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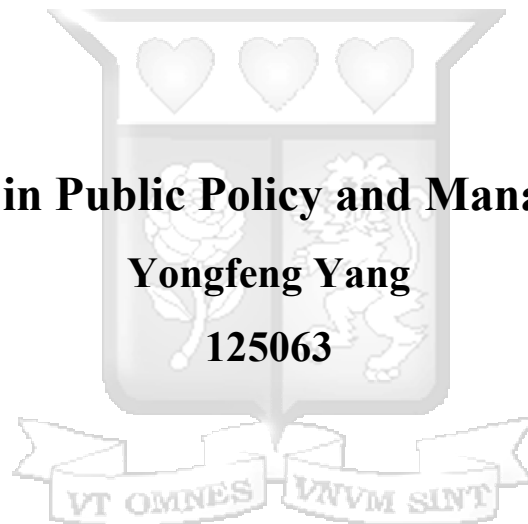
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Study on Sound Management of Standard Gauge
Railway in Kenya through Demand Elasticity
Analyzing

Master in Public Policy and Management

Yongfeng Yang

125063



Strathmore University Business School

2023



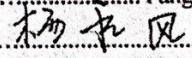
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Abstract

Railway is intuitively more of competitive advantage in long haulage and mass carrying by decreasing the cost of factors of production, and optimizing goods distribution channel. For the purpose of sound management within railway industry, the demand elasticities of SGR in Kenya are taken into assessment.

Time series data in monthly interval was procured from 2017 to 2021. The sensitivities of SGR demand to critical elements are determined by econometric approaches. Within the scenario of passenger, the demand is expressed by fare, GDP per capita and fuel price. Non-stationary data was analyzed by Autoregressive Lag Distribution, in the long run, elasticity to fare is elastic at -2.6, elasticity to GDP per capita is 4.2, and elasticity to other road mode is -4.2. Results show that passenger demand has positive relation with GDP, while modal competition advantage to other road mode is not significant.

Within the scenario of freight, volume moved is expressed by freight charge, international trade, GDP in transport sector, and fuel price. Stationary data was evaluated by Johansen co-integration approach. In the long run, elasticity to charge is 0.4, to GDP and international trade are 1.0 and 1.63 respectively, to other road modes is 2.6. Findings imply that price increase can raise the revenue, freight volume is positively affected by GDP and international trade, and mode shift to other road mode is also not significant. In the short run, any disequilibrium will be adjusted with a speed at 0.47. Therefore, the price framing policy can be employed to increase the revenue in freight sector solely, while more subtle works should have been done, which may lead to competitive advantage for both passenger and freight sectors.

Table of Content

Chapter One: Introduction	1
1.1 Introduction	1
1.2 The background to the study	3
1.3 SRG service in Kenya	4
1.4 Problem statement	6
1.5 Research objectives and research questions	7
1.5.1 Research objectives	7
1.5.2 Research questions	8
1.5.3 Research hypothesis	8
1.6 Scope of the study	9
1.7 Significance of the Study	9
Chapter Two: Literature Review	11
2.1 On passenger demand	11
2.2 On freight demand	13
2.3 Appraisal model debates	15
2.4 Research gap	19
2.5 Conceptual framework	21
2.6 Variables operationalization	22
Chapter Three: Research Methodology	25
3.1 Research design	25
3.2 Data collection and econometric model	26
3.2.1 Data collection	26
3.2.2 Theoretical and econometric model	26
3.2.3 Variables in the research work	27
3.3 Data Process Method	28
3.2.1 Bound Test from ARDL	28

3.3.2 Johansen co-integration Test	29
3.3.3 Error Correction Model	29
3.4 Research quality	30
3.5 Ethics in research	30
Chapter Four: Result Analysis and Discussion	32
4.1 Descriptive data	32
4.2 Passenger scenario	33
4.3 Freight volume scenario	35
4.3.1 Long run model	35
4.3.2 Short run model	38
Chapter Five: Conclusion, Policy Implication and Future Overview	41
5.1 Conclusion	41
5.2 Policy implications	42
5.3 Further research overlook	43
Appendix I. Unit Roots Test	45
Appendix II. Optimal Lag Length	46
Appendix III. Bounds Test and Rank of Co-integration	47
Appendix IV. Ethic Approval Permit	48
Acknowledgment	49
References	50

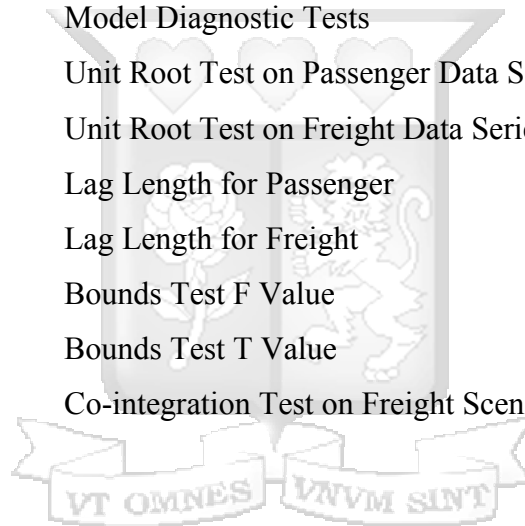
List of Figures

- Fig 1-1 SGR Service Flow over the Past 5 Years
- Fig. 2-1 Diagram of Conceptual Framework



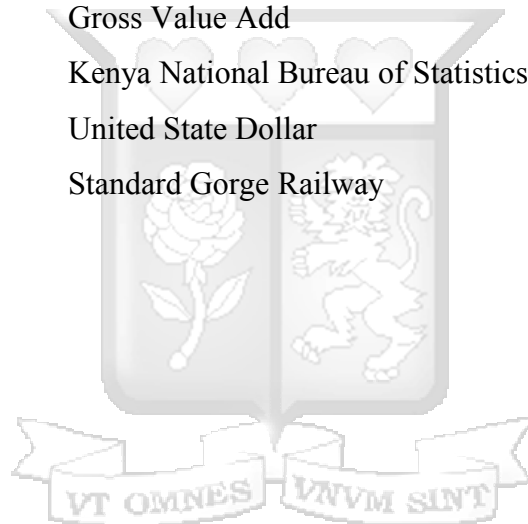
List of Tables

Table 1-1	Research Objectives Enumerated by Scenarios
Table 2-1	Summary of Variables Specified by Similar Research Work
Table 4-1	Descriptive Data on Passenger
Table 4-2	Descriptive Data on Freight
Table 4-3	ARDL Test about Passenger Demand
Table 4-4	Demand Elasticity for Long Run about Freight Movement
Table 4-5	Demand Elasticity for Short Run about Freight Movement
Table 4-6	Model Diagnostic Tests
Table 6-1	Unit Root Test on Passenger Data Series
Table 6-2	Unit Root Test on Freight Data Series
Table 6-3	Lag Length for Passenger
Table 6-4	Lag Length for Freight
Table 6-5	Bounds Test F Value
Table 6-6	Bounds Test T Value
Table 6-7	Co-integration Test on Freight Scenario (lag length=1)



Abbreviation and acronym

ARDL	Auto-regressive Distributed Lag
BRI	“One belt and one road” initiatives, a cosmopolitan development vision initiated by Chinese politicians
CIMB	China Import and Export Bank
ECM	Error correction model
EAC	East Africa Community
GDP	Gross domestic product
GVA	Gross Value Add
KNBS	Kenya National Bureau of Statistics
USD	United State Dollar
SGR	Standard Gorge Railway





Chapter One: Introduction

1.1 Introduction

East Africa Community (EAC) comprises seven countries in the great lake region, a transnational strategy bases on regional integration that aims at economic prosperity, where road transportation is a crucial mean to fulfil this spectacular goal. The same ambition provoked in Kenya, big four agenda came up with four pillars in food security, affordable housing, universal health care and manufacturing, so as to lift Kenya to a middle-income country. Toward this magnificent goal, railway industry helps with constructing basic transportation pathway which links trades from origin to destination.

In Kenya, the first railway initially named Uganda Railway, devised in line with the standard of meter gauge rail. It was constructed by British Colony Empire from 1896, aftermath completed in 1901 with intention to shape a transport corridor for hinterland country Uganda. Now, due to lack of maintenance, dysfunction of management, it has exacerbated to a status of partially abandoned, featured of extremely low speed at 30 Kilometers per hour, days of traveling time and low efficiency of energy consumption apparatus. Whereas, in conjunction with the advocacy of Chinese “one belt and one road” initiative (BRI), Kenyan incumbent party Jubilee regime reached a consensus that accepting the concessional collaboration mode-90% of total cost was loaned from China Import and Export Bank (CIMB), a fund managerial authority subordinates to Beijing administration. Final project contract was implemented with an unprecedented investing capital at 3.8 billion USD (Wang & Wissenbach, 2019), which is the largest infrastructure project for Kenya since independence era.

In the year of 2017, an iconic single-track railway (Standard Gauge Railway-SGR) stretched from east coast to west hinterland, which connects costal city-Mombasa and capital city-Nairobi, and thereafter it may expand to other neighboring counties, it also constitutes one

part of the master-plan for regional economic growth. Overall, SGR has shaped Kenya's national identity, by which thoroughly altered the domestic travelling choices, and land logistic solutions on savannah. For Kenyans, the thrill moment which are awaited with temporal range around one century. In addition, it underpins Kenya's national willpower to engage in building a more integral, cohesive EAC, as well as facilitates Kenya to pursue a prosperous country.

Since the explosion of British industrial revolution in the late of 19th century, steam engine railway was perceived of reshaping the road transportation across the world, it appeared with popularity of higher productivity characterized of relieving human labor by transforming with automatic machinery in long haulage and mass movement. Obviously, modern railway is more effective in eliminating road congestion, accident mortality and greenhouse gas emission. Furthermore, evidences show that railway would activate people and freight transition in temporal and spatial dimensions. Therefore, it attracts more and more interests who are proactively seeking national industrialization by means of railway investment.

