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Industrial Engineering Department

**OPTIMIZING THE IMPACT OF CHINESE
RAILWAY INVESTMENT ON INDUSTRIAL
DEVELOPMENT: A COMPARATIVE STUDY OF
NIGERIA AND GLOBAL BEST PRACTICES**

Mohammed Auwal ABUBAKAR

Master's Thesis

Supervisor

Asst. Prof. Dr. Yavuz Çağlar CERŞİT

İstanbul, 2024

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XXXXXXXXXX

DEDICATION

Firstly, I would like to thank Almighty Allah for allowing me to write this thesis with health and perseverance. It is indeed incredible to overcome all the challenges and struggles.

Secondly, I would like to express my utmost gratitude to my parents for supporting me with all they can during this journey of mine, may Allah reward them abundantly. Ameen

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ABSTRACT

OPTIMIZING THE IMPACT OF CHINESE RAILWAY INVESTMENT ON INDUSTRIAL DEVELOPMENT: A COMPARATIVE STUDY OF NIGERIA AND GLOBAL BEST PRACTICES

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The impact of Chinese railway investments on industrial development is a subject of considerable interest and debate, particularly in emerging economies like Nigeria. The primary goal of this study is to qualitatively examine the strategic/political, economic, and social effects of Chinese engagement in the development of Nigeria's railways. Relying on open sources ranging from press reports, and scholarly works, to unclassified official records, the study investigates Chinese financing and construction of Nigeria's railway system in the 21st century. The study contributes to the body of research questioning whether the economic cooperation between the PRC and Nigeria is to the detriment of the latter. The findings highlight the importance of good governance and planning in maximizing the benefits of railway investments for industrial growth. It also discussed the importance of collaborating with international bodies to achieve the success of the Nigerian Railway sector, moreover, the study looked into how easily Nigeria can optimize the development of Chinese Investment within its terms and conditions. The research suggests mutual or win-win cooperation between the two countries.

Keywords: Railway Investment, Economic Growth, Chinese Investment, Industrial Development, Transportation Infrastructure.



ÖZET

ÇİN DEMİRYOLUNUN ETKİSİNİN OPTİMİZE EDİLMESİ ENDÜSTRİYEL GELİŞİME YÖNELİK YATIRIM: ANİJERYA VE GLOBAL EN İYİLERİN KARŞILAŞTIRMALI ÇALIŞMASI UYGULAMALAR

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Çin demiryolu yatırımlarının endüstriyel kalkınma üzerindeki etkisi Özellikle Nijerya gibi gelişmekte olan ekonomilerde hatırı sayılır bir ilgi ve tartışma yaşanıyor. Bu çalışmanın temel amacı, stratejik/politik, ekonomik ve Nijerya demiryollarının geliştirilmesinde Çin'in katılımının sosyal etkileri. Güvenen Basın raporlarından ve bilimsel çalışmalardan sınıflandırılmamış resmi kaynaklara kadar uzanan açık kaynaklar Kayıtlara göre çalışma Çin finansmanını ve Nijerya demiryolu inşaatını araştırıyor 21. yüzyıldaki sistem. Çalışma, olup olmadığını sorgulayan araştırmaların bütününe katkıda bulunuyor. ÇHC ile Nijerya arasındaki ekonomik işbirliği ikincisinin zararınadır. Bulgular, verimliliği en üst düzeye çıkarmada iyi yönetim ve planlamanın önemini vurgulamaktadır. Demiryolu yatırımlarının endüstriyel büyümeye faydaları. Ayrıca öneminden de bahsedildi Nijerya Demiryolu sektörünün başarısını sağlamak için uluslararası kuruluşlarla işbirliği yapmak, Dahası, çalışma Nijerya'nın Çin'in gelişimini ne kadar kolay optimize edebileceğini de inceledi. Şartları ve koşulları dahilinde yatırım. Araştırma karşılıklı veya kazan-kazan önerisinde bulunuyor iki ülke arasındaki işbirliği.

Anahtar Kelimeler: Demiryolu Yatırımı, Ekonomik Büyüme, Çin Yatırımı, Sanayi Kalkınma, Ulaştırma Altyapısı.



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ABBREVIATIONS

BRI	:	Belt and Road Initiative
CCECC	:	China Civil Engineering Company
EXIM	:	Export-Import Bank of China
FOCAC	:	Forum on China-Africa Corporation
NBS	:	Nigerian Bureau of Statistics
NRC	:	Nigerian Railway Corporation
PRC	:	People's Republic of China
SOEs	:	State Own Enterprises

1. INTRODUCTION

1.1 OVERVIEW

The attention to increasing infrastructure investment in the transportation network has been drawn from various factors in modulating industrial development patterns in the current global economic views. Nigeria is one of the countries in Africa that needs to address the issues and lack of infrastructural development, in this regard, Chinese railway investment is one of the essential trends driven by its efforts such as the Belt and Road initiative to connect different regions economically. Nigeria is Africa's most populous and largest economy and needs to grow strongly to tackle its railway sector to diversify the economy and get rid of poverty [1]. Moreover, boosting railway investment will help bring more opportunities for trade and industrial growth and solve critical challenges facing the Nation. This thesis will discuss the complications and solutions of Chinese railway investments in Nigeria and best practices from around the world by qualitatively getting some findings from various sources such as journals, reports, scholarly sources, books, and academic databases.

1.2 LITERATURE REVIEW

Nigeria's railway system has a rich historical legacy, dating back to the colonial era, while China boasts one of the world's most extensive and advanced railway networks. Railway infrastructure is crucial for economic development, enabling efficient movement of goods, fostering trade, and stimulating industrial growth. China's primary interest in Nigeria stems from the country's enormous raw mineral deposits, strong market potential, and investment track record in Africa [2]. Nigeria is a major oil producer outside the Middle East; this particularly makes China accord Nigeria special attention in their economic cooperation. China and Nigeria share some common attributes. Both countries happen to be the most populous nations as well as holders of the largest economies in Asia and Africa, respectively [3]. The World Bank revealed in 2021 that China's GDP stood at \$17.7 trillion, while that of Nigeria was at \$440.8 billion [4]. Since the beginning of the 21st century, the PRC has increased commercial activities in Nigeria because CCP leaders identify the country as one of the geostrategic and vital business destinations in Africa with which to engage as a global power. The start of major commercial ties between China and Nigeria dates back to 2001

when the two countries made agreements for Chinese oil companies to operate in Nigeria's oil and gas sector [5].

1.3 THE STUDY PURPOSE

At its core, this research seeks to address fundamental questions: What are the mechanisms through which Chinese railway investments influence industrial development? How does Nigeria's experience compare with global exemplars in tackling the transformative potential of railway infrastructure?

The structure of this thesis unfolds as follows:

It begins by laying out the theoretical foundations underpinning railway investments and industrial development, drawing upon relevant literature and conceptual frameworks. Subsequently, it analyses the qualitative approach to achieve various understandings between Nigeria and China. With this, through a synthesis of findings, A distillation of actionable recommendations has been aimed at optimizing the impact of Chinese railway investments on industrial development in Nigeria and beyond. In essence, this research seeks not only to contribute to academic discourse but also to inform evidence-based policy decisions and practical interventions aimed at fostering sustainable industrialization and economic growth.

1.4 THESIS FINDINGS

The increased economic involvement of African countries through the PRC has attracted mixed reactions from different camps. Supporters of China's involvement in Africa see China as the continent's champion of economic development, while China's critics argue that China is economically "recolonizing" African countries including Nigeria. Historically, the PRC's foreign policy focused primarily on encouraging African countries to resist Western colonialism [6]. After the Cold War, China increasingly shifted its focus to deepening relations with developing countries, especially Africa. Nevertheless, research shows that China's interest in Nigeria is aimed at fulfilling Beijing's four main interests concerning Africa, politically, philosophically, security-wise, and trade. It has been suggested that [7]. Formal ties between the PRC and Nigeria were cemented in 1972 when Chinese and Nigerian representatives reached an open-ended agreement for technical trade

and economic cooperation. Between 1972 and 1999, the Sino-Nigerian Economic relationship was modest, especially due to political volatility in Nigeria [8]. With the return of a civilian administration in Nigeria, relations improved steadily from around 2000. Another key enabling factor for their developing relationship at that time was the PRC's rejuvenation of its foreign policy toward cooperation with Africa, as embedded in the framework of FOCAC. Railway systems are essential in contributing to economic development, especially when considering collaborative efforts between Nigeria and China. These findings looked into the focal point between railway infrastructure and economic progress, focusing on optimization strategies within the context of Nigeria-China collaboration.

1.5 THE PROBLEM STATEMENT

Chinese investment in Nigeria's railways is facilitated through bilateral agreements and financing arrangements between the two countries. China's financial institutions, such as the China Exim Bank, provide loans and credit lines to support railway construction projects in Nigeria, often on favorable terms. The Railway construction in Nigeria with Chinese financing and SOEs' involvement is vulnerable to political calculations, misinterpretations, or distortions that can breed an atmosphere of dissatisfaction in a certain region(s). Yunnan Chen, a senior researcher on Chinese development financing has observed that the route of railways has a propensity to change based on an incumbent administration's attachment of importance to presidential policy. The Kaduna–Kano standard-gauge segment in northern Nigeria, along the larger Lagos–Kano route connecting the country's South to the North—is viewed by some citizens in other regions as a symbol of the aspirations, interests, and domination of northern politicians in the Buhari administration [9]. In the same way, the proposed extension of the Kano standard gauge track to Gusau, Sokoto State in northwest Nigeria is perceived by other ethnic groups as a reflection of the significance given to the traditional Sokoto Caliphate, in anticipation of political support. In southern Nigeria, a pro-secessionist group, the Indigenous People of Biafra, has agitated over the perceived non-inclusion of the region in national railway modernization plans by successive governments, in addition to other allegations of marginalization [10].

1.6 RESEARCH METHODOLOGY

This study follows a pattern that will enable its readers to be able to differentiate between railway investments and roads, the method for the research was done using data collection methods such as qualitative analysis with a small consideration of quantitative analysis, going through online sources to find solutions to the problems facing Chinese investment in Nigeria. Nigerian railway projects often need to improve infrastructure quality and adherence to international standards compared to global best practices. This includes track quality, signaling systems, station facilities, and overall operational efficiency. Addressing these gaps is crucial to ensuring safety, reliability, and interoperability with international railway networks

Global best practices emphasize the integration of modern technologies into railway systems to enhance efficiency, safety, and passenger experience. However, Nigerian railway projects often lack advanced technological solutions such as automatic train control, real-time monitoring systems, and predictive maintenance algorithms. Embracing innovative technologies is essential to modernizing Nigeria's railway infrastructure and improving overall performance [11]. The study aims to bring out essential findings and recommendations on optimizing the impact of Chinese railway investment in Nigeria and Africa.

2. BACKGROUND

2.1 HISTORY AND LITERATURE REVIEW

This section will give some insight into the historical context of Nigeria's railway sector and the benefit it gets from Chinese investment. Nigeria's railway system was first started by the British colonial regime back in the year 1896 the first railway construction began in the year 1898 in the city called Iddo in Lagos in the southern part of the country. The second phase started in a city called Abeokuta and reached Ibadan in 1901, which covered a distance of about 190km. Moving forward, in the early 1960s, the Nigerian railway was able to carry an average of 12 million passengers annually [12]. The British colonial government took hold of it until the year 1955 when the Nigerian came into power. It later became known as Nigeria Railway Cooperation (NRC) until to date.



Figure 2.1: Railway System of Nigeria [13].

An illustration in Fig 2.1 shows us the Nigerian Railway system across the country, the first construction started from the south linking the South-East to the North-East. Constructions have been going on to link up the remaining regions.

