UNIVERSITY OF NAIROBI

RAIL FREIGHT TRANSPORT OPTIMIZATION, A CASE STUDY OF STANDARD GAUGE RAILWAY TRANSPORT IN KENYA

BY

ELPHAS OYUGI

REG. NO. X50/35830/2019

Supervisor: Dr. Samuel Nyandemo

A Research Paper Submitted to the School of Economics, University of Nairobi in Partial Fulfilment of the Requirements for the Award of the Degree of Master of Arts in Economics

November, 2021

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ACRONYMS

SDG	Sustainable Development Goals
UN	United Nations
COVID-19	Corona Virus Disease-19
UNCTAD	United Nations Conference on Trade Development
UK	United Kingdom
AU	African Union
EAC	East Africa Community
SGR	Standard Gauge Railway
TEU	Twenty Equivalent Unit
FEU	Forty Equivalent Unit
ICD	Inland Container Depot
KPA	Kenya Ports Authority
KIFWA	Kenya International Freight Forwarding and Warehousing Association
KRC	Kenya Railways Corporation
WTO	World Trade Organization
OOR	Office of Rail and Road
UIC	International Union of Railways
IBEF	India Brand Equity Foundation
SCEA	Shippers Council of Eastern Africa
CS MOT	Cabinet Secretary, Ministry of Transport
EU	European Union
NICD	Nairobi Inland Container Depot

AfDB	African Development Bank
ICD	Inland Container Depot
KRA	Kenya Revenue Authority
EU	European Union
MGR	Meter Gauge Railways
ARIMA	Autoregressive Integrated Moving Average
ANOVA	Analysis of Variance

AKNOWLEDGEMENT

I am thankful to the University of Nairobi, and in particular the School of Economics for exercising the integrity of higher studies, and to be specific, register a special acknowledgement to my supervisor *Dr. Samuel Nyandemo* for his dedicated thorough guidance he accorded me during the course of my research project. Further, I extend my deepest appreciation to the lectures of the School of Economics in addition to some key industry practitioners, together with my fellow classmates for their inputs and contributions to my research paper. Finally, I say a big thank you to God that has made everything possible for the success of my research project.

DECLARATION

This research paper is my original work, and has never been presented to any other university for the award of a degree

Signature…   Date: ***30th November, 2021***

Supervisor

This research paper has been submitted for examination with my approval as University Supervisor.

Signature…………………………………   Date…1/12\2021……………………

ABSTRACT

Railway freight transport systems involve integration of complex decision processes which aim at improving overall efficiency of the systems. Depending on the nature of the working environment, optimization of railway freight transport performance requires compound mathematical formulation and/or programing. Optimization of railway freight transport is a sub-class of transport problems in operations research. This study aimed at optimization of freight transport through standard gauge railways (SGR). The study examined factors influencing SGR revenue collection and how such factors can be modeled or adjusted to increase revenue collection. This study was anchored on optimization theory. Both qualitative and quantitative methods were used in this study. Qualitative results showed that main operational challenges, in order of weight, included inadequate capacity, multiple handling and scarce labor, uncoordinated operations and planning, SGR network infrastructures limitation, exorbitant charges and poor communication. It was also observed that suitable remedies to these challenges included formulation of integrated transport policy, adoption of appropriate capital and financial policy allocation system, merging KPA and KRC and reviewing SGR freight tariff, among others. For quantitative responses, time series and regression models were used. In the former model, revenue collection since January 2018 till April 2021 exhibited a general increasing trend. This was further confirmed using exponential smoothing, an aspect of time series modeling. Key factors that influence revenue collection were observed to be number of available wagons and transit time. From regression modeling, number of available wagons has a significant positive influence while transit time influences revenue collection negatively. This is true since the corresponding p – values were less than 0.05. Based on these observations, the study

recommended that the proposed policies and strategies be implemented to improve freight capacity and revenue collection of SGR freight transportation.

CHAPTER ONE: INTRODUCTION

1.1 Background of the Study

A reliable and efficient transport network system plays a major role in the global trade. With the rise of international trade, the demand for a sustainable transport network is necessary. The UN Sustainable Development Goals specifies that economic growth and development can be driven by a well interconnected transport infrastructure network (United Nations, 2021). Investments in infrastructure is therefore essential in achieving sustainable development agenda, by promoting and facilitating international trade. The rise in global commerce, and various trade agreements among countries, regions and continents has driven global trade flows. With the use of advanced technological innovation, industrial production output has improved significantly, a factor that has influenced increase of global commerce. According to UNCTAD, the global e-commerce has been on the rise yearly, with a record of $ 25.6 trillion by 2018 (UNCTAD, 2020). However, COVID-19 slightly reduced global economy, though it has strengthened multilateralism, with a renewed push for global trade agreements and rule-based international trading system. This has contributed to stronger global trade growth. Again, from Global Economic Outlook Report (2021) of the World Bank, it indicated that global trade is expected to experience a model pickup to an average of 5.1% for the year 2021-2022 (World Bank Group, 2021). Moreover, Oxford Economics, in its latest baseline forecast, also indicated that world trade to grow by 2.6% per year from 2020-2030 (Oxford Economics, 2020).

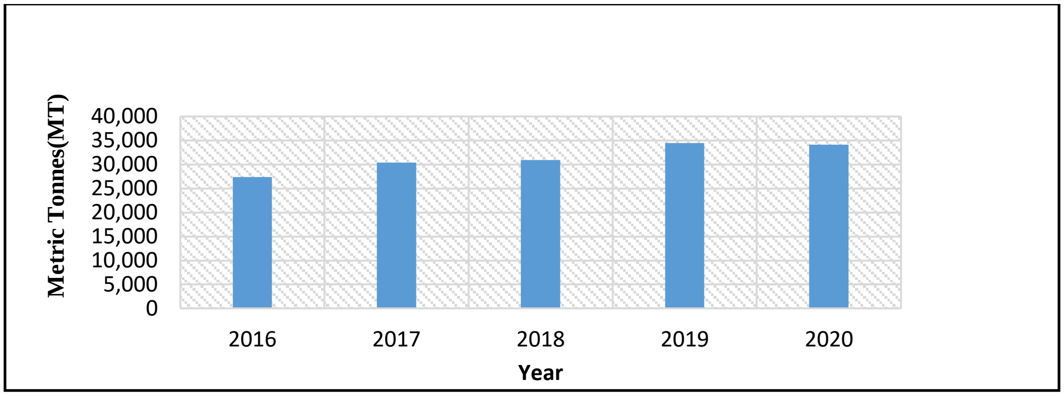
As a result of global trade growth forecast above, many countries are therefore paying close attention to the sustainability of freight transport. Among other transport modes, rail transportation is considered to be the only transportation mode that is effective, cheap and a reliable means of global freight transport. Emerging economies such as China, UK, and India are some countries that have mobilized resources to expand railways infrastructure network as a move to strengthen and expand both regional and global supply chain network. In reference to global ranking of rail network in size, China is the second, while India is taking third position, including UK, also one of the countries taking the lead (UIC, 2021).

Essentially, global rail freight transport market is expected to continuously grow from $247.39 billion in 2020 to $271.87 billion in 2021 at a compound annual rate of 9.9% (Businesswire, 2021). For example, India, with over 9000 freight trains operating daily, accounting for 10% of the global market share, made progressive performance growth every year. In the first quarter 2021 performance, Indian railways freight loading stood at 109.68 million tonnes, compared to 100.96 million tonnes for the year 2019. However, in terms of revenue earning, in 2020, the Indian railways earning was $1.44billion from rail freight loading, an increase of 4% compared with $1.38billion in 2019 (IBEF, 2021). Meanwhile, for the UK whose railways system considered to be oldest in the world, a robust network expansion and development with advanced technology has transformed its transport infrastructure. As indicated in quarter one report for the year 2021, UK rail freight performance has been on an upward trend. The report further showed that freight moved in 2020 increased by 12%, equivalent to 17.8 million tonnes, compared to performance record, 2019. (Office of Rail and Road, 2021).

One of the key flagship projects under Agenda 2063 of African Union is integration of African with high-speed network that aims at connecting all African continent capital and commercial centers through high-speed trains to facilitate movement of goods and services (African Union, 2019). Towards actualization of the African Union Agenda 2063, infrastructure investment to step-up cross-border rail freight has gained momentum across different parts of Africa, a strategy to increase economic integration, industrial development, poverty eradication, and access of new regional markets within the landlocked countries. For instance, East African Community (EAC) has adopted railways master plan that guides railways infrastructure development for long distance freight. The plan recommends the rehabilitation of existing old meter-gauge rail network, that is seen to meet the railways demand by year 2030, and explore investment into Standard Gauge Railways (SGR) that would have direct benefits in terms of capacity, open more regional markets, reduce transport logistics cost, and offer great business opportunities in the region (EAC, 2018). In addition, EAC in its Vision 2050, aspires to have high speed capacity trains, placing priority on improving inter-state road and rail links, connected to the inland waterways with a view to make freight logistics cost-effective and fasten market accessibility (EAC Vision, 2030).

1.2 The Port of Mombasa and Annual Trade Growth

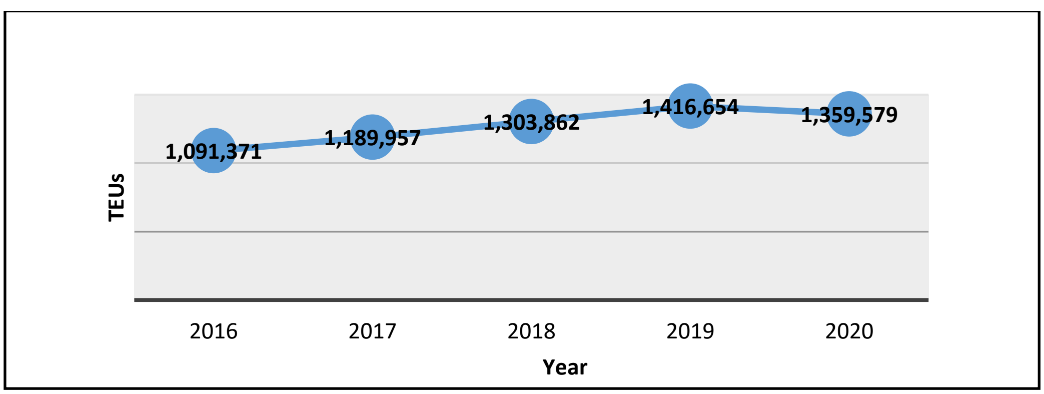
In line with EAC Vision 2050, one of the components of economic pillars of Kenya's Vision 2030 was to have a firm interconnection between railways infrastructures and other modes of transport from the port of Mombasa to the hinterland, along the northern corridor. Proximity of Mombasa port provides direct connectivity to over 80 ports worldwide. In addition, the port also acts as a gateway to regional trade of East and Central Africa, which facilitates movement of goods to the regional markets, and in particular, landlocked neighboring countries. At present, the capacity of the port is 2.65 million TEUs (KPA, 2020). Mombasa port throughput performance continues to grow, rising from 30.92 million tonnes in 2018 to 34.44 million tonnes registered in 2019, representing a significant growth of 11.4%, see figure 1.1(KPA Bulletin Statistics, 2019). The significant throughput performance of the port, resulted from improved port efficiency and expanded modern rail and road infrastructure network development, linked to the port infrastructure facility and hinterland terminals and logistics centers.



Source: KPA

Figure 1.1: Annual Port Throughput for 2016-2020 ('000'MT)

Equally important, for the analysis of the annual capacity in TEUs shown in figure 1.2, Port of Mombasa has achieved performance growth from 1.09 million TEUs in 2016 to 1.4 million TEUs in 2019, with a slight decrease to 1.3 million TEUs in 2020 due to Covid-19 pandemic interfering with global supply chain performance. The capacity growth at the port has been reported to be attributed by expansion and development of transport and terminal infrastructures, in addition to sustained increase of use of containerized freight cargo that is easily handled in multimodal transport system, both at the port and terminals at hinterland. Other driving factors were fluidity at the transit cross borders and inter-regional trade cooperation.



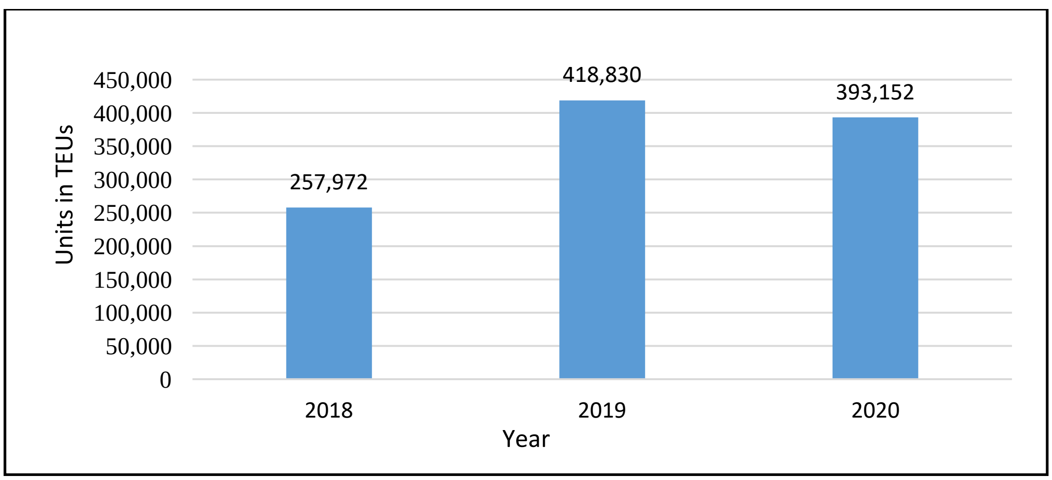
Source: *KPA*

Figure 1.2: Annual Capacity Performance in Mombasa Port in TEUs, 2016-2020

1.3 The Kenya's Railway Network and Rail Freight Transport by SGR

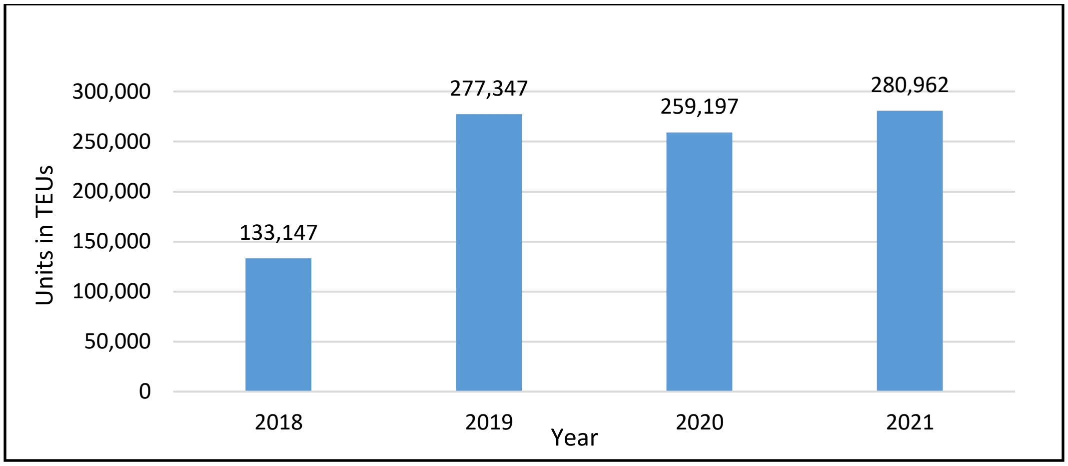
The 2009 Master Plan for East Africa Railway provides for the SGR between Mombasa-Nairobi as phase one, then phase two of Nairobi-Malaba, divided into three sections; Nairobi-Naivasha, Naivasha-Kisumu and Kisumu-Malaba, to be interlinked with other SGRs being constructed by the partner states of East Africa Community (NCTTCA, 2021). In the context aforementioned, the Government of Kenya, guided by its Vision 2030 Economic Blueprint, constructed a single-track SGR between Mombasa to Nairobi whose route length of 480km-long and a total length of 609km, with an additional extension of 120km from Nairobi to Naivasha (KRC, 2018). However, considering the role of Mombasa port in global supply chain and the regional markets of East and Central Africa, SGR infrastructure is connected to the port to enhance its sustainability and effectiveness. Further, to enhance SGR viability, its linkage to achieve both, first and last miles connectivity for seamless movement of freight has been fully considered as a key development project. The Government has therefore embarked on revamping and refurbishing locomotives for the old meter-gauge lines from Nakuru-Malaba, Kenya/Uganda border and Nakuru-Kisumu port in Lake Victoria. In addition, to boost reliability of SGR, Kenya Railways currently face-lifting and connecting the old meter gauge to Longonot, Thika and Nanyuki lines to the SGR. According to Kenya Railways, the revitalization of the old meter gauge rail lines will play a significant role in sustaining business, as well as creating the requisite cargo volumes to leverage the SGR and cement its viability (STAR, 2021).

Meanwhile, SGR viewed as a critical milestone development to accelerate economic growth, and anticipated to provide much efficient, faster and reliable transport mode to facilitate continuous movement of freight within Kenya and beyond her borders of East African Region. Similarly, the SGR was intended to decongest Mombasa port, offer higher efficiency and productivity, and possibility of opening new markets in East and Central Africa. Consequently, the SGR was intended to speed up development of business along the transit corridor by reducing logistics cost (Juma, Gogo, Abdulkadr, & David, 2020). However, as mentioned earlier, the cargo dwell time at Mombasa port has improved as a result of increased cargo evacuation by SGR, a reason of performance growth in annual port throughput and traffic capacity as shown in figure 1.3 and 1.4, respectively. Again, as indicated in figure 1.3, the SGR annual capacity in TEUs of containerized cargo to and from Nairobi ICD recorded a positive improvement from 2018 to 2019, with a slight decrease in 2020. In figure 1.4, the analysis from 2018-2021 between January to August for each year, there was a slight positive margin in 2021 compared to 2020, though 2019 performance was much better compared to 2018 and 2020. However, for the Naivasha rail freight terminal depot, since its operations begun in October, 2019, for the annual performance for the year 2020, Naivasha only managed to handled 10,029 TEUs, both for export and import, and only 12 trains have transited to Naivasha ICD from Nairobi ICD between the month of January and July, 2021, see figure 1.3.