In 1850s, railway construction culminated in British with a total mileage appropriately at 32 thousand kilometers. Afterwards, United State of America has accomplished 370 thousand kilometers railway network across North America continent in 60 years since 1850. Once in a time, the Russians have made a trial test stretched 6.5 kilometers long-haul freight at 47403 tons. Within the territory of Asia, the rapid Chinese economic progress enables central government to grant development priority in railway transportation sector. Till now, Chinese are the second largest rail freight and the largest passenger carrier in the world.

It is wide acknowledged that railway industry characterizes of comparable competitive advantages in cost-saving, lower energy consumption, long-haul freight, and environment-protection. And a range of convincing examples occurred on railway pathway or network

expansion among the economic powers across the world. Hence, there has no doubt to agree with that railway industry has become an indispensable road transportation instrument in promoting social-economic progress.

1.2 Background of the study

In the Sub-Saharan African countries, there though exist massive of nature resources, economic development is seriously but not solely restricted by scarcity of accessibility to land transportation. As we know, Kenya possesses 536 kilometers of Indian Ocean costal line, natural deep-water ports, for example, Mombasa and Lamu, sustain majority of merchandised transaction throughput, as well as crossing border trade and intercontinental commodities exchanging activities in East Africa. Mombasa is a port city, dwelling more than 1 million populations, it plays a crucial role in linking land transportation system with global maritime transit network. Moreover, Mombasa port severs of 582 646 km² of area and 300 million of populations in East Africa Continent (Brain, 1999), it is also one of substitutable ports for supplying goods and service to landlocked continents, such as Uganda, Sudan, Rwanda, Burundi, and some part of Democratic Republic of Congo.

Beside the natal advantages we have mentioned above, several generations of Kenyans are persistently seeking for effective channels which can fulfil their commitment to nation's great prosperity. Though without remarkable accomplishments in world level, the inception of SGR is noteworthy. It is definite to aware that transportation restriction in Kenya severely confines the impulse of economic growth by cost of production and goods distribution. In contemporary era, with massive of efforts have been made, a more widely known institutional inclusiveness is shaped in the process of modern nation construction, so much so that plenty of foreign government authorities, international bodies and non-government organizations are converging at this arena, which entitled the capital city-Nairobi to become the hub of global diplomacy.

The ambitious goal to become a middle-income country illustrated by Kenya's national strategy, as well as the commitment for infrastructure augmentation which is in consistence with EAC's development goal, thus massive of action plans and executive efforts are formulated under those wishful aspirations. During the past period of time, in the terms of public policy implementation, some of critical domains on which were remarkably stressed, such as renewable energy, water reservation, road communication, poverty elimination, environment protection and so on. Obviously, railway industry investment plays a paramount function in facilitating the progress of Kenya's economy to national goal. Furthermore, the aspirational theme about regional integration will become more and more feasible in coordinating with the development of railway transportation industry.

1.3 SRG service in Kenya

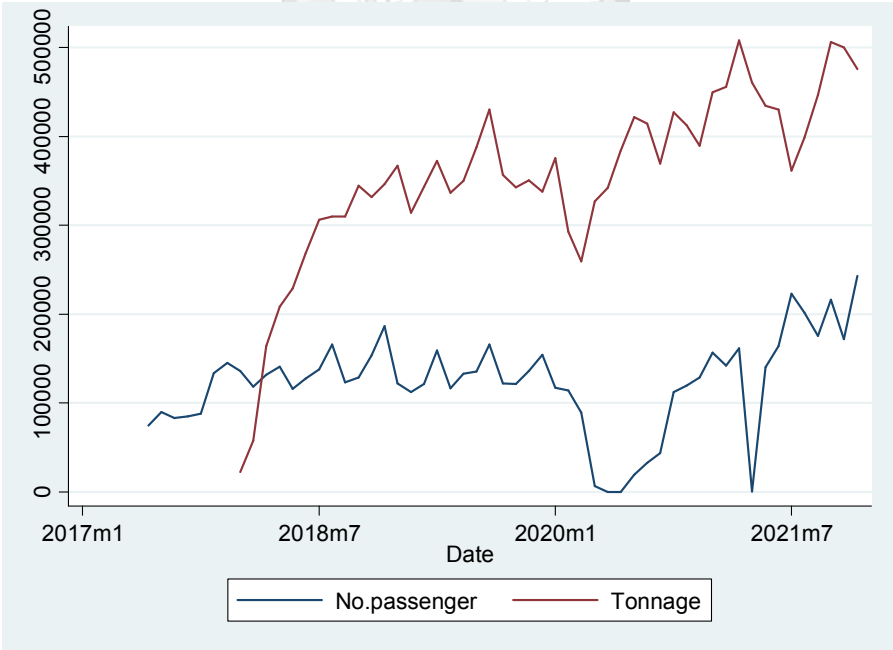
Holistic project construction was completed in 2017, at the beginning of coach trials, sole passenger service was supplied through SGR line. Within approximate half year of operation and subtle adjustment, afterward the railway operators started their freight service. In line with the concessional contract signed between socialist Peking regime and jubilee Nairobi government, the railway system is subordinated to Kenya Railway Authority, and operates in a certain time period by Africa Star Railway Operations Co., Ltd, the Kenya registered company is a subsidiary undertaking of China Road and Bridge Company, whom transformed the constructional role to rail operation and management.

As depicted by the curves showed below, in figure 1-1, SGR passenger boarding is fluctuating approximately at 120,000 when operation enters normality, except during the service termination period due to covid-19 curfew regulation (thereafter, covid-19 acts as exogenous facet importing to relation modeling, notates with dummy variable in mathematical analysis). According to the data from Kenya National Bureau of Statistics (KNBS), till the end of 2021,

the aggregate passenger volume is around 7.25 million. Where the long haulage freight volume is increasing drastically from null at the beginning, soaring up with tendency to surpass 500,000 tons a month, to a large extent, it was also affected by covid-19 from the earlier time of 2020. From the beginning to the end of year 2017, the accumulated freight volume is 18.57 million tons.

According to Kenya port authority report2021, the volume of railway freight equivalent to 15.6% of total port throughput, the ratio is clearly below 40% as the expectancy as we do SGR project feasible analysis. Till 2022, referring to the newspaper (Kimanthi, 2022) reported that SGR only carried 40% of containerized cargo and 10% of conventional cargo the freight haulage, which is far to reach at saturation of SGR, and the remaining transportation is still carrying out by road movement.

Fig 1-1. SGR Service Volume over the Past 5 Years



Data: sourced from KNBS

1.4 Problem statement

In the developing countries, debt is as sensitive as some other social unrested issues elaborated in the framework of sustainable development goals (Muhanji & Ojah, 2016). Referring to the study (Whajah et al., 2019), the authors suggested that public debt has a negative impact on inclusiveness of economy, so guidance to optimize debt distribution should be proposed sooner in African countries. Though the SGR in Kenya is completed by concessional intra governmental debt, which is also foreign debt, the genuine burden of activated debt is not deniable that will be shared by the resident of Kenya, per se by the future generations, in which persistent challenges still exist.

SGR derived foreign indebtedness should be thoroughly considered of, a sound approach to sustain the foreign debt is persisting on the perception of self-reliance that enabling considerable revenue to cover the foreign debt, and countervails the attendant interest which is prescribed in the signed contract. De facto, there are massive of failed mega projects (Rothengatter, 2019) which can't fulfil expected criterions. With respect to the case of Kenya, a fierce debate was ignited in the past few years, since the SGR project has launched smoothly while it cannot bring considerable return ratio to the cost. In addition, SGR is the first modernized rail system in Kenya that equipped with superb potentials in haulage and comparable competition advantage. More specially, empirical research which can be utilized to railway industry administrative practice is relatively shortage. Therefore, railway demand should be calibrated elaborately to discern the core determinants in a way by associating price charging, endogenous or exogenous aspects, and comparing with other transport modes, which may be used as regulatory of framework to increase the revenue produced from railway industry.

It is well acknowledged that the railway demand elasticities are varied across several elements, thus a territory where railway demand elasticities necessitate be in depth explored. First of all, demand is relied on own price, varied by socio-economic elements and cross price resulting

from competitive transportation modes. Secondly, owing to the data sets we have obtained is historical evidences, while those data are used to estimate the future trend which may lead to estimation default, therefore time plays a critical role in estimating the tendency of future demand. Thirdly, the characteristics between passenger and freight market should be distinguished to some extent, thus the parameters associated with those two different market models are dissimilar. Within the content of Kenya, demand sensitivities to different variables, to time series data and to features of different markets are elusive, it is also an entire empty domain where it needs to be fully explored in Kenya.

1.5 Research objectives and research questions

1.5.1 Research objectives

For the purpose of ease understanding of the research methodology, we proceed from passenger scenario at first, then after to freight scenario. In table 1-1, the research objectives have been tabulated respectively.

Table 1-1 Research Objectives Enumerated by Two Scenarios

Passenger	<ul style="list-style-type: none"> (1) The effect of own price on passenger demand; (2) The effect of income per capita on passenger demand; (3) The effect of other transport mode on passenger demand.
Freight	<ul style="list-style-type: none"> (1) The effect of freight fare on freight demand; (2) The effect of economic status quo on freight demand; (3) The effect of import and export volume on freight demand; (4) The effect of other freight movement mode on freight demand.

The specified variables discussed above are measurable, which will facilitate to construct railway passenger and freight movement mode, so as to explain the future demand parameters in guiding railway plan and management by the acquired time series data.

1.5.2 Research questions

The next approach in the following section, research questions will be elaborated.

- a). What are the key determinants that have a significant influence on railway demand?
- b). How is performance of railway demand, is the parameter of demand elasticity significant, and are all those parameters obtained which is reliable?
- c). Can the effect of time period on the railway demand be predictable, are all demand elasticities significant distinguished by time length?

