IMPROVEMENT OF THE ECONOMIC AND OPERATIONAL EFFICIENCY OF FREIGHT ROAD AND RAIL TRANSPORTATION IN SOUTH AFRICA

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ABSTRACT

In South Africa, freight transport movement is largely provided by parastatals in railways, ports, pipelines, and aviation. However, freight transportation suffers from the challenges and limitations such as adverse environmental impact, congestion, overloading and high freight costs. Therefore, the objective of this study was to explore how to improve the economic and operational efficiency of freight road and rail transportation by implementing the new freight transportation system. In other words, how both transportation modes can be used effectively to enable lesser travel times, low freight load costs and fast delivery of diverse commodities in South Africa. The methodology adopted in this study was through the collection of data by survey questionnaires among various stakeholders involved in the freight industry which later underwent comparative analysis. The findings reveal that freight road is much more competitive than freight rail as it can provide fast travel times, carry less freight loads, and accommodate various commodities. Furthermore, based on the current study, a domestic intermodal freight transportation is recommended for an improved economic and operational efficiency of freight road and rail by consideration of aspects such as freight costs, travel factors and economic contribution; thereby allowing freight rail to be utilized on long haul distances and road for short distances.

Keywords: Freight, Road, Rail, Transportation, Economic Efficiency, Operational Efficiency.

1. INTRODUCTION

Freight transportation involves the movement of cargo from various destinations using several transportation modes such as rail, road, maritime and airline to meet the market demands. South Africa as a developing country has extensive road and rail network that consist of approximately 254 000 km for roads and 20 000 km for rail network. Roads were initially established in the 1910's, which were later enhanced with the introduction of freeway sections in major urban areas that led to the current state of road network infrastructures. Concurrently, rail infrastructures were built in the 1860's with the first lines being between Durban and Cape Town which were controlled by both the Natal and Cape governments (Stander & Pienaar, 2003). Contrastingly, freight transportation has increased rapidly in South Africa owing to the fast economic growth and expanding international trade. Therefore, since the freight transport demand is derived from economic activities that are expected to grow in the future as well, improving economic and operational efficiency in the freight transport sector has important implications for sustainable transport development in general.

Furthermore, both rail and road transportation modes are used for freight transportation in South Africa. In 2013, freight rail handled 210 million tons of freight consisting of block train consignments of primary minerals, such as ores and coal, as well as secondary commodities. Freight rail also catered for commodities like timber, steel, grains, fuels and smaller proportions of industrial outputs, and imports and exports, such as motor vehicles, containers, and chemicals and rail had a distinctive advantage over freight road (State of Logistics Survey, 2013). However, the freight road transport system in South Africa carries a range of commodities such as clothes, food, livestock, materials, and grains which are predominantly based on the availability of road space, and the condition of infrastructure to accommodate the transportation of these goods (National Freight Logistics Strategy, 2015). In the current freight transportation system, road is the primary mode of transport for various reasons such as fast travel time, less load capacity and utilizes infrastructures that requires less maintenance. Although the road freight delivery has significant advantages, the great number of freight vehicles contributes to overloading and the subsequent deterioration of the road network and infrastructure. Even though rail freight still exists in South Africa, the rail market share declined due to operation policy constraints on the rail service providers by the government and excessive cost of repair and maintenance (Schoeman, 2014).

The new system proposed in this study is called a domestic intermodal freight transportation system. This system involves short-distance road feeder services to an intermodal terminal in a logistics hub where freight is consolidated into main-line block trains running the length of the corridor to a destination terminal. Once it has arrived at the destination terminal, it is transported to distribution centres via road transport (Kruger, 2018). An advantageous element of using the new system will be an equal utilization of road and rail in the movement of freight to various distribution centres with the aim of reducing overall transport and logistics costs and externality costs (e.g., road damage, road accidents, road congestion, noise pollution and carbon emissions). Furthermore, Van Eeden and Havenga (2011) proposed the domestic intermodal freight transportation system as a solution to address freight logistics challenges with specific reference to improving economies of density and size, increasing for marginalized rural economies, and sustainably lowering logistic costs in South Africa (Van Eeden and Havenga, 2011). Concurrently, there are much higher logistics costs in South Africa than other countries due to the dependence of high value imported consumer goods and geographical landscapes during the transportation of agricultural products to economic centres (Ministry of Foreign Affairs, 2020). Hence, the purpose of this study is to make a comparative analysis of the economic and operational efficiency between road and rail for the current and new freight transportation system. This will be done by assessing the current and new freight transportation system in terms of cost per tonnage between freight road and rail, the income generated by freight road and rail, and to examine the travel factors involved in freight road and rail movement.