Source: KPA

Figure 1.3: Annual Capacity Performance in TEUs at Nairobi ICD for SGR



Source: KPA

Figure 1.4:Capacity Performance in TEUs for Nairobi ICD from Jan-Aug, 2018-2021

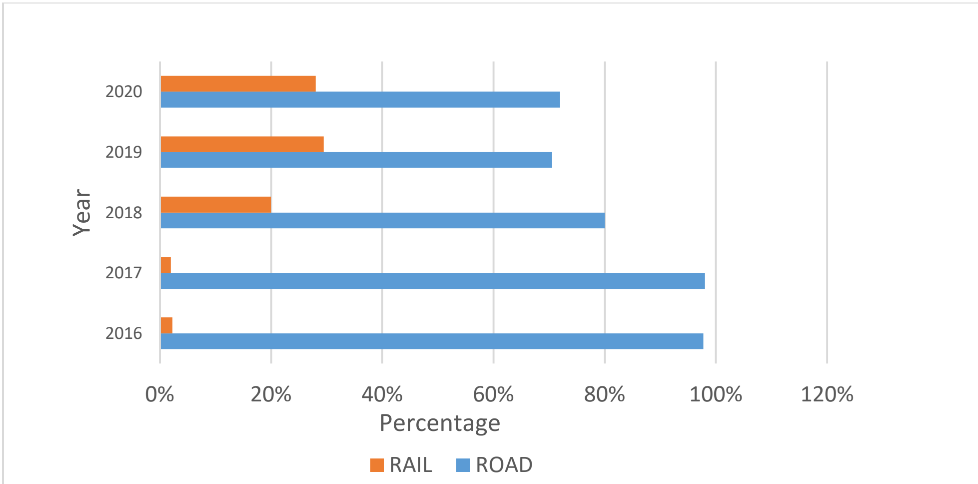
Table 1.1: SGR Performance at ICD Naivasha

Year	Imports (TEUs)	Exports (TEUs)	Import (No. of Trains)	Exports (No. of Trains)
2020 (May-Dec)	8610	1419	87	63
2021 (Jan-July)	311	79	7	5

Source: KPA

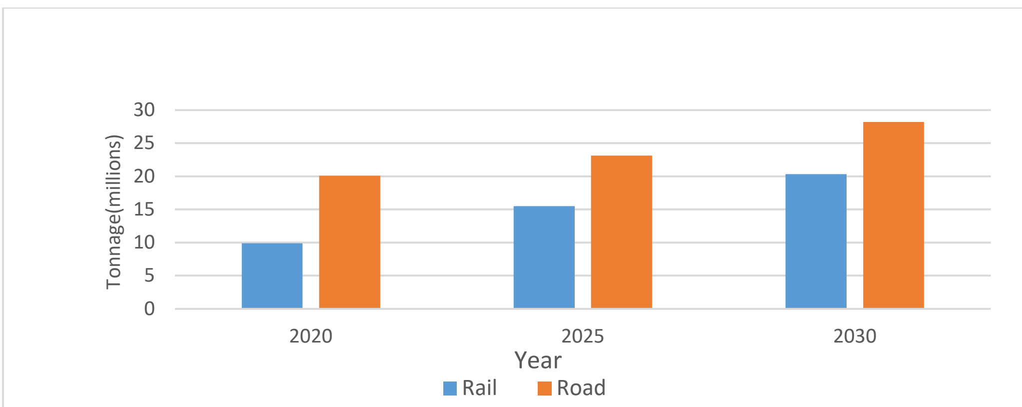
1.4 Road Verses SGR on Freight Transport

Ideologically, sustainability strategy of railways transport is about capacity, speed and operational cost. Currently, in Kenya, freight transport between the port of Mombasa and its hinterland is competitively between road and rail. By June 2017, road handled more than 95% of the freight moved from Mombasa port, an indication that trucks influenced cargo shift from rail to road (API, 2017). However, annual performance of SGR has recorded progressive improvement from 28% in 2018 to 40% in 2019 as indicated in figure 1.5. Nonetheless, figure 1.6, it is evident that percentage share of total imports and exports, road as an alternative mode of freight transport still gives rail transport a higher competition.



Source: KPA

Figure 1.5: % Cargo Share by Rail and Road Between Mombasa-Nairobi

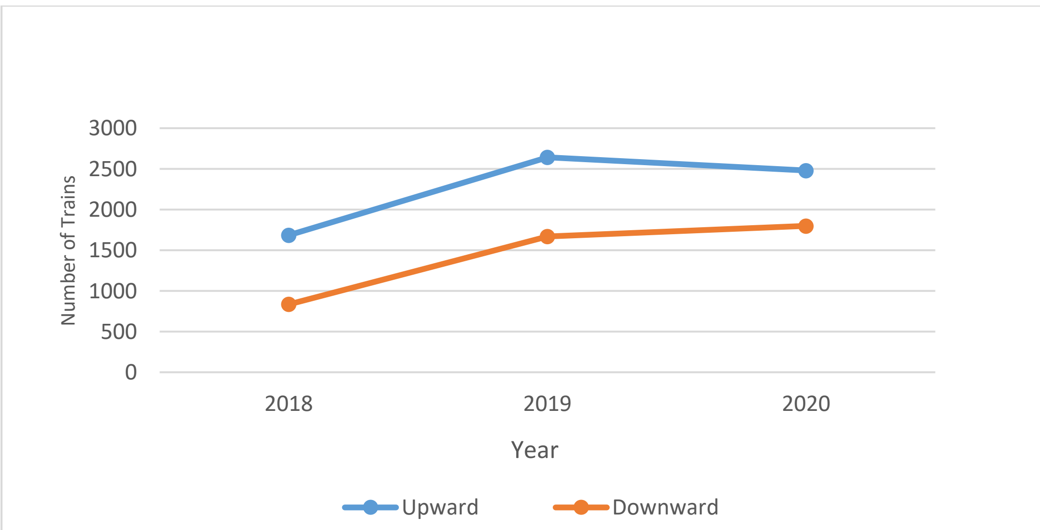


Source: JICA

Figure 1.6: Projected Road and Rail Tonnage Capacity Share for 2020-2025-2030

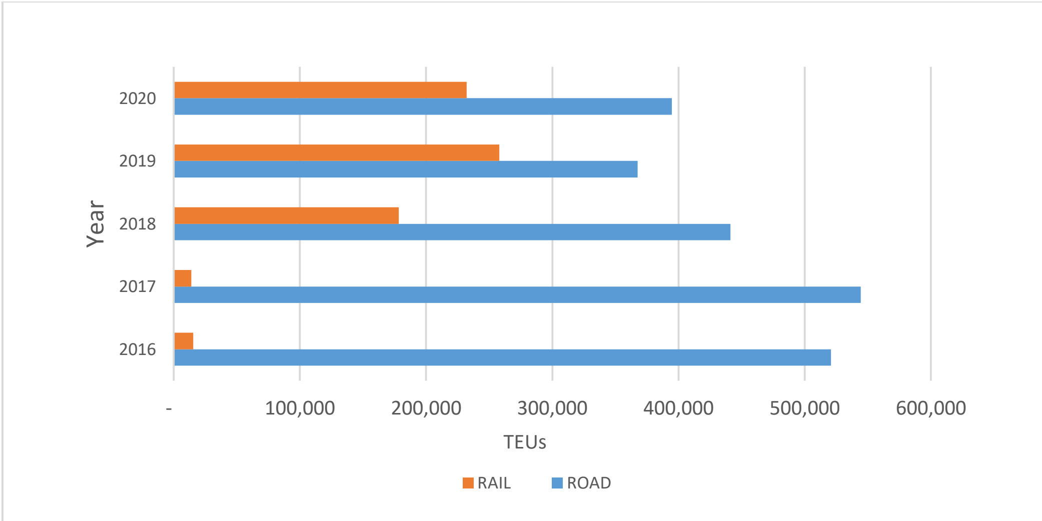
For the year 2021, freight trains from Mombasa Port to Nairobi Inland Port recorded a decline from 242 to 187 upward direction, and 158 to 112 downward directions from Nairobi Inland Port to Mombasa Port, for January and April respectively (SCEA, 2020). As indicated in figure 1.7 the number of trains for both imports and exports moved by SGR decreased from 2019 to 2020, though 2018 to 2019 recorded a positive trend. At the Nairobi Inland Container Depot, the freight train terminal, only 393,152 TEUs were handled for the year 2020, compared to 418,830 TEUs for the year 2019, a decline of 25,228 TEUs, equivalent to 6%, see figure 1.3.

Meanwhile, the performance for 2019 and 2020 were far much below the SGR annual capacity required at the Nairobi ICD, whose annual capacity is 450,000 TEUs. Again, from figure 1.6, the feasibility study report by JICA indicates a projected road and rail tonnage for the year 2020, 2025 and 2030. From the JICA report, railway tonnage share will be 33% by 2030, while road tonnage share will be 46% for the same year, hence truck traffic will be 1.54 times in tonnage by the year 2050 (JICA, 2017). One of the local daily newspapers "The Standard' (2014), reported that World Bank cautioned Government that SGR would only prove some economic sense if it could receive between 20-50 million tons of freight annually, considering that much cargo is still hauled by road from the port of Mombasa to its hinterland (The Standard, 2014).



Source: KRC

Figure 1.7: Number of Trains (Upward and Downward, 2018-2020)



Source: KPA

Figure 1.8: Capacity Share Evacuated by Rail and Road in TEUs 2018-2020

1.5 The Existing Challenges

As indicated in figure 1.1, annual performance throughput at the port of Mombasa has steadily increased in the recently years due to reduction of cargo dwell time, attributed by cargo uptake by SGR, as well as increase of use of containerized cargo that is easily handled in a multimodal transport network. Nonetheless, operations of SGR still experience cyclical challenges, giving road as an alternative mode of transport a competitive advantage. Several latest industry reports have indicated dismal performance of SGR since its operations begun in 2017. For instance, in its first year of operation, Taylor (2020) underlined that the cabinet secretary of ministry of transport reported that SGR made Ksh 9.8 billion loss, largely because of low cargo business. Subsequently in 2018, only 5.038 million tonnes were transported from Mombasa port to the container depot in Nairobi (Taylor, 2020).

The operations of SGR have been facing unending challenges which has made it less attractive for cargo owners, both exports and imports, a major factor of its under-performance. For example, the monthly average storage cost of freight containers delivered by SGR at the NICD has reached $118,245 from $73,006 between the month of March and April, 2021, which in addition, requires cargo owners to pay storage cost of between $ 68,660-135,310 per week (SCEA, 2020). Average cost of transportation by road from Mombasa port to Nairobi for 20TEU and 40FEU is $650 and $850 respectively, while for rail transport to NICD from Mombasa port, 20TEU and 40FEU is $1420 and $2120 respectively, according to a report of Joint Technical Committee on the implementation of efficiency and cost-effectiveness of transport of cargo by SGR. The committee further stated that upon cargo arrival at the Nairobi ICD, last mile logistics cost of Ksh 15,000 and Ksh 20,000 is incurred for road transport by truck for 20TEU and 40FEU respectively to the premises of cargo owners. In addition, other associated costs related to rail transport such as handling, storage, remarshalling, demurrage, and return of the empty containers were cited in the report making the logistics cost by rail twice much higher compared to road transport.

Meanwhile, one key essential factor for putting railways a more competitive mode in the transport sector is high traffic density, hence low transport volume has dire impact in the higher costs of its operations, that subsequently increases the logistics costs higher, according to (Olievschi, 2013). Therefore, transport sector is a factor that for many decades intensified the trade growth, and in particular, the freight transport by rail is typically more competitive over long voyage. To be feasible, rail requires higher trade volumes (AfDB, 2015). Developing economies are therefore after transport mode that enhances freight movement at the lowest possible cost (Nancy, 2020).

1.6 Statement of the Research Problem

Conceived as a flagship project under the Kenya's Vision 2030 development agenda, the government of Kenya developed a modern standard gauge railway (SGR) infrastructure. Upon completion, the SGR operations for freight transport services from the port of Mombasa to the Inland Container Depot Nairobi begun in January 2018, while for Naivasha container depot begun in October, 2019 (Railways Technology, 2014). However, since the operations begun, the expected annual freight capacity for the SGR has never been achieved, with most downward trains and wagons to Mombasa port from the rail freight terminals from Nairobi and Naivasha in many occasions running empty. Further, the upward trains from Mombasa port to rail terminals in Naivasha and Nairobi depots has never achieved the full freight capacity required due to higher competition from freight-truck transporters. This in addition has denied SGR freight transport meet the revenue targets and achieve the minimum logistics cost for freight transport by rail. Therefore, for sustainability and viability of SGR, rail transport requires adequate freight volumes, both downwards and upwards.

Again, the operation of SGR for freight transport has experienced cyclical challenges citing reasons for annual dismal performance. For instance, additional operational costs in rail logistics have been found to be too high and many as compared to other modes of transport such as road. Thus, most cargo owners, importers and exporters, still prefer road haulage transport service instead of rail freight transport, despite challenges that road transport presents.

Furthermore, sustainable transportation and climate change is a global concern. Since road transport is one of the major contributors for carbon emission, its negative impacts into the environment are high, hence need for policy strategy for adaptation and mitigation of the impacts of climate change. In regards to that, road transport for freight from Mombasa port has been taking a lead for the last decades, and according to the future freight transport forecast by JICA, road transportation will still control bigger freight share by the year 2050 from the port of Mombasa across the Northern Transit Corridor to the hinterland. For the future sustainability of the environment, climate change campaigners and activist are therefore sending a global call that bulk freight should move on rail transport from road.

1.7 Justification of the Study

Since the standard gauge railways begun cargo transport operations in early 2018, unending operations challenges has been experienced to present, both at the port and inland container depots. This has contributed to dismal productivity, inefficiency and high service costs on the freights (KPA, 2019). Rail freight turnaround time at the port and the inland container depot in Nairobi has been reported to be long, taking between 9 to 11 hours, for either loading or offloading which is attributed by lack of proper operations planning, a factor that contributes to inefficiency and tardiness. In addition, rail freight transportation bares more additional logistics costs. For example, the monthly average storage cost of a freight container delivered by SGR at the Nairobi ICD has reached $118,245 from $73,006 between the month of March and April 2021, which requires cargo owners to pay storage cost of between $68,660-135,310 per week (SCEA, 2020). On the other hand, average cost of transportation by road from Mombasa port to Nairobi for 20TEU and 40FEU is $650 and $850 respectively, while for rail transport to Nairobi ICD from Mombasa port, 20TEU and 40FEU costs $1420 and $2120 respectively if other costs are summed up, according to Joint technical committee on the implementation of efficiency and cost-effectiveness of transport of cargo by SGR. The committee further stated that upon cargo arrival at the Nairobi ICD, last mile logistics cost of Ksh 15,000 and Ksh 20,000 is incurred for road transport by truck for 20TEU and 40FEU respectively. In addition, other associated costs related to rail transport such as cargo handling, remarshalling, demurrage, and return of the empty containers is reported to be still high. All these costs summed up makes the logistics cost by rail twice more compared to road for freight transportation.

As a result of unending operational challenges mentioned above, among others, SGR freight transport has never achieved its annual performance target. For instance, for the year 2018, only 257,972 TEUs were handled by SGR, while for the year 2019 and 2020, only 418,830 TEUs and 393,152 TEUs were handled respectively, a performance below the targeted annual capacity at the Nairobi inland container depot for SGR. Further, at Naivasha inland container depot, for the year 2020, between the month of May and December, only 10,029 TEUs was handled by SGR which is far below the annual performance target of 72,500 TEUs. Nonetheless, from January to July 2021, only 12 trains delivered 390 TEUs of cargo to Naivasha container depot. Again, for the year 2021, between January and April, freight trains from Mombasa port to Nairobi inland port recorded a decline from 242 to 187 upward direction, and 158 to 112 downward directions (SCEA, 2020).

Also, from the analysis of percentage share of cargo carried by rail and road annually, road still gives rail higher competition for cargo transport, both for export and import. Although rail transport has recorded little improvement for the last three years. Generally, as a results dismal performance resulting to low-capacity output, SGR freight services stills continues to struggle for revenue targets, triggering Government directives and interventions to shift more freights to the rail in a bid to make SGR investment sensible and for its future sustainability (Juma, Gogo, Abdulkadr, & David, 2020).

Moreover, cargo owners prefer road than rail for cargo transport, however, road transportation comes with more challenges and negative impacts. As documented in JICA report, road will still take a bigger share of freight by 1.54 times than rail by the year 2050. This therefore pose more danger on the road that will continuously results to; road accidents and transport congestion, negative social impacts, increased harmful environmental impacts such as pollution, calling for environmental sustainability and climate change strategy (NCTTCA, 2021)**.** Freight transport by road also bares a couple of additional challenges such as damage to the road, theft of cargo on transit, constant wear and tear, and long transit hours that comes with fatigue for truck drivers. Thus, in the spirit of trade facilitation, guided by the WTO Trade Facilitation Agreement, transportation of cargo by road is not economical for international trade, and supportive to development of a nation. This implies that, for a country's trade products to remain competitive in the global market, efficient access to a reliable, cost-effective and affordable transport system remains paramount. Hence access to a well-functioning railway transport system enables seamless trade flows by reducing multiple logistics costs. A legislative framework and policy strategy are some key critical tools required to influence increase of freight transportation by rail from road.

This study thus intends to explore how best freight transport on rail network can be optimized with a focus on standard gauge railways system in Kenya.

1.8 Objectives of the Research

1.8.1 General Objective

The proposed study is based on the general objective of optimizing freight transport on standard gauge railways transport system in Kenya.

1.8.2 Specific Objectives

Specific objectives of the proposed study will be:

i. To examine operational challenges of freight transport on SGR transport network.

ii. To establish strategies for addressing operational challenges of freight transport on SGR transport network.

iii. To construct a time series model for forecasting revenue collection of freight transport on rail transport network

iv. To construct a multiple regression model relating revenue collection of freight transport on rail transport network and freight tonnage, transit time, train turnaround time and freight capacity.

1.9 Research Questions

From the specific objectives, the study will be guided by the following research questions:

i. What are the operational challenges of freight transport on rail transport network?

ii. What are the strategies for addressing operational challenges of freight transport on rail transport network?

iii. How can returns of freight transport on rail transport network be maximized using optimization model?

iv. How do freight tonnage, transit time, train turnaround time and freight capacity influence revenue collection of freight transport on SGR transport network?