2.1.1 Bilateral Cooperation

Nigeria gained Independence in 1960, but the bilateral cooperation between Nigeria and China began years after Nigeria's independence due to issues concerning the two governments. A diplomatic tie was officially signed by the year 1971 [14]. Chinese financing often comes in the form of loans with stringent repayment terms. Excessive borrowing from China could lead to a debt trap, where Nigeria becomes heavily indebted and struggles to meet repayment obligations, potentially compromising its financial sovereignty.

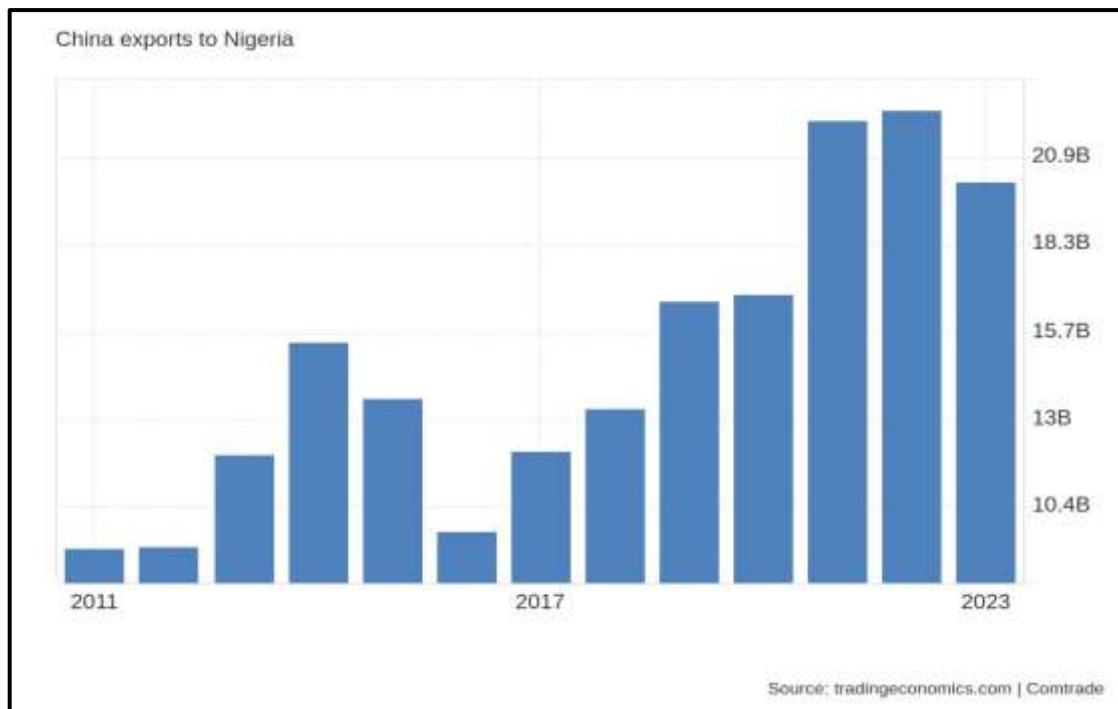


Figure 2.2: China Export to Nigeria [15].

The Figure above describes the bilateral cooperation between Nigeria and China, it appears imports from China to Nigeria are higher than exports to China. Nigeria needs to start production to help with its economy.

Nigeria's outstanding loans from China stood at about \$3 billion [16]. Most loans have a tenure of between five and 20 years and are payable with interest rates ranging from 2.5 percent to 3 percent [17]. While the interest rates seem modest, the gestation term is fairly prolonged for developmental projects, and also above average for financing third-party projects in a developing country like Nigeria. As of now, many economic analysts, government officials, and other global as well as regional organizations have expressed in the long run.

Table 2.1: The Nigeria-China trade statistics in USD million.

Year	Export	Import	Trade balance	Total
2023	2.191.200.257	17.302.232.222	15.111.031.965	19.493.432.479
2022	1.560.856.891	6.897.908.332	5.337.051.441	8.458.765.223
2021	950.789.098	5.189.896.890	4.239.107.792	6.140.685.988
2020	790.667.469	3.500.890.100	2.710.222.631	4.291.557.569
2019	1.665.029.549	12.060.017.952	10.394.988.403	13.725.047.501
2018	1.039.790.002	8.348.841.485	7.309.051.483	9.388.631.487
2017	721.261.181	5.847.733.761	5.126.472.580	7.393.899.107
2016	470.985.841	6.922.913.266	6.451.927.425	10.620.320.578
2015	795.110.857	7.874.990.147	7.079.879.324	8.345.976.022
2014	1.669.691.442	10.201.900.147	8.532.208.705	11.871.591.589
2013	1.110.437.365	9.679.426.512	8.568.989	10.789.863.877
2012	8.038.724.047	7.715.360.743	323.363.304	15.754.084.790
2011	2.527.021.650	9.447.756.748	6.920.735.098	11.974.778.398
2010	1.440.809.163	7.324.398.627	5.883.589.464	8.765.207.790

Table 2.1 above shows Nigeria and China's trade statistics imbalance in Favor of the PRC from 2010 to 2023. The Data was collected from UNCOMTRADE. In the year 2012, Nigeria's trade gained momentum outlining China. Nigeria has a lower number of exports to China due to the lack of production sites the country is lacking. Establishing a railway network will boost inter-state trade and make logistics easily transferable.

2.2 APPROACH PROCESS

Nigeria should implement policies aimed at promoting local content in railway construction projects. This involves incentivizing the development of domestic industries and manufacturing capabilities to produce railway components, equipment, and technologies locally. Also, by reducing dependency on imported technology, Nigeria can enhance self-sufficiency, create employment opportunities, and stimulate economic growth [18].

2.2.1 Asset Optimization Process

Optimizing asset lifecycle management is critical to ensuring Nigeria's railway infrastructure's efficiency, reliability, and longevity. The need to Develop risk management processes to identify, assess, and mitigate risks to rail assets, including natural disasters, cyber threats, and service interruptions. Implement resilience planning measures to improve the robustness and adaptability of rail infrastructure in the face of changing environmental and operating conditions.



Figure 2.3: Railway System Market Size, Analysis [19].

An illustration of an example of global best practices in the railway system market size is shown in Fig. 2.3 The processes and market dynamics Nigeria can follow to navigate its railway sector in the long run.

2.2.2 Tech Transfer Processes

While technology transfer is a potential benefit of Chinese investment, it could also lead to dependency on Chinese technology and expertise. This could limit Nigeria's ability to innovate and develop indigenous capabilities in railway technology and management. The dominance of Chinese technology suppliers in Nigeria's railway projects may lead to a loss of technological sovereignty, where critical infrastructure decisions are dictated by external actors. This poses risks in terms of data security, intellectual property rights, and control over strategic assets. China now has more investments in several non-oil sectors of Nigeria, such as agriculture, telecommunications, manufacturing, power generation, rail, road, and airport infrastructures [20]. Power infrastructure and generation in Nigeria have been a major challenge for many years. In 2006, China provided about \$3.5 billion for the construction of five hydroelectric dams, representing an aggregate of 6000 megawatts capacity across Nigeria. By the end of 2023, the CCECC is also expected to complete another huge hydropower plant in Nigeria, costing about \$5.8 billion, with China's Import-Export Bank providing 85 percent of funding for the project [21]. In the technical sector, a notable Chinese.



Figure 2.4: The Lagos-Ibadan Double-Track Standard-Gauge Nigeria [22].

The above Fig 2.4 shows the rate at which technology transfer can be achieved to optimize the development of the railway system in a short time. The Lagos-Ibadan railway line became officially active for passengers in June 2021, with a 157 km long line and a 150 km/h speed. The passenger traffic crossed over 2 million as of March 2024 [23].

2.2.2.1 Tech transfer discussion

a. Digital Signaling Systems:

The Implementation of digital signaling systems improves safety and operational efficiency by providing real-time monitoring and control of train movements. Digital signaling minimizes the risk of accidents, enhances capacity utilization, and enables smoother coordination between trains and railway infrastructure.

b. E-Ticketing and Passenger Information Systems:

The introduction of e-ticketing and passenger information systems improves convenience for passengers, allowing for online booking, seat reservation, and real-time travel updates. These systems streamline ticketing processes, reduce queuing times, and provide travelers with essential information, such as train schedules and platform announcements.

c. Rolling Stock Modernization:

Modernization of rolling stock involves the procurement of new locomotives, coaches, and wagons equipped with advanced features for comfort, safety, and energy efficiency.

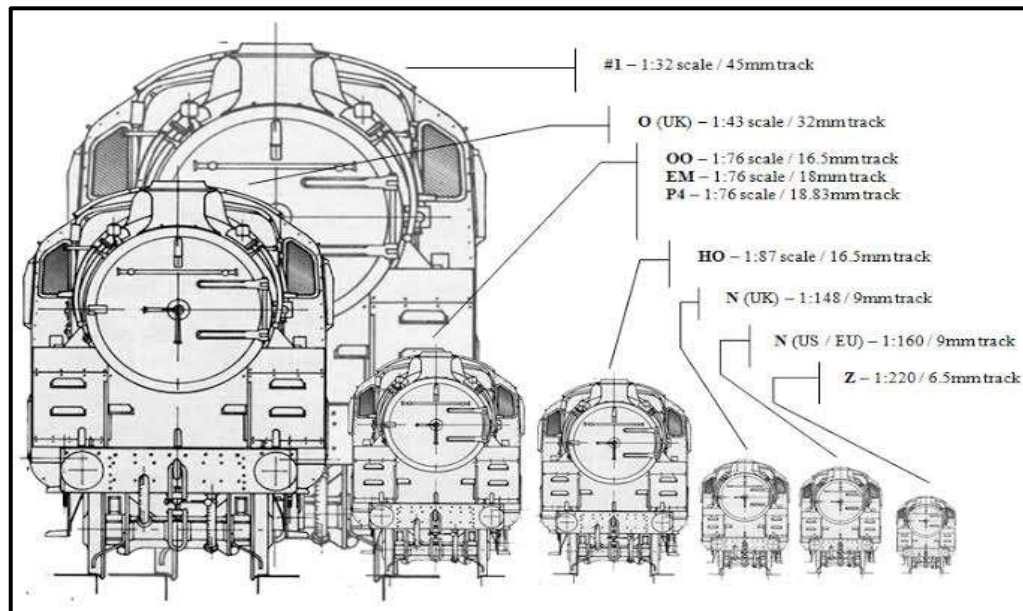


Figure 2.5: Illustration of Standard Gauge Size Railway System [24].

2.3 QUALITY ASSURANCE AND COMPLIANCE

The implementation of rigorous quality assurance standards and compliance mechanisms ensures that railway infrastructure meets technical specifications, safety requirements, and

international best practices, also, by conducting independent audits, and inspections, verifying the quality and integrity of construction work, and addressing any deficiencies promptly.

Table 2.2: The Construction of the Nigerian Railway System.

No	Year	Gauge-Type	Distance	Construction Phases of the Rail
	2016-2021	Standard	157	Lagos-Ibadan
1	2011-2016	Standard	457	Abuja-Kaduna
2	2011-2016	Standard	330	Onne-Port Harcourt
3	1990-2003	Standard	287	Ajaokuta-Itakpe
4	1963-1964	Narrow	302	Maiduguri-Gombe
5	1961-1963	Narrow	166	Gombe-Bauchi
6	1958-1961	Narrow	238	Bauchi-Bukuru
7	1922-1927	Narrow	101	Bukuru-Kafancha
8	1922-1927	Narrow	179	Kafancha-Kaduna
9	1916-1924	Narrow	220	Markurdi-Enugu
10	1914-1916	Narrow	243	Enugu-Port Harcourt
11	1909-1915	Narrow	255	Minna-Jebba
12	1907-1911	Narrow	562	Baro-Kano
13	1901-1909	Narrow	295	Jebba-Ibadan
14	1898-1901	Narrow	193	Ibadan-Lagos
Total Distance in Kilometres			3.828	

The above Table gives us the complete history of the construction of the Nigerian Railway system. The need to make the system active and gain quality assurance must be made by getting examples through global best practices. China played a big role in the maintenance of the Nigerian railway sector; A lot needs to be done to the industry to achieve the target in the development of the railway system in Nigeria.