The freight transport demand, by nature, it is affected by various factors such as travel factors, direct costs and socioeconomic factors and the level of economic activities of a country (King, 2019). Most of the freight movement take place by a traditional system such as either by rail or road depending on the availability and efficiency of the modes of transportation. Therefore, there is a need to examine how the economic and operational efficiency of freight transportation can be enhanced in the new system compared to the current system of freight transportation.

The objectives of this study were to assess the current and new freight transportation system in terms of cost per tonnage between freight road and rail, the income generated

by freight road and rail. In this paper, a quantitative research method was used by collecting primary data through survey questionnaires and secondary data from internet sources which were further analyzed through comparative analysis. The current system reveals that freight road is more economical and operationally efficient than freight rail as it generates 40% more income annually towards the economic growth of South Africa and provides reliable service delivery as perceived by freight suppliers and clients.

2. STUDY CONTEXT AND RESEARCH METHODS

2.1 Study Context

This study was based on the assessment of the economic and operational efficiency for road and rail of the current and new freight transportation systems. In South Africa, transport costs provided a total turnover of an estimated R274 billion limited to companies involved in mining, retail, and manufacturing which is about 36% decline to the country's economic growth as compared to other years (Ministry of Foreign Affairs, 2020). Even though freight transport users are comfortable with the speed and reliability offered by road transport, there should be other options available in decreasing the transport cost such as intermodal freight transportation system. However, South Africa suffers from lack of intermodal integration and transshipment facilities. For freight industry to produce optimum targets, there should be an improved economic and operational efficiency of transportation modes in freight movement by overcoming challenges such as high logistics cost, poor service delivery and lack of infrastructural maintenance.

2.2 Research Methods

A survey research method including primary data collected from stakeholders and secondary statistical data from authentic freight companies of South Africa and relevant statistical analyses was used for the study.

Consequently, random sampling was conducted from the data collected by survey questionnaires. This was done by scheduling physical or virtual interviews with the operational managers and officials (operators/ truck drivers) of various freight and logistics companies including freight rail. The survey questionnaires consisted of a set of directive questions such as the quantity of freight being transported, the distance being travelled, the cost per tonnage, the number of trips, the hours of travel etc., by road and rail transportation modes. Free State was chosen as the origin location for the freight movement as it formed more links than any other regions based on the primary data. Subsequently, 41 samples of data were collected which reflected a 63% response rate that proved adequate for this study, taking into account of a total 65 registered freight and logistics companies contributing significantly to the country's economic growth (King, 2019). This was then augmented, by secondary data which consists of historical data obtained from internet sources such as Stats SA to provide an overview of the economic and operational efficiency of road and rail freight transportation in South Africa. This data was obtained by visiting different sites on the internet that consists of historical and statistical data of the freight and logistics sector in South Africa. The study aimed to interpret both data sets together to show the efficiency and contribution of these two freight transportation modes on the economy and to further examine the implementation of the new transportation system.

The collected data (primary and secondary) was analyzed by comparative analysis of the cost per tonnage, income generated annually, freight time attributes and freight load

capacity for the current and new freight transportation system. Further, the data was consolidated and represented in terms of tables and graphs and analyzed accordingly. This analysis was important in identifying the economical and operational efficiency of the two transportation modes for the current freight transportation system, in order to identify aspects that can be improved in the new system. The similarities and differences which were obtained between these two-freight transportation modes were used as basis for improving the current freight transportation system in South Africa.