1.10 Scope of the Study

The proposed study will concentrate on the railways transport industry. In particular, the study will focus on standard gauge railways with attention on freight transport, between Mombasa port and railways freight terminal in Nairobi inland container depot. Further, the study will encompass the sea port sector, inland container depots (dry ports), hinterland logistics hubs, railways operators, and the railway regulatory authority. Moreover, study will obtain information from Kenya Railways Corporation, Kenya Ports Authority, other public entities and private sector players in the railway industry in Kenya.

1.11 Significance of the Research

The proposed study seeks to explore how best freight transport capacity on rail network can be optimized with a focus on the standard gauge railways system in Kenya. The study shall, at its completion, formulate policies that will be significant in instituting performance strategies suitable, both to railways operators and railways regulatory agency. Equally important, the study's findings will be used as a tool for literature development on rail transport network, both in the railway industry and academia.

1.12 Limitations and Delimitations

The study may encounter some conditions and shortcomings that may influence the outcome of the findings of this research.

Limitations that the study may encounter could be; incompleteness or difficulty to control entirety of data and other relevant evidence to effectively arrive at a verifiable conclusions and recommendations of the study.

However, for delimitation, as a researcher, there could be a possibility of encountering influence of boundaries and choices mode.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

This chapter encompasses some literature sources that explored and focuses on the optimization of railway transport operations and services, particularly in the freight transportation industry. It also entails theoretical framework, in addition to a conceptual framework. Subsequently, the empirical review section discuses some various related studies that were conducted on the subject of optimization modelling.

2.2 Theoretical Review

This study shall be guided by two theories, Optimization theory and Modernization theory.

2.1.1 Optimization Theory

From Oxford dictionary, optimization is defined as a process that makes something effective and perfect. Nonetheless, Cambridge dictionary defines optimization as a process that makes something as effective as possible. A common thing therefore appears from the two definitions, that is, perfection of a process, method or design to achieve effectiveness. History proves that much previous literature used the concept optimization in 100 BC for calculating distance between the two points (Sinha, 2020). However, from Wikipedia, optimization was studied in the seventeenth and eighteenth centuries. Certainly, with much improvement and development in the areas of science, technology and mathematics, good attempts have been made to achieve better performance of applying optimization in real life situations. Similarly, advanced techniques in computing, optimization have received attention from researchers in various fields to handle numerous practical problems (Tsai, Carlsson, Ge, Hu, & Shi, 2014). Therefore, some specific objectives of this study will be addressed through the application of the optimization modeling.

2.1.2 Modernization Theory

Modernism is used to justify implementation of a process, more so in least developed nations visa vie developed states, both in economic success and democratic stability that is achieved through economic well-being, advanced technology, mobility and transport (Tipps, 1973). Essentially, modernization theory begun in the early 1950s that examined how civilized western societies ascended to development that resulted from a progressive transportation and communication through a modernization process as regions becomes more urbanized (Hussain & Tribe, 1981). Meanwhile, theoretically, in Africa, to be specific in Kenya, the connection between transport infrastructure system and modern development appears to be evident. Hence, an efficient and reliable transport infrastructure network provides a modern connectivity condition that are critical to the movement of people and commodities. In essence, nations that are progressing to modern economy like Kenya, are after means of transport that increases the regional connectivity and integration, mobility of her people, and the movement of goods at the lowest possible cost with highest returns. Therefore, rail transport should be given the most priority as the best alternative mode of transport for the reasons mentioned above.

In sum, by applying the modernization theory, the study explores optimization of rail freight transport, considering its critical role to the transformation of Kenya towards enhanced service sector and economic growth.

2.3 Empirical Review

This section underpins closely, previous related study on the optimization modelling of freight haulage in the rail transport sector. It also unveils theories and concepts applied, and defines gaps that supports this study.

Alaghband and Moghaddam (2019) in their study, examined how optimization of freight logistics on a single rail track with a focus on scheduling and allocation of cargo to freight trains. Their study explored on minimization of trip time of train in a single line corridor, and allocation of cargo to scheduled freight trains. The author's expected results were to maximize freight, and minimize reduction of tardiness of freight at the end point of destination. Integer linear programming models was used, supported with an integrated heuristic algorithm to address train allocation and scheduling in a railway network system, exclusive to freight trains, that revealed an acceptable solution within the constraints of the objective functions. Meanwhile, their study findings further showed that the algorithm used achieved quite well, with an indication of a better performance output.

A benchmark study on freight routing and scheduling within the carload service segment, with an aim to produce rail trip plan through an optimization model (Backaker and Krasemann, 2012). Their study pointed that rail freight operators manage a couple number of various service segment, of which is the load car service segment that cascades and distributes the freight down into a unit of single rail car. They found that high level of flexibility obtained, resulted in the way trip plans are designed. Further, the authors found that every transport demand, such as, rail car, is allocated a route and a schedule through train service availability within the network, which shows that flexibility appears in terms of routing and the scheduling points. Consequently, the authors recommended an optimization-based freight routing and scheduling (OFRS), as a strategy to deal with the rail freight trip plan generation problem. The OFRS strategy used, involves a mixed integer linear programming formulation. In their study findings, results showed that OFRS application registered a reduction in the total transportation times, and a significant reduction in the service frequency transport demand.

Industry experts in the rail freight sector reveals that management of the operational cost to a minimum level is a key factor of making rail transport much more attractive mode of freight haulage. Vorobyov, Reger and Tanaio (2018) investigated a cost management model on railway operations, an optimization of a mathematical model for logistics system on transportation, storage, and cargo handling operations. Their study explored optimization criterion as aggregate cost reduction, where cost function was applied as a local function of numerous segments along the network of railway. However, modeling result included plans of transportation and supply with lower costs. The authors conducted the study by spatial and dynamic models that were found the most efficient. In their findings, cost functions obtained indicated optimum number of load batches distribution in rail transport network, recorded to be more applicable within the service level needed by rail users in the economic system of a state, and its regions of the area of the study.

Strategy of shifting freight transport from road to rail seems to be a very exciting area of study by scholars in the transport sector. Bortas I, N and C (2018) examined in their study, cargo transport route optimization from road to inland waterway and rail transport, with an aim of reducing the transport costs, transport congestion and environmental pollution. In their research, scientific methodology was applied, where factors affecting delivery of freight flows through intermodal transportation were analyzed using fuzzy logic to make optimization model. Their results showed that the selection of fuzzy logic modelling system was considered best mathematical apparatus for handling undefined and ambiguous data, based on objective functions for calculations. Hence, in their results, by testing the optimization model, optimum choice and selection of the transport route was found to be successful. The assessed variables, however indicated that an optimum choice of traffic and transportation of cargo was railway transport, but through intermodal transport network. Results further showed that railway traffic was an optimal choice of transport through the intermodal transport corridor. Meanwhile, their findings also proved that the model offers a better traffic scheduling, and a better support in the transport mode choice.

Another key factor that determines performance level in operations is planning. Rail planning for effective and efficient operations is progressively gaining more attention on research in the transport industry. Research done by Maia and Couto (2013) to institute a supporting tool for planning and policy decisions, specificaly to improve rail network. Based on strategic traffic model, an optimization model was applied to establish macronetworks, with a focus on cargo traffic at international, regional and national scale. The optimization model further applied a search heuristic to ascertain a balance between effectiveness and efficiency on cargo transfer within a reasonable time. The objective of the authors was to find out how transportation network be improved to maximum level on network optimization model. The model was developed for the assignment of traffic on road and rail network, and other corresponding network links, like the case of intermodal terminal, connecting the rail and the roard networks. The author's empirical evidence revealed that rail as transport mode was much likely to be relied on and used as a result of its capacity compared to raod. The model further pointed that rail transport maybe improved to meet the optimization of rail network.

Arnold, Peeters and Thomas (2003) published a transport research paper that presented highlights on modeling rail-road intermodal network system by optimization. Their study aimed at finding the impact of changes in the supply of transport on modal shares in the flows of freight transportation. The researchers formulated a linear programming, solved by a heuristic approach. Consequently, an alternative hub-type formulation was applied, based on multi-commodity fixed-charge network design problems. However, the model shows that specific transport supply chain decision effect be considered at local level, while downstream effects reveal that much criteria needs to be used to evaluate changes in the transport system. At the end, the optimization solution appears to be almost optimal with a better balance of rail/road distribution.

A most recent study conducted by Hickish, Fletcher and Harrison (2019) investigated a rail network optimization by a Bayesian Optimization against a genetic algorithm, the first application of its kind, according to the author's knowledge. The authors intended to enable rail network service providers to improve the performance of their network. From the author's investigation, Bayesian Optimization implementation creates an approximation using proprietary optimization. The algorithm computation registered a faster task with more trains, according to the data used. The results therefore indicated improvement of the targeted performance, resulting to exponential rise in the number estimation to be achieved by the Bayesian Optimization.

Crainic, Ferland and Rousseau, (1984) examined scheduling train services and freight routing traffic in response to a fierce competition faced by rail, while targeting an increase of market shares in the freight transportation sector in Canada. Nevertheless, their key goal was to establish a good level operating strategy, and a tactical planning that's more reliable and economically sound. Their study dealt with parameters which includes; train and traffic routing, blocking, and resource allocation. Under these parameters, the authors developed an optimization model, aimed to integrate trade-offs between operations of the trains and traffic, with an objective of achieving best operations strategies at a minimal cost, while providing service quality. The application of the model, generated a nonlinear mixed integer, in which a heuristic algorithm applied for good solutions at a reasonable period of time. However, from the author's findings, the optimization model results were quite impressive, in which the operating cost was at minimum level, and the service quality attained as well.

Planning and operating railway transport network system is quite an enormous uphill task, considering its huge size, technical nature and the complexity. The technicality and complexity of the rail challenges can be enhanced and addressed by mathematical models and optimization techniques to gain the railways operations aspects of cost reduction and service quality. It is within these aspects that a research investigation conducted by Borndörfer, et al. (2015) looked at the success stories on optimization of railway transport network. The authors demonstrated a concrete application of mathematical optimization with an attempt to establish railway planning and operations for a better efficiency, and with a focus on freight train routing, at a strategic planning level, within a simplified transport network. The author's primary objective was to find a tactical solution to meet challenges of the railway sector. Certainly, the findings pointed that the mathematical models and optimization illustrated a greater efficiency of railway operations, and this calls attention for innovative tool to meet repeated challenges of the railway industry.

Another area reviewed that is potentially of interest, is an optimal model for the rail freight train movement. Charnes and Miller (1956) study attempted to apply a technique to manage some scheduling hitches. The author's intention was to establish an evolution of the special methods of analysis of the models. They applied a programming model on train scheduling tested on railroad against the actual operating schedules. In view of the authors, an encouraging rail motion in a long run planning level was quite sufficient. At the end, the formulated programming model used in scheduling operation registered a significant solution of managing recurring challenges, particularly at the planning level.

Vorobyov, Manakov, Reger and Tanaino (2018) devoted a study that focuses on improving the manageability and efficiency of business operations by developing a mathematical model for the logistics system of transportation, storage and cargo handling operations. A spatial and dynamic modeling in the parameters of end-to-end planning of operations method was used in the study. The modelling results emphasized that cost minimization on the railways polygon was possible when developing a transportation plan by mathematical modeling.

Efficiency and high degree of quality services are key factors that attract business cargo owners to consider rail as a mode of transportation. Cenek, Bednar and JanoSikova (2001) commissioned a study on optimization of rail cargo transport. Their study paid close attention on the efficiency of railways operations and the higher quality of service for customers. By using available data on estimated costs, infrastructure link, and transportation movements on the rail network, a model of cargo traffic was designed. Results proved that the optimization process unsuccessful since the optimization found some reserves to achieve effectiveness of operations, however, on the other hand, the model failed to offer the solutions.

Another published research on rail transport investigated a concept of diverting some freight from road to railway, considering its beneficial value in reducing negative environmental impacts associated with transport (Liu, et al., 2017). In their study, user equilibrium model for freight flow assignment on general network was formulated and the features of the model analyzed. Consequently, the analysis revealed its influence on the flow distribution which proves a theoretical method for estimating the measures for diverting bulk freight flow from road to rail.

Freight model shift from road to rail, a probable means of reducing damage to the environment, and negative social impacts of transport, according to (Woodburn, 2004). The author explored some recent changes in the supply chain to determine substantial integrations of logistical structures and the choice of rail for freight and identify means of logistical changes in order to increase the share of freight moved by rail. In addition, the author looked at the interface between structures of supply chain and the freight transport policy, focusing on the ability to devise policy interventions on the rail in order to achieve a more sustainable transport. A combined questionnaire and interview were applied in the study. From the author's findings it is evident that rail can only gain a substantial share of freight if it can meet the stringent requirements of the industry. Consequently, the results further indicated a bigger percentage change, representing a very considerable increase in the uptake of rail freight services for a longer distance flow to be switched to rail considering the big expectations that rail to rise to the challenge and meet future demands. Meanwhile, considerable evidence showed that there is potential to be tapped by rail, in condition that the supply-side issues addressed.

Table 2.1: Summary of Research Gaps from Literature Review

Researcher(s)/Author(s)	**Area of Focus**	**Results/Findings**	**Research Knowledge Gaps**
Alaghband and Moghaddam (2019)	Scheduling and allocation of freight to cargo trains to minimize voyage time on a single rail track	Results indicated that optimization model used gave good results, with better performance outcome. The concept can be applied in other problems such as routing of trains	Further studies need to be pursued on mathematical model for operational scheduling and routing problems
Backaker and Krasemann (2012)	Develop rail trip plan through an	Reduction of transit time and	The study recommended application strategy of

	optimization	service frequency of the train is obtained in terms of routing and points of schedules.	optimization-based freight routing and scheduling in solving the rail transport trip schedule problem
Vorobyov, Reger and Tanaio (2018)	To develop a model for management through optimization within logistics system of transportation, freight handlings operations and storage in determining transportation plan and supply at a minimum cost	Model of cost management process in railways was developed for cargo storage, handling operations and transport network	Further research is required with a focus on high tech modelling of the processes.
Bortas I, N and C (2018)	Cargo transport route optimization from road to multimodal rail-inland waterways transport to reduce transport	Results recorded a shift of cargo from road to inland waterways and rail transport network with further prediction of the route. The results were used to	Scientific study maybe required with the aim of advancing technological application in the transport process.

	congestion, environmental pollution and other external factors	improve planning process of transport services and cost reduction, and minimize environmental pollution	
Maia and Couto (2013)	Rail freight network optimization to support policy decision and planning	The findings obtained demonstrated positive adaptability to handle problem by application of optimization model that can be relied on at strategic planning level	There is a need to improve rail transport system to meet the optimization of rail network for cargo transport, and modelling the strategic network link of road and rail transport
Arnold, Peeters and Thomas (2003)	Modelling road-rail intermodal transport optimization, and identify impacts of changes in the supply and the flow of cargo	Innovative policies required to reduce negative impacts, and to promote integrated transport network chains	The study didn't explore the impacts of modal share of freight between rail and road in the transportation supply chain. This requires more study to bring out the findings. There is also a need for research to come up with innovative policies to promote an integrated multimodal transport

Hickish, Fletcher and Harrison (2019)	Optimization of rail transport network to improve performance	Results recorded an exponential improvement and performance in the perspectives of the service users	There is requirement of research investigation of optimization on a wider range of driving tasks and train scheduling with a greater number of variables
Crainic, Ferland and Rousseau, (1984)	To increase market share in the freight transport by examining the train schedules and traffic routing	The model integrated trade-offs between the operations of the trains and traffic, the results were impressive attaining good improvement of services. Adaptable model tool developed is valuable for tactical management of freight transportation	The model can be used in operations planning. Meanwhile, more work still required for the model to be applied in real life situation and analysis of some terms in the objective functions
Borndörfer, et al. (2015)	Success stories on optimization of railway transport network with a focus on train routing and	Modelling can support the planning operations of the railway system which can lead t greater efficiency	There is a need to innovate a powerful technological software tool to meet challenges of the railways industry

	planning	of the railways operations	
Charnes and Miller (1956)	A study to develop techniques of managing train scheduling hitches through modelling	The recorded results proved to be encouraging, train motion in long run planning recorded sufficient results. Programming model further registered solution for managing recurring challenges in the planning levels	A more complex policy study is necessary to develop specialized extension of the model itself on the management of the problem
Cenek, Bednar and JanoSikova (2001)	Optimization of rail cargo transport for quality service	the results demonstrated that traffic in the railway network changed partially	Further research required to be conducted on the same using a reliable data to develop model that will be necessary for the implementation of the system
(Woodburn, 2004)	To establish the interface between the structure of logistics and rail mode choice for freight transport and identify how rail can increase	Rail freight capacity growth was found to be unguaranteed since rail industry not able to cope with the placed demand in the transport choice	The kind of data collected couldn't be relied on since it didn't represent the practicality of the rail industry. There is a need to explore further research paying attention on the industry demand that rail

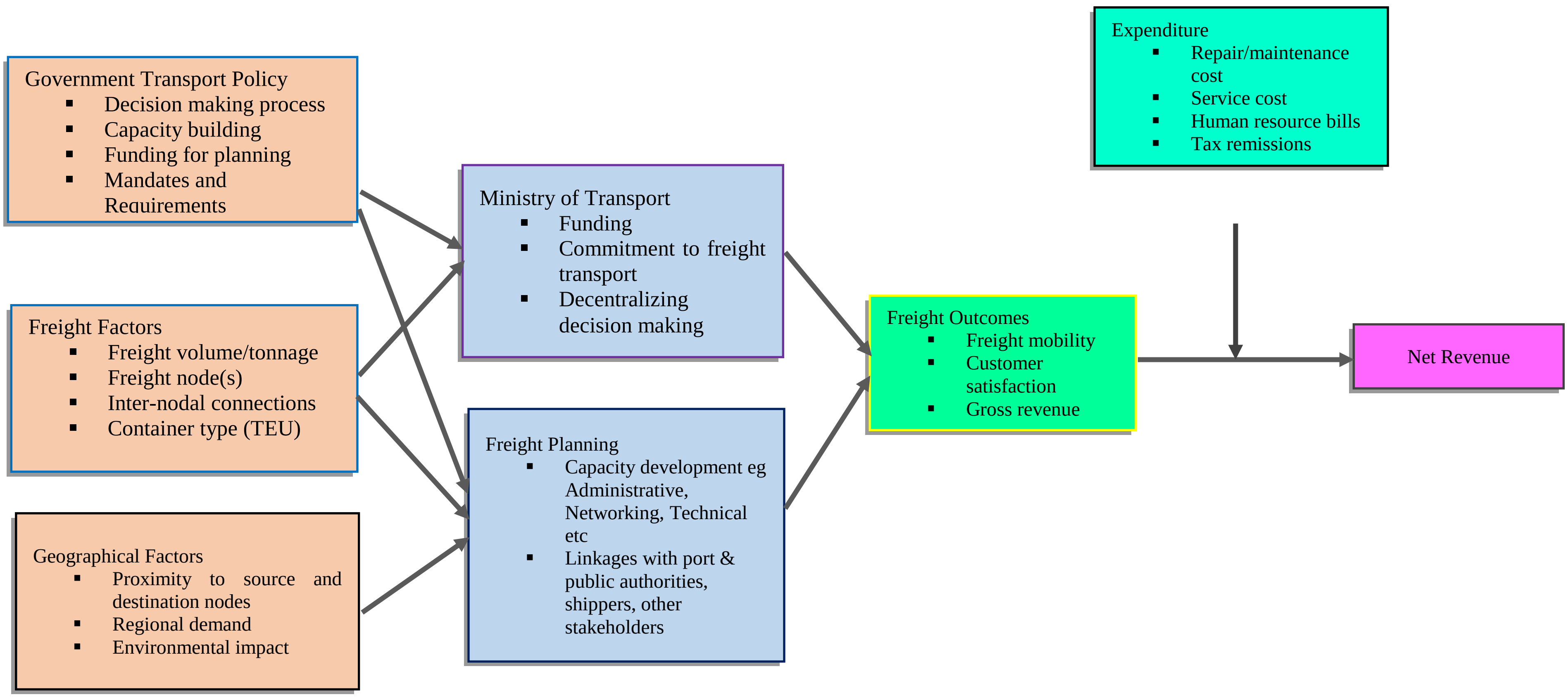
	its freight cargo movement		performance is required to cope up with.