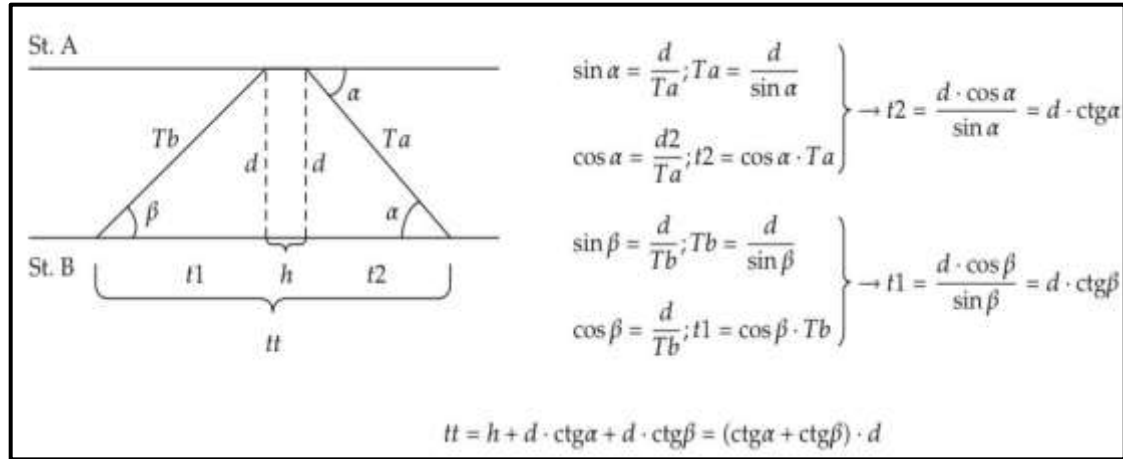


Figure 2.6: A Round-Trip Journey for a Train Trip.

The objective is to study the train tracks and database, (d) the distance, and find the $t2$ to be the

time the train track moves.

$t2$: time (seg).

D: distance (m) $\tan a = d/12 \rightarrow a = \arctg (d/12) = a [0,90]$

An illustration of how a train travels is shown in Fig. 2.6 For a train to maintain its distance, a mathematical problem must be solved to know the time and distance a railway travels between stations. Hence, the train and the track are set to represent the speed on each track. Looking at the angle (a), the arc tangent of distance (m) is divided by the time (s) which is connected to the angle in between $\{0, 90\}$ as seen in the map above. Hence, the point or angle (a) = 0 indicates the train has traveled a short distance, while the angle (a) = 90 indicates the train traveled a long distance in a shorter time.

Moreover, the practical relations and the orientation policy of foreign investment must be checked regularly, international economy advances on the construction of railways to boost trade and make life easier for their citizens.

Nigeria should develop national standards and specifications for railway construction that align with international best practices while considering local needs and conditions. Establishing clear standards, can enhance regulatory oversight, promote interoperability, and create a level playing field for technology providers. This approach reduces dependency on external standards and empowers Nigeria to set its agenda for railway development [25]. Engaging with neighboring countries and regional organizations facilitates information exchange, best practice sharing, and collaborative research efforts. Also leveraging regional expertise and resources, Nigeria can enhance its capacity to develop innovative solutions and reduce dependency on external technology [26].

2.3.1 Long-term Maintenance and Operation

Drawing inspiration from China’s renowned expertise in railway infrastructure, Nigeria can implement comprehensive long-term maintenance culture and operation strategies to ensure the sustainability and efficiency of its railway network. Here is an expansive look into strategies derived from China’s experience.

Table 2.3: The Nigerian Railway Corporation Profile.

Traction	The Conversion of engine locomotives to diesel fuel took place mid -1950s and led to a complete withdrawal of steam locomotives in the 1970s
The Rail Track	Steel/timber, single track, sleepers,
Gauge	3505 route km, 1067mm or 3’6, 4332 track km.
The Technical Support	China Civil Engineering and Construction Corporation (CCECC)

The table above shows how the NRC managed its railway sector in 2016, providing China with technical support in the industry to achieve good maintenance.

Holistic Maintenance Planning and Execution:

Develop a holistic maintenance plan encompassing routine inspection, preventive maintenance schedules, and timely repairs to uphold the reliability and safety of railway infrastructure.

Follow China's lead in fostering a skilled workforce capable of executing maintenance tasks effectively and optimizing resource utilization.

2.3.2 Technological Advancement

Collaboration with China enables Nigeria to access state-of-the-art railway technologies and innovations, including high-speed rail and digital signaling systems. Embracing technological advancements enhances operational efficiency, safety, and passenger experience, positioning Nigeria's railway system for sustainable growth. The 2001 treaty for enhanced economic ties has significantly bolstered Sino-Nigerian bilateral trade [27]. According to the Harvard University Observatory of Economic Complexity's database, the total trade value recorded between China and Nigeria in 2000 was \$561.6 million, and it peaked at a total of \$19.9 billion by 2020 [28].

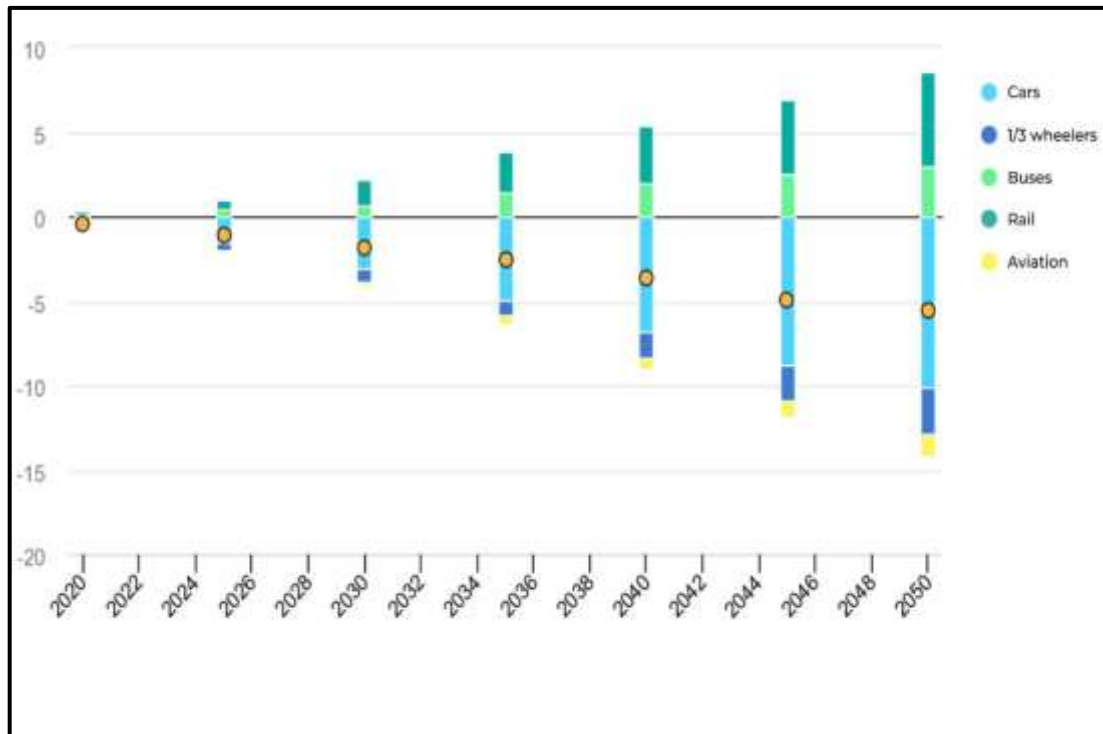


Figure 2.7: Transportation Advancement Compared to Railways [29].

As the largest economies in their respective continents, China and Nigeria have opportunities to benefit from trading with each other. A cursory look at the trend in Figure 2.7 That passenger activity increased higher than any other mode of transportation, however, this indicates a continuous inequality in the trade balance between the PRC and Nigeria. The annual difference in the volume of bilateral trade from 2000 to 2020 has always benefited China—with the annual trade surplus indicating a gradual increase, ranging from \$295 million to \$14.9 billion within the period.

2.4 STRATEGIC INVESTMENT

The optimal utilization of Chinese investments involves strategic planning and prioritization of projects aligned with Nigeria's economic development goals. Capacity building initiatives, including training of local personnel and technology transfer, are essential for sustainable operation and maintenance of railway infrastructure. Chinese support for Nigeria takes many forms, while financial loans appear to be closely attached to economic engagement and

infrastructure development. The PRC's MOFCOM is primarily responsible for allocating foreign aid or loans to recipient countries like Nigeria, and the financing is largely done through the banks in China, the EXIM bank, and other Chinese financial and diplomatic institutions [30]. Figure 2.8 illustrates how Chinese aid and loans to Nigeria feature across various sectors of the country. Small-scale Chinese aid and grants are often directed to education, non-profit, or humanitarian support, while loans are utilized for the financing of capital projects, which are most often implemented using Chinese construction companies.

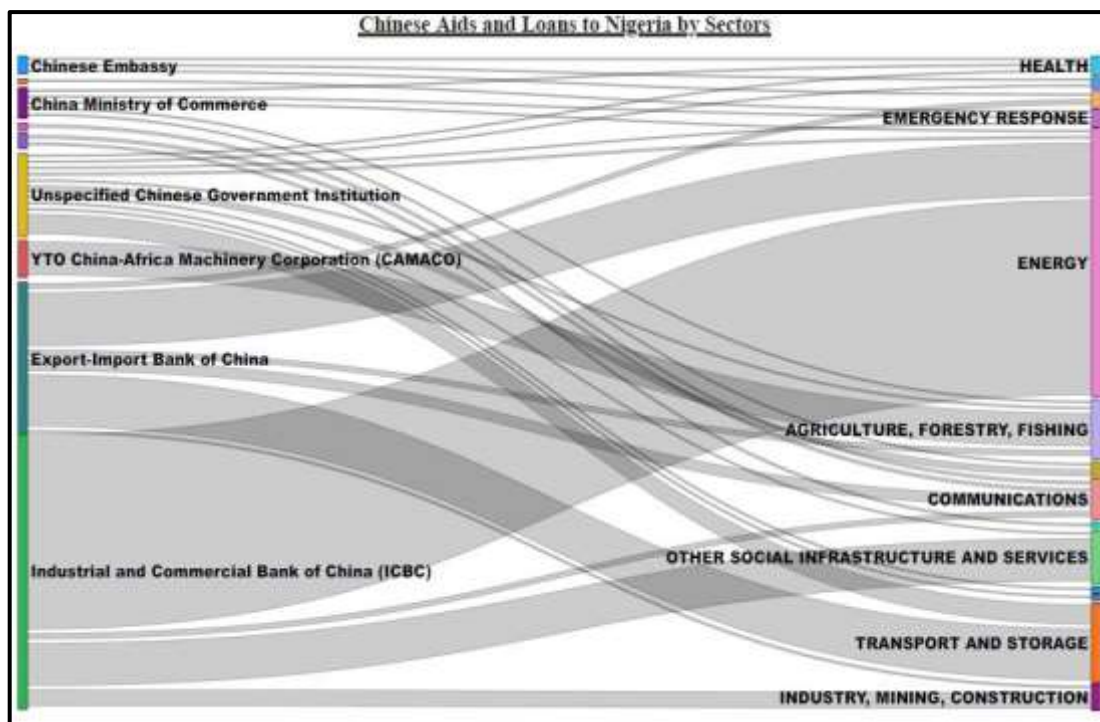


Figure 2.8: Chinese Aid and Loans to Nigeria by Sector [31].