1.5.3 Research hypothesis

With respect to research questions, we set out the operational research hypotheses below.

- (1) HYPOTHESIS 1. Null hypothesis: determinants set out in above paragraphs don't have significant effects on rail demand; alternative hypothesis: determinants have significant effects on rail demand.
- (2) HYPOTHESIS 2. Null hypothesis: the parameter of demand elasticity is not significant, reliable in demand analysis; alternative hypothesis: the parameter of demand elasticity is significant and reliable.
- (2) HYPOTHESIS 3. Null hypothesis: the effect of time length to demand elasticity is not significant; alternative hypothesis: the effect of time length to demand elasticity is significant.

1.6 Scope of the study

This study will focus on sustainable development in railway transport industry in Kenya, as we have illustrated funding SGR infrastructure is not only a notion of economic growth, but it also associates with econometric model in attempting to construct the causal chain relationship, with measurable elements in assessing the viability of previous investment. We will analysis via aggregate time series data in modeling the long run and short run demand elasticity by distinguishing with passenger and freight sectors. At the macro level, aggregated data set will be utilized in the modeling process. In this study we will only consider passenger flow and freight volume at national level without distinguish path, corridor, station. At the micro level, Kenya as the particular case will be an example analyzed comprehensively on the demand sensitivity, whereof the elasticity parameter is paramount to decision making on railway service planning and administration in the future time, so as to rationalize the railway industry.

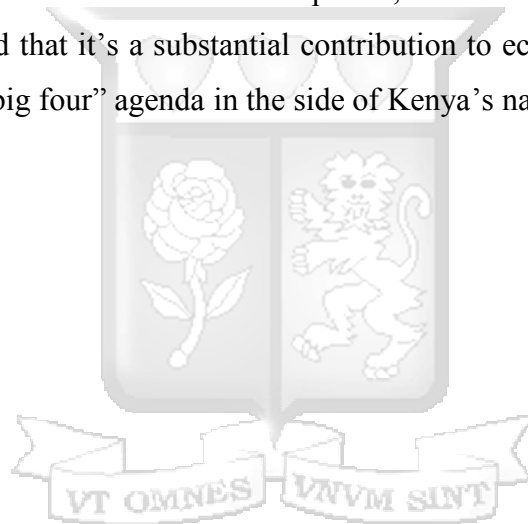
1.7 Significance of the Study

Due to its competitive advantage in long haulage and massive carrying, railway industry plays an important role in facilitating regional economic development. Railway industry in Kenya is exemplary of public transportation infrastructure functioning as catalyst in driving economic growth. With increasing fund invested in railway industry in Kenya, whereas, research works on SGR sector is totally neglected, thus a set of theoretic framework is required urgently in guiding railway operation planning, management and administration.

To the very large of my knowledge, this research work is a pioneering contribution in seeking the determinants that have a crucial influence on railway service demand via case study of SGR in Kenya. With a deep understanding of elasticities of railway service demand, it is empirical but instructive for policy makers and regulation formulators, analysts, railway agencies and operators to deliberate the process of railway service adjustment, in order to

satisfy the main goal of maximum coverage of invested cost and relief the debt burden originating from railway construction, which it is also pivotal requirement in railway reinvestment for sustainable development goal.

The research shows us empirical time series data about railway transport service demand, it enables us to explore the determinants that have major impact on railway service demand, and to what extent those variables have influence on railway service demand, both are unexploited area in utilization of time series data analysis for SGR demand evaluation. It is of significant milestone in the sector of infrastructure development, then a set of empirical theory is expected to be constructed that it's a substantial contribution to economic growth, which are also in compliance with “big four” agenda in the side of Kenya’s national strategy.



Chapter Two: Literature Review

Railway demand elasticity refers to the responsiveness of railway service demand to the changes with respect to the determinants of interest. Refer to empirical estimation (Ramanathan, 2001), the long run and short run railway service demand elasticity incorporating passenger and freight service were estimated simultaneously within Indian context. Because railway service demand is conditional on utility deriving from the needs of individuals or commercial entities, whereas different contexts of various countries have more or less difference in the aspects of path, corridor, phase of economy development, groups of commodities, agencies, carriers and operators. To varying degrees, the identified research conclusions and attendant policy applications may distinguish across countries. Hereafter in the following sub chapter, we will review existing literature over time on passenger, freight demand elasticity estimation, and prevailed study methodology respectively.

2.1 On passenger demand

The demand for passenger service refers to the willingness of individual to pay for traveling from one to another place for the purpose of social activities through railway system, for instance, commuter for job, visit, study and entertainment. Massive of studies stressed emphasis on developed countries, such as, UK, USA, and Australia. At the beginning of our literature review, Spanish suburban railway ridership (Asensio, 2000) was taken into academic estimation, the study provides us the short and long run demand elasticity to own price, and to service quality related variables. Academician (Wardman, 2006) conducted a causal-chain study on Great Britain railway demand scaling by external factors using time series data from period of 1970-1990, conclusion presents us that GDP is the most crucial variable, wherein additional influences come from fuel price, car time, car cost, population and post privatization time trend. At the meantime, public transports (bus, rail, car) are of the research subjective in Great Britain, wide range of factors such as fare, service of quality, income and car ownership are determinants that principally affect transport demand elasticity

(Paulley et al., 2006). In 2012, UK's passenger demand elasticity was estimated by time series data from 1850 to 2010, findings suggest that dynamic demand elasticities with timeline during the research interval, moreover, the price and income elasticities are very large in the middle of nineteenth century, and declining with economic development (Fouquet, 2012). In 2013, aggregate assessment of demand to price elasticity of public transport specialized to integrated fare system in Chile was undertaken, more so, the relationship between sole explanatory component fare and user flow was constructed explicitly with empirical data set (DeGrange et al., 2013). In 2014, passenger demand of four major Australian cities was put into analysis, consequences signify demand in-elasticity to railway fare while city population and the mileage of kilometer run are the dominant determinants (Wijeweera et al., 2014). Likewise, Australian city Melbourne's railway passenger demand was modeling with respect to fare, city population, petrol price and passenger flow, interpreted results imply us fare increasing leading to accumulation of total passenger revenue, owing to inelastic passenger demand to fare (Wijeweera et al., 2014). In 2016, authors (Rahman & Balijepalli, 2016) undertook an investigation on Indian suburban rail passenger demand sampling with five divisions in three cities, inelastic passenger demand to fare which is consistent with massive of existing literature. In 2017, an article titled with the effect of timetable related service quality on rail demand in Britain was published (Wheat & Wardman, 2017), wherein a composite index Generalized Journey Time is expressed via traveling time, service headway and time penalty for interchange, through which respective responses of railway demand to service quality related variables are derived. In 2019, empirical study (Wardman et al., 2019) about cross elasticity of railway demand to motoring cost was undertaken in Great Britain. Analyst (Toner et al., 2020) conducted a passenger demand assessment in Big British, by which the author delved the principal determinants via ticket sales data, evidences show that own price and deduced cross price elasticities are computed robustly and significantly with different ticket types. In 2021, two different measurements (passengers and passenger-kilometers) on railway passenger demand was adopted to estimate Pakistan railway demand

from 1980-2017, in turn, findings vary accordingly while shed light of valuable policy implication on revenue increase and modal split (Khan & Khan, 2021).

Passenger service supply is to some extent fulfilling the basic needs originated from socialized activities practiced by human being. As the literature reviewing enumerates above, rail passenger demand is deemed as a commodity that is affected by own price, and economic activity (income per capita, economic growth rate, unemployment). A further while interested notion (Fouquet, 2012) bring us to discern the characteristic of the specific goods, for instance, that “luxury good” will arise the demand proportionally comparing to income increasing trend, slow down the trend while reaching a saturation point. Demand elasticity of necessary goods will not vary a lot with respect to income changes, while demand of inferior goods shrinks responding to income increase. And also, rail ridership relies on cross price from other passenger movement modes, service quality (travel time, accessibility and connectivity), and demographic elements.

2.2 On freight demand

Freight demand goes indirectly into the process of product or distributes goods and service that are spatially differentiated. Indian freight demand features were depicted with time series data from 1960 to 1990, evidences suggest that high GDP elasticity and low price elasticity, in addition, any disequilibrium in short run will be corrected to sustain stability in the long run by GDP and freight demand variables, last but not the least, stable demand system in long run will be affected by system wide shocks and converges to equilibrium in around 3 years after the shocks (Kulshreshtha et al., 2001). In 2012, Swedish rail freight demand was decomposed into short, medium, and long term period, results show that freight demand is coupled with GDP and without any signs of decoupling in the long term, moreover, short and medium rail freight demands are affected by temporary changes in import and export (Andersson & Elger, 2012). Obviously, regression variables is crucial in deciding validity and

accuracy of the modeling process, with respect to dependent variable for freight shipment, two indicators to quantify moved weight presented by unit of ton and weight moved divided by distance. The former is deemed as direct indicator, the latter is indirect indicator. Further, the empirical study also found that freight rate and volatility of Australian dollar are the dominant determinants to freight demand, in addition, the feed-in effect happens in a way that an explanatory variable functions and indirectly has influence on freight demand (Wijeweera et al., 2014a). Academicians (Khan & Khan, 2021) employed time series data from 1972-2017 in Pakistan to analysis railway freight demand, study used three elements- freight rate, economic activity (gross value added) and cross price as proxy of fuel price to regress the log linear relationship, so as to forecast freight demand, whereof long run demand elasticities to variables of interest are obtained, and any disequilibrium is corrected by short run driving impulse, there also exists substitution relations between railway and road haulage. In 2019, empirical study (Jourquin & Beuthe, 2019) adopted the changes of total cost of transport, transit time and travel speed to characterize the demand elasticity, European continental freight (road, inland waterway, rail) demands were in depth analyzed, and substantial demand elasticity parameters was inferred, except that, own and cross elasticity to transport cost and time were provided, more specially, speed acts as composite elasticity that has an influence on transport cost and time.