The literature sources reviewed explored optimization of railway transportation, focusing on; train scheduling, trip and route planning, management, cargo handling operations, safety and environmental pollution control and intermodal network, as well as transport congestion and security. A study on rail freight optimization to maximize revenue returns, while minimizing logistics and operations cost, as well as freight capacity forecast is a missing gap in the field of railway transport sector, to be specific, the new Kenya's SGR operation between the port of Mombasa to dry port hinterland in Nairobi and Naivasha.

However, despite improvement of railways transport infrastructure, noting its significant role in trade facilitation, economic and social development, performance of the railways still faces decline (Olievschi, 2013). Essentially, one key factor for putting railways a more competitive mode in the transport sector is high traffic capacity, hence a low transport volume has dire impact in the exorbitant costs of its operations, which subsequently increases the logistics costs much higher (Olievschi, 2013).

Similar to the above, according to AfDB (2015) report, transport is a key factor that for many decades intensified trade growth, and in particular, the report pointed that freight transport by rail is typically more competitive over long voyage for bulk cargo. Thus, rail transport requires higher trade volumes to be better feasible. In addition, Nancy (2020) in its published research paper emphasized that modern economies are after transport mode that enhances freight movement at the lowest possible cost. Thus, Kenya as one of the emerging states striving to modernize its economy developed a new modern standard gauge railway (SGR) transport, a component of Norther Transit Corridor Transport Infrastructure, both for passenger and cargo. The SGR freight is connected to the port of Mombasa, whose current capacity is 2.65 million TUEs, with direct connectivity close to eighty (80) ports worldwide. Mombasa port, also provide a gateway to regional trade of East and Central Africa through the Northern Transit Corridor. Due to a considerable annual freight capacity through Mombasa port, plus its progressive annual performance growth, and geographical hinterland coverage it serves, the SGR stands to gain and attain the desired freight volumes to be feasible and sustainable. Thus, expediting seamless cargo transport, and high degree of efficiency at a minimum logistics cost are the key determining factors of choice of mode of freight transport. And so, the reasons to formulate strategies and policies for SGR in Kenya to increase the largest freight transport share, and attain adequate annual carrying capacity in order to record highest revenue returns, while strengthening its future sustainability and effectiveness.

2.4 Conceptual Framework



CHAPTER THREE: RESEARCH METHODOLOGY

3.1 Introduction

This chapter explains the research methodology that was used in carrying out the study. The chapter discusses the research philosophy, research design, and targeted population of the study, sample size and sampling technique the method of selection, measurement of variables under study, research instruments and administration procedures. The chapter also explored data analysis methods and ethical considerations.

3.2 Research Philosophy

Kumar (2018) explains that, in most academic research, two main philosophical orientations exist. The two orientations are positivism and phenomenology. Classification of these orientations was based on the assumptions involved in each case. Positivism was pegged on the claim that problems, or the world in general, is objective. That is, various problems in the world can be solved in an objective manner using some specific analytical procedure. This can be done using well defined hypotheses and testing them. Phenomenological orientation, on the other hand, entails creating a meaning out of occurrences in the surrounding. Positivistic and phenomenological are thus distinguishable by the fact that a positivist researcher tests well known theories using model building techniques, while a phenomenologist researcher builds up a theory.

The proposed study adopted a positivistic approach. This choice was because the study involved looking at existing problems objectively by building some models. In this study, the models were built using quantitative data, which was another feature of positivism approach. Moreover, this approach allowed construction of empirical models which explain the type of relationship that exists between the main research variables.

3.3 Research Design

Silverman (2011) defines research design as the overall approach or strategy taken to carry out research. Research design is pegged on the nature of the research objectives and the expected deliverables. A research design is key in identifying the type of participants, nature of the required data and the method of data collection and analysis to be adopted. The proposed study focuses on optimization of revenue collection of rail freight network of the standard gauge railway. Data on revenue collection and/or the general operation or performance of the standard gauge railway is time-based and consequently, a time series data. Due to the time series data that was used in this study, the proposed study used longitudinal research design.

In longitudinal research design, observations were made repeatedly over some duration on the same study subject(s) (Mugenda & Mugenda, 2009). As a key feature of longitudinal research design, the researcher does not, in any way, influence the observations or responses. By having the ability to detect developments or changes on a particular population characteristic of interest, this research design was useful in examining sequence of events over some duration.

3.4 Target Population

Population, as defined by Kumar (2018), constitutes a group of people, items or objects with some common observable characteristics that can be examined or investigated. For this study, target population included senior staff members employed by SGR as well as all other key stakeholders, both from public and private sectors. In particular, Table 3.1 provides the targeted individuals for this study.

Table 3.1: List of Target Population

Title/Profession	Institution
Corporate Development Manager	Kenya Ports Authority
Senior Research and Policy Officer	Kenya Ports Authority
Conventional Terminal Manager	Kenya Ports Authority
Chief Executive Officer	KSAA
Shipping Manager	Messina Shipping Line
Operations Manager	Messina Shipping Line
Container Terminal Manager	Kenya Ports Authority
SGR Port Operations Manager	Kenya Railways Corporation
Operations Manager	CMA CGM Shipping Line
OGEFREM Manager	OGEFREM DRC
Managing Director	Weston Logistics
Managing Director	Kidima Enterprises Ltd
Executive Officer	KIFWA
General Manager Operations	Kenya Ports Authority
Senior Marketing Officer	Afristar Ltd
National Chairperson	KIFWA
Managing Director	Express Shipping Logistics
Managing Director	Box Back Ltd
Senior SGR Freight Manager	Kenya Railways Corporation
Transport Economist	Independent Consultant
Senior Policy Advocacy	Shippers Council. EA

Operations Director	Transport Online Agency. EA

3.5 Sample and Sampling Procedure

In picking respondents, purposive sampling was used. In purposive sampling, which is a non-probability sampling technique, the researcher picks respondents whom he/she thinks possesses some specific traits (Kumar, 2018). In this case, inclusion of a unit in the sample was solely decided by the researcher and thus, this technique lacks the element of randomness. This sampling procedure was used since only some specific individuals in some specified management levels were well informed about operations of the SGR freight transport network.

Since the researcher could not know all and/or vital players in the SGR freight network system, snowball sampling was adopted. In snowball sampling, existing respondents recruit or refer future participants from among their associates. Though the researcher was guided by the respondents enlisted in Table 3.1, individual identification of other participants was through snowballing.

3.6 Research Instrument Data Collection Procedure

Both primary and secondary data sources were used in the proposed study. Primary data sources entail scheduled interviews and key informants' discussions with relevant persons within the SGR freight transport. This method therefore, yielded qualitative data. The semi-structured oral interview scheduled was based on the main themes of the study. Specifically, this method was key in obtaining information about operation challenges and various strategies used to address the challenges. Interview schedules were vital in obtaining in-depth information about the general operation of SGR. Interview guides contained open-ended questions (as shown in Appendix I). Interview schedules were used since they allowed collection of true data or making actual observation without restricting or controlling the mind of a respondent (Hennink, Hutter & Bailey, 2020). Unlike closed-ended questionnaires, interview schedules allow a respondent to give his/her knowledge about the problem or the topic being investigated.

After identifying the key informants, prior booking of appointments was made to avoid any excuse of inconvenience. The researcher was flexible to fit into the schedule of a respondent. This was however, preceded by seeking authorization from the University of Nairobi and other relevant bodies to conduct the survey. Interview protocol that ensures consistency and standardized administration process was developed to increase reliability of the findings. Secondary sources, on the other hand, was obtained from records from the SGR about freight transport. In particular, the data retrieved provided the revenue collection, freight tonnage and capacity, transit time, train turnaround time, and number of wagons from SGR operations. As shown in Appendix II, data retrieved was from 2018 to April 2021. Secondary data was used to build time series model and in regression modeling.

3.7 Data Analysis and Presentation

Data analysis involves inspecting, cleaning and formatting gathered information to discover its usefulness for sound decision making (Rosopa, Brawley, Atkinson, & Robertson, 2019). That is, the process entails extracting meaning and improving quality of some collected information. Both qualitative and quantitative analytical methods were adopted in analyzing collected data. Qualitative methods involved cleaning and coding of qualitative data according to major themes and concepts of the study. While categorizing qualitative data thematically, data completeness and accuracy was checked for each theme or category. Qualitative data was vital in addressing the study objectives on operational challenges and strategies used to address the challenges.

Quantitative analytical methods involved using quantitative data to construct time series model and multiple regression model (Rosopa et al, 2019). The nature and internal structure of quantitative data was first explored in tables and graphs, if need be, and explanations be done in prose. Both descriptive and inferential statistics were computed while exploring quantitative data. Descriptive statistics entailed calculation of means, variances and explained variations without giving detailed explanation of the values computed. This was presented in tables and graphs. Inferential statistics were used to provide deeper understanding of descriptive statistics. This involved obtaining empirical models for time series modeling and regression modeling as discussed herein.

3.7.1 Time Series Modeling

Time series modeling was used to address the third objective of the proposed study. Since the data, from the exploratory analysis, lacked seasonality and cyclic variations, ARIMA Model was not used. Initially, the study had proposed to use ARIMA models to forecast revenue collection of SGR cargo freight network. Available data on revenue collection portrayed a general increasing trend, an observation that disqualified the use of ARIMA models. Instead, exponential smoothing was used in forecasting. Exponential smoothing is suitable in series that do not have seasonal and cyclic variations (Shumway & Stoffer, 2011). In this model, both prior actual and prior estimates to forecast future values.

3.7.2 Regression Modeling

Multiple regression modeling involved regressing revenue collection on number of available wagons (which dictates freight volume), capacity, transit time and turnaround time. The model therefore, took the form

$$\boldsymbol{Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \varepsilon}$$

Where;

Y	=	Revenue collection	(Dependent variable)
X_1	=	Number of available wagons	(Independent variable)
X_2	=	Capacity	(Independent variable)
X_3	=	Transit time	(Independent variable)
X_4	=	Turnaround time	(Independent variable)
β_0	=	Constant (model intercept)	
β_1	=	Coefficient for number of available wagons	
β_2	=	Coefficient for Capacity	
β_3	=	Coefficient for Transit time	
β_4	=	Coefficient for turnaround time	
ε	=	error term	

Before fitting the regression model, diagnostic tests were conducted to ensure that the data was fit for regression modeling (Field, 2009). Diagnostic tests involved testing for normality, linearity, multicollinearity and homoscedasticity of the data. Testing for linearity involved verifying the assumption of linear relationships between the dependent and independent variables. Normality test was used to check whether the observations of revenue collection were normally distributed. This was done using Shapiro-Wilk test whose value ranges from zero to one. Multicollinearity involved checking whether there was some abnormal high level of correlation among the independent variables. Multicollinearity was tested using tolerance levels and Variance Inflation Factors. Homoscedasticity, on the other hand was tested by use of Levene's t test (Rosopa et al, 2019). All diagnostic tests were done at the level of significance of $p < 0.05$.

3.8 Ethical Considerations

Prior to data collection and accessibility of secondary data, permission was obtained from the University of Nairobi, where an introductory letter was provided. Quality of the proposed research was assured through observance of certain research ethics. The principles not only ensured that rights of all participants were observed, but also ensured that the study was strictly conducted as was intended (Brownstein & Saul, 2016). One research ethic was the principle of voluntary informed consent (Kumar, 2018). This involved informing participants on the importance of the study, and their role before onset of the study. As highlighted by Bell, Bryman and Harley (2018), the proposed study strictly adhered to the principles of pre-informed consent, confidentiality and anonymity and protection from any harm. The proposed study, therefore, made deliberate effort to observe the above ethical considerations.

CHAPTER FOUR: RESEARCH FINDINGS AND DISCUSSIONS

4.1 Introduction

This chapter presents research findings and discussions of results. The chapter is organized into two main parts, which are qualitative and quantitative results. Qualitative data was used to address research objectives one and two, while secondary data was used to address objectives three and four.

4.2 Respondents and Data Source

For qualitative data, key informant interviews were conducted. Qualitative data covered operational challenges of freight transport on SGR transport network and possible strategies that can be used to address the challenges. A total of 22 respondents were interviewed. Table 4.1 shows distribution of respondents and their corresponding institutions.

Table 4.1: Distribution of Respondents

Institution	No. of Resp.	Institution	No. of Resp.
Kenya Ports Authority	3	Kidima Enterprises Ltd	1
KSAA	1	KIFWA	2
Messina Shipping Line	2	Afristar Ltd	1
Kenya Ports Authority	2	Express Shipping Logistics	1
Kenya Railways Corporation	2	Box Back Ltd	1
CMA CGM Shipping Line	1	Independent Consultant	1
OGEFREM DRC	1	Shippers Council. EA	1
Weston Logistics	1	Transport Online Agency. EA	1

On the other hand, secondary data was used in quantitative data analysis, which included time series modeling and multiple regression analysis. Secondary data was obtained both from Kenya Ports Authority and Kenya Railways Corporation. Before onset of analysis, the data was cleaned to remove any outlier.

4.3 Responses on Each Study Objectives

The study had four specific objectives, that were categorized into two parts based on the nature of the expected data. The first part consisted of the first two objectives, which were about operational challenges of freight transport through the SGR and viable strategies of addressing the challenges. This first part utilized qualitative responses.

4.3.1 Qualitative Responses

4.3.1.1 Operational Challenges of Freight Transport on SGR Transport Network

The first objective in this study was to identify operational challenges in freight transport on SGR transport network. Respondents listed a number of challenges and the extent to which the factors or challenges affect operations of freight transport on SGR transport network. Summary of the weights of the challenges was as shown in Figure 4.1

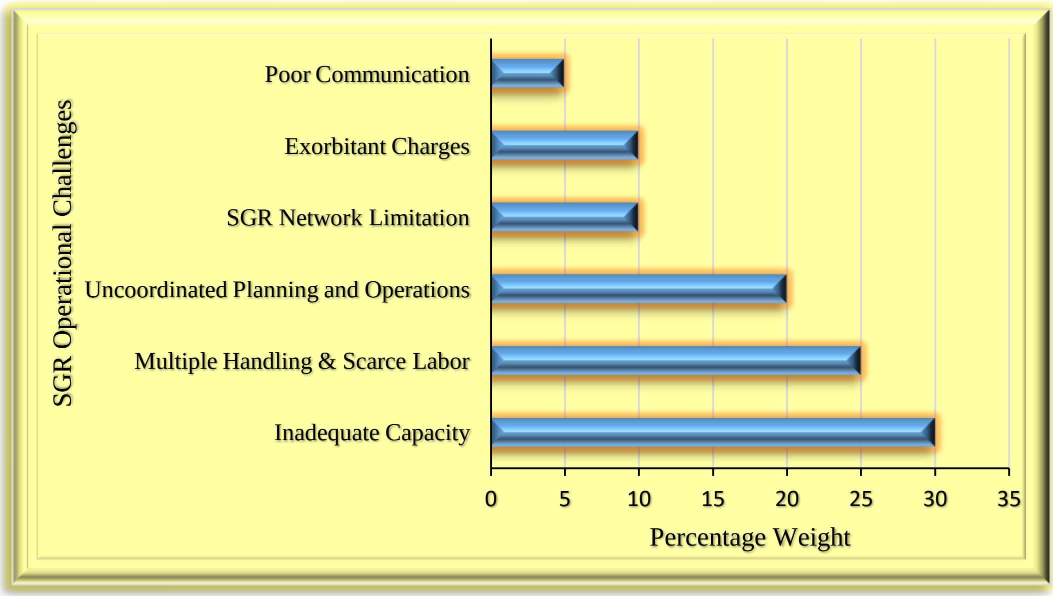


Figure 4.1 Extents of Operational Challenges:

Inadequate Capacity

One critical determinant that influence good productivity or performance of railways cargo transport is the availability of adequate equipment, enough space for handling and operations, and important supporting facilities or infrastructures that have direct influence on the train operations', that was an emphasis from one of the respondents interviewed. Contrary to the mentioned key factors, SGR freight performance challenges come from inadequate train wagons required for loading cargo at the port that determines the capacity of each train. Also, cargo yard space at the port and ICD Nairobi for temporary holding containerized cargo awaiting loading and offloading has made operations difficult due to its limited space.

In addition, the respondents indicated that handling equipment and machines at the port and ICD train terminus was inadequate to facilitate performance loading and offloading of the trains that has led to poor productivity, that subsequently contributed to negative impacts SGR performance in terms of cargo evacuation at the port and ICDs.

