Analysis of Rail Technological Innovations on Commuters' Comfortability along Lagos-Ibadan Train Corridor

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Abstract- ***Technological advancements in rail operations are setting new standards for user engagement, demonstrating the transformative potential of modern rail systems. This study explores the influence of rail transport advancements on passenger comfortability along the Lagos-Ibadan Train corridor. The study employed survey research design with the use of structured questionnaire over the final quarter of 2024. According to the Nigerian Railway Corporation (NRC) Annual Statistical Report (2024), the total estimated ridership for this period was 2,690,730 commuters, with a daily average of 29,897 commuters using purposive and incidental sampling techniques to select a sample size of 353 respondents. Inferential statistic of multiple regression analysis was applied to analyze the data. Findings from the result of multiple regression analysis on the impact of rail technological innovations on commuters' comfortability showed that five (5) out of seven (7) explanatory variables were statistically significant in explaining the variation of commuters' comfortability. These variables are automated ticketing systems (β = .344, p < .001), advanced climate control systems (β = 10.681, p < .005), advanced safety features (β = .134, p < .000), passenger information display system (β = -.563, p < .000) and ergonomic seating (β = .194, p < .003). The study concludes that rail technological innovations improved commuter's comfortability along the Lagos-Ibadan route. It was recommended that Government should continue investing in technology to enhance comfort and accessibility.***

Indexed Terms- ***Rail, Technological Innovations, Commuters comfortability, Nigerian Railway Corporation (NRC), Lagos-Ibadan route***

I. INTRODUCTION

Urban rail transport is at the forefront of revolutionizing the way people navigate bustling cities. As metropolitan areas expand, rail systems emerge as essential conduits of connectivity and efficiency, fostering sustainable urban development (Nguyen & Smith, 2023). These advancements not only enhance infrastructure but also elevate the commuter experience through improved accessibility and reliability (Hernandez et al., 2022). The essence of commuter satisfaction lies in the quality of service, where factors such as punctuality and comfort create a seamless travel experience (Baker & Lee, 2021). Moreover, technological advancements in rail operations are setting new standards for user engagement, demonstrating the transformative potential of modern rail systems (Taylor, 2024).

Rail transport is a means of transport using wheeled vehicles running in tracks, which usually consist of two parallel steel rails (Oliver, 2019). Rail transport is one of the two primary means of land transport, next to road transport. It is used for about 8% of passenger and freight transport globally, thanks to its energy efficiency and potentially high speed. Rolling stock on rails generally encounters lower frictional resistance than rubber-tyred road vehicles, allowing rail cars to be coupled into longer trains (Rodrigue, 2023). Power is usually provided by diesel or electrical locomotives. While railway transport is capital-intensive and less flexible than road transport, it can carry heavy loads of passengers and cargo with greater energy efficiency and safety (Woodburn, 2019). Precursors of railways driven by human or animal power have existed since antiquity, but modern rail transport began with the invention of the steam locomotive in the United

Kingdom at the beginning of the 19th century (Chester & Horvath, 2019).

Commuter comfort in Nigeria is a critical yet often overlooked aspect of urban life, profoundly influenced by the quality and reliability of transportation infrastructure (Olasupo, 2021). As urban centers expand and populations grow, the demand for efficient and accessible transportation options becomes increasingly imperative (Federal Ministry of Transportation, 2020). Historically, Nigeria's transport networks have struggled to keep pace with rapid urbanization, leading to congestion, long commute times, and frustration among commuters (Oyesiku and Odufuwa, 2002).

Recent efforts to improve transportation infrastructure, including road upgrades and the revitalization of the rail network, aim to alleviate these challenges (Nigeria Railway Corporation, 2021). The introduction of projects like the Lagos-Ibadan railway, part of a broader modernization initiative, offers promise in enhancing the daily commute experience by providing faster, safer, and more reliable travel options (Nigeria Railway Corporation, 2021). Improving commuter comfort in Nigeria requires sustained investment in infrastructure and innovative transport solutions that cater to the evolving needs of urban dwellers (Olasupo, 2021). This study explores the ongoing efforts to enhance commuter comfort through improved transportation networks, contributing to a better quality of life for millions of Nigerians.

A significant milestone in Nigeria revitalization effort is the Lagos-Ibadan railway project, inaugurated in 2021, which represents a flagship initiative in the modernization of Nigeria's rail infrastructure (Nigeria Railway Corporation, 2021). This standard gauge railway aims to provide faster and more reliable transport options between two major economic hubs, significantly impacting commuter experiences by reducing travel times and enhancing safety and comfort (Nigeria Railway Corporation, 2021).