3. FREIGHT RAIL AND ROAD TRANSPORT IN SOUTH AFRICA

3.1 The Current System

3.1.1 Background

Freight transportation provides an important element in the development of the economy and the society; however, currently the growth of freight flows is becoming challenging to suppliers and even to the government based on conditions of transport infrastructures (Zanne & Beskovnik, 2019). Although, road freight delivery presented advantages, it has significantly contributed to deterioration of road infrastructures, road accidents and leading to poor traffic flow more specifically on national roads during freight movement. In contrast, the rail market share declined due to operational policy constraints on the rail service provider that was enacted by the government as a major shareholder which led to inconsistent maintenance of the rail infrastructures (Transnet Freight Rail, 2013).

3.1.2 Cost Per Tonnage for Freight Road and Rail

In freight transportation the economic efficiency of freight movement is often measured by the cost per tonnage of the involved transportation modes. This refers to the cost aspect related to tonnages that each transportation modes will incur during transportation of freight between two points (origin to destination). The cost per tonnage which is also referred to as logistics costs contributes significantly to the country's economic growth by means of Gross Domestic Products (GDP) as it constitutes of the movement of commodities. The logistics costs (excluding externality costs) for South Africa have increased quite significantly since 2010, up to estimate of 46.7% of transportable GDP(CSIR,2013). Although, the logistics costs as a percentage of transportable GDP are rising, it is not a question of logistics efficiency, but rather an increase in production of commodities. Therefore, a comparative analysis was conducted for the cost per tonnage of both freight rail and road using the major centres for freight movement in South Africa. This analysis is important in determining the economic efficiency between freight road and rail for the current freight transportation system in South Africa. Table 1 below represents the cost per tonnage for the major centres in South Africa based on the obtained primary data. The results reveal that cost per tonnage for freight rail is higher than freight road by 10-20% for major centres in South Africa. This implies that freight rail cost per tonnage is higher than freight road as it accommodates more load during freight movement, however it proves to be economically inefficient.

Table 1: Cost per tonnage for Freight Road and Rail in major centres of South Africa

Regions	Distance (km)	Freight Road (R/km/t)	Freight Rail (R/km/t)
Free State - Gauteng	398	13.10	14.15
Free State - Western Cape	1005	18.70	23.33
Free State – KwaZulu- Natal	635	14.24	17.51
Free State – Eastern Cape	569	17.80	24.90

3.1.3 The Current Income Generated by Freight Road and Rail

Freight income is usually determined by modelling of national freight flows which is driven mostly by the sectoral supply and demand status of the economy (Kruger, 2011b). Therefore, there is a gradual need to consider corridor freight for long haul, typically to determine the income generated by freight transportation modes from demarcated points in cities to a divergence point where distribution occurs (Havenga, 2011b). In this study, national freight flow movement assessment was conducted to determine the income generated by freight road and rail in South Africa. This data revealed the contribution that each transportation mode has on the economic growth in terms of the income it can produce (see Figure 1). From Figure 1 it can be observed that freight road contributes 40% more income than freight rail annually for a period of 10 years thus proving to be the most economically efficient mode of transportation. This implies that freight road is largely utilized by stakeholders involved in the freight and logistics industry irrespective of the breakeven distance benefit.

