.
2. **Road Connectivity:** Although road connectivity did not significantly influence supply chain performance, government agencies should expand and integrate rural road networks to ensure better linkage between farming communities, storage facilities, processing centres, and markets, thereby supporting future agricultural and economic development.
3. **Road Accessibility:** As road accessibility was found to have no significant influence, efforts should be directed toward ensuring year-round accessibility through the construction of all-weather roads, bridges, and drainage systems, particularly in remote farming communities that experience seasonal isolation.
4. **Travel Time Reliability:** Given the significant negative influence of travel time reliability, relevant authorities should implement effective traffic management measures, routine road maintenance, and rapid response mechanisms for damaged road sections to reduce travel delays and improve the predictability of agricultural transport.
5. **Road Maintenance Effectiveness:** Since road maintenance effectiveness significantly improved supply chain performance, governments should establish sustainable road maintenance programmes, allocate adequate funding for routine and periodic maintenance, and strengthen community participation in monitoring the condition of rural roads.
6. **Transport Cost Efficiency:** As transport cost efficiency emerged as the strongest positive predictor of supply chain performance, policymakers should introduce measures that reduce transportation costs, including improving road conditions, supporting rural transport services, encouraging private sector investment in agricultural logistics, and providing incentives that lower vehicle operating and freight costs for farmers and transport operators.

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