Though the freight demand estimation is plausibly scarce in contrast with passenger study, the determinants of interest associated with freight demand can be concluded as below. Generally, freight demand elasticity is relied upon own price, economy tendency, modal shift effect resulting from other modes (such as road, inland waterway), and pertaining aspects that affect the elements aforementioned.

2.3 Appraisal model debates

Other than there existed varying results on demand elasticities within different contexts, so did the tailored methodologies substantiate in the previous literature. Thus, the appraisal modes utilized to railway demand elasticity evaluation will be interpreted through extensive of literature surveys from the facet of data attributions, functional form, and conventional algorithm, which are suitable technique for generic time series data processing.

Commonly, data employed to railway demand elasticity estimations can be categorized into two main classifications (Wijeweera et al., 2014a): (1) survey-based data, (2) time series data. Survey data is deliberately procured through specific plan of action, sampling and data collection methods, it is the method to acquire primary data (Wardman et al., 2019). Time series analysis is related with historic data to extrapolate what has happened in the previous time when variable of interest changes. While, time series data are always aggregated in the integral framework of system lasting for a number of years, exhibits in the features of macro or micro magnitude, collects by either analysts or agencies. Refer to the publication (Paulley et al., 2006), a clear boundary is provided that most of academics take 1-2 years as short run, 12-15 years as long run (few of them take 20 years), while 5-7 years as medium run. Basically, data introduced to the rail freight studies with characteristics of, and factoring with the criterion of research scaling, it was sorted into two sub groups: (1) disaggregate data (Toner et al., 2020), (2) aggregate data (DeGrange et al., 2013). By definition, disaggregate mode means unit of observation is individual decision maker while aggregate mode is unit of observation is aggregate decision maker. Basically, disaggregate data in passenger flow context analysis is more common to see than in freight carrying demand, because of the nature of disaggregate data for freight transition is confined by its commercial implications what are reluctant to be disclosed (De Jonga et al., 2004), but passenger ridership is more common to be reflected from the modern ticket sale platform with the assistance from digital system. Disaggregate data sets sourcing somehow from basic rail route focused on specific

commodity from the sense of assumed individual (shipper, carrier, consignee, freight forwarder, and consigner). Obviously, disaggregate data will facilitate the quality in accuracy of estimation, refer to empirical evidence (Asensio, 2000; Toner et al., 2020), disaggregated ticket sales data was used to explore revenue augmentation method by the notation of differentiation of products and differential pricing. While, the validity and efficient profits resulting from disaggregate data are the potential challenges which is also time consuming in data collection. By way of contrast, the highly aggregated level of data characterizes by using index of total flow on national, regional level of data without obvious distinction of routes, corridors, modes, commodities and so on (Asensio, 2000). In addition, the data sets hold no attribution to explicitly incorporate all explanatory variables. The main advantage for this method is the lower cost to obtain the individual data. Albeit, the accuracy of the estimation model is elusive which provoked fierce debates, due to the aggregate procedure ignores potential sectoral impacts that variation pertaining to demand elasticity exists throughout freight tasks. With respect to the limitation of smaller sample size and general assumption of distribution and asymptotic trends, a static and dynamic modeling methodology was employed and specialized to developing country in India (Rahman & Balijepalli, 2016).

There has a variety of templates that committed to time series rail demand elasticity estimates, as per prior literature (Khan & Khan, 2020; Toner et al., 2020), functional form which are suit for rail demand forecasting that can be sorted into three distinguished paradigms, (1) economic method, (2) econometric method, and (3) network based method. And those of methods experienced long period of pragmatic innovation from origin format to nowadays' variant, whilst, joint application to deal with sophisticated transport demand question seems be broadly accepted.

Economic method refers to rail demand deriving from the need of utility pursuing by individuals or from the demand of the input to the entities in the process of product. There

exists a range of relationship on economic theory that is conducive to rail demand parameters prediction (Toner et al., 2020). In general (Tavasszy & de Jong, 2014), several kinds of economic theoretical basis specified to freight movement are established with integral production, consumption and trade disciplines that are generalized furtherly as input and output economics, moreover, trade gravity models what are based on economic geography. From the point of Marshallian ordinary elasticity, consumers prefer to a transport mode which are more incentive with the intention of maximization their utility under a given budget constraint (Khan & Khan, 2021). Because of the drawbacks of econometric modeling form frequently appeared in acquiring relative small, context specified elasticity, and concerned correlation with other variables, economic theory was adopted complementally to explore the sensitivity of rail boarding to changes from similar modes by a few empirical research works (Toner et al., 2020; Wardman et al., 2019). Econometric method (Kulshreshtha et al., 2001) investigates the causal-effect chain of the variable of interest responding to the changes of extensive explanatory determinants. Generally, econometric method is functioned with the equation of single linear algorithm approach that dependent variable is affected by a variety of explanatory variables. Joint analysis (Toner et al., 2020) incorporate demand system with respect to economic theory and market research exercise was undertaken, by which the difficulties in deriving cross price conducted with single equation in the context of differential pricing tickets is addressed, findings suggest that joint analysis method obtains significant, then robust, own price and cross price elasticity, and furthermore, joint method is superior than conventional single equation method in deducting cross price elasticity. Finally, network-based method focuses on optimum of routes in combination with task assignment, so as to reach an equilibrium status in supply and demand network.

In details understanding of the modeling forms that were commonly utilized, so did attendant algorithm estimators. Previous existing literature concentrated evaluating model either in the form of the aforementioned solely above, or in the form of joint model to deal with complex

problem significantly. Whereas, ordinary least square (OLS) or multiple-steps of OLS, this sort of estimator is frequently used in linear or log linear equation resolution. Maximum likelihood is specialized for simple or multinomial logit modeling approach. Furthermore, co-integration is the most welcomed method in address time series data, represented by Engel and Granger two-steps method. Except that, model choice is also well known in transport demand application analysis, such as Marcov random walking, hierarchical model choice tree and so on. Other than the novel methods solely used or jointly used which place emphasis on single and multivariate co-integration, vector auto-regression (VAR), and error correction model (ECM). Considering the barriers that eliminate the robustness and significant features of statistical regression, several traits pertaining to modern data processing can't be ignored. First of all, on the characteristic of stationarity of level data , traditional time series data regression is construction on classical Gaussian asymptotic theorem, whereof, the assumption of validity to the method of ordinary least square is conditional upon stationary time series data, otherwise, spurious regression and misleading inference are hardly to be avoided (Kulshreshtha et al., 2001). Prior to the conduction (Ramanathan, 2001), a range of academic studies put emphasis on the modeling through CI process with consideration of non-stationary data set, and initially focused upon the field of fuel consumption prediction. The prerequisites to adopt CI modeling is the stationary of regression data sets at the same integration order, or the method effects probably basing on the assumption of the integration order of independent variables is larger than that of dependent variable, or at least at the equal level. Thus, several data variables though have unit roots, equivalent to non-stationary characteristic, a linear combination of them may have stochastic trend terms that are mutually offsetting the force from disequilibrium by each other, in turn, the error term becomes stationary. Definitely, non-stationary data can be transformed to stationarity by detrending, by which it is a standardized statistical way of differentiation dealing with level data series (Ramanathan, 2001).

Secondly, endogenous bias signifies that feed-in effect exists between two or more variables. In response to the drawback of endogenous regressors, Vector Auto-regression (VAR) method is developed through assuming that all variables are endogeneity . Thirdly, owing to infrequent and very a limited variation to fare changes for an integral fare system, the features result in serious collinearity between various explanatory variables and dependent variable which lead to elusive robustness and accuracy of the regression results. There also exists fare endogenous effect that fare relies on the number of traffic flow in different period of time, while the traffic flow responds to the fare level. For the purpose of deriving viability of modeling function in econometric analysis, discrete choice models (multiple linear regression, multinomial logit and hierarchical logit and mixed models) were used to infer the fare of demand elasticity for integrated transit system in Chile (DeGrange et al., 2013)

Last, but not the least, regression bias results from long run spontaneous adjustment of associated variables that while in the short run the responsiveness meaningfully follows the generalized elasticity in sustaining intuitive stability. More so, a range of empirical studies (Kulshreshtha et al., 2001; Ramanathan, 2001; Wijeweera et al., 2014) focus upon time series rail demand estimation with ECM in the short run to obtain inference, so much so that to distinguish the probable deviation with the long run generalization which is closely associating with magnitude of time period.

2.4 Research gap

Railway demand elasticity estimation is quite common to reach within the context of British, USA, and other developed countries. In the previous research works, they focus on aggregate and disaggregate demand data sets which was used to railway system administration with the intention of encourage of rail haulage and increase the efficiency of railway industry. For this research topic, scarcity of literature is found with fascination in exploration of railway operation and management in Kenya. Even though a body of publications shed the light of

railway construction and operation in Africa (Rode et al., 2019), most of them stressed emphasis on international relations, geopolitics, especially about the distribution equity under the framework of reciprocal coordination between China and Africa.

It is well acknowledged that the demand elasticity varies across modelling context, moreover, there are a number of empirical theorems that have applied to simulation approach about railway demand, therefore, derived elasticity parameters under different assumption fluctuate to a large extent.