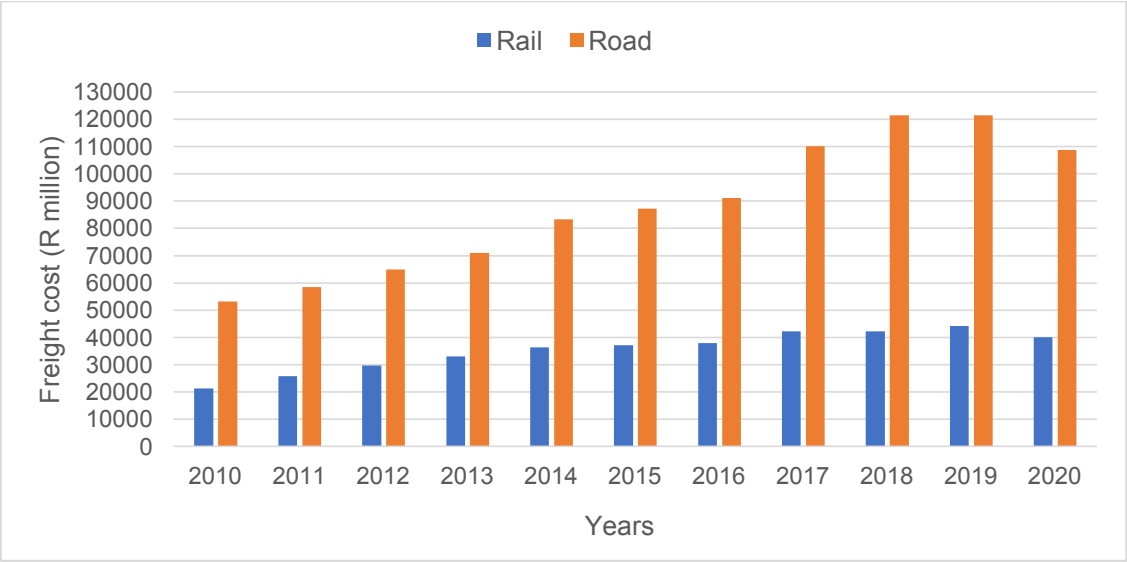


Figure 1: The annual freight income for road and rail transportation over a period of 10 years (2010-2020)

3.2 Assessment of Travel Factors

3.2.1 Freight Time Attributes

Freight time attributes refers to the attributes related to time such as stoppage time, loading and offloading time, etc. during freight movement. This aspect is important in determining the operational efficiency of freight road and rail in terms of service delivery and reliability. However, there is a tendency in South Africa for long-distance freight transport growth to be captured predominantly by road transport which has led to profound impact on both the road infrastructure (through overutilization) and rail infrastructure (through underutilization), and the same trend ultimately has influenced the efficiency of service delivery by road and rail transportation modes (Havenga et al., 2011c). Currently, the economic feasibility of an intermodal freight transportation system shows that for transporting freight under normal circumstances over distances longer than 300km, should be shorter and faster by road than rail transportation mode (Hansen et al., 2012). The assessment was made on the freight time attributes concerning both freight road and rail on one of the major routes for freight movement in South Africa. Figure 2 shows the average travel time, average stoppage time and average loading and offloading time during the movement of freight between rail and road transportation modes. The results shows that freight road takes 8.76 hrs. less average travel time, 0.06 hrs. less average

stoppage time and 4.59 hrs. less average loading and offloading time than rail transportation. This implies that freight road is much faster than freight rail in the movement of freight and proves to be more operationally efficient.

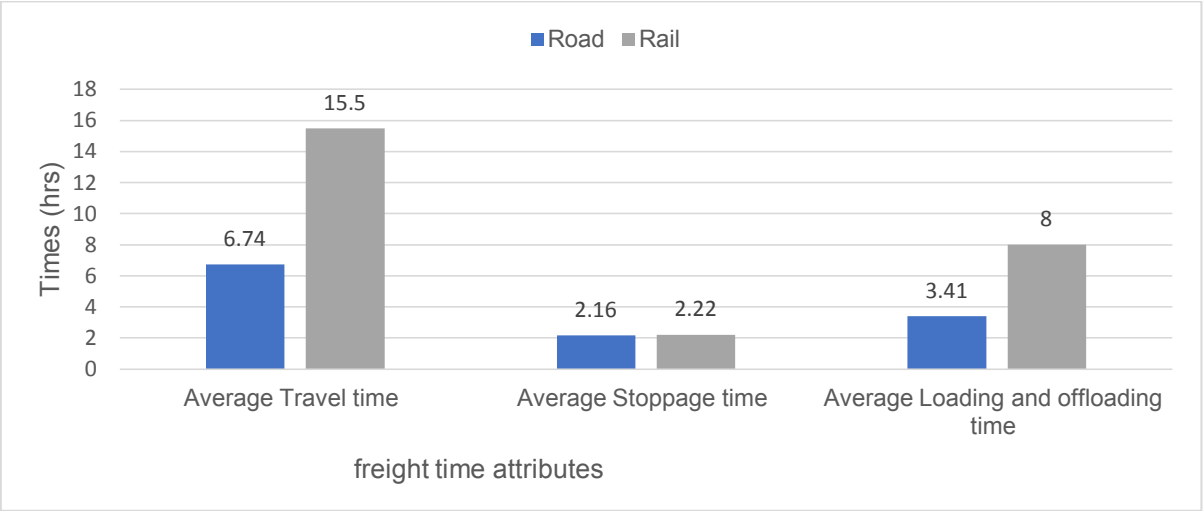


Figure 2: The essential freight time attributes for road and rail transportation mode