Lastly, supporting facilities and infrastructures were reported to be scarce and in poor state, which should be linked to SGR freight haulage has contributed to dismal performance. For example, access roads to the SGR port terminals, ICDs, industrial plants, large business centers and logistics hubs were narrow and in bad state as reported by truckers. It was also reported that there was lack of waiting or holding bay near the ICDs for the trucks leading to truck congestion and long hour turnaround time of the trucks in the ICDs that again contributed to dismal performance of SGR.

Exorbitant Last Mile Freight Logistics Costs

The association of shipper's council of East Africa and the shipping agent's association proposed for immediate interventions on operational issues that makes SGR freight transport cost higher than road. One, the SGR freight service faced with the limitation to provide end to end freight delivery services. As a result, it requires last mile connectivity by road transport. The Shippers Councils of East Africa further reported that freight transport through multiple transport modes under separate documentation and, terms and/or conditions has made SGR logistics cost exorbitant. As indicated by some respondents, from Nairobi ICD, charges for last mile connectivity were reported to be multiple since it requires hiring a truck to enter into the ICD to pick the containers to the premises then back to the ICDs which attract waiting charges to offload the cargo from the container, in addition, charges for loading the container onto the truck, then offload the container from the truck upon empty freight container delivered back to the ICD. The same concerns were raised by association of clearing agents indicating that upon the empty freight container delivered to the at the port by train, additional cost for the truck to pick the container to the empty depots out of the port involves additional cost. Cumulatively, the logistics cost by SGR due to multiple handling was high, making it uneconomical and expensive in logistics supply chain.

Uncoordinated Operations and Planning Cooperation at the Port and ICDs

For train to provide seamless cargo haulage services, either from the port or ICD's rail terminus, there must be a proper coordination between the main facilitators especially KPA, KRA and KRC, as well as shipping lines and clearing and forwarding agents, among other key players. SGR freight transport users reported that pre-planning and coordinated cooperation for an efficient operation has been lacking and a challenge from the time cargo offloaded from the ship until loaded to train wagons. Again, as indicated by the shipping lines and clearing agents, there was lack of proper coordination synergy between KRC and KPA since each agency performs its operations in a silo manner. On account of poor coordination and planning, non-visibility of cargo tracing from the ship to shore to rail has contributed to erroneous or wrong cargo containers loaded to the train wagons. Similarly, as a result of non-visibility of cargo containers at the port due to lack of coordination and planning, numerous freight containers meant for SGR has been erroneously left at the port for a close to a period of thirty days. As a result of which, attract high demurrage charges from the shipping lines and storage charges from KPA after the free period elapse, a concern that was raised by many stakeholders.

Limitation of Standard Gauge Railways Cargo Transport Services

Sustainability of the rail transport depends on availability of adequate cargo volumes or freight tonnes; SGR freight transport therefore needs to adopt diversification for various categories of cargo haulage. However, limitation from difficulty of paring double track freight containers due to lack of knowledge of the freight contents homogeneous was one serious challenge, according to KRC. Also, limited capacity of SGR to accommodate dangerous cargo such as flammable petroleum products has been a challenge as well. For the out of gauge cargo, limitation of the rail track lines causes difficulty during transit time due to awkward shapes of the out of gauge cargoes considering that SGR has a single track, with narrow sidelines for transit train interchange. Indeed, limitation of SGR track network at port terminals only permits loading and unloading near the rail track, that is far meters away from the ship's shore, a concern that was raised by both KPA and KRC that has contributed to loading operational challenges. Generally, with all these limitations and challenges, achieving operational performance target and output has been an uphill task. As pointed out, direct loading from ship to rail wagons (ex-hook) cannot be done which therefore leads to multiple transfer of cargo consignments from ship to the wagons far away at the rail track line that attract numerous handling cost. Further, for special cargo that can as well be transported through SGR, limitation comes from lack of specialized train wagons and handling facilities for the special cargoes, which therefore limit capacity adequacy that trains can haul through SGR, according to KRC, a concern that was also raised by KPA.

Inaccurate Information and Poor Communication

The rule that drives performance and productivity depends on the correctness and reliability of information, according to the respondents. To achieve better results in SGR freight operations, a well flow of communication amongst the parties was considered critical. The freight merchants, clearing agents, truck transporters providing last mile services and the shipping lines raised concerns that in many occasions out of picture on daily process flow of rail cargo operations at the port and at the ICDs. Kenya ships agents' association, association of clearing agents, and shippers' council on the other hand, had repeatedly raised complains on inaccurate information and poor communication, a negative factor attributed to low performance of SGR for cargo transport. Also, negligence in recording wrong information of cargo into the KPA system has heavily costed many cargo owners to transport their consignment through the SGR. On the other hand, as indicated by key stakeholders, due to scanty information and uncoordinated communication between KPA and KRC, delays for cargo evacuation from the port resulted to expensive cost for storage and demurrage charges for KPA and shipping lines. Furthermore, lack of information updates on loading/unloading operations denies the cargo owners cargo visibility to monitor and plan the required end logistics for the delivery of cargo to their premises or destinations. Wherefore, communication gap, that's scanty and uncoordinated has pushed away many importers and exporters from rail to road as their mode of freight transport, that has increasingly denied SGR cargo capacity volumes to achieve its revenue targets and capacity for its sustainability.

Multiple Handling of SGR Cargo, and Lack of Adequate Skilled Labor

The SGR is a new modern railway transport system whose operations must be manned by well trained workforce with extensive skills, expertise and knowledge. For the case of SGR freight transport, daily train operations experienced unending breakdown of equipment due to lack of enough skilled-knowledge of handling by the operators, in addition to many reported cases of accidents. More so, damaged or broken wagons and other components of the trains requires continuous maintenance and repair to sustain the train load capacity, thus the human resource available doesn't have the technological skills for such tasks.

As earlier mentioned, for cargo to be loaded on train wagons, multiple handlings involved. For instance, containerized cargo requires at least three process flows of handling from the ship to the shore, and finally from the shore to the train wagons. The same applies to lose cargoes at the conventional terminal, where loading of cargo from the staking yard to the wagons has been subcontracted to third party private service providers. Similar to dry bulk terminal for grains and clinker, loading facilities belongs to the private third party whose operations performance and planning cannot be controlled by either KPA or KRC. To sum up, all these three terminals at the port that handles different categories of SGR cargo requires multiple handling for loading, and to some extent offloading at the ICD. However, each component of handling has got various charges paid by the cargo owners, thus making SGR an expensive mode of cargo transport.

4.3.1.2 Strategies and Policies That can be Used to Address SGR Freight Transport Operations Challenges

During the interview, the respondents were asked to give percentage score in terms of the weight of the strategies and policy proposed. Figure 4.2 therefore depicts the outcome of their score. A detailed emphasis of each strategy and policy are provided as indicated in figure 4.2;

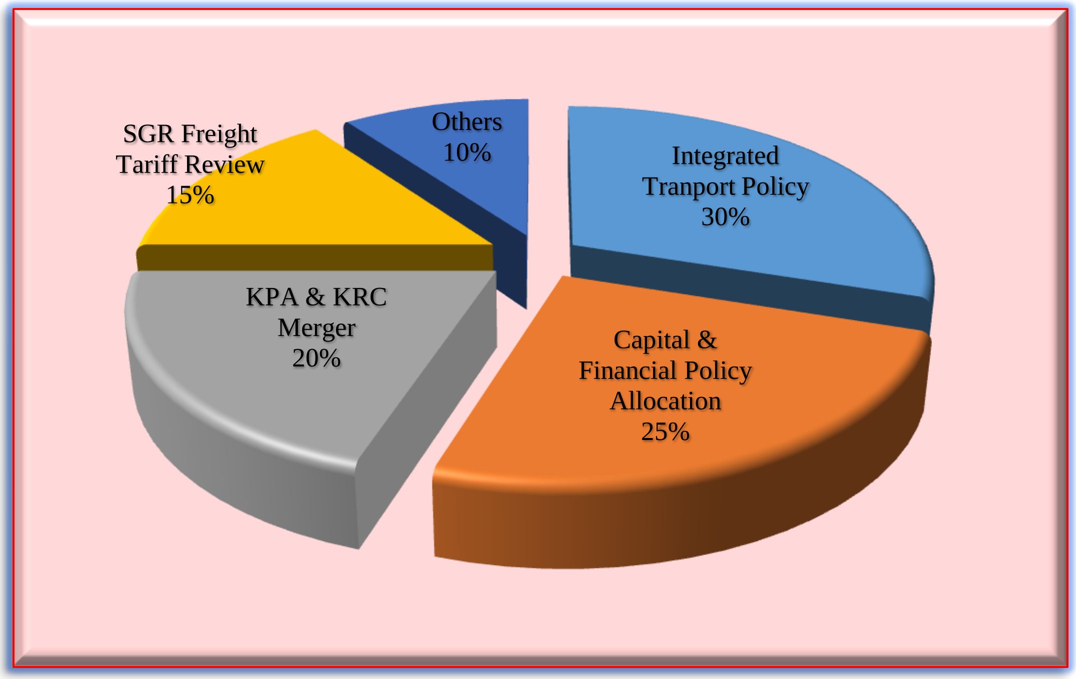


Figure 4.2: Strategies and Policies for Addressing Identified Challenges

Formulate and Implement Law or Policy of Merging Kenya Ports Authority and Kenya Railways Corporation as One Agency

As emphasized by Cenek, Bednar and JanoSikova (2001), efficiency and high degree of quality services are key factors that attract business cargo owners to consider rail as a mode of transportation. The major challenge of the operations of the SGR cargo transport was due to difference operational management, planning and coordination from KPA and KRC under different leadership, mandates and functions. A consideration of merging the two institutions will help synchronize and streamline well-coordinated freight operations, pool the diverse resources to perform operational functions and further, expand the infrastructures and facilities to achieve the desired inclusive socio-economic development in the sectors of transport and trade. Meanwhile, establishment of the Kenya Transport Logistics Network to bring together KPA, KPC and KRC was mooted by the national government in August 2021, however, its actualization should be realized, and in particular, merger of KRC and KPA to form one entity under one ministry with policy oversight role. The proposed merger was to significantly strengthen and facilitate synergy, reduce bureaucracy, increase efficiency and foster competitiveness, as well as streamline operationalization of services to lower costs of operations, in addition to pool their resources for major transformation in the transport and port sectors.

Policy on Financial and Capital Allocation

SGR freight transport operational challenges partly rises from inadequate equipment from both sides of KPA and KRC. Insufficient facilities to optimize performance has resulted to limitations of the train's operations.

In particular, infrastructure expansion, extension and development were key factors for the sustainability and performance of SGR cargo transport. Revival and revitalization of old meter gauge railway network was critical to expand SGR freight network to enhance last mile logistics services. Extension of existing road infrastructure and revitalization of old meter gauge was considered an important factor to enhance end to end connectivity to the established industrial economic zones with high production of export goods and incoming import goods. In addition, the policy decision of extending SGR track line further to the neighboring border was a viable strategy noting the availability of adequate freight capacity for transit goods along the northern corridor. Expansion of existing Nairobi ICD to accommodate a double capacity of the current annual capacity that stood at 450,000 TEUs.

Meanwhile, loading of freight cargo to the train wagon at the port involves multiple transfer that attracts more handling cost due to lengthy distance from the shore to SGR track line. Thus, extension of the SGR track line to the vessel berths for both container and conventional terminals contributes to direct loading from ship to train wagon (Ex-Hook). At Nairobi ICD, rail track lines were limited to accommodate more trains to load and offload at the same time, causing delays for long hours. Also critical, is the expansion of existing and open new access roads to the port and ICDs for the trucks that deliver and evacuate freight containers, both at the ICD and at the port that positively influence port efficiency and performance productivity of the SGR cargo trains. It is therefore important to note that all these infrastructure and facilities development and expansion, needs a strong policy for adequate financial allocation that requires a solid legal framework supported and implemented by the national government and development partners.

To add, the capacity of SGR trains has been affected due to fewer number of wagons. And large number of wagons requires repairs and maintenance due to their bad state. Equipment for loading at the port and at the ICDs were also few to achieve the required balanced loading and offloading speed. On the other hand, existing and new equipment requires routine check and maintenance and spare parts purchase. Hence, all these investments require strong financial policy funding to guide and support sourcing, allocation and utilization for the expansion and to sustain facilities and infrastructure supporting SGR freight services.

Carbon Emission Tax Policy on Freight Truck, and Tax Levy on Local Road Freight Transport

As a strategy to shift freight from road to rail, and focusing on competitiveness of rail against the road, government of Kenya needs to enact law or policy on tax levy for road freight transport, both for local exports and imports. This may push a good percentage share of freight from road to rail assuming road freight transport cost may be high in addition to tax levy.

Diverting freight transportation from road to rail contributes to substantial benefits in reducing environmental negative impacts Liu, et al., (2017). Similarly, in Kenya, road has been known to be a major contributor of the climate change resulting from carbon emission from the trucks fumes. The smokes from the trucks are to be the major contributor of pollution to the air and degradation of the environment. Further, freight trucks cause major road congestions snarl-ups on transit corridors, rampant damage to the roads leading to high cost of maintenance and repair. Its therefore important to consider a strategic policy approach of formulating a legislation for the carbon emission tax policy on road freight trucks for both local and transit cargoes. If carbon tax emission policy formulated and enforced on freight road haulage, road freight transport charges shall increase freight transport cost higher, therefore, shifting to rail as a mode for freight transport could be a better option. This strategy was also emphasized by Bortas I, N and C (2018) in their study findings.

Also important, implementation of the proposed policies may register significant positive benefits in addressing issues related to safety and security of the freight and the truck drivers that had experienced loss of life and theft caused by thugs and terrorist along the road transit routes.

Robust Integrated Intermodal and Multimodal Transport Policy and Regulation

European Union integrated transport policy aim was to ensure smooth, efficient, safe and free movement of people and freight by mean of integrated networks of all modes of transport; road, rail, water and air (EU, 2021). As emphasized by Arnold, Peeters and Thomas (2003), a better-balanced intermodal transport network provides solution of freight transport optimization. However, in Kenya, the transport sector has never implemented an integrated transport policy with a well-integrated framework and synergy of all modes of transport linked to logistics business hub centers, industrial production plants, cities, airports, seaports, inland waterways and dry ports at hinterland. The lack of implementation of an integrated multimodal and intermodal transport network has been connected to challenges of SGR operations and performance in cargo transportation and distributions. Thus, a unified network of multimodal and intermodal contributes to thirty percent of successful performance where a single consignment under one documentation can be transported through multiple modes of transport at a negotiated lump sum freight rate. The synergy between different transport modes needs to provide other facilities that support logistics facilitation such as; trucks waiting bay, sideline rail tracks extended to major business and industrial centers, temporary storage areas for empty containers, including other auxiliary services supporting the operations of freight transportation. In this regard, the Ministry of Transport in collaboration with relevant state agencies needs to implement a robust policy and regulation of an integrated multimodal and intermodal transport network with strong synergy between other transport modes, regional and international transport policy.

Freight Haulage Policy on Bulk, High Valued, and Agricultural Export Cargoes by SGR

Freight transport by rail is typically more competitive over long haulage for bulk cargo. As provided in KPA bulletin statistics of 2020, all imports received in the port of Mombasa, bulk cargo counts for bigger percentage share especially for break bulk, liquid bulk and dry bulk. Thus, availability of adequate bulk cargoes for SGR transport was a reality. Government then needs to formulate a policy that restrict transportation of certain categories of cargo by road, but only by SGR. The policy be formulated to strictly direct transportation of cargoes such as heavy bulk minerals and agricultural exports must be transported through SGR. Additional cargoes such as dry bulk cargoes, both breakbulk and dry bulk to be also transported by SGR. However, for this proposed policy to be implemented, government in partnership with the private sector players may need to incur some investments to develop facilities and infrastructures for handling, loading, unloading and storage for these cargoes, either at the loading or offloading terminals.

Application of a Highly Advanced Integrated Technological Systems on SGR Freight Operations

Application of advanced technology in mobility and transport is a key contributing factor of economic transformation, Tipps (1973). Uncoordinated operations between KPA and KRC reported to be resulting from manual planning for the loading and unloading operations due to lack of a well-integrated automated advanced technological systems, similar to other developed ports around the world. Cargo visibility from ship to shore then to train wagons, and during transit requires application of modern technology, an important factor for cargo owners to track their cargoes, and coordinate logistics services at the end. Also important, application of self-updating real-time monitoring automated system was critical. Similarly, cargo visibility was also important during loading and offloading and movement of freight containers at the port, which requires terminal monitoring application system.

Further, the requirement of automation for documentation was reported to be currently done manually for the freight containers for SGR. There was an urgent need of an integrated system automation for documentation for both KPA and KRC to help address the issues of delays of loading cargo on train wagons, and loading wrong containers due to inaccurate manual records. Therefore, automation of an integrated system for KPA and KRC was considered important to enhance information sharing and proper operations planning for offloading and loading at the port and ICDs.

A Comprehensive Review of a Competitive Freight Rate for SGR Cargo Transport

Comparing transport cost for rail and road, road transport was much cheaper than SGR cargo haulage charges. As a competitive advantage, road also provide transport delivery to the premises of the cargo owners, while SGR service requires additional last mile transport by truck to complete logistics service, requiring an additional cost for the truck and handling charges at the ICD.

To make SGR cargo transport competitive and economical, KRC in consultation and collaboration with key agencies and relevant stakeholders must undertake a comprehensive review of the tariff rates for SGR cargo haulage. For the case of SGR Kenya, a pragmatic strategy, and a comprehensively reviewed tariff rates should provide a lump sum freight rate, inclusive of all related handlings costs for loading at the port, train transit charges, unloading charges at the ICD, and last mile charges for truck and cost of return of empty containers. In view of the aforementioned, a memorandum of cooperation among key players; KRC, KPA, shipping lines and truckers be considered for the review of the SGR rates to accommodate all operational and logistics charges. Finally, to establish a seamless last mile logistics service through SGR cargo transport, KRC then needs to have strong partnership, supported by service level agreement with a known group or association of truckers to provide last mile cargo logistics services from and to the ICDs.

Provision of Tax Incentives and Rebates to Cargo Owners

This strategy was recommended to be applied and offered to cargo owners importing and exporting large quantities of consignments. For tax incentive and rebates to be offered, cargo owners must provide a minimum quantity of cargo to be transported by SGR on a periodical basis. In addition to incentives and rebates, priority services such as a free temporary holding space for freight, faster and reliable cargo services to them. Similarly, KRC was to adopt and apply rebates to a minimum cargo volume on TBL negotiated through shipping lines. But the rebates should have direct benefits to the cargo owners only. For the last mile services, a consideration was also critical for the provision of the rebates as well.