Loans from the PRC have enabled Nigeria to address some of its developmental challenges concerning power, transport, and agriculture, amongst others [32]. Nigeria has increasingly relied on external funding sources, and Chinese financial institutions have been providing the desired loans. Chinese loans to Nigeria accounted for about 12 percent of Nigeria's external debt stock of about \$27.6 billion. The outstanding loan from China stood at about \$3 billion [33]. Most loans have a tenure of between five and 20 years and are payable with interest rates ranging from 2.5 percent to 3 percent [34]. While the interest rates seem modest, the gestation term is fairly prolonged for developmental projects and above average for financing third-party projects in a developing country like Nigeria. Currently, many economic analysts, government officials, and other global and regional organizations have

expressed worries that taking excessive loans from China will potentially harm Nigeria's economy in the long run. Improved railway connectivity enhances Nigeria's economic competitiveness by reducing transportation costs, facilitating trade, and attracting investments. Integration of Nigeria's railway network with PRC's broader BRI initiative fosters sectional connectivity and opens up new trade corridors, enhancing economic opportunities for both countries.

2.5 THE POLITICAL ASPECT

To highlight some aspects, the Chinese Communist Party leaders have used state-owned industrial technology resources in the form of railway construction and concessional loans to further their foreign policy and secure China's energy needs in Nigeria. Meanwhile, Nigerian politicians are also using China's railway project to gain political support. Although China's involvement in the railway sector has made a small contribution to achieving Nigeria's medium-term economic goals, the loans received by China to finance railway construction are gradually putting pressure on the country's national budget. On the social front, the Chinese-made train has facilitated the movement of some middle-class commuters, but the relatively high price of train tickets for the average Nigerian makes the train cost-effective. It does not seem to be effective. Overall, China appears to have benefited more from Chinese rail projects than Nigeria.

Regression coefficients predicting favorability toward China				
<i>Estimate represents the predicted shift in probability that a respondent would have a positive or negative opinion of China. Because a lower value of distance indicates closeness, a negative coefficient indicates increased positivity as respondents grow closer. For other variables, a negative coefficient indicates decreased positivity. The model also included terms that accounted for the year in which each survey was conducted.</i>				
	Estimate	Std. error	T value	P value
(Intercept)	1.822	0.819	2.224	0.026
Respondent distance	-0.000	0.001	-0.247	0.805
After Railway - True	-0.482	0.364	-1.323	0.186
Religious identify - Christian	-0.743	0.772	-0.963	0.336
Religious identify - Muslim	-0.455	0.781	-0.583	0.560
Religious identify - other	-0.291	0.839	-0.346	0.729
Education (Linear)	0.309	0.096	3.220	0.001
Education (Quadratic)	0.122	0.100	1.228	0.220
Education (Cubic)	-0.007	0.104	-0.063	0.950
Age	0.003	0.003	0.866	0.387
Region - North East	0.592	0.242	2.448	0.015
Region - North West	-0.010	0.207	-0.046	0.963
Region - South	0.437	0.222	1.965	0.050
Region - South East	0.845	0.280	3.015	0.003
Region - South West	0.156	0.232	0.674	0.500
Ethnicity - Ibo	0.197	0.266	0.739	0.460
Ethnicity - other	0.118	0.179	0.656	0.512
Ethnicity - Yoruba	0.575	0.242	2.375	0.018
Respondent distance By After Railway - True	-0.002	0.001	-3.010	0.003

Figure 2.9: The Political Prediction Favorability Toward China.

The construction and investment of railways in Nigeria faced huge Political hindrances in Nigeria, thus China's effort to gain more investment needs to play her role to succeed.

3. METHODOLOGY

3.1 INTRODUCTION

The study acquired a unique methodology through findings, research from various sources, and data collection from both countries. The reader would be able to know which steps and ideas were followed in performing the assessment. This thesis aims to discuss how Nigeria can benefit more from Chinese railway investment and how to optimize it by following global best practices. Literature studies were carried out to make it more understandable. Methods used in this research will contribute to finding solutions to the Nigerian Railways networks.

3.2 A CASE STUDY

The case study in this selection discusses the influence and presence of China's railway investment on the development and industrialization of railways in Nigeria. Africa's largest economy, Nigeria benefits from the ongoing Chinese investment projects and vice-versa. The case study identifies Nigeria as a nation with less of a strategic policy to find solutions to the problems and challenges facing the infrastructure of railways in the country.

3.2.1 Research Questions

- i. What is the main reason behind the decline of railway infrastructure in Nigeria?
- ii. How effective is the quality of China's construction of railways in the 21st century?
- iii. To what extent can Nigeria improve its experience following global best practices?
- iv. What factors can contribute to the industry's maintenance culture?

Finding answers to these questions will help navigate the Nigerian railway sector's challenges. China is one of the leading developers and the financier of effective infrastructure in the continent of Africa, China gets in return natural resources, and raw materials to boost its economy.

3.3 RESTORATION EFFORT

The Nigerian government planned to revitalize the railway network in various ways, different restoration and modernization projects were sent off, recovery acquirement trains and moving stock, and the development of railroad lines. One of the remarkable tasks is the Abuja-Kaduna rail route line, which was finished and inaugurated in 2016, giving a cutting-edge and proficient rail connection between the capital city, Abuja, and Kaduna. Notwithstanding Nigeria's potential for economic growth weak infrastructure remains a common challenge for Nigeria and many countries across the African continent. In Sub-Saharan Africa, for instance, regional trade has yet to achieve the desired economic output.

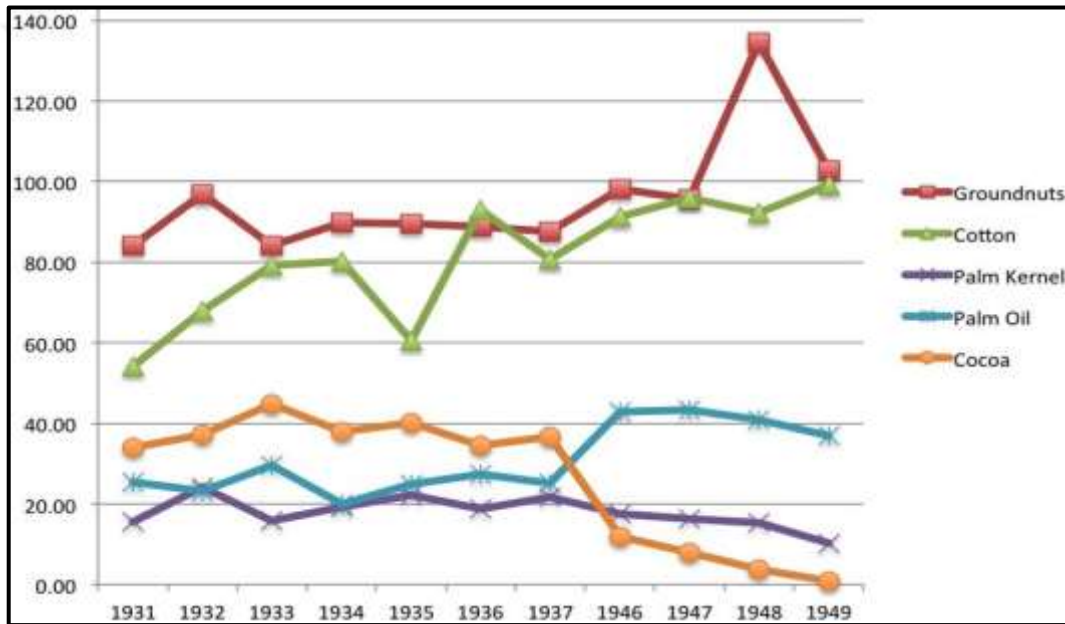


Figure 3.1: Railways demand between Northern and Southern Nigeria [35].

From the above figure, 3.1 describes the percentage of goods transported by the railroad during the colonial era, we can see the Northern part of Nigeria requires much use of the railway to trade its products such as groundnuts, and cotton while the southern part of the region prepares the use of road system instead of railways. The need for railway restoration began long ago due to the necessity to trade and transport large quantities of goods.

Having gradual and prominent developers and financiers of critical infrastructure in many African countries including Nigeria, pledged by Chinese companies for investment in infrastructure development, job opportunities for local employees, and income provision through natural resources royalties have become more appealing to many developing African

nations. The PRC's interest in Nigeria is driven by China's need for raw materials, natural resources, and a thriving market to enhance its economy. Amidst the mutual need for resources and energy to secure the PRC's economic growth and Nigeria's infrastructure development.

3.3.1 Infrastructure Rehabilitation

Recognizing the critical role of railways in economic development and transportation, the Nigerian government embarked on ambitious restoration efforts to revitalize the sector. Central to restoration efforts is the rehabilitation of existing railway infrastructure. Below is the data presented in the railway sector.

Table 3.1: A Breakdown of Data on the Railway Transportation System in Nigeria.

Quarter	Passengers	Revenue from cargo in (USD)	Revenue from passengers (USD)	Goods/cargos Tons
Q1	441,725	181,270,800	768,438,658	59,966
Q2	474,117	188,028,350	1,100,941,295	56,029
Q3	594,348	286,775,780	1,489,200,328	81,963
Q4	672,198	423,215,481	1,067,915,479	119,286
Total	2,182,388	1,079,290,411	4,426,495,760	317,244

Nigeria's road networks often suffer from congestion, especially on major highways and urban routes. As a result, businesses may opt for rail transport to avoid delays and disruptions associated with road congestion. Railways offer a more predictable and efficient means of moving goods, particularly over long distances.

Nigeria has partnered with China to restore its railway sector, leveraging Chinese expertise, technology, and financing to modernize infrastructure and expand the network. Chinese

companies, backed by government support, have been instrumental in executing major railway projects in Nigeria.

PRC-Nigeria relations are economically connected by trade, provision of loans, financial aid, and investments. Meanwhile, Nigeria's need for urgent solutions to address the country's infrastructure gaps makes the PRC's investments in infrastructure and financing approach to developing countries rather attractive. China's lending agreements without imposing rigorous settlement terms, as well as its seeming non-intervention principles in any host country's domestic affairs, also build an enabling environment for the Sino-Nigerian economy.

3.4 SOCIO-ECONOMIC BENEFITS

A well-functioning railway system generates employment opportunities, stimulates local economies, and promotes inclusive development, particularly in underserved regions. The socio-economic benefits of railway infrastructure extend beyond transportation, catalyzing urbanization, industrialization, and poverty reduction. The PRC counts heavily on Nigerian energy and raw materials, with petroleum gas, crude oil, zirconium, lead, and zinc exports among the highest as of 2019. Oil and gas together accounted for nearly 89 percent of Nigeria's total exports to China. Despite this large percentage, Nigeria's crude oil export to China still comprises a small fraction of China's global oil and gas imports [36]. As the largest importer of crude oil in 2020, for example, China imported about \$150 billion in total value of the commodity across the world, of which the trade with Nigeria accounted for only about \$1 billion. In general, Innovations in railway technology, and digital processes, enhance, safety, the passenger comfort. Investments in research and development drive technological advancements, positioning railways as a mode of choice for sustainable transportation.

Table 3.2: The Nigerian Government Investment and NRC Total Revenue.