3.2.2 Freight Load Capacity

Freight load capacity involves the determination of load that freight road and rail can accommodate during freight movement. This is important in identifying which freight transportation mode between road and rail is operationally efficient in terms of the load capacity it contains. Currently, the high cost, inefficiency, strained load capacity, multiple stoppages, time spent in truck queues and over-regulation system are some of the challenges and constraints identified in South Africa (Vilakazi, 2018). Figure 3 shows the load capacity of road and rail during freight movement for a period of 10 years. This is to determine the freight mode that is suitable for carrying more load/weight in tons over the past ten years and to establish the operational efficiency within this period. The results reveals that freight load capacity of rail was greater by 40-50% in tonnages from 2011 to 2017 to road and between 2016 and 2020 by 60-70%. This implies that rail has greater freight load capacity as compared to road transportation mode and is therefore more operationally efficient.

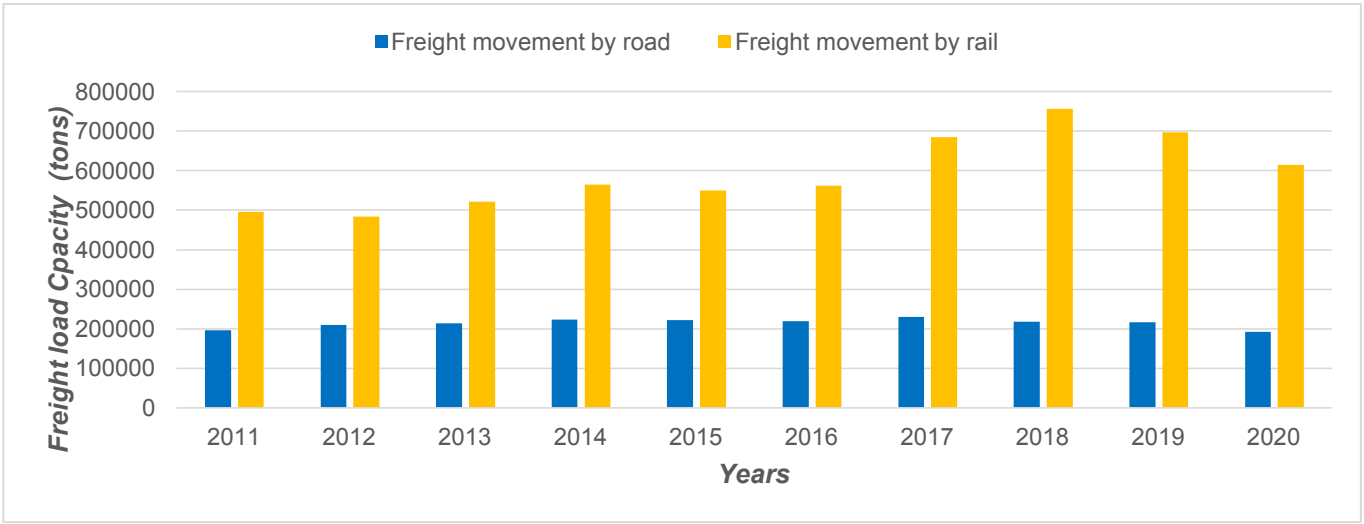


Figure 3: The Freight Load Capacity for road and rail during freight movement.

3.3 The New System

3.3.1 Background

The new system for freight transportation in South Africa is intended to improve the economic and operational efficiency of both freight road and rail by considering factors such as freight time attributes, freight income, freight cost per tonnage and freight load capacity. Consequently, this domestic intermodal freight transportation will be a significant and critical factor in the success of hyper-competition among supply chains of the future. Furthermore, the implementation of this new freight transportation system will also improve the information and communications technology and continue to overcome the challenges and constraints on transport infrastructure.