Establishment of Central Points of SGR Cargo Service One-Stop Centers

Relevant stakeholders' engagement and participation on services related to SGR cargo transportation were to be established and well-coordinated. Shipping agents, private cargo handling operators, clearing agents, exporters and importers, and truckers had raised couples of complains on lack of information related to whereabout of their consignments, inaccurate documentation, follow-up on loading/unloading operations and their involvement on SGR cargo services. Failure to address the identified challenges guarantees SGR cargo transport poor performance. Therefore, a multi-agency institution, both from the public and private sectors be brought under one-stop center at the port and ICDs, as a central coordination points for planning and operations. Likewise, the one-stop centers to be centers for information and communication coordination and dissemination, as well as centers for information enquires with toll free numbers that can be used by the stakeholders to make follow ups. This strategy was supported by Maia and Couto (2013) in their published research, indicating that operations planning for rail freight operation requires center of command and coordination.

Marketing Campaign Strategy for the SGR Cargo Transport Services and Opportunities

The Mombasa port annual capacity performance has registered a progressive growth which stood at 1.3 TEUs for the year 2020, an indication of adequate cargo availability for SGR. Compared to road transport which still controls more than 60% of cargo evacuation from the port of Mombasa, and on the other hand, only 40% or below being shared between SGR and MGR. Thus, 60% share controlled by the road was an indication of existing capacity potentiality and opportunity for SGR to exploit if good marketing campaign strategy and other operational issues were resolved. As stated by Crainic, Ferlaud and Rousseau (1984), train services and freight routing in response to targeting market coverage was laudable approach of increasing rail freight capacity. Kenya Railways Corporation therefore needs to establish a multi-agency technical team, both from public and private players to develop a comprehensive marketing strategy for the full utilization of available SGR cargo transport services. The marketing strategy outreach should include neighboring countries for the transit markets, both for East and Central Africa.

4.3.2 Quantitative Responses

4.3.2.1 Constructing Time Series Model for Forecasting Revenue Collection

To obtain a suitable time series model for forecasting revenue collection of SGR cargo transport, exploratory data analysis was performed to understand the internal structure of the time series data. These included checking for symmetry of revenue collection and whether there is any seasonal variation amount of revenue being realized by SGR cargo transport. For test of normality, both Shapiro-Wilk test and Kolmongorov-Smirnov test were performed and output summarized as shown in Table 4.2

Table 4.2: Test of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Revenue	.193	40	.001	.927	40	.013

In test of normality, a p – value less than 0.05 implies a lack of normality in the series. That is, if p – value < 0.05, there is insufficient evidence that the data is normally distributed. In Table 4.2, both Shapiro-Wilk test and Kolmongorov-Smirnov tests show p – values 0.001 and 0.013, which are both less than 0.05. Hence, there is absence of normality in revenue collection, as a time series data.

To further look at the structure of the data, a plot of the series against time shows lack of seasonal variations, as shown in Figure 4.3

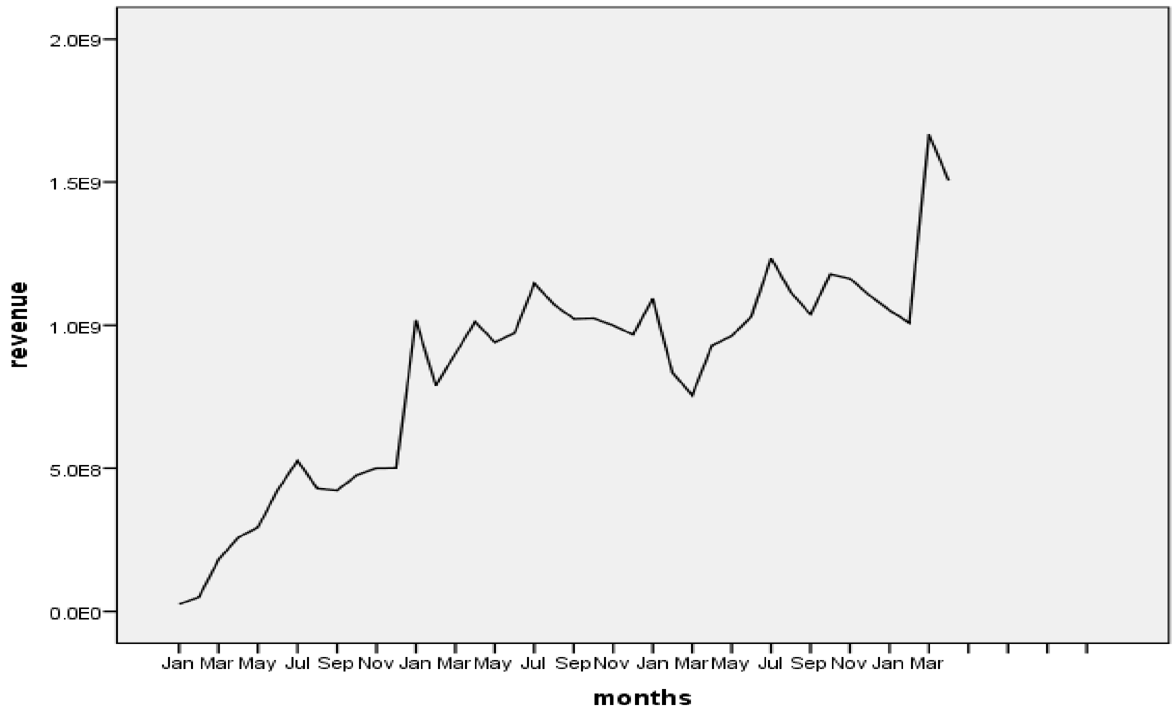


Figure 4.3: Time Series Plot of Revenue Collection

Absence of seasonality implies existence of linear trend in the time series data. This was examined using a Normal Q-Q Plot as shown in Figure 4.4

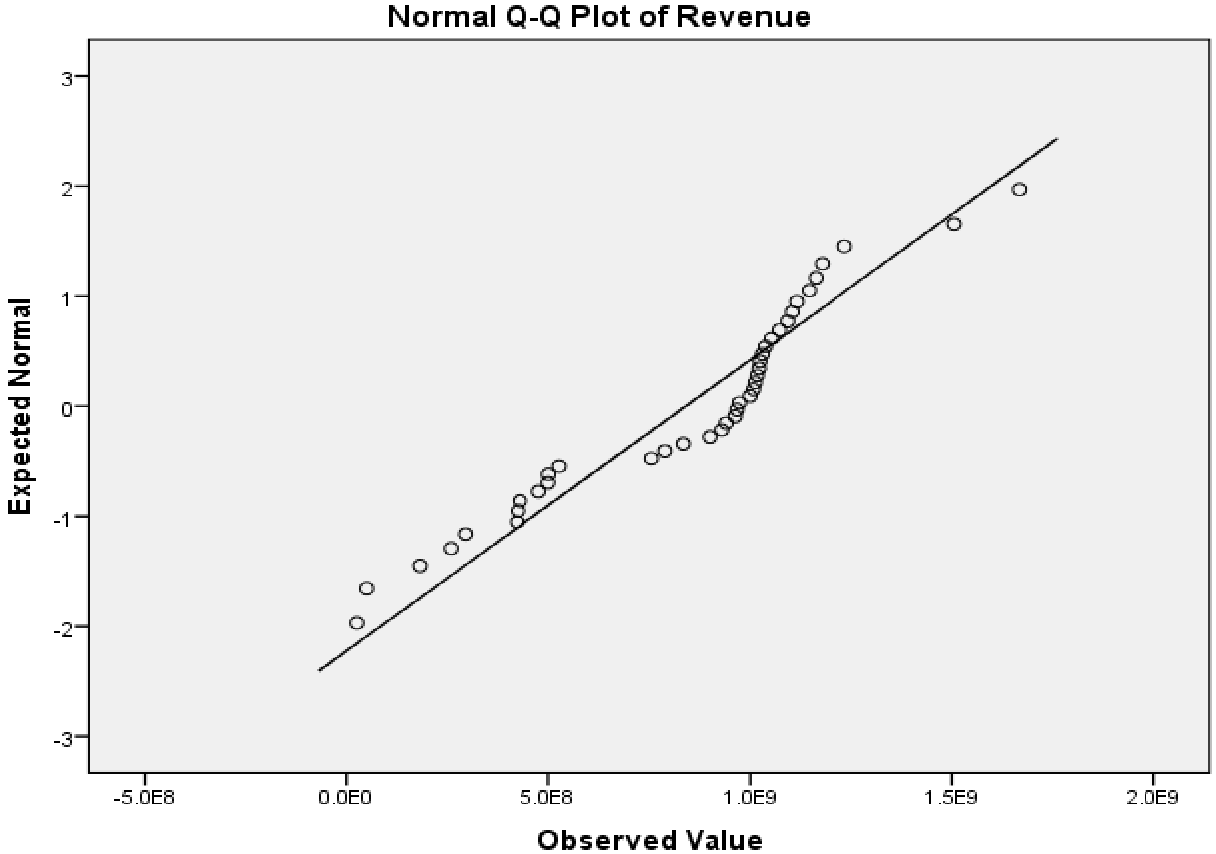


Figure 4.4: Normal Q-Q Plot of Revenue Collection

It can be seen from Figure 4.4 that the series exhibit some linear trend. Absence of seasonal variation disqualified the use of ARIMA model and consequently, an additive model was considered. In particular, exponential smoothing predictive model was used. Exponential smoothing is used when fluctuations in a time series is roughly constant over time or the series display some general increasing or decreasing trend. As an aspect of exponential smoothing, Holt Winters' Additive Model was used. This model was suitable for the data since it takes care of any trend, can obtain moving averages and addresses any cyclic variation observed.

Holt Winters' time series modeling gives several outputs based on the input commands. However, for this objective only three outputs were considered; model statistics, exponential smoothing model parameters and a plot of observed values, fit values and forecasted values using the time series model. Model description and model statistics were as shown in Table 4.3

Table 4.3: Model Description and Statistics

Model Description							
			Model Type				
Model ID	revenue	Model_1	Winters' Additive				
Model Statistics							
Model	**Number of Predictors**	**Model Fit statistics** R-squared	**Ljung-Box Q (18)** Statistics	DF	Sig.	**Number of Outliers**	
revenue-Model_1	0	.890	12.377	15	.650	0	

Table 4.3 has two parts; model description and model statistics. Model description outlines the type of time series model that was used in modeling the data. In this case, Holt Winters' Additive Model was used and main time series data was revenue collection. Model statistics section has number of predictions, model fit statistics, Ljung-Box Q statistics and number of outliers. Of interest in this section is R-squared and significance of Ljung-Box Q statistics. The value of R-squared (= 0.89) implies that the model explains a total of 89.0% of the total variations in revenue collection. The p – value for Ljung-Box Q statistics (= 0.650) implies that there is very little evidence of non-zero autocorrelations in the in-sample forecast errors. The explained variation is due to the model parameters given in Table 4.4

Table 4.4: Exponential Smoothing Model Parameters

Model			Estimate	SE	t	Sig.
Revenue-Model_1	No Transformation	Alpha (Level)	.699	.165	4.226	.000
		Gamma (Trend)	.113	.028	4.028	.008
		Delta (Season)	.001	.393	.003	.998

Table 4.4 shows that time series modeling was done using the actual values without any transformation. Exponential smoothing model parameters are three as shown in the table, with each having a portion that it measures or it signifies given in brackets. For Alpha, Gamma and Delta, parameter estimates and standard errors were 0.699 (SE = 0.165), 0.113 (SE = 0.028) and 0.001 (SE = 0.393) respectively. The corresponding t-statistics were 4.226, 4.028 and 0.003. In the significance column, the p – values are used to determine whether the corresponding parameter is significant or not. In this case, Alpha (p – value = 0.000) and Gamma (p – value = 0.008), which measure level of smoothing and trend, were significant since the corresponding p – values were significant at 5% level of significance. Delta parameter, which measures seasonality, was not significant since the p – value = 0.998 < 0.05. This is due to the fact that the series lacked seasonality.

Using the significant parameters, a comparison of the observed (actual) values and model fit values can be seen in Figure 4.5

Figure 4.5: Plot of Observed and Model Fit Values

This model was further used to forecast revenue collection up to December 2022. Table 4.5 shows forecasted values with a corresponding 95% prediction interval.

Table 4.5: Revenue Forecast

MONTH	FORECAST	UCL	LCL
May 2021	1504345819	1765684816	1243006821
Jun 2021	1581812492	1900807371	1262817612
Jul 2021	1741995314	2109786397	1374204231
Aug 2021	1645598115	2056494399	1234701831
Sep 2021	1601197489	2051146598	1151248379

Oct 2021	1667189185	2153116811	1181261559
Nov 2021	1662252850	2181723895	1142781805
Dec 2021	1632311649	2183335942	1081287357
Jan 2022	1743099767	2324011561	1162187973
Feb 2022	1616867898	2226246623	1007489172
Mar 2022	1823144709	2459760426	1186528992
Apr 2022	1873914450	2536688901	1211140000
May 2022	1850833237	2538832274	1162834200
Jun 2022	1928299910	2640647947	1215951874
Jul 2022	2088482732	2824410828	1352554636
Aug 2022	1992085533	2750896465	1233274602
Sep 2022	1947684907	2728742758	1166627056
Oct 2022	2013676604	2816398359	1210954848
Nov 2022	2008740268	2832588932	1184891605
Dec 2022	1978799068	2823277973	1134320163

A plot of the forecasted values is shown in Figure 4.6

Figure 4.6: Plot of Observed, Model Fit and Forecasted Values

It can be seen from Figure 4.6 that the forecasted values still exhibit a general increasing trend, an indication that revenue collection linearly increase with time. A simple linear regression model to was obtained to examine the extent to which time, as a factor, influences revenue collection in SGR cargo network. The output for this analysis was summarized as shown in Table 4.6

Table 4.6: Influence of Time on Revenue Collection

Model Summary					
R	R^2	Adjusted R^2	Std. Error	F Change	Sig.
.870	.757	.750	1.889×10^{8}	118.212	.000

ANOVA					
	Sum of Squares	df	Mean Squares	F-statistics	Sig.
Regression	4.217×10^{18}	1	4.217×10^{18}	118.212	.000
Residual	1.356×10^{18}	38	3.568×10^{16}		
Total	5.573×10^{18}	39			

Regression Coefficients				
	Beta	Std. Error	t-statistics	Sig.
(Constant)	2.640×10^{08}	6.087×10^{07}	4.337	.000
Time (Months)	2.813×10^{07}	2.587×10^{06}	10.873	.000

Dependent Variable: Revenue Predictors: (Constant), Time in months

This procedure involved expressing revenue collection as a linear function of time. Therefore, the underlying model took the form

$$X_t = \beta_0 + \beta_1 t + \varepsilon$$

Where:

X_t = Revenue

t = Time in months

β_0 = Regression constant term

β_1 = Regression coefficient for time

ε = Error term

Table 4.6 is divided into three parts, which are model summary, regression coefficients and the ANOVA section. The model summary section gives the correlation coefficient (R) and the explained variation in revenue collection brought about by variations in time. The p-value n this section tests whether the relationship between the independent variable and the dependent variable is significant or not. Regression coefficient section gives the model coefficients, the corresponding standard errors and p-values. ANOVA section tests model fittingness to the data. From Table 4.6, R-squared is 0.757 and F-statistic is 118.212. The value of R^2 implies that time explains up to 75.7% of the total variation in revenue collection and the remaining 24.3% is explained by factor(s) not included in the model. This explained variation was found to be significant since the corresponding –value for R^2 was 0.000, which was less than 0.05.

The obtained model was also observed to correctly fit the data since the F-ration in the ANOVA section was significant at 5% level of significance. In the regression coefficients section, time was observed to have a significant influence on revenue collection at 5% level of significance. This was due to the fact that p-value (= 0.000) for time less than 0.05 (0.000 < 0.05). Thus, the model relating time (in months) and revenue collection was expressed as

$$\mathbf{X_t = 2.640\times10^{08} + 2.813\times10^{07}\ t} \;\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \mathbf{(4.1)}$$

A comparison of the time series forecasted values and regression fit values (using Model 4.1) using this regression model is shown in Figure 4.7

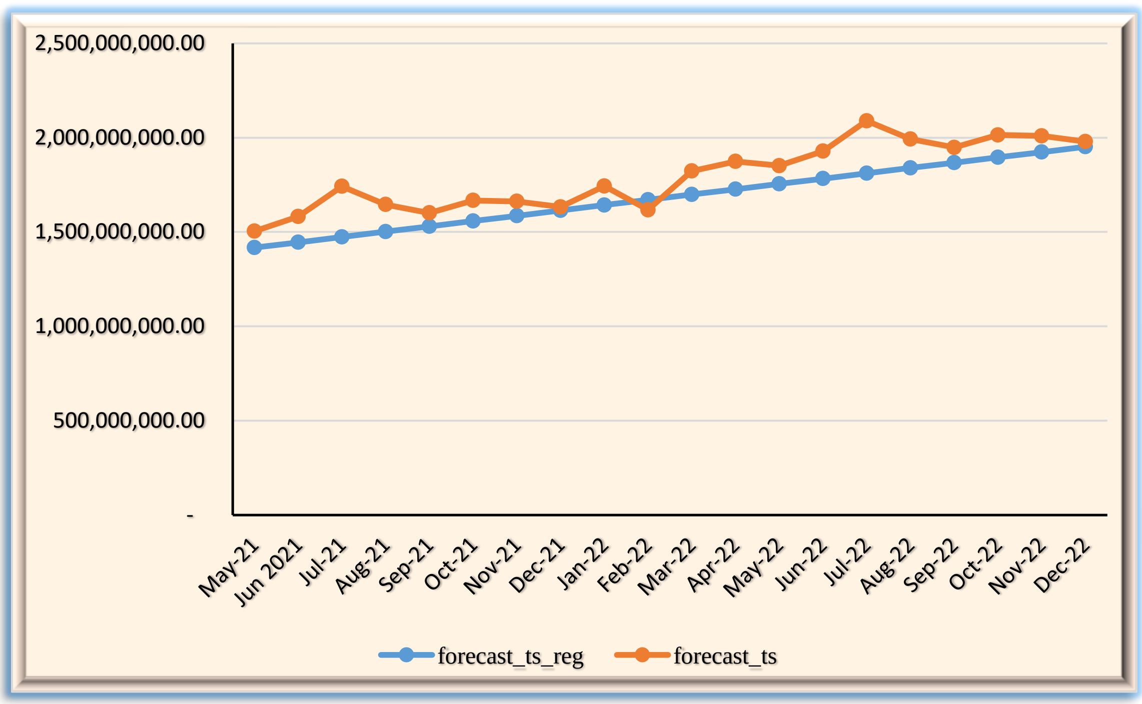


Figure 4.7: Plot of Forecasted Values Using Time Series Model and Regression Model

It can be in Figure 4.7 that the regression-based regression model is a linearized form of the time-series forecasted values. In this case, therefore, the two model are equivalent.