There are significant disparities in the implementation of rail technology innovations across different regions and rail operators. While some systems rapidly adopt and integrate cutting-edge technologies, others lag due to financial constraints, regulatory issues, or infrastructural limitations (Moses, 2022). These disparities can result in unequal levels of comfort for commuters, exacerbating the issue of inconsistent service quality across different rail networks. Commuter expectations evolve with technological advancements. Innovations in other modes of transport and everyday technologies continually raise the bar for what commuters expect from rail services. Understanding whether these rail technology innovations meet or exceed commuter expectations is crucial for rail operators striving to maintain high levels of satisfaction (Oseni & Oseni, 2020). Therefore, this makes it imperative to study the nexus between rail technological innovations and commuter comfortability along Lagos-Ibadan Train Corridor, Nigeria.

II. LITERATURE REVIEW

TECHNOLOGICAL INNOVATIONS IN NIGERIAN RAIL TRANSPORT

Technological innovations in rail transport have proven to be pivotal in enhancing the efficiency, safety, and overall service quality in many regions globally, including Nigeria. In the Nigerian context, where the rail system has historically been plagued by inefficiency and underdevelopment, the recent introduction of modern technologies is seen as a transformative step. These innovations are reshaping Nigeria’s rail transport, improving commuter experiences, and boosting economic productivity by providing more reliable and efficient transport options. Modern Rail Infrastructure and Automation: The modernization of Nigeria's rail infrastructure is one of the most notable technological advancements in the country's rail sector. This includes the development of high-speed rail lines, which drastically reduce travel times between cities, as well as the introduction of automated systems for ticketing and scheduling. Automated ticketing, for instance, has minimized the delays often associated with manual processing, thereby enhancing the commuter experience (Ibrahim & Abubakar, 2020). Similarly, automation in scheduling allows for better coordination between trains, which reduces waiting times and increases overall operational efficiency.

Energy Efficiency and Sustainable Technologies: Sustainability is a growing concern globally, and Nigeria is no exception. The introduction of energy-efficient technologies, such as electric trains and regenerative braking systems, is a key innovation in Nigerian rail transport. These technologies not only reduce fuel consumption but also help to lower carbon emissions, contributing to more sustainable transport options in the country. According to Ogundare and Akinola (2021), the implementation of regenerative braking in modern Nigerian trains has led to significant energy savings and reduced operational costs, benefiting both operators and commuters.

Smart Technologies for Safety and Monitoring: Safety remains a critical issue in Nigerian rail transport. Technological innovations aimed at improving rail safety have included the introduction of smart technologies such as automatic train control (ATC) and real-time monitoring systems. These systems enable better communication between trains and control centers, allowing for rapid response to emergencies and reducing the risk of accidents (Ojo & Adekunle, 2019). Real-time monitoring also enhances the ability to track train locations and manage rail traffic, which minimizes the chances of collisions and ensures that trains run on schedule.

Digital Connectivity and Passenger Information Systems: Another critical innovation is the integration of digital connectivity and passenger information systems. Commuters can now access real-time information about train schedules, delays, and seat availability through mobile applications and digital displays at stations. This has greatly enhanced the customer experience, as passengers are better informed and can make more efficient travel decisions (Ademola & Olatunde, 2022). The digitization of rail services aligns with global trends and contributes to the development of a more integrated and modern transport network in Nigeria.

COMMUTERS' COMFORTABILITY

Comfort is a significant determinant of commuter satisfaction. Comfort involves factors such as seating quality, space availability, cleanliness, and ambient conditions within the train (e.g., temperature, noise levels). The availability of amenities like Wi-Fi, charging ports, and real-time information displays also contributes to a comfortable travel experience (Givoni & Rietveld, 2019). Comfort in rail transport refers to the physical and psychological aspects of the passenger experience. It includes factors such as the quality of seating, the cleanliness of trains and stations, the provision of amenities, and the overall ambiance of the travel environment (Santos et al., 2021).

Physical comfort includes the ergonomics of seating arrangements, climate control, and cleanliness. Seating Arrangements: Comfortable seating is essential for long-distance and daily commutes. Seats should offer adequate space, support, and be maintained in good condition (Hine & Scott, 2008). For example, comfortable seating arrangements on the London Underground were found to significantly enhance commuter satisfaction (Hensher, 2020). Climate Control: Effective climate control systems, including heating, cooling, and ventilation, are critical for maintaining a pleasant environment for passengers (Buehler & Pucher, 2012).