3.3.2 Cost Per Tonnage for Freight Road and Rail

A domestic freight transportation system aims at having equal share of freight movement by both transportation modes without compromising quality of service delivery. Once this new system is adopted in South Africa, there will be a reduction in freight cost per tonnage due to minimized travel distances between the road and rail transportation modes. In order to reach an optimum domestic freight transportation system, the intention is to obtain a 50/50 share of freight between road and rail transportation modes. Subsequently, this 50/50 share of freight will result with 50% reduction in cost per tonnage from each transportation modes under study. Table 2 shows the cost per tonnage for the major centres in South Africa after the new system has been implemented. The results show that the cost per tonnage for freight rail is higher than freight road by 5-10% for the same major centres in South Africa. This implies that there would not be a high variation in cost per tonnage between freight road and rail and thus leading to an almost equal utilization of both transportation modes by involved stakeholders in the freight industry.

Table 2: The Cost per tonnage for Freight Road and Rail after the implementation of the new system in major centres of South Africa

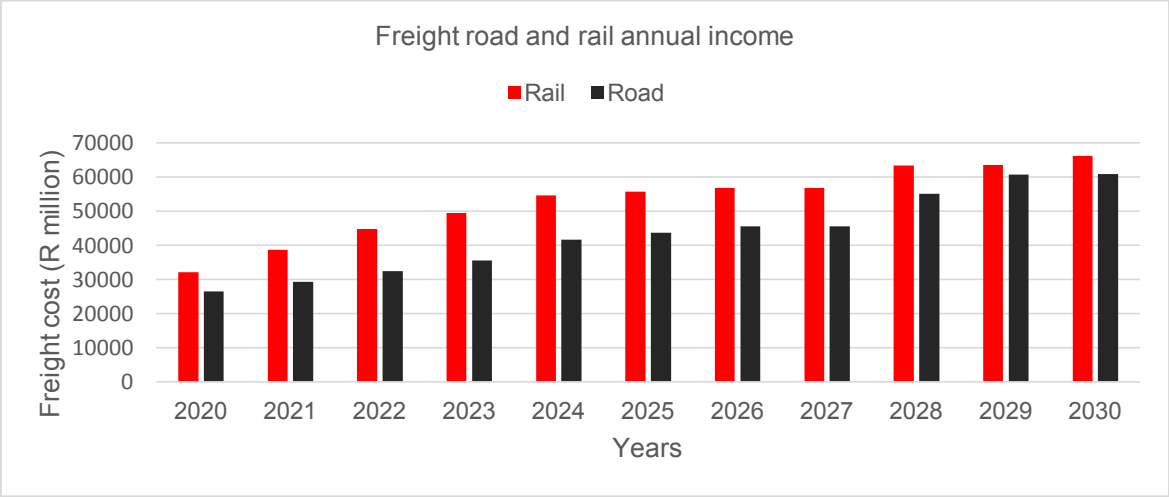
Regions	Distance (km)	Freight Road (R/km/t) -50% Share	Freight Rail (R/km/t) -50% Share
Free State - Gauteng	398	6.55	7.08
Free State - Western Cape	1005	9.35	11.67
Free State – KwaZulu- Natal	635	7.12	8.76
Free State – Eastern Cape	569	8.90	12.45

Source: Stats SA, 2020

3.3.3 The Income Generated by Freight Road and Rail

To obtain an efficient domestic Intermodal freight transportation system there is supposed to be collaboration and coordination of multiple entities involved in the freight industry together with the government. This collaboration allows for a balanced and equal use of freight road and rail in South Africa and thus resulting in equal income generated by both transportation modes. Figure 4 shows estimated income generated annually by freight road and rail once the new system has been implemented. The new system is likely to reduce the income generated by freight road with approximately 50% and increase the income generated by freight rail with the same percentage since both transportation modes are utilized equally. From the annual income generated, the trend shows that freight rail would contribute approximately 10% more income annually than freight road.