Year	No. of Passengers ‘000	Freight Hauled In Tons	Investment in USD ‘000	Total Revenue in USD ‘000	Tenures
2015	20.759	1.115	N/A	6.710	Jonathan
2014	18.178	962	25.100.000	10.461	Jonathan
2013	N/A	N/A	41.019.200	N/A	Jonathan
2012	4.155	182	1.490.000	5.912	Jonathan
2009	1.285	52	81.300	1.769	Yar’adua
2006	708	41	8.300.000	1.487	Obasanjo
2004	1.731	62	840.000	2.072	Obasanjo
2003	1.622	58	52.220	2.238	Obasanjo
1995	1.729	108	528.000	3.466	Abacha
1988	3.629	294	88.000	8.726	Babangida
1983	13.012	1.619	32.000	67.969	Shagari

The Figure above shows the lack of revenue Nigeria is getting due to the need for interest in the regulation of the industry, changes have been made after the coming of Chinese investors into the railway sector.

3.4.1 The Benefit of Railway Enhancement Using Tech

Technological advancements and innovation play a crucial role in transforming Nigeria's railway sector, enhancing efficiency, safety, and passenger experience. This section explores key advancements and innovations shaping the modernization of Nigeria's railway infrastructure.

Some of the rail systems have been connected to comm. systems also as the electrification. A successful railway network can develop access to spread ease tasks and the execution of rural telephony alongside the electrification and initiatives persists as a measure. Should the implementation be achieved with exact contributors to National employment statistics? Starting from the foundation phase of rail-laying, extending through the difficulties of station construction, the assembly of rolling stocks and carriages, all the way to the operational logistics and diverse employment opportunities that can manifest. These include but are not limited to role-spanning engineers' clerks, managers, ticket printing professionals, legal experts, medical practitioners, financial accountants, surveyors, casual labor forces, and educators.

The capacity for job creation within this sector is endless. It is to be noted that railroad transport stands as a primary employment generator internationally. Data from various timelines and geographics underscore this assertion, the Polish railways, in the year 1992, accounted for 276, 000 employed persons while the Japanese National Railways maintained a workforce of 415,000 in the year 1980, which saw a reduction to 281,000 pre-privatizations; and the Nigerian Railway Corporation supported over 46,000 jobs at the end of 1970s [37].

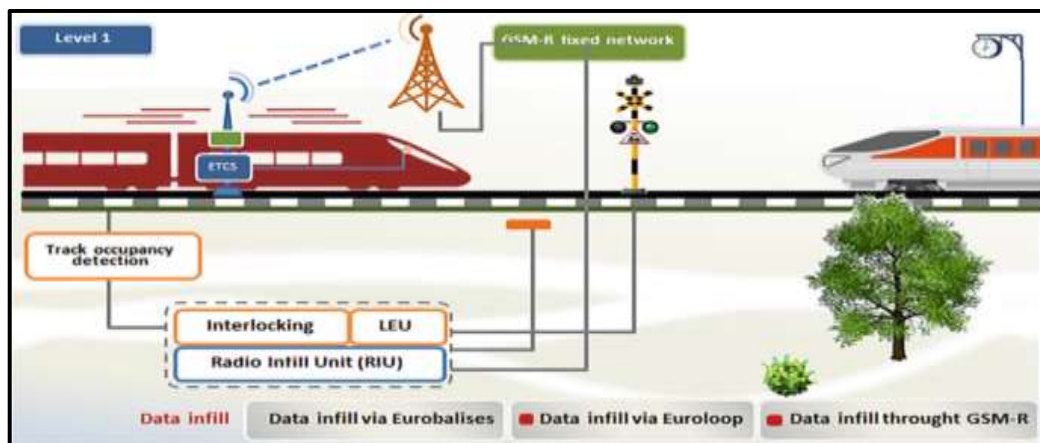


Figure 3.2: The Use of IT in Railway Transport [38].

As shown in Fig 3.1 The benefit of rail transportation lies in its capability to transport large quantities of goods across long-range distances on a routine basis. The railway industry leverages information technology like the other transportation sectors to uphold strong service quality and circumvent hindrances. The realm of rail transportation encompasses a diverse array of information systems, encompassing managerial and technical safety

components, and the enhancement of process efficiency through the orchestration of an assortment of systems and technologies, among other aspects.

3.5 DATA-DRIVEN DECISION-MAKING

Policymakers should emphasize data-driven decision-making in maintenance planning and asset management, leveraging data analytics, predictive modeling, and asset management systems to optimize maintenance strategies and resource allocation. Follow China's lead in utilizing data-driven insights to enhance the Nigerian Railway sector in maintenance and efficiency control. It will also reduce costs and improve asset reliability.

Loans received by the PRC for the construction of railways in Nigeria are estimated to be over USD 6 billion [39]. Although the Chinese government has shown generosity and political apathy in providing loans for the construction of Nigeria's railways, the growing debt appears to be having an undue influence which becomes unsustainable, considering only USD 500 million of loan received from EXIM bank in 2010 for the construction Abuja and Kaduna.

3.6 CHAPTER OVERVIEW

The overview of this chapter described the methodology used in assessing this thesis work to the goal and objectives of this research. Questions were asked to help identify the problems and find a solution through this chapter's methodology. The study case is being reviewed thoroughly to help find the benefit of using technology in the development of railways, in a nutshell, decision-making is vital to achieve these aims and values.

4. DEVELOPMENT OF STANDARD AND SPECIFICATION

4.1 INTRODUCTION

Development of Nigeria's Railway system should follow National development standards through the findings of global best practices. This will help establish a unique way to enhance technology in the railway sector. Leading railway systems prioritize eco-friendly technologies such as regenerative braking systems, energy-efficient rolling stock, and sustainable materials in infrastructure construction.

This chapter will look into some models that will help in the optimization of industrial development on Chinese investment. While embracing environmentally friendly practices and technologies, the minimization of its carbon footprint mitigates environmental impact and contributes to global sustainability goals. Despite having abundant natural and human resources, an infrastructure deficit continues to pose an impediment to Nigeria and Africa, hindering the realization of the continent's fullest economic growth potential. The existing infrastructure in some African countries was built under European colonialism. Most of these structures have further deteriorated often due to neglect under administrations in post-colonial periods or were damaged during domestic conflicts or civil wars [40]. Besides, low rates of domestic investment in these infrastructures have rendered them undeveloped and incapable of addressing the issues. In addition to the dearth of necessary public funding to develop key infrastructure, some African countries are guilty of poor financial management and low credit scores in the international market.

4.2 MODELS PROPOSALS

The study follows models that will navigate the development of railways in Nigeria and Africa through some analysis and approach from global best practices. The rail industry has been projected to be the best globally because it generates revenues daily. This research presents an approach to data modeling techniques in the operation of the railway system and its maintenance.

4.3 WORK DATA ON RAIL INDUSTRIES

Rail transport is undergoing a fast transition towards the integration of technology and innovations, with the effect of the enhancement of safety, environmental attraction, and efficiency. This brings the adoption of cutting-edge developments such as rapid-speed rail infrastructure, automated locomotives, maintenance protocols, and intelligent management mechanisms.

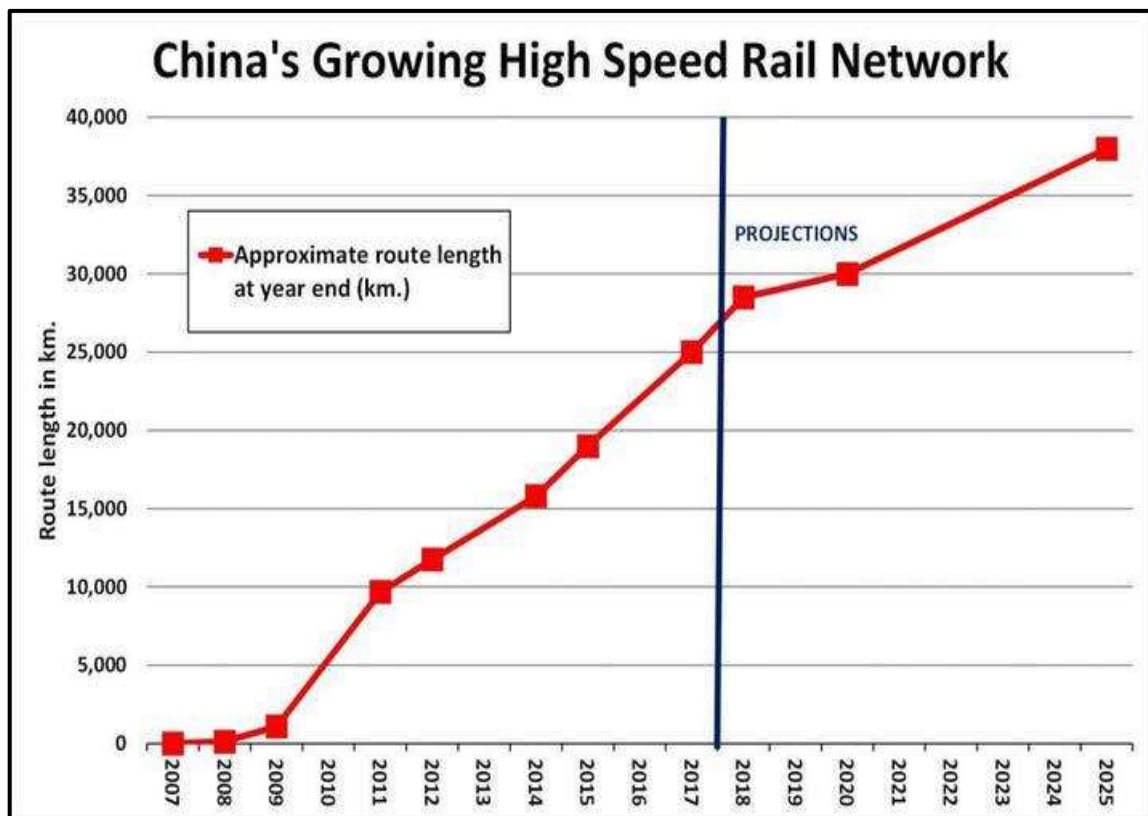


Figure 4.1: China's High-Speed Railway Project [41].

The chart above in Fig. 4.1 shows the effort China has put into the railway sector from 2007 until 2025 is incomparable with any other country, the railway tracks almost reached every place in China both rural areas and urban. Data is collected by generating the time-frequency models and remaining time through the first pattern and the second phase begins by receiving the signal from the second pattern.

4.3.1 Technology Assisting Data Model

Chinese companies are responsible for project execution and management, and overseeing of various aspects of construction, procurement, and quality control. The company brings

firm expertise in large-scale infrastructure development, ensuring timely completion and adherence to technical specifications. The technology to assist the system solutions to problems requires models that allow the capacity engines to work efficiently.

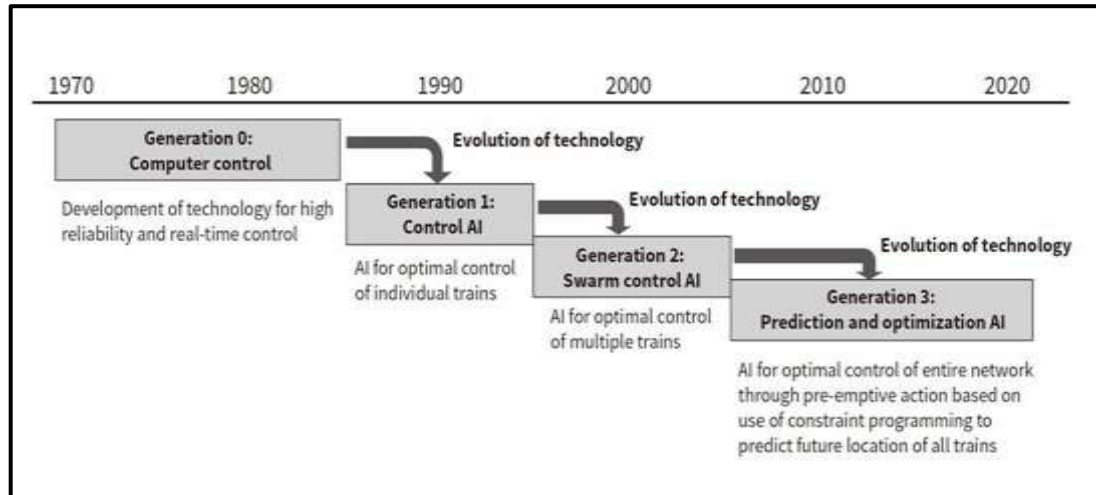


Figure 4.2: Technology Assistance in Rail System [42].