Studies have shown that climate control affects not only comfort but also the overall satisfaction with rail services (Givoni, 2006). Cleanliness of trains and stations is a significant component of comfort. Regular cleaning schedules and visible maintenance efforts contribute to a positive perception of the transport system (Tyrinopoulos & Antoniou, 2008). Clean environments are associated with higher levels of commuter satisfaction and perceived quality of service (Chien et al., 2002).

EMPIRICAL REVIEW

Adamu and Bello (2021) studied the evaluation of technological innovations in Nigeria's Rail Sector employed a mixed-methods approach, including commuter feedback, technical performance data, and stakeholder interviews. The study indicated that while new rail technology has started to improve commuter comfort and convenience, issues like inconsistent service and limited coverage still hinder broader acceptance. The findings underscore the need for sustained investment and policy support to maximize the benefits of technological innovations.

Reddy and Gupta (2017) analyzed metro rail innovations and commuter comfort in India conducted

a mixed-methods study combining commuter surveys, interviews with metro operators, and analysis of technological upgrades in Indian metro systems. The study revealed that recent metro rail innovations in cities like Delhi and Bangalore, including air-conditioned coaches, automated fare collection, and real-time information systems, significantly improved commuter comfort and convenience. However, the benefits were more pronounced in urban areas compared to rural regions.

Santos and Oliveira (2019) examined the role of technological advancements in enhancing rail transport in Brazil used case studies of rail systems in São Paulo and Rio de Janeiro, along with commuter surveys and technical performance evaluations. The study found that technological advancements, such as modern train cars and advanced signaling systems, improved commuter comfort and convenience. However, the impact was limited by persistent issues like overcrowding and inconsistent service reliability.

III. METHODOLOGY

The study area focused on the Lagos-Ibadan train corridor, a critical rail route connecting Lagos, Ogun, and Oyo states in southwestern Nigeria. Key stations included Ebute Metta (Mobolaji Johnson Station), Agege, and Iju in Lagos State; Abeokuta and Kajola in Ogun State; and Moniya (Obafemi Awolowo Station) and Omi-Adio (Samuel Ladoke Akintola Station) in Ibadan, Oyo State. These stations were selected for their socio-economic and infrastructural importance, capturing diverse urban, suburban, and regional commuting patterns. This selection allowed for a detailed analysis of the impact of rail technological innovations on commuter comfortability along the corridor. The study employed survey research design with the use of structured questionnaire over the final quarter of 2024. According to the Nigerian Railway Corporation (NRC) Annual Statistical Report (2024), the total estimated ridership for this period was 2,690,730 commuters, with a daily average of 29,897 commuters using purposive and incidental sampling techniques to select a sample size of 353 respondents. Inferential statistic of multiple regression analysis was applied to analyze the data.

IV. RESULT AND DISCUSSION

Findings from the result of multiple regression analysis provided critical insights into the impact of rail technological innovations on commuter comfort. The Model Summary in Table One (1) revealed that the regression model explains 87.6% ($R^2 = 0.876$) of the variance in commuter comfort, with an adjusted R^2 of 0.873 indicating that the model remains robust even after accounting for its complexity. The low standard error of the estimate (.203) suggests that the model's predictions closely align with actual observations. This indicates that the rail technological innovations evaluated in the study have a substantial influence on commuter comfort along the Lagos-Ibadan rail route. Also, the ANOVA results in Table One (1) further demonstrated the model's statistical significance, with a F-statistic of 347.802 and a $p < 0.000$. This finding confirms that the combined impact of the predictors (Onboard Wi-Fi, advanced climate control systems, passenger information displays, automated ticketing systems, ergonomic seating, safety features, and accessibility features) is significant in explaining commuter comfort. The result validates the hypothesis that rail technological innovations collectively play a crucial role in enhancing passenger satisfaction.

The Coefficients Table Two (2) provided specific details about the contributions of each variable to commuter comfort. First, Passenger Information Display Systems have a significant but negative impact ($\beta = -.563$, $p < .000$), suggesting that their current design or usability may be causing dissatisfaction. This indicates a need for improvements in these systems to ensure they meet commuter expectations and contribute positively to comfort. Automated Ticketing and Boarding Systems show a strong positive impact on comfort ($\beta = .344$, $p < .001$), emphasizing their importance in enhancing convenience and reducing delays. This finding highlights the value of investing in seamless and user-friendly ticketing systems to maintain and increase commuter satisfaction. Similarly, Advanced Safety Features ($\beta = .134$, $p < .000$) positively influence comfort, demonstrating the importance of safety in shaping passenger experiences. This underscores the need to continually innovate and prioritize safety enhancements in rail systems.