This implies that there will be an almost equal contribution of income towards the economy annually by rail and road thus making both transportation modes economically efficient.



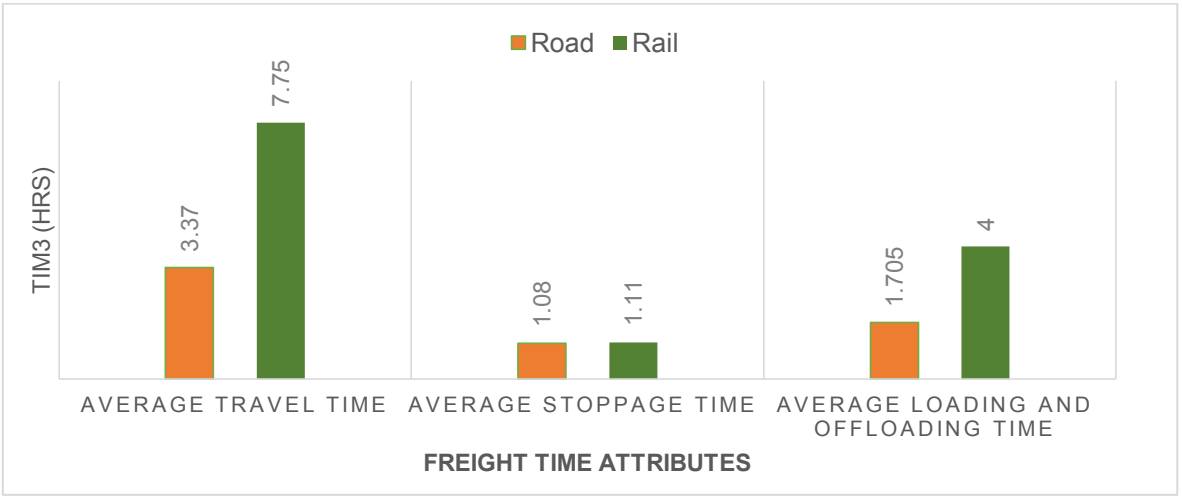
Source: Stats SA, 2020

Figure 4: The estimated annual freight income for road and rail transportation after the implementation of the new system (2020-2030)

3.4 Assessment of Travel Factors

3.4.1 Freight Time Attributes

The implementation of a domestic intermodal freight transportation system will involve the use of various transportation modes and in this case, freight rail and road. Thus, freight time attributes will be optimized since freight road will not be the only mode transporting goods to various locations, instead both transportation modes will operate simultaneously and leading to reduced freight time attributes. Figure 5 shows the freight time attributes after the implementation of the new system. From the freight time attributes, it is evident that freight road would be 4.38 hrs. less in average travel time, 0.03 hrs. less in average stoppage time and 2.29 hrs. less in average loading and offloading time than freight road which is insignificant compared to the current system. This implies that freight road is still more operationally efficient than freight rail, but the variation is not that much significant as compared to the current system being used in South Africa.