An illustration in Fig. 4.2 shows technological progression in using computers and rolling down to Artificial intelligence. The optimization and development techniques follow a simultaneous pattern in diversifying railway traffic management. An effective system containing these differentiates the capacity power of the train load. Chinese investment in Nigeria's railways is facilitated through bilateral agreements and financing arrangements between the two countries. China's financial institutions, such as the EXIM Bank, provide loans and credit lines to support railway construction projects in Nigeria, often on favorable terms. China's foreign policy emphasizes sustained cooperation with Nigeria because of its geostrategic and political status as the most populous nation and the biggest economy in the West. The most prominent Chinese construction company that has been playing a key role in infrastructural development in Nigeria over the last three decades is the CCECC.

4.3.2 Discussion

Nigeria can draw valuable lessons from China's experience in railway development, including long-term planning, efficient project execution, and integration of railways into broader economic strategies. China's emphasis on innovation, public-private partnerships, and stakeholder engagement offers insights for optimizing Nigeria's railway sector.

Chinese involvement in Nigeria's railway sector includes technology transfer and capacity-building initiatives aimed at empowering local engineers, technicians, and railway personnel. Nigerian professionals receive training and technical assistance from Chinese experts, enabling them to acquire skills in railway construction, operation, and maintenance.

The long duration and nature of railway construction, coupled with the protracted stay of Chinese companies and expatriates in Nigeria, has the ancillary effect of allowing PRC representatives to gain unofficial access to raw and natural minerals or locate unexploited resources.

4.3.3 Solutions

The adoption of energy-efficient technologies, including regenerative braking systems and energy-saving lighting, reduces operational costs and environmental impact. Energy-efficient practices contribute to sustainability goals, minimizing carbon emissions and resource consumption in railway operations. Nigerian government officials, and occasionally. Before the end of President Olusegun Obasanjo's tenure in 2006, many political supporters of his regime gave him credit for inaugurating the construction of the Lagos–Kano standard-gauge railway track by the Chinese Civil Engineering Construction Company. In summary, work data on railways is an effective way to maintain the composition and complex features of the industry.

4.4 QUALITY DEVELOPMENT

The Implementation of rigorous quality assurance and development standards, and compliance mechanisms to ensure that railway infrastructure meets technical specifications, safety requirements, and international best practices. A description of conducting an independent audit, inspections, and assessments to verify the quality and integrity of construction work and address any deficiencies promptly through various sources was conducted. Constructed with little consideration for the potential social benefits of the railway for adjoining communities, the narrow-gauge tracks were economical in connecting passengers and freight between the northern and southern regions of the country. Establishing local factories and manufacturing steel to make rail tracks will have an assurance of quality development. The Nigeria Minister of Transportation, Senator Said Alkali has said the Kano-Maradi rail project when completed would facilitate trade and boost

bilateral relations between Nigeria and Niger. Foster constructive dialogue and engagement with affected communities, local authorities, and civil society organizations to address concerns, solicit feedback, and promote inclusive decision-making. Incorporate community input into project design, planning, and mitigation measures to minimize social conflicts, displacement, and adverse impacts on livelihoods. Shortly after the RITES and “Ogbemudia Revolution” efforts to rejuvenate the NRC, the Nigerian government turned to China to improve its rail infrastructure. In 1995, the CCECC was awarded a \$528,697,000 three-year contract for the repair, repositioning, strengthening, and reduction of the sharp bends along Nigeria’s railway tracks [43]. The contract obligated Chinese companies to supply rolling stocks, wagons, locomotives, and coaches to the NRC. At the expiration of the contract period in 1998, the CCECC was, however, unable to meet all its obligations, with only minor improvements to the railways being made. In 2002, the Federal Government of Nigeria adopted a 25-year strategic plan that internationally acceptable standards [44]. According to the plan, the “colonial-era built” narrow-gauge (1,067 mm) tracks were to be reformed into standard-gauge (1,435 mm) The 36 states and economic focal points in Nigeria. The plan was also projected at a total cost of \$60 billion: 20 percent of the funding was to be provided by the government, while the remaining 80 percent would be sourced from local and foreign investors. PPP option helps to improve the overall quality of service of the railway transport system.

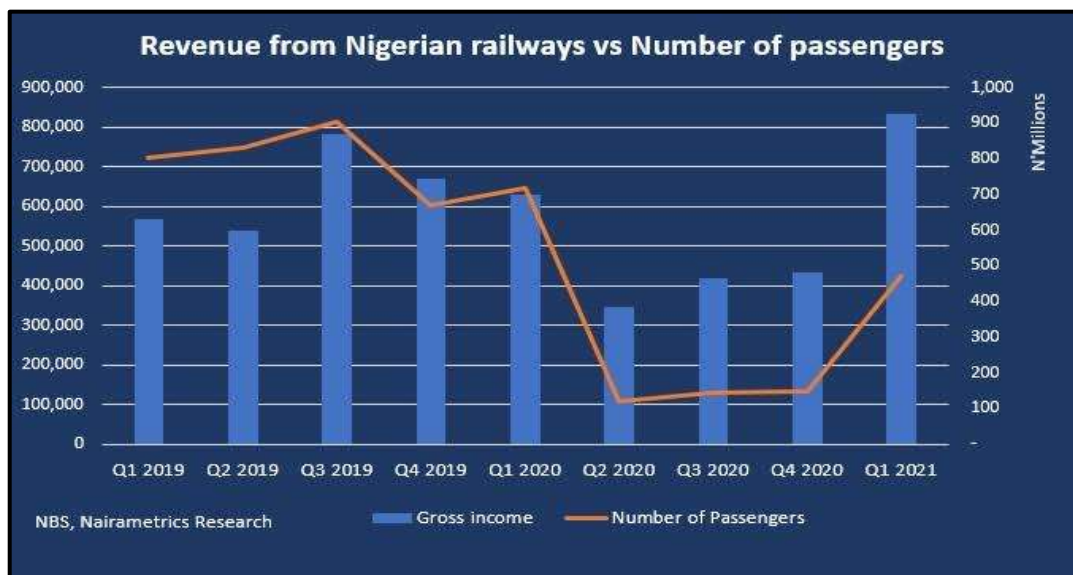


Figure 4.3: Nigerian Rail Revenue Generation [45].

Q1 Number of Passengers = 647.055

Q2 Number of Passengers = 424.460

In Q1 2021 the Revenue of the Nigerian Railway recorded the highest. Total Revenue generated = N 5.8 billion Naira (USD 4.8 million).

Table 4.1: Passenger Numbers that Used Railway Transport in 2022 in Nigeria.

Date	Passengers Number	Income generated from Passengers (in Naira)
Q1, 2022	501.46 thousand	726.10 million
Q2, 2022	690.43 million	1.16 billion
Q3, 2022	712.11 million	1.72 billion
Q4, 2022	1.43 million	2.13 billion

As shown in Fig. 4.1 the passenger number in the first quarter of 2022 was more than half the second quarter, and the revenue generated happened to have appreciated in the second quarter. The data shows the passenger numbers and the revenue generated keep increasing quarterly, this could only be achieved by continuous maintenance and development throughout the year.

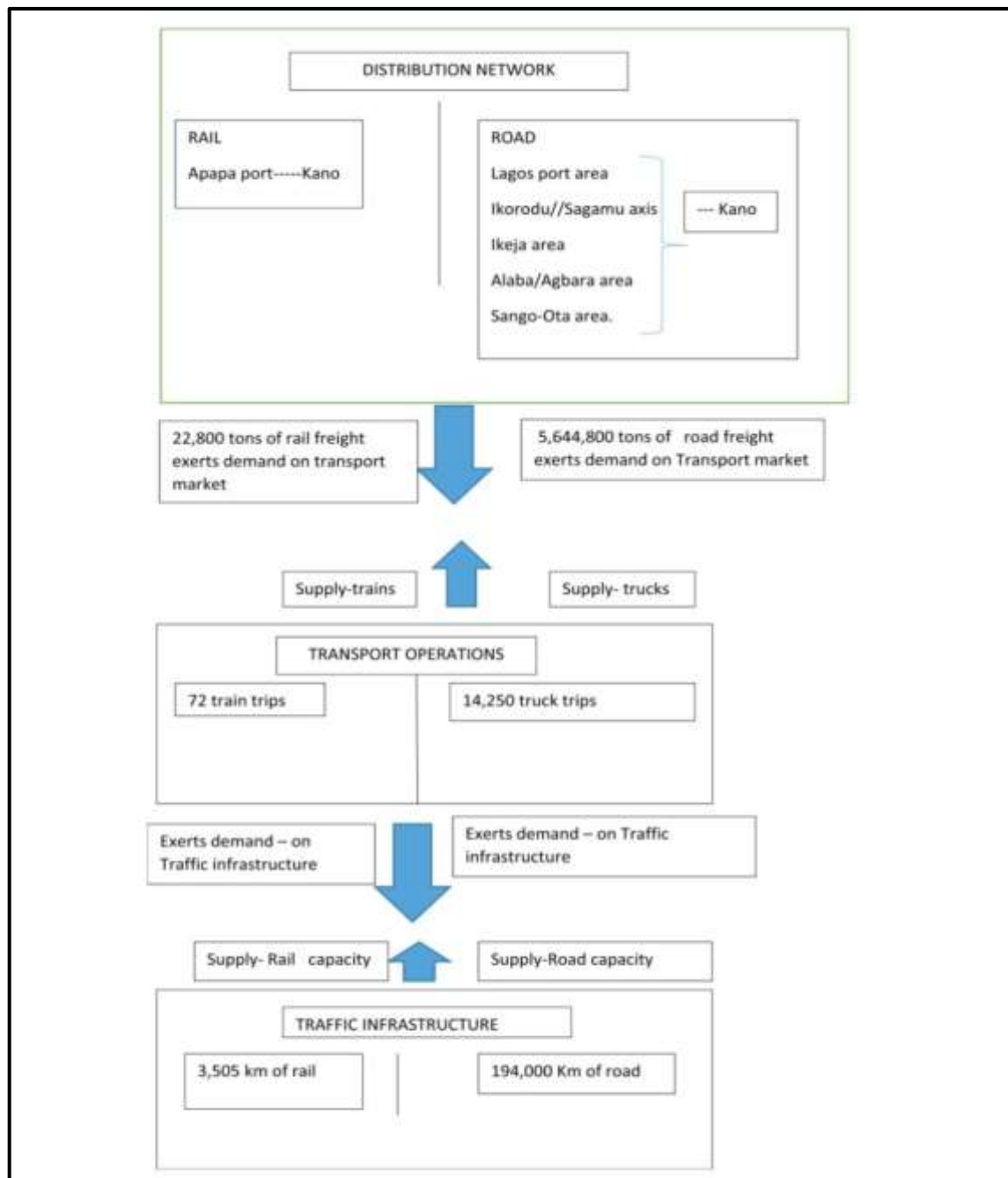


Figure 4.4: Rail VS Road Distribution Network in Nigeria.

The above figure describes the effect of road and railway distribution networks. The Kano to Apapa port rail line transports approximately 22,800 tons of goods daily while road transport accumulates 5,644,800 tons of goods and products. This illustrates the lack of a rail line network in Nigeria. The train supplies less than the road.