The results also revealed that Ergonomic Seating and Modern Cabin Designs have a significant and substantial positive impact on commuter comfort (β = .194, p < .003). This finding confirms that physical comfort plays a critical role in overall satisfaction, necessitating ongoing investments in cabin and seating design. Conversely, Enhanced Accessibility Features (β = -.047, p = .541) have no significant impact on commuter comfort, suggesting that existing accessibility provisions may not fully meet the needs of all passengers. Government and Rail operators should reassess the adequacy and relevance of these features, particularly for passengers with disabilities or mobility challenges. Advanced Climate Control Systems exhibit a modest yet significant positive impact on comfort (β = .107, p = .005). This indicates that features such as temperature regulation and air quality improvements are valued by commuters, highlighting an area for further optimization. Finally, Onboard Wi-Fi and Digital Connectivity Services (β = .007, p = .764) have a non-significant impact on comfort, suggesting that connectivity features may currently fall short of commuter expectations in terms of reliability or coverage.

The analysis underscores the pivotal role of rail technological innovations in enhancing commuter satisfaction. The findings suggest that while automated systems, ergonomic seating, and safety features significantly improve passenger experiences, there are opportunities to address inefficiencies in passenger information systems, enhance accessibility features, and improve onboard digital services. By focusing on these areas, rail operators can further elevate commuter comfort and satisfaction along the Lagos-Ibadan route.

Table 1: Model Summary and ANOVA[a]

Multiple R	.936[a]
R Square (R^2)	.876
Adjusted R Square (R^2)	.873
Standard Error	.203

Analysis of Variance Table

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	100.537	7	14.362	347.802	.000[b]
	Residual	14.247	345	.041		
	Total	114.784	352			

Source: Data Analysis (2024)

Table 2: Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.436	.058		24.729	.000
	Passenger information display systems	-.002	.000	-.563	-7.304	.000
	Automated ticketing and boarding systems	.175	.010	.344	16.833	.001
	Advanced safety features	.066	.011	.134	6.021	.000

The ergonomic seating and modern cabin designs	.116	.013	.194	9.175	.003
Enhanced accessibility features	.000	.000	-.047	-.612	.541
Advanced climate control systems	.038	.013	10.681	2.832	.005
Onboard Wi-Fi and digital connectivity services	.004	.012	.007	.300	.764

a. Dependent Variable: Commuters Comfortability
Source: Data Analysis (2024)

The findings from the multiple regression analysis suggest that various rail technological innovations along the Lagos-Ibadan railway route have a significant impact on commuters' comfort. The model, which includes factors such as onboard Wi-Fi, advanced climate control systems, passenger information displays, automated ticketing, ergonomic seating, advanced safety features, and enhanced accessibility, shows a strong positive relationship with commuter comfort ($R = .936$, $R^2 = .876$, Adjusted $R^2 = .873$). The regression analysis confirms the significant contributions of these innovations to commuter comfort, with a F-value of 347.802 and a $p < .000$, indicating that the model is statistically significant.

Among the predictors, automated ticketing and boarding systems, advanced safety features, ergonomic seating, modern cabin designs, and advanced climate control systems are positively associated with commuters' comfort. For instance, automated ticketing systems ($\beta = .344$, $p < .001$) and advanced climate control systems ($\beta = 10.681$, $p < .005$) have strong positive impact. On the other hand, while passenger information display systems and enhanced accessibility features were included as predictors, their impact were less pronounced. Passenger information systems showed a negative coefficient ($\beta = -.563$, $p < .000$), suggesting that these systems might not significantly improve comfort as expected. These findings align with research emphasizing the importance of technological innovations in enhancing comfort and convenience in public transportation systems (Akinyemi & Obafemi, 2022; Osipova et al., 2021). The results suggest that while some features, such as automated ticketing and ergonomic seating, significantly improve comfort, other features like Wi-Fi and accessibility systems might need further enhancements to yield a greater impact on commuter comfort.

CONCLUSION AND RECOMMENDATION

Based on the findings, the study therefore concludes that, rail technological innovations have a statistically significant impact on commuter's comfortability along Lagos-Ibadan route. However, it was recommendations that; To sustain and improve commuter comfort along the Lagos-Ibadan route, Government should continue investing in and upgrading technological features. Innovations such as advanced climate control systems, automated ticketing, and ergonomic seating should be periodically reviewed and optimized to align with passenger expectations. Additionally, features like passenger information displays and Wi-Fi, which showed room for improvement, should be enhanced to better meet commuter needs. Accessibility for elderly and mobility-challenged passengers should also be prioritized through advanced designs and technology, ensuring inclusivity across all demographics.

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