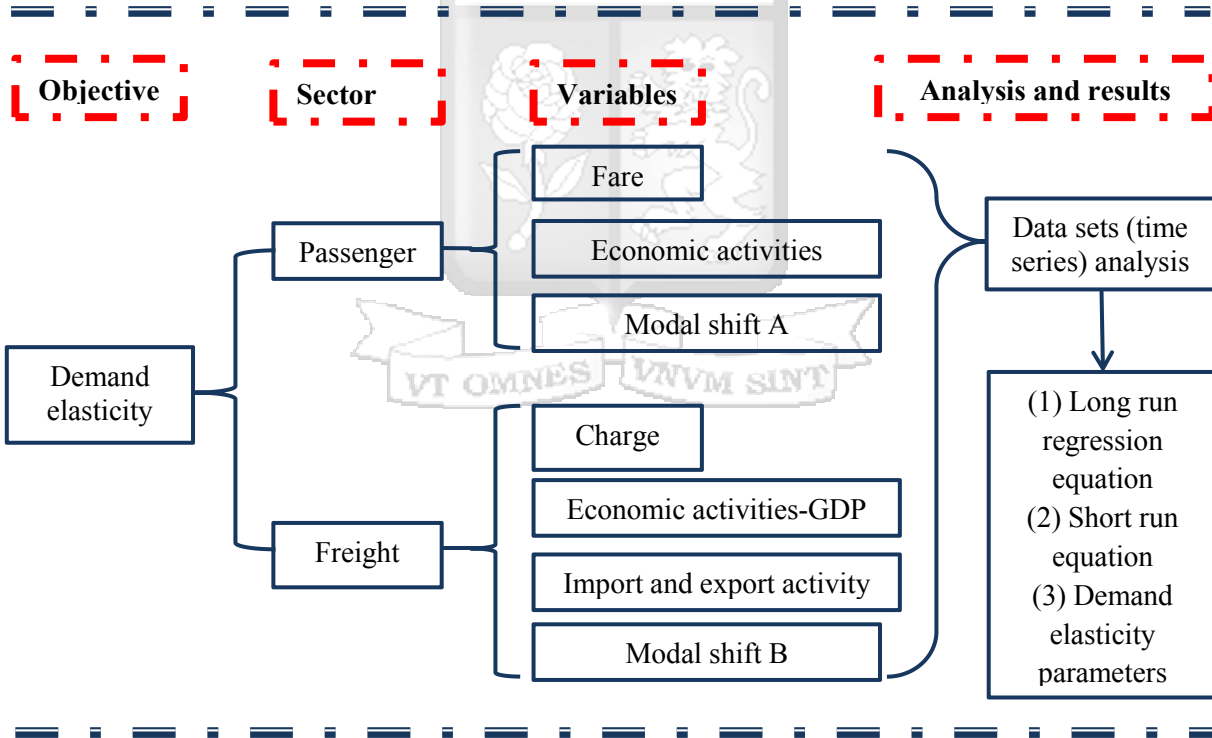
Therefore, the research aims at constructing a set of theory which is suitable for analyzing the effects of railway under the specific situation. What's more, the controversies on railway investment master-plan in EAC should be addressed by the method of scientific inference, rather than speculation, agitation and elusively following the public express.

Most important of all, China is a global powerful practitioner with a robust financial system, existing under a specific context which is largely distinguished with Sub-Saharan countries. Though, unconditional debt equivalent to concessional cooperation is strongly advocated and proliferated to some extent in mega infrastructure investment, the natal premises can't be ignored, and reviewers should put more stress on host countries rather than unilateral willingness from China. Therefore, this research work will place emphasis on the research gap in EAC, whereof the author will quantify the determinants on rail demand by viable regression approach. Finally, this article will present reliable reference in the format of policy implication to policy analyst, policy maker, railway agencies, operators, and produce a set of reliable theoretical base, in order to construct prosperous Kenya and a more integrated EAC.

2.5 Conceptual framework

This research work centers on railway operation data in Kenya, it purposes to establish a robust statistical model in assessing the SGR service demand by considering of own and cross price, economic elements that are closely relevant to railway demand and other variables that have unneglectable influence on railway demand. In general, econometric model is preferable in analyzing the causal chain relationship, and non-stationary time series data are intend to analysis by co-integration method. Finally, the diagram below explicates the research framework well.

Fig. 2-1 Diagram of Conceptual Framework



2.6 Variables operationalization

Variables feature of whether endogeneity or exogeneity that play a principal role in deciding the significance of regressive results. In this paper, we dismiss in-depth explaining the definition of variables those are common to perceive in terms of space limitation. Refer to previous chapter in literature review, a summary on variables identification is set forth in the table below.

Table 2-1 Summary of Variables Specified by Similar Research Work

Variables	Scenario	Mean	Reference
Own price and service quality*	Suburban railway passenger	The variable is defined as the number of places-km, divided by the length of the suburban rail network at each city.	(Asensio, 2000)
External factors: GDP, car times, fuel costs, car ownership, population and a post privatization time trend*	Non-commuting rail passenger	Privatization is transformation of property from public to private undertakings, here it is a transient effect on passenger demand.	(Wardman, 2006)

Fares, quality of service*, income and ownership	Urban car transport	surface	(1) Directly involved time (access time, service interval and in vehicle time); (2) Others (vehicle or rolling stock characteristics, interchanges between modes, service reliability, information provision, marketing and promotion, and various bus specific factors).	(Paulley et al., 2006)
Income* and price	Passenger		GDP per capita harnessed as proxy to income in regression equation	(Fouquet, 2012)
Price	Passenger		Magnetic ticket system records the fare charged by rail, bus and distinguishes time period	(De Grange et al., 2013)
Price, City population, fuel price, fatality*, vehicle price and number of kilometers run	Passenger		The perception of passenger to rail's overall safety.	(Wijeweera et al., 2014)
Generalized Journey Time	Non-London passenger inflow		Composed of station-to-station journey time, service headway and a penalty for the need to change trains.	(Whear & Wardman, 2017)
Independent variables: fare, income, fuel price, route density*	Passenger		Total route in Kilometers to the total land.	(Khan & Khan, 2021)

Variables	Scenario	Mean	Reference
Price, GDP, growth rate of goods vehicles*	Freight	Exogenous variable.	(Kulshreshtha et al., 2001)
GDP, GVA*, Import and export	Freight	Gross value added in production sector.	(Kulshreshtha et al., 2001)
Freight rate and the volatility of the Australian dollar*	Freight/ Australia	Exchange rate and refers to international business condition.	(Wijeweera et al., 2014a)
Freight rate, GVA, international trade*, fuel price	Freight/ Pakistan	Capture the impact of goods movements with other trading countries on rail freight, express in currency.	(Khan & Khan, 2020)
Transportation costs*, transit times and speed	European/ freight	Costs include those of labor and capital, fuel, maintenance, insurance, etc.	(Jourquin & Beuthe, 2019)

* Denotes the variable is explicitly explained

Chapter Three: Research Methodology

3.1 Research design

Railway demand elasticity analysis is exemplary with Kenyan SGR empirical data over the past 5 years. Contexts are analyzed by different scenarios within the research subject. Accordingly, two scenarios are set up through aggregate indicators of ridership demand, and freight volume demand from the perspective of macro level. We intend to assess the vital determinants in economic and socioeconomic facets, and in depth evaluate the dimension of those determinants what have impact on railway service demands, whereof a quantitative approach is introduced.

Theoretically, railway service is ordinary goods that the demand is of the function of market price in an inverse relation, in the scenario of freight transportation, economic activities definitely have an effect on demand. In this research work, two remarkable indexes, gross domestic production and international trade are used in regression expression, besides that, identical transportation modes which compete with the railway transport system are also considered, thus, modal shift is a common phenomenon which is reacting with several transportation modes.

Likely, the ridership demand is inversely conditional to fare rate, due to the data availability under Kenya circumstance, vectors for instance, GDP per capita, income, and fuel price are considered which have main influence on ridership demand.

This research work is conducted with panel data in time series characteristics, the attribution of stationarity for data necessitates multiply regression function for the purpose of achieving demand elasticity. Data reprocess by means of Johansen Co-integration and vector error auto-

regression is introduced, as well as vector error auto-regression model is employed, so as to obtain the long run and short run demand elasticity parameters.

3.2 Data collection and econometric model

3.2.1 Data collection

The aggregate data set incorporates passenger boarding, origin to destination freight flow, macro-economic and social index from 2017 to 2021 those can be obtained through the statistic release portal, from a browser that is administrated by KNBS. Monthly time series data thoroughly recorded railway actual demand, which are supportive to this research work and the web site link is given as <https://www.knbs.or.ke/>. Purporting to generalization of absolute value of variables of interested, normalize the unit data by contingent deflator to the base year of 2017 is strictly followed.

3.2.2 Theoretical and econometric model

Two logic notions reach the public consensus about the modeling mechanism of consumers' behavior, one branch of economy theorists insist that consumer maximizing the utility subjecting to budgetary constraint, another school of academics are in favor of minimizing the cost in obtaining the constant level of utility. Generally, utility dimension is difficult to characterize quantitatively in a numeric type, therefore the former concept is theoretically expressed by the totality deriving from transportation utility and those that from other goods and services.

$$U = MAX(X_t, X_g) \quad 3-1$$

X_t, X_g mean utility expressed functionally on the scenario of transport and other goods and services respectively.

Theoretically, a simplified transportation model in the function of influencing determinants is developed.

$$Y_t = f[\text{var}_1, \text{var}_2, \text{var}_3, \dots, \text{var}_n] \quad 3-2$$

$\text{var}_1, \text{var}_2, \text{var}_3, \dots, \text{var}_n$ represent the variables that have impact on railway demand in considering economic, social and demographical elements.

Refer to existing literature (Khan & Khan, 2020, 2021; Kulshreshtha et al., 2001) railway demand expression in natural logarithm fashion is written as.

$$\ln Y_t = \partial_0 + \partial_1 \ln x_{t/1} + \partial_2 \ln x_{t/2} + \partial_3 \ln x_{t/3} + \dots + \partial_p \ln x_{t/p} + \mu \quad 3-3$$

Y_t denotes railway demand at the time t, $x_{t/1}, x_{t/2}, x_{t/3}, \dots, x_{t/p}$ represents variables that have impact on railway demand at the t time, $\partial_0, \partial_1, \partial_2, \dots, \partial_p$ means influencing parameters derive from the regression function, μ is the error term.