4.4.1 Long-Term Maintenance and Operation

Drawing inspiration from China's renowned expertise in railway infrastructure, Nigeria can implement comprehensive long-term maintenance and operation strategies to ensure the sustainability and efficiency of its railway network. Develop comprehensive maintenance and operation plans to ensure the long-term sustainability and efficiency of railway infrastructure beyond the construction phase. The Investment in training, equipment, and infrastructure for maintenance crews, establishing maintenance schedules, and allocating sufficient budgetary resources for ongoing upkeep and repairs. China's extensive experience in railway infrastructure development provides valuable insights into long-term maintenance and operation strategies that can be applied to Nigeria's railway sector.

Table 4.2: NRC Analysis in Comparison.

Infrastructure	1945	1995	2005
Freight Wagons	258	71	173
Passenger Vehicles	340	151	602
Locomotive Engines	3.887	1.501	3.484
Standard Guage Tracks	3.407	3.506	3.506
Narrow Guage Tracks	-	-	288
Population	21.000.000	89.500.000.	120.000.000

Fig. 4.2 shows the performance of the Nigerian railway corporation at its very beginning, due to a lack of focus coupled with a lack of maintenance and new development the railway sector almost became non-existent. The establishment of Chinese investment revitalized the NRC into what it is now.

The Implementation of performance-based contracts in railway maintenance incentivizes contractors to achieve specific performance targets related to uptime, reliability, and customer satisfaction. Emulate China's success in driving efficiency and quality improvements through performance-based contracting mechanisms. The immediate or

distant future. Sustainable transport systems align economic growth with social and environmental priorities as they provide the physical networks and services upon which a nation depends.

Table 4.3: Nigerian Railway Passenger Traffic Number.

Passenger Traffic	
Year	Volume
1964	11.289.000
1974	4.343.000
1978	6.800.000
1984	15.600.000
1991	4.000.000
2003	1.700.000

The history data of the NRC passenger traffic number from 1964 to 2003 is shown in Fig 4.3 indicating the abandonment of the sector, people often prepared to use road and air transportation systems instead of trains because of the lack of passenger carriages and destroyed rail tracks.

According to the African Development Bank, most of Africa's railways are in poor condition and require billions of dollars of investment to maintain track and signalling systems, much of which was built during colonial times to remove mines and other natural resources and ports. It was built to connect.

- a. The need for better and more integrated logistics
- b. Increased demand for transportation due to the growth of African economies
- c. The need to provide new urban mass transport.

- d. The need to build a high-capacity infrastructure capable of handling mining in bulk volumes.
- e. The need to provide access to the sea with capacity and reliability.
- f. Increase in the African integrated trade.
- g. Increased environmental and social sensibility.
- h. Direct and indirect creation of jobs.

Table 4.4: Nigerian Rail Freight Traffic.

Freight Traffic	
Year	Tones
1964	2.961.000
1974	1.099.000
2000	99.000

As seen above in Fig. 4.4 data shows the old Nigerian rail freight traffic from 1964 to 2000 in tonnes, the decline happened as a result of a few remaining train cargo in the rail industry. Thus, it is recommended to look into possibilities to make things work. This could be done by adopting comprehensive long-term maintenance and operations strategies inspired by Chinese expertise, Nigeria can make its railway infrastructure more reliable, safe, efficient, and sustainable throughout the lifecycle of railway projects. This can pave the way for innovative development and optimal performance.

Table 4.5: The Price of the Lagos-Ibadan Train Fare in December 2022.

Class	Old price (Naira)	New price (Naira)
88-seater coaches	2500	3600
56 and 68-seater coaches	5000	6500
24-seater coaches	6500	9000

As seen in Fig. 4.5 the price change was due to inflation and an increase in the number of passengers from Lagos to Ibadan in December because of festivals and holidays.

The issue could be solved by incorporating data-driven decision-making and advanced asset management practices is critical to optimizing the performance and longevity of Nigeria's railway infrastructure. Here is a comprehensive approach that draws lessons from successful implementations in China.

4.4.2 Data Collection and Integration

Establish a robust data collection mechanism to collect information on various aspects of railway operations, such as track conditions, vehicle performance, and passenger flow. Integrate data from multiple sources such as sensors, maintenance records, and passenger feedback into a central system for comprehensive analysis. Apply reliability engineering principles to optimize asset performance, improve uptime, and minimize disruption to rail operations. Perform ownership over the life of a railroad asset, including acquisition, operation, maintenance, and disposal. Allocate budget strategically to balance short-term maintenance needs with long-term asset renewal and replacement needs.

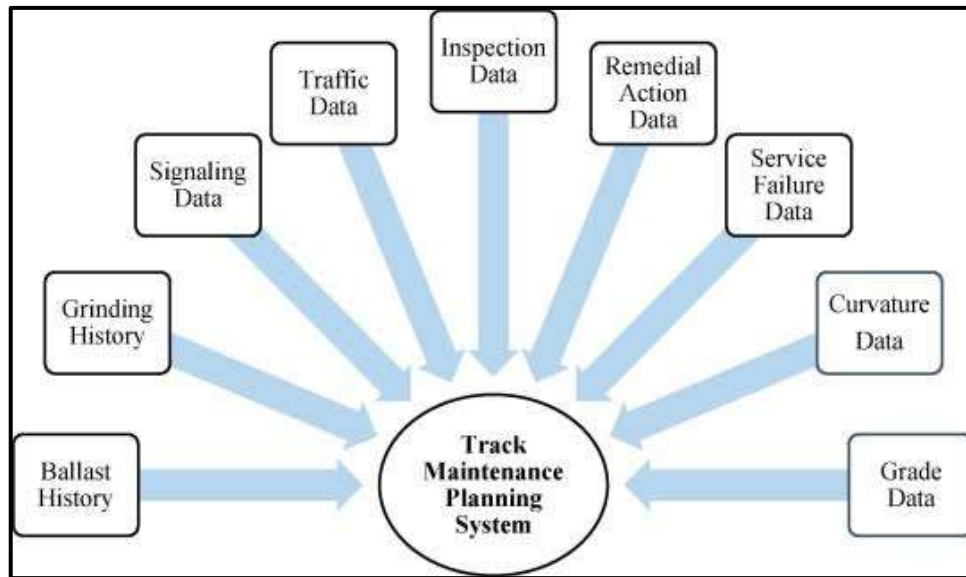


Figure 4.5: Data Collection System in Railways [46].

It has been assigned to instruction positions immediately after the proposed Nigerian Transport University has been commissioned. As of now, the CSR activities of Chinese companies seem to have gained local recognition in certain remote areas. Traditional leaders in the communities where the railway projects are involved have largely applauded the presence and contributions of Chinese companies in their societies. The newly constructed Chinese railways in Nigeria have eased mobility and facilitated safer, more comfortable, and rapid passage between smaller towns and cities along connected rail routes. For daily commuters, particularly working-class civil servants who travel to work using high-density rail routes like Abuja–Kaduna and Lagos–Ibadan.

4.4.3 Risk-Based Prioritization

Nigeria should adopt a risk-based approach to prioritize maintenance and renewal activities and assess factors like asset criticality, consequence of failure, and probability of failure, so resources can be allocated where they are most needed. This approach ensures that critical assets receive adequate attention, minimizing the risk of disruptions and ensuring operational reliability. Establishing a culture of continuous improvement is important for refining asset management practices over time. Regular reviews and adaptation to technological advancements and changing regulatory requirements ensure that strategies remain relevant and effective. This adaptive approach enables Nigeria to stay at the forefront of asset management best practices.

In conclusion, optimizing asset inventory and condition assessment practices is crucial for the sustainable development and efficient operation of Nigeria's railway infrastructure. By getting some inspiration from global best practices and leveraging lessons learned from China's experience, Nigeria can enhance its asset management capabilities, ensuring the reliability, safety, and longevity of its railway network for generations to come.

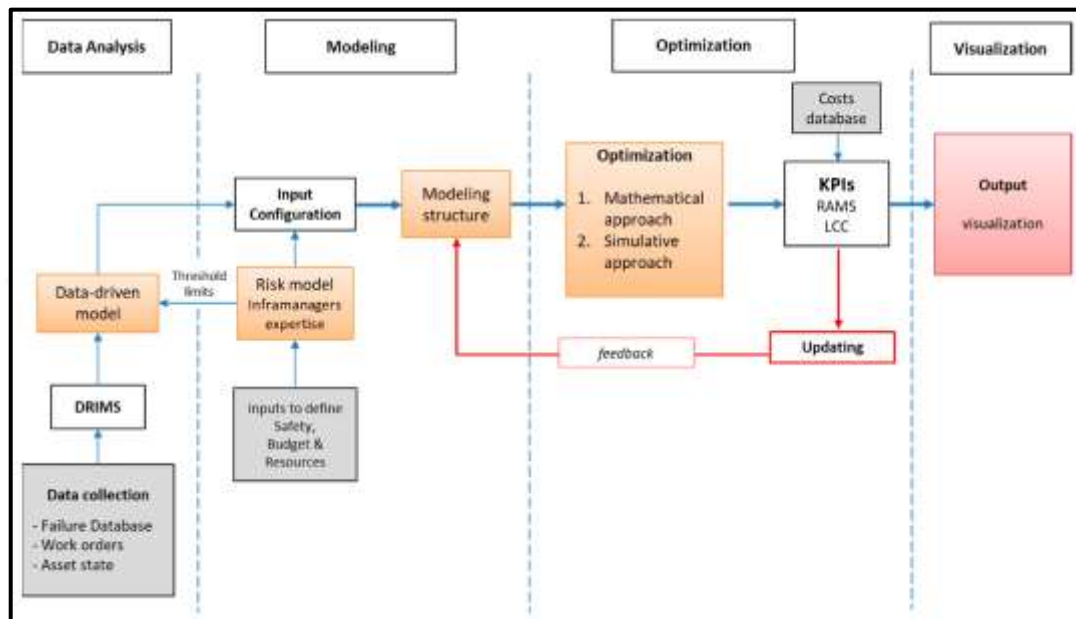


Figure 4.6: Application of Machine Learning and Simulative Approach to Railway [47].

The figure above shows us some steps towards the development of a digital twin for the rail asset management process by merging data analysis, machine learning, and simulation techniques. Chinese investment in Nigeria's railway construction holds immense potential to catalyze economic growth, enhance connectivity, and improve the quality of life for millions of Nigerians. By leveraging these benefits effectively and addressing associated challenges, Nigeria can harness the transformative power of railways to drive sustainable development and prosperity across the nation.

This thesis looked into some data from various sources such as academic literature, government reports, and industry publications to provide a comprehensive understanding of the topic to provide findings on the Opportunities and Challenges of Chinese Investment in Nigeria's Railway Construction," comprehensive research and analysis would be required. This could involve examining various aspects. Efficient railways facilitate the movement of goods within Nigeria and serve as crucial links for international trade.

4.4.3.1 Infrastructure development

Chinese investment contributes to the expansion and modernization of Nigeria's railway network, offering significant infrastructure development opportunities. The establishment of new railway corridors and the rehabilitation of existing lines enhance transportation efficiency, reduce congestion on road networks, and promote sustainable urban development. Furthermore, improved connectivity between urban centres and rural areas fosters regional integration and stimulates economic activities along railway corridors. The Sino-Nigerian relationship in Chinese companies also suffers from cultural differences or discrimination. Even with supported foreign cultural exchange programs between the Chinese and Nigerian governments, social integration between top-level Chinese managers and the low-level Nigerian workers of Chinese construction companies is shaky. Chinese workers have been accused of refusing to participate in unofficial events with local employees. For example, they only visit “Chinese-style” bars during leisure outings and import most of their food items [48]. Like the situation in other African competitors alike.