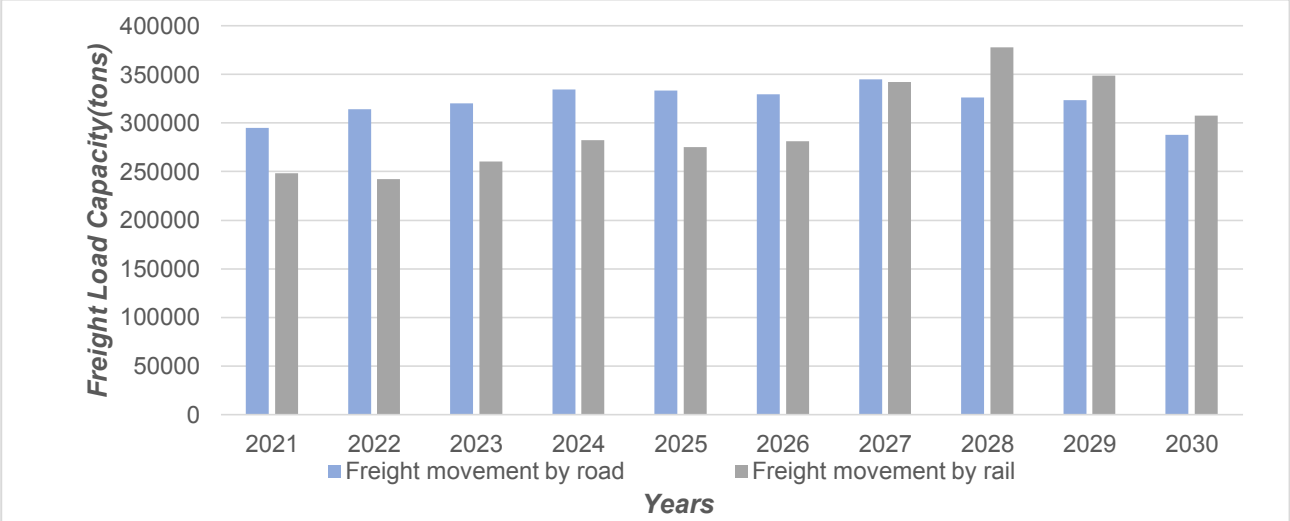


Source: Survey questionnaire, 2020

Figure 5: The essential freight time attributes for road and rail transportation mode after the implementation of the new system

3.4.2 Freight Load Capacity

As this aspect involves the determination of the load that freight road and rail can accommodate during freight movement, the new system will balance the freight load distribution amongst the two freight transportation modes, namely, freight road and rail. A domestic intermodal freight transportation system is the solution of providing a fair split of freight load between road and rail to reach an efficient operational system. Figure 6 shows the freight load capacity for road and rail after the implementation of the new system for freight movement. Since the new system aims at having an equal share of freight load capacity between rail and road, the results show that freight load capacity of road will be greater by 5-10% in tonnage to rail from 2021 to 2027 and lower by 0-7% in tonnage between 2028 and 2030. Therefore, this implies that once the system is implemented then road and rail transportation modes will share an almost equal freight load capacities and thus both being operationally efficient.



Source: Stats SA, 2020

Figure 6: The Freight Load Capacity for road and rail during freight movement after the implementation of the new system (2021-2030)

3.4.3 Results' Implications for Logistics Operators and Decision Makers

Based on the findings, the application of a domestic intermodal freight transportation will not only provide a fair split of freight load between road and rail but will also allow the government together with involved decision makers to develop transport policies that can help to improve the economic and operational efficiency of the two transportation modes. Subsequently such measure could include policies in favour of modal split between freight road and rail to ensure equal share of freight, investments in infrastructure expansion and to promote efficiency and competitiveness in the freight and logistics industry (Lee, 2012). Additionally, this system will create an environment that will allow logistics operators to have adequate rest intervals, informed decision-making processes, more engagement, and improved service delivery due to collaboration of the two transportation modes for freight movement.

4. CONCLUSION

In conclusion, the current system reveals that there seem to be an imbalance of freight share between rail and road transportation due to freight road being more economically and operationally efficient than freight rail. Furthermore, freight road incurs less cost per tonnage, provides less freight time attributes and generate an income of 40% annually

towards the country's economy based on primary data. Therefore, freight road is more competitive as compared to freight rail which is one of the most significant tools to the economic development of the country as perceived by involved stakeholders.

However, the new system aims at addressing the high logistics costs by collaboration of freight rail and road in the movement of freight. A domestic intermodal freight transportation is the new system which will incorporate the use of both freight transportation modes with freight rail being used for large quantities of cargo on long-haul distances and freight road still transporting the same amount of cargo but for short-haul distances. If the system is used, there would be improvements in economic and operational efficiency as the equal use of both transportation modes can provide fast travel times, reduced freight load costs and diverse delivery of commodities. Additionally, the expected changes of the new system will have a favourable impact on the environment and infrastructure by reducing gas emissions and overloading on road infrastructures. Generally, upon implementation of the new system, there will be an improved collaboration of the government and involved stakeholders by equal freight share between road and rail, reduction in logistics costs through shared travel distances, and fast distributions for the future freight industry.

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