4.3.2.2 Constructing Multiple Regression Model

In this objective, the study involved regressing revenue collection on capacity, number of wagons, turnaround time and transit time. This procedure, therefore, involved obtaining a multiple linear regression model, where the dependent variable was revenue collection while the independent variables were capacity, number of wagons, turnaround time and transit time. However, before the model was obtained, diagnostic tests were run to check on the fittingness of the data to perform regression analysis. The tests included tests for normality, linearity, homoscedasticity and multicollinearity.

Normality Test

The main objective of normality test involves determining whether survey data significantly depart from normal distribution. This test measures the amount and significance of deviation from normal distribution of a data set. In normality test, the null hypothesis is that survey data is normally distributed against an alternative claim of skewed distribution. This test was done using Shapiro-Wilk test. Results for this test were as shown in Table 4.7

Table 4.7: Tests of Normality

Shapiro-Wilk		
Statistic	**df.**	**Sig.**
.977	40	.505

From Table 4.7, Shapiro-Wilk test statistics is less than one for the dependent variable. The degrees of freedom column correspond to the number of observations. The corresponding p – value for the variable is greater than 0.05, an indication that the null hypothesis of no significant departure from normality is accepted. Failing to reject the null hypothesis at 0.05 level of significance is evidence that the condition of normality is fulfilled.

Linearity Test

Linearity test checks whether there is a relationship between the dependent variable and the independent variable(s). In this study, linearity test was done using eta and correlation coefficients, which measures the nature of relationship between the dependent variable and the independent variable(s). Eta-squared measures the explained variation in the dependent variable attributed to variations in the independent variable(s). Eta value ranges from 0 (zero) to 1 (one), where 0 (zero) implies absence of any linear relationship and the value 1 indicates a perfect linear relationship. Results for this test were as shown in Table 4.8

Table 4.8: Linearity Test Results

		Value	**Approx. Sig.**
Revenue Collection (Dependent Variable)	Pearson's R	.951	.015
	Eta	.959	
	Eta-squared	.920	
Number of Valid Cases		**40**	

Table 4.8 shows that there is a linear relationship between the independent variables and dependent variable. This is shown by eta value (= 0.959), which is not zero, and the correlation coefficient value of (= 0.951). The explained variation is 92.0%, significant at 5% level of

significance level since the corresponding p – value was observed to be 0.015 (< 0.05). Based on these results, the condition of linear relationship was satisfied.

Multicollinearity

Multicollinearity test determines whether there exist inseparable associations among predictor variables other than with the dependent variable (Field, 2009). In regression analysis, any predictor variable that associates with other predictor variable is usually ignored since it increases standard error of regression coefficients. This effect in turn alters significance of the coefficients. Presence of multicollinearity is determined using Tolerance values and Variance inflation factors (VIF). A tolerance value of less than 0.1 indicates existence of multicollinearity (Field, 2009). For variance inflation factor, absence of association between predictor variables is shown by VIF values of 1. A VIF of at least 5 is a signal of collinearity associated with that variable. Such variable(s) should be removed from the regression model (Field, 2009). Multicollinearity test results were as shown in Table 4.9.

Table 4.9: Multicollinearity Test Results

	Collinearity Statistics		
Predictor Variables	**Tolerance**	**VIF**	**Comment**
Capacity	.106	9.403	Possible multicollinearity
Number of Wagons	.770	1.298	No multicollinearity
Turnaround Time	.807	1.238	No multicollinearity
Transit Time	.577	1.733	No multicollinearity
Dependent Variable: Revenue			

Table 4.9 shows that all VIFs were less than 10 and all Tolerance values greater than 0.1 for all predictor variables except for Capacity. As stated in the comment's column, these values implied absence of multicollinearity for number of wagons, turnaround time and transit time and

presence of collinearity for capacity. To determine which predictor variable capacity interacts with, a bivariate correlation analysis was performed and absolute correlation coefficients were noted. Table 4.10 summarizes these results.

Table 4.10: Bivariate Correlation Results

		Turnaround Time	Capacity	Wagons	Transit Time
Turnaround Time	Pearson Corr.	1	.180	.153	.426
	Sig. (2-tailed)	-	.267	.346	.006
Capacity	Pearson Corr.	.180	1	.944	.553
	Sig. (2-tailed)	.267	-	.000	.000
Wagons	Pearson Corr.	.153	.944	1	.543
	Sig. (2-tailed)	.346	.000	-	.000
Transit Time	Pearson Corr.	.426	.553	.543	1
	Sig. (2-tailed)	.006	.000	.000	-

It can be seen from Table 4.10 that a high correlation, which was significant at 5% level of significance (p – value = 0.000 < 0.05), exists between the number of wagons and capacity of a train. This is due to the fact that as the number of available wagons increase, carrying capacity of a train increases. This is a proof of existence of multicollinearity between capacity and number of wagons. Based on this observation, instead of using both capacity and number of available wagons in regression analysis, number of available wagons was selected to be used in the subsequent analysis. Further, non-significant correlation between turnaround time and other predictor variables also implied a little or no impact in the regression model. In fact, turnaround time, according to Table 4.10, only has a significant correlation with transit time. Based on this observation, turnaround time was not used in subsequent analysis. Instead, transit time was used.

Homoscedasticity

Homoscedasticity test was used to check whether there is a uniform variance of the dependent variable across all levels of predictor variables. Homoscedasticity or uniform variance is usually examined using Levene's test statistics. In this test, the null hypothesis is that there is no significant difference in variability of the dependent variable across all levels of the predictor variables. At 5% level of significance, homoscedasticity is shown by a p – value greater than 0.05 while heteroscedasticity is shown by p – value less than 0.05. In this study, secondary data was used for quantitative analysis and all the predictor variables had single measurement level and consequently, examining constant variation was not possible. Thus, based on the nature of the secondary data, the condition of homoscedasticity was satisfied.

Therefore, based on the results of the diagnostic tests, the dependent variable was revenue collection, while the independent variables were number of available wagons and transit time. The corresponding multiple regression model took the form

$$X_t = \beta_0 + \beta_1 W + \beta_2 T + \varepsilon$$

Where:

X_t = Revenue

W = Number of wagons

T = Time in months

β_0 = Regression constant term

β_1 = Regression coefficient for number of wagons

β_2 = Regression coefficient for time

ε = Error term

Output for this procedure was summarized as shown in Table 4.11

Table 4.11: Multiple Regression Model for Number of Available Wagons, Transit Time and Revenue Collection

Model Summary						
R	R^2	Adjusted R^2	Std. Error	F Change	Sig.	
.952	.907	.902	1.183×10^{08}	180.653	.000	
ANOVA						
	Sum of Squares	df	Mean Squares	F-statistics	Sig.	
Regression	5.055×10^{18}	2	2.528×10^{18}	180.653	.000	
Residual	5.177×10^{17}	37	1.399×10^{18}			
Total	5.573×10^{18}	39				
Regression Coefficients						
	Beta	Std. Error	t-statistics	Sig.		
(Constant)	613675853.781	193061358.826	3.179	.003		
Wagons	56770.287	4426.742	12.824	.000		
Transit Time	-34355965.527	7128325.744	-4.820	.000		
Dependent Variable: Revenue						
Predictors: (Constant), Number of Wagons, Transit Time						

As previously explained, regression modeling yields three key outputs, which are shown in Table 4.11. Model Summary section gives the extent to which variations in the dependent variable is attributed to a change or changes in the independent variables. This is determined using coefficient of determination or the R-Squared value. In Table 4.11, the observed R-squared was 0.907 with an F-statistic of 180.653. The value of R^2 implies that up to 90.7% of the total variations in revenue collection is attributed to variations in the number of available wagons and transit times. This observation further implies that the remaining 9.3% of the total variations in the dependent variable is explained by factor(s) other than number of available wagons and transit time. This explained variation was significant since the corresponding p-value was less than 0.05 (that is $0.000 < 0.05$).

In the regression coefficients section, the coefficients for the constant term and number of available wagons were found to be 613675853.781 (SE = 193061358.826) and 56770.287 (SE = 4426.742). The corresponding t-statistics and p-values were obtained to be (-3.179, 0.003) and (12.824, 0.000). However, for transit time, a negative regression coefficient was observed (β_2 = -34355965.527, SE = 7128325.744). The negative coefficient implied that transit time has a detrimental impact on revenue collection. That is, increase in transit results to a reduction in revenue collection. Significance of this predictor variable was determined using the corresponding p-value (= 0.000 < 0.05). The ANOVA section, which measures the model fittingness, gave the F-statistic and the corresponding p – value. It can be seen that the observed F-statistic was 180.653 and a p – value of 0.000. An indication that the regression model of revenue collection on number of available wagons and transit time correctly describe the data. Consequently, the regression model was expressed as

$$\mathbf{X_t = 613675853.781 + 56770.287\, W - 34355965.527\, T \quad \ldots\ldots (4.2)}$$

A plot of the actual values and regression-fit (using Model 4.2) is given in Figure 4.8

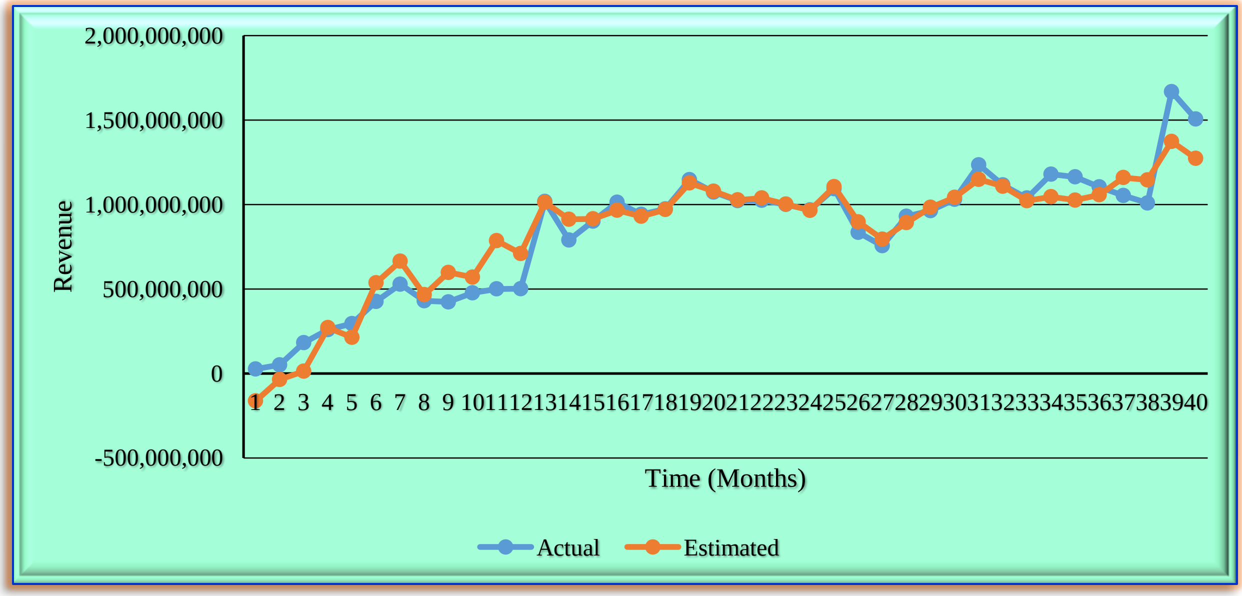


Figure 4.8: Plot of Actual Values and Regression-Fit (Using Model 4.2)

4.4 The Best Model

Section 4.4 has discussed modeling revenue collection using both exponential smoothing as a time series model and linear regression model. The problem that exists now is how to choose the best model to handle time series data. Use of either exponential smoothing or regression models is situational based. That is, each approach has its weaknesses and strengths depending on the existing situation. For instance, in terms of accuracy of forecasts, exponential smoothing produces accurate forecasts than regression models since the former it utilizes both prior actual data and prior actual data and the difference between the two to obtain forecasts. Exponential smoothing takes care of random error by assuming that observed data is the sum of two or more components. Regression models, on the other hand, uses on historical data and assumes a reliable predictor variable(s) with a strong correlation coefficient. These models are suitable when the aim is fitting a line of “best fit” and finding causal relationship between variables.

The main weakness of exponential smoothing is the fact that forecasts lag behind because of smoothing or averaging. This model ignores the ups and downs associated with random variation and consequently, this model is suitable for short-term forecasting and in the absence of seasonal and cyclic variations. Despite these demerits, efficiency of exponential smoothing can, however, be enhanced using Holt Winters' Additive Model. Regression models have several drawbacks when used in modeling time series data. These models are prone to collinear problems, linearity is not always guaranteed in time series data and increase in the number of predictor variables reduces reliability of regression models. Therefore, the choice between exponential smoothing and regression models is based on the nature of data and the main objective for modeling the data.

4.5 Discussions

The qualitative and quantitative data analysis performed revealed some significant results. To begin with, the study established SGR freight operational challenges and, their impacts on efficiency, productivity and capacity performance. Consequently, based on the operational challenges established, a number of essential policies and substantial strategies were recommended.

Meanwhile, quantitative data analysis produced considerable results. The models applied generated a linear trend on freight forecast, which indicates that incase challenges identified resolved, train capacity performance will improve. The results further showed that freight capacity and tonnage, transit time and train turnaround have direct significant impacts on SGR freight revenue collection.

CHAPTER FIVE: SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This section encloses the summary of the study results and inference on how objectives were achieved. Further, it also encompasses the strategies and policy recommendations on the basis of the results and findings. Then, the section ends by proposing an area for further research.

5.2 Summary and Conclusion

The first two objectives of this study were to find out the operational challenges of freight haulage by SGR within its network and, policies and/or strategies applicable to address the operational challenges. The study therefore established that there were key operational challenges derailing SGR freight performance. The main operational challenges include; multiple handling of SGR freight, SGR network limitation, poor information and communication, poor planning and uncoordinated operation, inadequate capacity of equipment/machinery/facilities/infrastructure for KPA and KRC, and connectivity gap for last mile with high logistics costs. Further, a number of strategies and policies were then proposed to provide solutions to the operational challenges outlined.

Secondly, under objective three and four, the study sought to establish how revenue returns of SGR freight transport could be maximized, and show how independent variables influence revenue collection of freight transport on SGR network. By using regression and time series models, the findings of the revenue forecast collection proved that the projected values exhibited a general increasing trend corresponding 95% prediction interval. An indication strong evidence that freight revenue collection linearly increases with time. Finally, from the model analysis, the findings again proved that the independent variables significantly influence and, have direct impact on the revenue collection.

5.3 Recommendations

5.3.1 Policy Recommendations

While freight annual capacity performance output of SGR registered annual improvement since its operations begun, there still existing serious operational challenges that requires policy interventions to improve SGR freight performance capacity and enhance operational efficiency. Therefore, this study proposes some policies for consideration by the railways operators and/or regulators and, relevant ministries for implementation, that is, integrated national transport regulation and/or policy, carbon emission tax levy on road freight, financial and capital allocation, merger of KRC and KPA, and specialized cargo haulage by SGR.

In addition, the study further recommended management strategies to compliment the policies proposed, that includes; a comprehensive review of the SGR freight rates, automation of operational processes, provision of tax incentives and rebates. Nonetheless, the study also recommended for establishment of one-stop shop coordination center of SGR operation, and finally a robust marketing strategy.

5.3.2 Areas of Further Research

Processes and procedures of simplification and harmonization, in addition to modernization emerged as very critical issues around the operational challenges of SGR freight transport. However, the three factors outlined are some significant provisions contained in the World Trade Facilitation Agreement that expedite clearance, release and movement of freight on transit. Since SGR plays a key role in trade facilitation along the transit through Mombasa port, this study proposes further research to establish how SGR freight haulage drives the implementation of the World Trad Facilitation Agreement’s provisions at the port of Mombasa by multi-agency institutions.

REFERENCES

African Union. (2019). *Flagship Projects of Agenda 2063*. Retrieved from African Union: https://au.int/en/agenda2063/flagship-projects

Agarana, M., Anake, T., & Okagbue, H. (2016). Optimization of Urban Rail Transportation. Scientific Research Publishing. http://www.scirp.org/journal/am

Alaghband, M., & Moghaddam, B. (2019). An Optimization Model for Scheduling Freight on a Single Rail Track. University of Central Florida, USA. arXiv:1912.04454v1

Alaghband, M., & Moghaddam, B. (2019). An Optimization Model for Scheduling Freight on a Single Rail Track. University of Central Florida, USA. arXiv:1912.04454v1

Arnold, P., Peeters, D., & Thomas, I. (2003). Modelling a rail/road intermodal transportation system. Transportation Research. https://www.journals.elsevier.com/

Backåker, L., & Krasemann, J. T. (2012). Trip plan generation using optimization. Journal of Rail Transport Planning & Management. www.elsevier.com/locate/jrtpm

Bell, E., Bryman, A. & Harley, B. (2018). *Business research methods*. Oxford university press.

Borndörfer, R., Lamorgese, L., Reuther, M., Klug, T., Mannino, C., & Schlechte, T. (2015). Recent Success Stories on Optimization of Railway System. Konrad-Zuse-Zentrum für Informationstechnik Berlin, http://www.zib.de

Bortas I, B., N, B., & Č, D. (2018). Transport Routes Optimization Model Through Application of Fuzzy Logic. Intermodal Transport Review. https://www.researchgate.net/publication/323496826

Brownstein, M., & Saul, J. (Eds.). (2016). *Implicit bias and philosophy, volume 1: Metaphysics and epistemology*. Oxford University Press.