4.4.3.2 Challenges and concerns

Despite the opportunities presented by Chinese investment, several challenges and concerns accompany the implementation of railway construction projects in Nigeria. These include issues related to debt dependency, where extensive borrowing from China may lead to debt sustainability challenges and potential loss of financial sovereignty. Additionally, concerns about the quality of infrastructure, environmental impact, social displacement, and limited local participation raise questions about the long-term sustainability and inclusivity of railway development initiatives.

While Chinese technology may offer initial cost advantages, long-term dependency could result in higher costs associated with maintenance, upgrades, and licensing fees.

Nigeria can leverage public-private partnerships (PPPs) to foster technology innovation and research in the railway sector. Collaborating with private sector entities and research institutions can accelerate the development of indigenous technologies and solutions tailored to Nigeria's specific needs.



Figure 4.7: Standard Railway Line of Lagos-Ibadan Nigeria [49].

Similar apprehension existed about the realities of technology transfer and job creation for Nigerian citizens. Public officials outside the foreign affairs sector explained that although Chinese businesses are more attractive partners because the development gap is less daunting than with the West, actual technological transfer and job creation are low because the Chinese import their labor.

Table 4.6: Comparing different modes of Transportation.

Vehicle	Weight ton/kg	Cost per tonne-km [15]	Truck emission	Carbon 2 / ton
Rail	150 (for freight)	Inexpensive	0.3/18	0.18
Air	250 (for freight)	Expensive	10.0/680	6.8
Road	1600 (for freight)	Moderately expensive for	2.7 (180) for truck	1.8 for truck

An illustration of how the mode of transportation differs is shown in Table 4.6 starting with the railway transportation system, in Nigeria, people often use road transport to deliver goods

from one region to another, then followed by air freight. This is an indication that more investment needs to be made in railways.

4.5 KEY FACTORS

These factors are key impediments to Africa's infrastructural development. Historically, some African regimes have funded the reconstruction of key national infrastructure, but the private sector stakeholders are largely unable to provide the required loans or funding to sustain long-term investments in infrastructure development. Given the pace of globalization as well as the rising global demand for Africa's naturally endowed mineral, its existing infrastructure. Initiatives like the Programme for Infrastructure Development in Africa (PIDA) and the G20 Compact with Africa have been focused on supporting infrastructure development in Africa with significant lending and financing arrangements. In the same vein, the infrastructure gap in Africa provides significant opportunities for foreign investors like China and its SOEs to finance and construct capital infrastructure assets, including roads, power plants, railways, and ports across the continent.

Countries with successful railway systems often prioritize integrated transportation planning, where railways are seamlessly connected with other modes of transport such as buses, trams, and metros. This approach ensures efficient and convenient travel options for passengers, reduces congestion on roads, and promotes sustainable urban development [50]. The adopting and adapting these global best practices to local contexts, countries can achieve sustainable, efficient, and inclusive railway systems that contribute to economic growth, environmental protection, and social development.

4.5.1 Optimization Factor

Railway integration between Europe and Asia has led to a significant increase in trade volume and economic growth along the transcontinental corridors. The efficient movement of goods and passengers has stimulated economic activity in regions connected by railways, fostering trade partnerships and attracting investments. Standardization and harmonization of railway infrastructure play a crucial role in facilitating seamless cross-border operations. Global best practices emphasize the adoption of common technical standards, interoperable signaling systems, and uniform safety regulations to ensure smooth and efficient railway connectivity between Europe and Asia. Efforts such as the European Train Control System

(ETCS) and the Trans-European Transport Network (TEN-T) aim to promote interoperability and streamline cross-border operations [51]. Several countries and regions have initiated various projects and strategies to enhance railway integration between Europe and Asia, incorporating global best practices in the process. Türkiye is recognized for its significant advancements and modernization efforts in railway infrastructure, positioning itself as one of the countries adopting global best practices in railways. It has invested substantially in developing a high-speed rail network, connecting major cities across the country. The Ankara-Istanbul high-speed railway, for instance, is one of the flagship projects, reducing travel time between the two cities significantly. This initiative aligns with global best practices in promoting fast, efficient, and sustainable intercity transportation. As the network continues to expand, it is expected to play a critical role in Türkiye’s long-term infrastructure strategy.

4.5.2 Comparing Railways and Roads.

SWOT analysis was conducted to describe the Strengths, Weaknesses, and Threats concerning railways vs roads. This analysis gives us insight into the analysis between the two factors. Below is an illustration of the SWOT Analysis.

Table 4.7: SWOT Analysis.

Strength	Weakness
Economic growth Regional integration Cheap, safe, and eco-friendly Social development	Limited coverage Infrastructure maintenance Regulatory constraints Lack of Financial resources

Table 4.7: SWOT Analysis “Table Continued”.

Opportunity	Threat
Technological Innovation	Political Instability
International Collaboration	Competition from road transport
Policy Reform	Environmental Challenges
Market growth potential	Absence of real-time policy

SWOT analysis shows the comparison of Strengths, weaknesses, opportunities, and threats involved in the railway and road transportation system in Nigeria.

4.6 CHAPTER SUMMARY

International railway case studies offer Nigeria valuable insights into its infrastructure development. The lessons provide insights into optimizing Chinese railway investments by examining successful projects in other countries. These nations have embraced innovative strategies such as electric railways, high-speed rail, modernized facilities, and transparent partnerships with China.

5. RESULTS AND CONCLUSION

5.1 SUMMARY OF FINDINGS

This is the last and final chapter of this thesis research. First and foremost, the dissertation began with an introduction and reviewing the literature, study case, and investigation through which the work gap could be identified solutions to the problems. An analysis of different aspects of the topic has been thoroughly analyzed.

5.2 THE SIGNIFICANCE

The research discussed the importance of railway investments in the 21st century. It is highly encouraging for nations to adopt railway systems and optimize their infrastructure according to global best practices. As seen in the previous chapters, Nigeria and China collaborate in the revitalization of the railway sector of the country which in return yields significant revenue generation. Furthermore, the rail system is more cost-effective than traditional roads. This signifies the advantages and socio-economic developments.

5.3 RESULTS

As a result of researching this topic, it has concluded that the Nigerian Railway Corporation must level up in every aspect to solve the challenges facing the railway sector, this will prevent it from returning to its olden days.

5.4 CONCLUSION

To sum up everything, the thesis project contains chapters, and each chapter explains rigorously the topic matter, the focus of this dissertation is to attract more researchers to help identify the difficulties in railway industries, optimization model, risk management, and the use of advance technology in railway industries can bring a positive solution to the sector.

The Chinese investors are moving at a speed to change the narrative on the development of railways in Nigeria and Africa. Nevertheless, Governments should investigate these firms first before embarking on any kind of contract. It must be a win-win agreement for both countries. We have seen countries falling into debt traps, this action needs to be done under any circumstances.

5.5 RECOMMENDATION AND FUTURE WORK

Based on the research and findings being conducted, it is recommended that future researchers make some findings on the concept of high-speed railway investment in Nigeria. To also focus on the manufacturing plants of steel production factories, the steel factor is the main subject of the development of rail tracks.

The future is bright, more discoveries should be made for the betterment of humanity.



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APPENDIX A

Table A.1: The Function and Characteristics of Train Routine Usage Level.

	Decisions	Occurrence	Percentage
The Modern present train Stations	Agree	13	28.00
	Disagree	25	32.00
	Strongly disagree.	17	21.33
	Neutral	1	2.67
	Strongly agree.	15	16.00
	Total	71	100.00
Safe Stations	Agree	20	25.33
	Disagree	23	29.33
	Strongly disagree.	21	26.67
	Neutral	0	0.00
	Strongly agree.	15	18.67
	Total	79	100.00

Table A.1: The Function and Characteristics of Train Routine Usage Level “Table Continued”.

Stations in good conditions	Agree	23	29.33
	Disagree	23	29.33
	Strongly disagree.	20	25.33
	Neutral	1	1.33
	Strongly agree.	12	14.67
	Total	79	100.00
System favourable	Agree	14	20.00
	Disagree	20	28.00
	Strongly disagree.	30	38.66
	Neutral	3	2.66
	Strongly agree.	8	5.33
	Total	75	100.00
The rail system is strongly reachable	Agree	11	16.00
	Disagree	22	25.33
	Strongly disagree.	40	50.67
	Neutral	2	2.66
	Strongly agree.	3	5.33
	Total	78	100.00

APPENDIX B

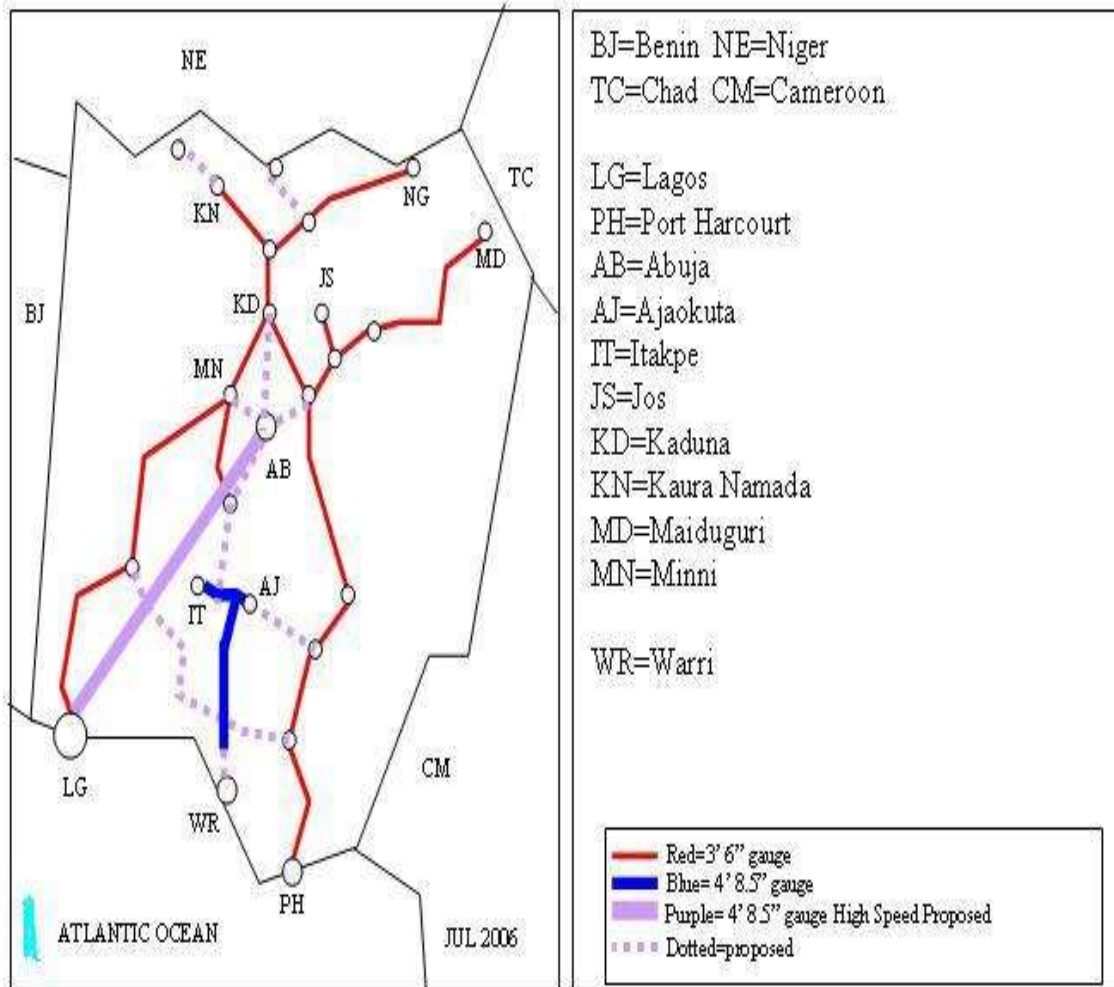


Figure B.1: NRC Network Recommendation.