3.2.3 Variables in the research work

According to the aforementioned theoretical equation, we derive the multiply linear regression on railway demand of passenger and freight respectively.

$$\ln y_p = \phi_0 + \phi_1 \ln x_c + \phi_2 \ln x_{gdp/c} + \phi_3 \ln x_{fuel} + \mu_p \quad 3-4$$

$$\ln y_f = \varphi_0 + \varphi_1 \ln x_f + \varphi_2 \ln x_{gdp/t} + \varphi_3 \ln x_{i-e} + \varphi_4 \ln x_{fuel} + \mu_f \quad 3-5$$

Where, y_p is the ridership in a monthly period, x_c is the passenger fare in aggregate form, obtained with total revenue of passenger service divide by the number of passengers, due to lack of relevant data set on income in time series, $x_{gdp/c}$ variable represents the individual

income, an index is computed with gross domestic product per capita, x_{fuel} intend to describe the modal shift against other passenger service mode, while somewhat incapable to collect the data of other service modes.

In addition, y_f refers freight movement from port Mombasa to Nairobi in tonnage unit, x_f means freight charge with unit of Kenyan shilling per ton, divides total revenue by haulage monthly, $x_{gdp/t}$ specializes the gross domestic product in the sector of transportation and storage, x_{i-e} represents economic activity specialized on international trade, unit in million Kenya shilling, x_{fuel} figures out modal shift between railway and trailers, in currency unit, the data of other freight service is hardly to acquire, considering this kinds of freight transit market is quite competitive, marginal cost is at large equivalent to market price, therefore, diesel is employed here to characterize modal shift dynamics.

Considering the data availability and its accuracy, we may not import other aspects which may have minor impact on railway demand, whether from the perspective of economy, society and demography. In order to guarantee the same capital value involved with the analyzed variables, all the value is deflated with attendant ratio to the base of 2017.

3.3 Data process method

3.2.1 Bound Test from ARDL

Due to non-stationarity of variables which are integrating to dissimilar level, exemplify a combination of $I(0)$ and $I(1)$, in order to get rid of misinterpretation, inconsistency and unrealistic. Basically, the model incorporates of current value and lagged value of variables,

the model is more efficient in dealing with small and finite sample scale. The generic model can be specified as follows.

$$y_t = c + \sum_{i=1}^p \beta_1 y_{t-1} + \sum_{j=0}^q \beta_2 M_{t-1} + \varepsilon \quad 3-6$$

Where y_t, y_{t-1} is dependent and dependent variable in lag form, M_{t-1} is independent variable in lag form, c, ε , is constant and error term respectively, p, q are the lag length, β_1, β_2 are regression parameters.

3.3.2 Johansen Co-integration Test

A linear equation has regressive relationship when it is dealing by time series data. if non-stationary level variables are assumed to integrate at the same level, then, there exists parameters $\lambda_0, \lambda_1, \lambda_2, \lambda_3, \dots, \lambda_p$ that produce reasonable regressive equation, while the error term that is stationarity. Engle Granger (Engle & Granger, 1987) and Johansen co-integration (Johansen, 1988) are the common method in addressing this kind of statistical condition. But Johansen co-integration is much broader in using to examine the co-integration rank for multi variant situation.

It suggests that k variables that existed maximal $k-1$ co-integration rank, which can be tested by maximum eigenvalue statistics and maximum trace statistics.

$$\varepsilon_p = \ln y_t - (\lambda_0 + \lambda_{1t} \ln x_{1t} + \lambda_{2t} \ln x_{2t} + \lambda_{3t} \ln x_{3t} \dots + \lambda_{pt} \ln x_{pt}) \quad 3-7$$

3.3.3 Error Correction Model

Refer to a range of time series data analyzing methods, inferences acquired via long run and short run model are common to perform, hereafter, we exemplify the concept as follows.

$$x_t = \beta_0 + \beta_1 M_t + \varepsilon_t \quad 3-8$$

$$\varepsilon_{t-1} = x_t - \beta_0 + \beta_1 M_{t-1} \quad 3-9$$

$$\Delta x_t = \beta_0 + \beta_1 \Delta M_t + \beta_2 \varepsilon_{t-1} + v_t \quad 3-10$$

Where X_t , M_t are variables sets in time series, ε_t , ε_{t-1} are error terms, β_0 , β_1 , β_2 are the regressive parameters.

Plug equation (3-8) to (3-9), we obtain error correction model below,

$$\Delta x_t = \beta_0 + \beta_1 \Delta M_t + \beta_2 (x_t - \beta_0 + \beta_1 M_{t-1}) + v_t \quad 3-11$$

This can be used to construct short run equation, and infer valid parameters for policy making purpose.

3.4 Research quality

The research work is a partial of process aiming at creating an effective model to appraisal the rail demand, it enables us to have a further study on wider economic effects of railway investment by one hand, and by another hand it will also deepen our knowledge on economy domain on rail demand elasticity.

The research objectives involved with new SGR passenger, freight demand time series data, in aggregate manner from year 2017 to 2022 is procured on the portal of KNBS, econometric approach is employed to infer the causal chain relationship between dependent and independent variables, so the data and contingent fashion is validity, reliability and in a practical way.

3.5 Ethics in research

(1) Confidential, the research work does not concern with any aspects of nation security, trade secret (intellectual property, pattern protection) and somehow affecting the normal operation

of entity. It aims to delving the determinants of interest scope that have influence on the demand of rail service in developing countries.

(2) Anonymity, the research work does not perform against any entities, groups, organizations, the only purpose of this study is exploiting the world unknown, especially in the discipline of transport demand elasticity quantifying by econometric approach in developing world.

(3) Furthermore, the research questions and research method do not concerned with any ethical disputes, it solely aims at dealing with social debate at the domain of transport sustainable development goals.



Chapter Four: Result Analysis and Discussion

4.1 Descriptive data

Descriptive data are tabulated elaborately as follows in the table 4-1, 4-2, data series data are analyzed by Stata 13 statistical analysis software. In avoidance of misrepresentative effects at beginning period of railway service, the initial 6 months of data cluster has been canceled out from original data sets. Moreover, the lagged time in operation for freight service, there is less observations within freight scenario. Owing to severe contagion of Covid-19 in April 2020, national containment policy was imposed in railway industry, passenger service was affected greater and more significant than freight sector.

Table 4-1
Descriptive Data on Passenger

Variable	Obs.	Mean	SD.	Min.	Max.
Passenger	55	122610.5	53698.8	0	242827
Fare	55	995.6	287.9	0	1449.1
GDP/Capita	55	48699.0	3929.8	42101.9	55353.8
Diesel	55	100.6	8.5	75.8	116.5

Table 4-2
Descriptive Data on Freight

Variable	Obs.	Mean	SD.	Min.	Max.
Freight	45	373117.1	69924.1	208577	507924
Freight charge	45	2289.6	598.3	1239.3	3282.1
GDP-transport	45	301500.6	28327.8	260081	367057.1
Import-export	45	206485.9	27488.71	155898.1	301583.9

Diesel	45	102.5	7.9	75.8	116.5
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Note: data is rounded by one decimal.

Source: KNBS

4.2 Passenger scenario

For the purpose of interpreting the characteristics (stationarity or non-stationarity) of variables of interest, unit roots test is applied to time series data. The test results are set forth in APPENDIX I, whereof passenger and fare variable series are integrating to order one, signified by $I(1)$. While GDP per capita and diesel price variable series are integrated to $I(0)$, it means that level data of this category has no unit roots or level data, which is stationary data. Considering features of time series data sets within passenger scenario can not fulfil the prerequisite (the same integration order) of co-integration test, overlooking may lead to spurious regression which is not in stochastic trend and asymptotic distribution, therefore Bound test (ARDL) is more suitable than other conventional models, which can be soundly applied within this context. The test parameters are exhibited in APPENDIX II, and in turn, the empirical coefficients are elaborated in the table 4-3 below.

Table 4-3

ARDL Test for Passenger Demand

D. Ln- <i>Passenger</i>	Coefficient	Standard error	$P > t $
ADJ			
<i>ln-Passenger</i>			
L1	-0.811	0.114	0.000**
Long Run			
<i>Ln_Fare</i>	-2.646	0.536	0.000**
<i>Ln_GDP</i>	4.172	1.745	0.021**
<i>Ln-Diesel</i>	-4.280	1.967	0.035**

Short Run			
<i>Ln-GDP</i>			
D1.	-13.031	5.879	0.032**
Constant	17.046	14.076	0.232

** , * denote in 5% and 10% of significance level respectively

In the long run, the demand elasticity to price is -2.64, it means perfect elastic demand. Price elasticity is significant and more so it has a great influence on passenger inflow. There exists findings that signify demand to price is elastic (Rao, 1978; Rahman & Balijepalli, 2016), there are also existing empirical coefficients that are contradictory with elastic price (Khan & Khan, 2021). With respect to price inelastic, academics concluded that price increasing can bring revenue growth though suppressing the passenger inflow in the long run. As we have stated in the literature reviewing chapter, price elasticity varies accordingly with distinction with transport mode, path, corridor, even territory, arithmetic method and etc. Within this scenario, it may attribute that railway service is not common goods, rather, where a subtle change in ticket price can lead to substantial change in passenger inflows. It may also be instability of utilizing econometric approach to deal with aggregate data or statistical inaccuracy deriving from original data. Otherwise, we may aspire to collect disaggregate data, for instance, ticket sales data from digital ticket sales system to assess passenger price elasticity (Toner et al., 2020).

GDP per capita is a pivotal socio-economic index that characterizes of the overall level of economic development. In this context, the passenger demand elasticity to GDP per capita is significant at 4.17, where the result is consistent with a variety of literature remarking conclusion (Wijeweera et al., 2014a). Results signify that economic development may reduce unemployment rate, therefore raising individual income, in turn, GDP per capita produces more incentives to travel for the general publics. Diesel price is proxy to the price of other

passenger transport modes, indirect characterization of cross price elasticity. Along the corridor that connects Mombasa, Capital and city Naivasha, the main motorized land traffic for passengers moving is public bus.