Businesswire. (2021). Global Rail Freight Market Report (2021-2030). Retrieved from Businesswire: https://www.businesswire.co

Cenek, P., Bednar, P., & JanoSikova, E. (2001). Optimisation of cargo services for the Slovak. Faculty of Management Science and Informatics, University of Zilina, Slovakia.

Charnes, A., & Miller, M. H. (1956). A Model for the Optimal Programming of Railway Freight. Management Science. http://dx.doi.org/10.1287/mnsc.3.1.74

Committee, J. T. (2018). Report of the joint technical committee on the improvement of efficiency and cost effectiveness of transportation of cargo using SGR. http://dc.sourceafrica.net/documents/118953-Report-of-the-Joint-Technical-Committee-on-the.html

Crainic, T., Ferland, J., & Rousseau, J. M. (1984). A Tactical Planning Model for Rail Freight Transportation. Transportation Science. http://dx.doi.org/10.1287/trsc.18.2.165

EAC. (2018). *East African Community Development Strategy*. Arusha, Tanzania: East Africa Community. http://repository.eac.int

EAC.(2015). *East Africa Community Vision 2030.* Arusha: East Africa Community. http://repository.eac.int/handle/11671/567

East Africa, T. M. (2021, July 26). Positive impact of SGR on the Kenyan economy. Retrieved from Trade Mark East Africa: https://www.trademarkea.com/news/positive-impact-of-sgr-on-the-kenyan-economy/

Field, A. (2009). Discovering Statistics Using SPSS: Introducing Statistical Method (3rd ed.). Thousand Oaks, CA: Sage Publications.

Hickish, B., Fletcher, D., & Harrison, R. (2019). Investigating Bayesian Optimization for rail. UK: Taylor & Francis Group. https://doi.org/10.1080/23248378.2019.1669500

Hennink, M., Hutter, I., & Bailey, A. (2020). *Qualitative research methods*. Sage.

Hussain, A., & Tribe, K. (1981, August 4). The American Historical Review. Retrieved from OxfordAcademic: https://academic.oup.com/ahr/articleabstract/87/4/1052/89673?redirectedFrom=fulltext

IBEF. (2021). *Indian Railways Industry Analysis*. Retrieved from India Brand Equity Foundation: https://www.ibef.org/industry/railways-presentation

KPA. (2019). *Annual and Financial Statement Reports*. Retrieved from Kenya Ports Authority: https://www.kpa.co.ke/Pages/Annual-Financial-Reports.aspx

KPA. (2020). Kwatos. Retrieved from Kenya Ports Authority: https://www.kwatos.kpa.co.ke/

KPA. (2020). *Strategic Plan 2018-2022*. Retrieved from Kenya Ports Authority: https://www.kpa.co.ke/InforCenter/Pages/Public-Announcements

KRC. (2018). Madaraka Freight Services. Retrieved from Kenya Railways: www.krc.com

Kumar, R. (2018). *Research methodology: A step-by-step guide for beginners*. Sage.

Liu, C., Lin, B., Wang, J., Xiao, J., Liu, S., Wu, J., & Li, J. (2017). Flow assignment model for quantitative analysis of diverting bulk freight from road to railway. School of Traffic and Transportation, Beijing Jiaotong University, Beijing, China, https://doi.org/10.1371/journal.pone.0182179.

Maia, L. C., & Couto, A. (2013, July 20). Strategic Rail Network Optimization. Journal of the Transportation. https://ur.booksc.eu/book/62614003/82f253

Mugenda, A & Mugenda, O. (2009). *Research Methods: Quantitative and Qualitative Approaches*. Acts Press. Nairobi, Kenya.

Nancy, G. M. (2020). The Successes and Challenges of Kenya's Mombasa-Nairobi Standard Gauge Railway Transport Operation. Research Gate, Murang'a University of Technology, https://doi.org/10.5430/rwe.v12n2p258.

Ndegwa, S. (2019, August 02). China's standard gauge railway makes strong impact on Kenya's economy. Retrieved from CGTN: https://news.cgtn.com/news/2019-08-02/China-s-standard-gauge-railway-makes-strong-impact-on-Kenya-s-economy-IPds2CE4zm/index.html

Office of Rail and Road. (2021). *Freight rail usage and performance 2020-2021*. Retrieved from Office of Rail and Road: https://dataportal.orr.gov.uk/statistics/usage/freight-rail-usage-and-performance/

Ogollah, K., Rucha, K., Aroni, J., & Ndua, G. (2019). Assessment Report Of The Socio-Economic Impact Of The Operationalization Of The Mombasa-Nairobi Standard Gauge Railways on Port City Mombasa. Nairobi: School of Business, University of Nairobi

Olievschi, V. N. (2013). Framework for Improving Railway Sector Performance in Sub-Saharan Africa. Zimbabwe: SSATP Africa Transport Policy Programe. http://www.ssatp.org/

Oumarou , A. (2015). Rail Infrastructure in Africa. Abidjan: African Development Bank. Abidjan. https://www.afdb.org/fileadmin/uploads/afdb/Documents/Events/ATFforum/Rail_Infrastructure_in_Africa_-_Financing_Policy_Options_-_AfDB.pdf

Oxford Economics. (2021). *Our forecast for world trade growth*. Retrieved from Oxford Economics: https://blog.oxfordeconomics.com/our-forecast-for-world-trade-growth

Railway Technology. (2021). *Mombasa-Nairobi Standard Gauge Railway Project*. Retrieved from Railways Technology: https://www.railway-technology.com/projects/mombasa-nairobi-standard-gauge-railway-project/

Railways Technology. (2020). *The world's 10 longest railway networks*. Retrieved from Railways Technology: https://www.railway-technology.com/features/featurethe-worlds-longest-railway-networks-4180878/

Rosopa, P. J., Brawley, A. M., Atkinson, T. P., & Robertson, S. A. (2019). On the conditional and unconditional type I error rates and power of tests in linear models with heteroscedastic errors. *Journal of Modern Applied Statistical Methods*, *17*(2), 8.

SCEA. (2020). *Logistics Spotlight*. Retrieved from Shippers Council of East Africa: https://www.shipperscouncilea.org/index.php/media-centre/logisticsspotlightmagazine

Shumway, R. H. & Stoffer, D. S. (2011). Time Series Analysis and Its Applications, With R Examples. Springer, New York.

Silverman, D. (2011). *Qualitative Research: Issues of Theory, Method and Practice*. 3rd Edition. London, Thousand Oaks, New Delhi, Singapore: Sage Publications.

Sinha, G. R. (2020). Modern Optimization Methods for Science, Engineering and. IOP Science, iopscience.iop.org.

STAR, T. (2021). Cargo haulage by SGR improves in last four months. Nairobi, Kenya. https://www.the-star.co.ke/business/kenya/2021-09-06-cargo-haulage-by-sgr-improves-in-last-four-months/

STAR, T. (2021). Cargo haulage by SGR improves in last four months. Nairobi, Kenya. https://www.the-star.co.ke/business/kenya/2021-09-06-cargo-haulage-by-sgr-improves-in-last-four-months/

Taylor, I. (2020). Kenya's New Lunatic Express: The Standard Gauge Railway. Florida: Center for African Studies, University of Florida. http://www.africa.ufl.edu/asq/v19/v19i3-4a3.pdf

Tipps, D. (1973). Modernization Theory and the Comparative Study of the Society. Society for Comparative Studies in Society and History. Cambridge University Press. http://www.jstor.org/stable/178351.

Tsai, J., Carlsson, J., Ge, D., Hu, Y., & Shi, J. (2014). Optimization Theory, Methods, and Applications in Engineering. Hindawi Publishing Corporation, http://dx.doi.org/10.1155/2015/345858.

UNCTAD. (2020). *Global e-Commerce hits $25.6 trillion – latest UNCTAD estimates*. Retrieved from UNCTAD: https://unctad.org/press-material/global-e-commerce-hits-256-trillion-latest-unctad-estimates

United Nations. (2021). *Build resilient infrastructure, promote sustainable industrialization and foster innovation*. Retrieved from Sustainable Development Goals: https://www.un.org/sustainabledevelopment/infrastructure-industrialization/

Vorobyov, V., Manakov, A., Reger, A., & Tanaino, I. (2018). Optimization of processes in railways based on. MATEC Web of Conferences 216, 02009 (2018). https://doi.org/10.1051/matecconf/201821602009

Vorobyov, V., Reger, A., & Tanaino, I. (2018). Optimization of processes in railways based on the cost management model. MATEC Web of Conferences. https://doi.org/10.1051/matecconf/201821602009

Vorobyov, V., Reger, A., & Tanaino, I. (2018). Optimization of processes in railways based on the cost management model. MATEC Web of Conferences. https://doi.org/10.1051/matecconf/201821602009

Woodburn, A. (2004). A logistical perspective on the potential for modal shift of freight from road to rail in Great Britain. Westminster Research, School of Architecture and the Built Environment.http://www.elsevier.com.

WORLD BANK. (2021). *Global Economic Prospects*. Retrieved from World Bank Group: https://www.worldbank.org/en/publication/global-economic-prospects

APPENDIX I: INTERVIEW GUIDE

1. **In what department do you represent the company and what level of management do you work in the company?** *You can categorize the levels as Top management, Middle level management, Supervisory and Others (if any).*

2. **In your opinion, how would you describe performance of the rail freight transport of [SGR]?** *Probe for both financial and non-financial performance, revenue collection, anticipated performance versus actual performance, compare rail freight transport and road freight transport.*

3. **How do you see the future performance of the rail freight transport of [SGR]?** *Probe for the projected revenue collection.*

4. **What do you think are the key determinants of performance of the rail freight transport of [SGR]?** *Probe for enumeration of each determinant in order of significance and the extent of effect of each determinant.*

5. **In your opinion, what are the main operational challenges of freight transport on rail transport network?** *Probe for how each challenge affects rail freight transport of [SGR].*

6. **What are strategies and/or policies that can be used to address the challenges identified above?** *Probe for specific policies and regulations frameworks, human resources policies, modern technological and information systems strategies etc. Also, probe for strategies*

adopted to ensure that rail freight transport remain gains competitive advantage over road freight transport.

7. **How would you describe the role played by the government of Kenya in influencing performance of rail freight transport of [SGR]?** *Probe for both positive and negative roles, financial and legislative roles.*

APPENDIX II: SGR REVENUE (KSH) DATA FROM 2018-2020

Amount of Freight (MT) Moved on SGR and Revenue (Ksh) Generated from 2018-2021

	2018		2019		2020		2021	
Month	Tonnage (MT)	Revenue (Ksh)	Tonnage (MT)	Revenue (Ksh)	Tonnage (MT)	Revenue (Ksh)	Tonnage (MT)	Revenue (Ksh)
Jan	22,346	25,500,249.00	365,356	1,017,267,936.07	375,828	1,092,488,053.00	449,731	1,052,531,751
Feb	57,633	49,878,557.00	308,540	788,980,196.52	293,088	834,306,615.00	456,135	1,008,013,109
Mar	164,254	181,540,087.00	331,906	900,456,088.88	259,138	755,413,357.00	507,924	1,667,079,399
Apr	208,577	258,500,427.00	356,906	1,012,526,073.56	327,091	929,475,946.00	460,787	1,505,276,768
May	228,800	294,078,696.00	319,757	940,487,424.76	342,326	962,667,608.00		
June	268,787	425,339,660.00	337,024	973,046,610.09	383,782	1,029,900,407.00		
July	306,105	527,416,399.00	394,717	1,146,164,048.50	421,745	1,233,867,659.00		
Aug	309,902	429,421,708.00	369,947	1,072,332,934.80	414,775	1,115,103,597.00		
Sept	309,873	422,571,065.00	343,819	1,021,968,322.06	369,246	1,037,717,598.00		
Oct	344,283	476,128,539.00	342,877	1,024,091,248.67	427,388	1,178,620,650.00		
Nov	331,751	500,019,744.00	350,611	999,682,252.54	412,426	1,162,966,849.00		
Dec	346,362	500,698,440.00	337,934	967,229,346.26	389,804	1,103,652,196.00		

Source: Kenya Railways Corporation

APPENDIX III: SGR FREIGHT OPERATIONS PERFORMANCE DATA FROM 2018-2021

Year	Month	Capacity (Metric Tonnes) Imports	Capacity (Metric Tonnes) Exports and Empties	Capacity (TEUs) Imports	Capacity (TEUs) Exports	Capacity (TEUs) Empties	Train Turnaround Time in Hours (ICDN)	No. of Trains_Containerised Imports	No. of Trains_Containerised Exports	No. of Wagons Imports	No. of Wagons Exports	Av. Transit Time Mbsa Port-ICDN	Av. Transit Time ICDN-Mbsa Port
2018	Jan	16581	5764	924	316	442	11.1	14	17	462	379	12	12
	Feb	47135	10497	2582	526	610	13.3	36	26	1291	568	11	11
	Mar	139499	23434	9108	1211	1183	12.4	92	36	4554	1197	14	13
	Apr	184486	24090	25036	893	2437	11.4	120	37	6211	1665	11	12
	May	187778	32749	12752	1209	5815	13.6	127	72	6376	3512	14	14
	Jun	243741	25046	17244	1119	5525	14	167	68	8622	3322	12	10
	Jul	275611	30494	18882	1055	8458	12	181	95	9441	4757	10	12
	Aug	277208	32694	19236	896	8539	11	183	90	9618	4718	14	14
	Sep	280320	29553	19052	1119	7073	13	174	81	9526	4096	12	11
	Oct	308748	35535	21232	1140	8778	12	192	101	10616	4939	13	14
	Nov	295851	35901	20848	976	10542	13	195	111	10424	5912	11	11
	Dec	312052	34311	21584	986	9836	14	205	104	10792	5411	12	12
	Total												

Year	Month	Capacity (Metric Tonnes) Imports	Capacity (Metric Tonnes) Exports and Empties	Capacity (TEUs) Imports	Capacity (TEUs) Exports	Capacity (TEUs) Empties	Train Turnaround Time in Hours (ICDN)	No. of Trains Imports	No. of Trains Exports	No. of Wagons Imports	No. of Wagons Exports	Av. Transit Time Mbsa Port-ICDN	Av. Transit Time ICDN-Mbsa Port
2019	Jan	318323	41421	22628	1122	11798	12.75	214	134	11425	7357	10.72	8.72
	Feb	259053	43640	18194	1234	11636	11.16	172	127	9199	6791	9.134	8.61
	Mar	289440	41009	19696	1153	10341	10.35	184	121	9875	6196	9	8.8
	Apr	318848	38058	21862	1086	10004	11.18	203	113	10931	6226	9.471	8.65
	May	281433	38325	20496	1062	10834	10.8	203	120	10248	6163	9	8.92
	Jun	296053	40971	20938	1197	11315	10.3	221	132	10469	6679	9.133	8.84
	Jul	336696	53042	24044	1333	13947	8.5	258	165	12107	8066	9.25	9.15
	Aug	321861	45733	23014	1312	12736	10.5	247	154	11542	7602	9.16	8.96
	Sep	297649	45001	21732	1383	12893	8.5	244	150	10886	7434	9.12	9.13

Year	Month	Capacity (Metric Tonnes) Imports	Capacity (Metric Tonnes) Exports and Empties	Capacity (TEUs) Imports	Capacity (TEUs) Exports	Capacity (TEUs) Empties	Train Turnaround Time in Hours (ICDN)	No. of Trains Imports	No. of Trains Exports	No. of Wagons Imports	No. of Wagons Exports	Av. Transit Time Mbsa Port-ICDN	Av. Transit Time ICDN-Mbsa Port
	Oct	298928	43327	21890	1140	12116	10.5	232	158	10955	7588	9.16	9.13
	Nov	306632	41698	21318	965	12640	9.5	254	162	10716	7441	9.43	9.28
	Dec	294287	43323	21106	999	11396	10.4	212	135	10558	6736	9.41	8.96
	Total												

Year	Month	Capacity (Metric Tonnes) Imports	Capacity (Metric Tonnes) Exports and Empties	Capacity (TEUs) Imports	Capacity (TEUs) Exports	Capacity (TEUs) Empties	Train Turnaround Time in Hours (ICDN)	No. of Trains Imports	No. of Trains Exports	No. of Wagons Imports	No. of Wagons Exports	Av. Transit Time Mbsa Port-ICDN	Av. Transit Time ICDN-Mbsa Port
2020	Jan	331543	41719	23472	830	14226	11.07	242	158	11776	7982	9.37	8.98
	Feb	252135	37035	17974	778	12424	9.3	210	147	9050	6925	9.15	9.02
	Mar	218915	39325	15540	1220	9560	10.38	148	110	7784	5799	8.6	8.6
	Apr	289291	36837	18994	1033	9821	8.32	187	113	9512	5798	8.4	8.8
	May	292089	51322	18854	1364	13234	8.43	191	151	9448	7585	8.7	8.7
	Jun	338475	45308	21036	1228	12406	13.33	211	150	10518	7550	8.8	8.6
	Jul	364032	57713	22874	1715	14215	13.03	223	168	11437	8620	8.67	8.92
	Aug	344852	58152	21744	1919	12799	12.53	218	159	11057	8228	8.75	8.75
	Sep	309665	52206	20548	1526	12476	12.12	203	153	10344	7830	9.13	9.03
	Oct	369064	53843	22566	1438	14422	12.98	224	165	11352	8458	10.06	10.1
	Nov	361703	48807	21772	1406	13226	12.48	215	159	10916	8226	9.59	10.1
	Dec	340341	49462	21031	1352	14413	12.18	208	166	10505	8449	9.07	9.35
	Total												

Year	Month	Capacity (Metric Tonnes) Imports	Capacity (Metric Tonnes) Exports and Empties	Capacity (TEUs) Imports	Capacity (TEUs) Exports	Capacity (TEUs) Empties	Train Turnaround Time in Hours (ICDN)	No. of Trains Imports	No. of Trains Exports	No. of Wagons Imports	No. of Wagons Exports	Av. Transit Time Mbsa Port-ICDN	Av. Transit Time ICDN-Mbsa Port
2021	Jan	398527	51204	24256	1122	16396	11.28	241	187	12090	8759	9.43	9.15
	Feb	276747	51209	23040	1275	15439	13.2	230	170	11653	8772	9.23	9.06
	Mar	298358	56716	21700	1666	15074	11.97	258	256	13097	13159	10.8	10.5
	Apr	321659	57090	18488	1543	15542	11.27	226	226	11597	11616	9.63	9.55
	Total												

Source: Kenya Railways Corporation & Kenya Ports Authority