Refer to our regressive result, the cross-price elasticity is -4.28, relation between long distance public bus and railway service is complementary, rather than competition. To a large extent, in comparing with bus, railway may not have dominant competitive advantage in cost, time saving, time schedules, and service quality within passenger context. It suggests that, particularly to railway operation agent, solutions to lower energy roll stocks, higher service quality coaches, ease to exchange should be taken into consideration, so as to increase competitive advantage for railway passenger service.

4.3 Freight volume scenario

Characteristics of time series data within freight scenario is distinguished from passenger's. Variables of interest are integrating to the same order by level and first difference data, data series here denotes by $I(1)$. Therefore, Johansen co-integration approach based on VECM is valid, and data set was taken firstly to determine the lag length, details used to infer the results are set forth in appendix II, table 6-4. After that, data set was taken into integrating rank test by Johansen co-integration method, sole one integration equation was examined by none trend setting, detailed process shows under appendix III, in table 6-7, and demand elasticity results are depicted in table 4-4 for long run, in table 4-5 for short run. Then, we proceed to discuss the obtained elasticity coefficients.

4.3.1 Long run model

Freight movement incorporates of a majority of railway industry revenue in Kenya. According to the tabulated results, obviously, freight charge is significant and inelastic to freight movement volume at 0.41 within this scenario, which is in line with a number of

empirical studies (Khan & Khan, 2020; Kulshreshtha et al., 2001) on rail freight demand analysis, though the coefficient magnitude may vary at some degree. The result denotes that increasing freight charge will decrease freight movement volume, but at the meantime, it will uplift the revenue to an extent. Therefore, pricing principles intending to increase revenue can be formulated, it is likely to be put into practice by categorizing different goods, or directly increasing the whole set of shelf prices without goods distinction.

Table 4-4
Demand Elasticity for Long Run about Freight Movement

Variable <i>Ln-Freight</i>	Coefficient	Standard error	$P > t $
<i>Ln-Charge</i>	-0.415	0.145	0.004**
<i>Ln-Ix</i>	1.004	0.541	0.063*
<i>Ln-GDP</i>	1.653	0.666	0.013**
<i>Ln-Diesel</i>	-2.665	0.586	0.000**
<i>Constant</i>	4.710	7.671	0.016**

** , * denote in 5% and 10% of significance level respectively

There exists a likelihood that massive of non-bulk commodities are moving by railway, though details are elusive that related authorities do not set open access to public. According to our analyzed results, that the international trade especially maritime transaction has a significant correlation with rail freight demand thought in 10% significant level. Demand elasticity to import and export is approximately at 1.00, which is approximately at unit elastic. It means that 1% of the volume change in import and export will bring 1% change in freight movement change. In the past one decade, Kenya experienced middle upper level of economic growth rate at around 4-8%, more so, it is wide acknowledged that freight transport demand is stimulated by economic activities. Moreover, the freight demand elasticity to the trend of economy growth represent by GDP growth, is also significant at 5% level, where the

sensitivity is performed as perfect elastic at 1.65, while greater than the effect to import and export activity. Because GDP is a much broader concept to describe economic activities than that of unique transport sector, so there may exist much stronger impulse to rise the rail demand rather than transportation sector solely. At this point, purporting of realization of freight classification, there exist necessities to figure out which sector is more productive to rail freight transport demand by a set of more disaggregated data in the future studies.

Lastly, diesel price series on behalf of cost to other land transition modes, especially to truck movement, the demand elasticity to diesel price is significant at 5% level, with rate at -2.66, which is in consistent with passenger demand elasticity we have discussed aforementioned. It means that the modes between rail and truck transit is complementary, a price increasing in one mode will lead to demand decrease in other mode. This is possible because of rail freight movement consumes foil fuel (heavy fuel) at the same time, so the influence on one mode to costs mainly by combustion fuel is simultaneous happened on the other mode. The main policy implication is that rail has competitive advantage partially at long haulage, but rail sector is disadvantage on fuel consumption, complexity in loading, transferring and unloading, at large, which can't decrease the cost in a way to erect competitive advantage for rail freight service.

4.3.2 Short run model

The consequents over short term are reparametrized via combination of the obtained regression error in one lag length and first differenced variables, then regressed by vector error correction model (VECM). The short-term elasticities are tabulated as the follows.

The short run elasticities are smaller than those in long run model, except that the value of elasticity to diesel price. In according to the parameters, short run elasticity to freight charge is 0.24, which is significant at 5% level. It means that when other influences are constant, 1% change in freight charge will lead to 0.24% of change in freight volume. The economic components represent by GDP and external transaction activities also have a positive impact on rail freight demand within short run, at rate of 0.35, 0.14 within 10% significant level respectively. In general, there is no doubt that sound economic circumstance is the main dynamic to stimulate rail freight movement demand across the world. Lastly, diesel price on behalf of cross price from truck transition, the elasticity is 0.017 at 5% of significant level, it suggests that in the short run, rail and truck operation are in relation of substitute, because of time constraint, participants in market can't respond swiftly to adjust market decisions, while it can happen in long run term. Due to sensitivity of study context, data processing skills, though some of them are not rigorously consistent with existing findings, the short run elasticities can be utilized to reaffirmation of long run data.

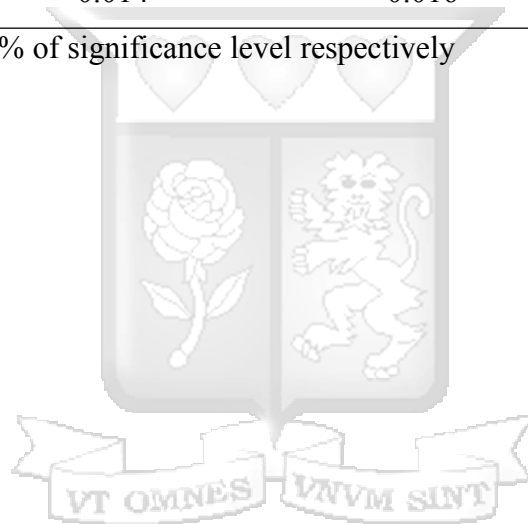
Most important of all, short run error correction term is -0.47 which is significant at level of 5% and the data is in the interval of (-1, 0). This means that any short run disequilibrium will be adjusted to long run equilibrium at a speed of 47% within one month of time. In the context, rail freight is heavily affected by covid-19 containment policy, but the demand determinant variables work as structural system that multivariate respond to demand deviation rather than unique variant.

Table 4-5

Demand Elasticity for Short Run about Freight Volume

Variable d. <i>Ln-Freight</i>	Coefficient	Standard error	$P> t $
<i>d. Ln-Charge</i>	-0.246	0.114	0.003**
<i>d. Ln-Ix</i>	0.144	0.195	0.052*
<i>d. Ln-GDP</i>	0.352	0.566	0.072*
<i>d. Ln-Diesel</i>	0.017	0.318	0.002**
<i>Error-L1</i>	-0.472	0.204	0.027**
<i>Constant</i>	0.014	0.016	0.088*

** , * denote in 5% and 10% of significance level respectively



4.4 Model diagnostics

After the models were established by relevant regression approaches, a rigorous regressive diagnostics are performed below in the purpose of test correlation, normality, series heteroscedasticity, and white noise. Thought it is not easy to acquire perfect results, to some degree, the models we illustrated above are acceptable basing on following diagnostic tests.

Table 4-6 Model Diagnostic Tests

Passenger model	<i>P</i> value	Critical value
Breusch-Godfrey LM test	0.065	No series correlation
Durbin-Watson	2.435	> 0.05
Swilk test	0.76	> 0.05
Jarque-Bera	0.992	Normality
Cameron & Trivedi's decomposition of IM-test	0.074	Homoscedasticity
Freight model	<i>P</i> value	Critical value
LM-test χ^2 (1)	0.396	No correlation at lag 1
Portmanteau test	0.402	>0.05
Swilk test	0.162	> 0.05
Jarque-Bera	Variable freight rate, diesel price series is not normality, while variable GDP, external trade is normality.	

Chapter Five: Conclusion, Policy Implication and Future Overview

5.1 Conclusion

Due to distinguished features of two sets of data, bound test and co-integration test based on ECM are introduced within those two scenarios. Referring to the results of the previous chapter, conclusions can be made as follows.

(1) Passenger demand elasticity to fare is perfect elastic at -2.64, it might suggest that passenger service is not common good within context of Kenya. Price increasing adjustment may not have a positive impact on revenue accumulation in the long run. Moreover, rail plays a complementary role with motoring ridership service, due to lacking of absolute competitive advantage for fuel cost.

(2) In the short run, passenger demand will adjust disequilibrium at rate of 0.92. In addition, both passenger and freight scenarios, economic aspects for instance, GDP per Capita, import and export activities are explanatory elements to railway service demand, and have a positive influence on railway demand.

(3) Freight demand to charge is inelastic at 0.41, which implies pricing regulation can function as the freight charging increasing, the revenue at freight sector will increase to an extent. The cross price elasticity deriving from truck service is -2.66, though complementary relation is existing, rail don't have absolute competitive advantage in fuel consumption. In the short run, freight demand will adjust disequilibrium at speed of 0.47.

5.2 Policy implications

In consistent with conclusions we have made above, there are several aspects of policy implication that can be elaborated, which is in line with price, socio economic circumstance, and cross price deriving from other land modes.

(1) First of all, in the scenario of passenger service, though the demand to price is perfect elastic, decreasing price arises passenger flow, but it doesn't have positive impact on passenger revenue. While in the scenario of freight, demand inelasticity to freight charge implies that increasing price though decreasing freight volume, it can lift revenue. Therefore, an in-depth investigation especially with the help from ticket sales data is needed for passenger price system, a more detailed structure of ticket pricing may be conducive to passenger service sector regulation. While freight demand elasticity to price is inelastic, it denotes that increasing price will lead to revenue uprising.

(2) Socio economic index and external trade activities elasticities have an influence on rail service demand positively. It indicates that with economic growth in Kenya, the rail demands both in passenger and freight sectors will increase gradually. Hence, operation participants and stakeholders should predict the transportation scale in more steps ahead to have clear layouts on volume of stations, carriage, stocks, locomotives and rolling stock, to name a few.

(3) Elasticity to other road transport mode is perfect elastic, while complementary relationship with rail. We can't infer a sound modal split mode which is advantage to rail revenue accumulation. But solutions can be taken into practice by increasing energy efficiency, such as low-cost locomotives, roll stock electrification, time schedule adjustment, in order to decrease the cost of rail and increase the quality of rail service.

(4) Covid-19 pandemic outbreak has a great influence on passenger sector, but do not affect freight volume tremendously, because the system has adequate impulses to adjust any deviation from structural equilibrium. Therefore, an emergent public health solution should be made in advance for rail sector, in order to minimize the adverse impacts on passenger revenue.

5.3 Further research overlook

Thought the study has substantiated some facets of rail demand particular to SGR in Kenya, but there still have a lot of ambiguities not yet to exploit. Here we enumerate some points unknown but may guide future commitments as follows:

(a) Though demand elasticities are much elusive with respect to varied contexts, data sets, and analysis approaches, aggregate data sets used in this study can't get rid of inference inaccuracy. Solution to combine aggregate and disaggregate data is very admirable, thus within context of rail demand elasticity in Kenya, data as ticket sales classified by origin and destination, quality of service and freight movement discerned by commodities are conducive to further demand elasticity analysis.

(b) Regional integration may help with empowering the prosperity of African countries, the influence exerted by road transport, particular rail in long haulage can't be ignored. Therefore, systematic rail demand theory should be established immediately by cross sectional research among those pioneering countries in rail commitment, such as Ethiopia, Tanzania, Nigeria, Morocco and to name a few.

(c) Prediction of revenue in rail investment is quite urgent for policy makers, agencies, public servants, and private participants, therefore a kind of theory can be used to analyze, predict, estimate the revenue and risk in rail investment territory is needed within context of

developing countries. Thus combination of economic and econometric components should put into in depth consideration, and further conclusion can stably support policy decision making, policy formulation, and policy administration process.

(d) The study particular to SGR in time series only encompassed 5 years which is relative shorter than most of identical study, this is also the reason that we can't thoroughly guarantee the accuracy of the research results, and de facto, there existed few points that are contradictory to previous insights, which can be address by long range of data sets possibly.



Appendix I. Unit Roots Test

In order to eliminate the analysis bias and spurious conclusion generalized with time series data, unit root test of each data series is employed basing on augmented Dicky-Fuller and Philips-Perron approaches. Null hypothesis unit root or non-stationary against alternative stationary is performed, when the tested value is less than the critical values, we can't reject the null hypothesis, the level variable series is non stationary. Mathematically, by differentiating is a way to obtain time series data stationary characteristics for further analysis.

Table 6-1

Unit Root Test on Passenger Data Series

Variable	Augmented Dicky-Fuller Test		Philips-Perron Test	
	Levels	1 th difference	Level	1 th difference
Passenger	-6.048**	-10.833**	-7.359**	-16.932**
Fare	-7.339**	-11.842**	-1.186	-7.987**
GDP/Capita	-1.206	-7.979**	-5.970**	-12.496**
Diesel	-2.277	-6.337**	-2.324	-6.244**

Table 6-2

Unit Root Test on Freight Data Series

Variable	Augmented Dicky-Fuller Test		Philips-Perron Test	
	Levels	1 th Difference	Level	1 th difference
Freight	-2.833	-5.922**	-2.943	-6.249**
Freight charge	-2.138	-7.389**	-2.022	-7.522**
GDP-transport	-1.122	-8.179**	-1.063	-8.247**
Import-export	-2.539	-11.846**	-2.308	-12.687**
Diesel	-2.277	-6.337**	-2.324	-6.244**

All the data in nature logarithm

** Denotes in 5% of significance null hypothesis was rejected

Appendix II. Optimal Lag Length

In general, co-integration models estimate with optimal lag length, long lag length may reduce the degree of freedom while short lag length will lead to a possibility of variable auto-correlation. The followings are lags length optimization process.

Table 6-3

Lag Length for Passenger

Lag	LL	LR	FPE	AIC	HQIC	SBIC
0	12.9125	-	0.000023	0.663236	0.721134	0.814752
1	104.313	234.45	4.3e-07	-3.30641	-3.01691*	-2.54883*
2	122.833	37.039	4.0e-07*	-3.40522*	-2.88413	-2.04158
3	130.93	16.194	5.6e-07	-3.09529	-2.34261	-1.12559
4	148.23	34.599*	5.6e-07	-3.14626	-2.16198	-0.57049

Table 6-4

Lag Length for Freight

Lag	LR	FPE	AIC	HQIC	SBIC
0	-	2.8e-10	-7.81843	-7.74324	-7.61568
1	226.94	5.0e-12*	-11.8397*	-11.3886*	-10.6232*
2	31.596	8.0e-12	-11.4215	-10.5944	-9.19122
3	55.959	7.8e-12	-11.5569	-10.3539	-8.31291
4	47.988*	1.1e-11	-11.5112	-9.9322	-7.25345

LR: Sequential modified LR statistic.

FPE: Final prediction error.

AIC: Akaike information criterion.

SC: Schwarz information criterion.

HQ: Hannan-Quinn information criterion

Appendix III. Bounds Test and Rank of Co-integration

Table 6-5 Bounds Test F Value

H_0 : no levels relationship

F = 100.563

t = -15.320

Significant level	10%		5%	
	[I_0]	[I_1]	[I_0]	[I_1]
K_3	2.72	3.77	3.23	4.35

Accept if F < critical value for I(0) regressors. Reject if F > critical value for I(1) regressors

Table 6-6 Bounds Test T Value

Significant level	10%		5%	
	[I_0]	[I_1]	[I_0]	[I_1]
K_3	-2.57	-3.46	-2.86	-3.78

Accept if t > critical value for I(0) regressors. Reject if t < critical value for I(1) regressors

Table 6-7

CI Test on Freight Scenario (lag length=1)

Maximum rank	Eigen value	Trace statistics	5% critical	1% critical
0		125.0656*	68.52	76.07
1	0.80088	49.2152*	47.21	54.46
2	0.39434	25.6478	29.68	35.65
3	0.29596	9.1543	15.41	20.04

Maximum rank	Eigen value	Maximum statistics	5% critical	1% critical
0		75.8503*	33.46	38.77
1	0.80088	23.5674	27.07	32.24
2	0.39434	16.4935	20.97	25.52
3	0.29596	8.5461	14.07	18.63

** Signify rejecting null hypothesis at 5% of significant level

Appendix IV. Ethic Approval Permit



17th February 2023

Mr Yang Yongfeng,
yongfeng.yang@strathmore.edu

Dear Mr Yang,

RE: Co-integration Modeling in Analyzing Railway Services Demand: Case Study of SGR in Kenya


This is to inform you that SU-ISERC has reviewed and approved your above SU- master's research proposal. Your application reference number is SU-ISERC1541/22. The approval period is from 17th February 2023 to 16th February 2024.

This approval is subject to compliance with the following requirements:

- i. Only approved documents including (informed consents, study instruments, and MTA) will be used
- ii. All changes including (amendments, deviations, and violations) are submitted for review and approval by SU-ISERC.
- iii. Death and life-threatening problems and serious adverse events or unexpected adverse events whether related or unrelated to the study must be reported to SU-ISERC within 48 hours of notification
- iv. Any changes, anticipated or otherwise, that may increase the risks or affect the safety or welfare of study participants and others or affect the integrity of the research must be reported to SU-ISERC within 48 hours
- v. Clearance for the export of biological specimens must be obtained from relevant institutions.
- vi. Submission of a request for renewal of approval at least 60 days prior to the expiry of the approval period. Attach a comprehensive progress report to support the renewal.
- vii. Submission of an executive summary report within 90 days of completion of the study to SU-ISERC.

Before commencing your study, you will be expected to obtain a research license from National Commission for Science, Technology, and Innovation (NACOSTI) <https://research-portal.nacosti.go.ke/> and obtain other clearances needed.

Yours sincerely,


for: **Dr Ben Ngoye,**
Secretary; SU-ISERC

Cc: Mr Ambrose Rachier,
Chairperson; SU-ISERC



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Acknowledgment

Study at Strathmore University Business School is impressive in my lifetime when I was in Africa. I would like to present my acknowledgement to the faculties and lectures who inspired me in every course, because of their commitment, spiritual emotion, novel thinking gave me distinguished mind on world, being, and art of human being. Definitely, I have acquired knowledge about logic, how to discern right and wrong by descriptive and normative specification, which is transformative thinking. Personally, studying at SBS is a kind of life style that varies from my previous experience that I was dedicated to the field of engineering, material science, a range of renewed thinking should entitle much appreciation to the school.

Secondly, tremendous gratitude goes to Dr. John Olukuru, I hope this time I do not wrong spelling his name, without his altruistic dedication, this study work may not be accomplished at such a smooth manner. Except that, I would like to present a body of thanks to my parents, brother and relatives, for their indispensable assistant.

Sincerely, appreciation should also reach at Professor Robert Mudida, smelled face and humorous speaking are his traits that amused all of us. In addition to, he advised me to seek for data at the beginning of my research work, and revised me to set out a close research topic about public policy. Finally, numbers of appreciations go to my partners, colleagues and supportive agencies with funding sources. All those ingredients I listed above result in the successful completion of the dissertation. The process though seems quite complex and time consuming, it is an invaluable experience that I may never have again.

Yongfeng Yang

Nairobi

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