Revitalising rail: The case of public-private partnerships

By:

Rudi Deon Kriel

Thesis presented in partial fulfilment of the requirements for the degree of MCom (Transport Economics) in the Faculty of Economics and Management Sciences at Stellenbosch University

Supervisor: Professor Stephan Krygsman

Co-supervisor: Mr Pieter Conradie

April 2022

Declaration

By submitting this thesis electronically, I declare that the entirety of the work contained therein is my own, original work, that I am the sole author thereof (save to the extent explicitly otherwise stated), that reproduction and publication thereof by Stellenbosch University will not infringe any third party rights and that I have not previously in its entirety or in part submitted it for obtaining any qualification.

Candidate: Rudi Kriel

Date: April 2022

Abstract

In response to the degrading state of the national passenger railway service, the President of South Africa recently announced plans to revitalise the service through private sector integration. This study set out to investigate the current financial and economic feasibility of the South African passenger railway service in order to determine the merits of potential private sector integration as a method of railway reform.

The study utilised primary data, provided by the Passenger Railway Agency of South Africa (PRASA), as well as publicly available secondary data, to perform an adjusted Cost-Benefit analysis (CBA) wherein both the financial and economic feasibility of the South African passenger railway service were investigated. To this end, the Cape Town Southern line was employed as a case study subject, under which the population growth, modal split, and travel demand were forecast over a 20-year analysis period. While the financial analysis aimed to determine the financial sustainability of the Southern line, the economic analysis explored the feasibility of rail use relative to alternative transport modes, with consideration for the direct and indirect costs of travel. Finally, the analysis determined the effects of private sector participation on both the financial and economic feasibility of the Southern line.

The analysis found the existing service to be both financially and economically not feasible. The financial costs associated with each journey on the Southern line were found to far exceed the revenue generated, culminating in considerable fiscal deficits and heavy reliance on government subsidisation. Economically, the Southern line was found to have the highest economic costs per journey out of all modes investigated - largely the result of excessive travel time costs. Through incorporating the possible effects of public-private partnerships (PPPs), the analysis estimates financial and economic savings of R2 billion and R20 billion respectively, in comparison to the base alternative. Even though financial savings occur under private participation, the analysis found that the service would remain dependent on government subsidisation. Economically, however, the Southern line would become viable under private control.

Therefore, since PPPs would lead to improvements in financial sustainability, as well as economic feasibility, the conclusion is made that private sector participation is a viable method of passenger railway reform in South Africa.

Keywords: Passenger rail privatisation, Passenger rail financial feasibility, Passenger rail economic feasibility, Passenger rail cost-benefit analysis.

Abstrak

In reaksie op die vernederende toestand van die nasionale passasierspoorwegdiens, het die President van Suid-Afrika onlangs planne aangekondig om die diens ‘n nuwe asem te gee deur privaatsektor-integrasie. Hierdie studie het ten doel gehad om die huidige finansiële en ekonomiese haalbaarheid van die Suid-Afrikaanse passasierspoordiens te ondersoek, ten einde die meriete van potensiële privaatsektor-integrasie as 'n metode van spoorweghervorming, te bepaal.

Die studie het primêre data, verskaf deur die Passasierspoorwegagentskap van Suid-Afrika, sowel as publiek beskikbare sekondêre data gebruik om 'n aangepaste koste-voordeel-analise uit te voer, waarin beide die finansiële en ekonomiese haalbaarheid van die Suid-Afrikaanse passasierspoorwegdiens ondersoek is. Vir hierdie doeleindes is die Kaapstad-Suidelikke spoorlyn aangewend as 'n gevallestudie area, waaronder die bevolkingsgroei, modale verdeling en reisaanvraag oor 'n 20-jaar-ontledingstydperk voorspel is. Terwyl die finansiële ontleding daarop gemik was om die finansiële volhoubaarheid van die Suidelike lyn te bepaal, het die ekonomiese ontleding die haalbaarheid van spoorgebruik relatief tot alternatiewe vervoermetodes ondersoek, met inagneming van die direkte en indirekte koste van reis. Laastens het die ontleding die uitwerking van privaatsektor-deelname op beide die finansiële en ekonomiese haalbaarheid van die Suidelike lyn bepaal.

Die ontleding het bevind dat die bestaande spoorwegdiens finansieel en ekonomies nie haalbaar is nie. Daar is gevind dat die finansiële koste verbonde aan 'n reis op die Suidelike lyn die inkomste wat gegenereer is ver oorskry, wat uitloop op aansienlike fiskale tekorte en groot afhanklikheid van staatsubsidies. Ekonomies is gevind dat die Suidelike lyn die hoogste ekonomiese koste per reis het uit alle modusse wat ondersoek is - grootliks die gevolg van buitensporige reistydkostes. Deur die moontlike uitwerking van publiek-private vennootskappe in te sluit, skat die ontleding finansiële en ekonomiese besparings van onderskeidelik R2 miljard en R20 miljard, in vergelyking met die basisalternatief. Al vind finansiële besparings onder private deelname plaas, het die ontleding bevind dat die diens van staatsubsidies afhanklik sal bly. Ekonomies sou die Suidelike lyn egter lewensvatbaar word onder private beheer.

Daarom, aangesien privaat sektor integrasie sal lei tot verbeterings in finansiële volhoubaarheid, sowel as ekonomiese haalbaarheid, word die gevolgtrekking gemaak dat die beleid 'n lewensvatbare metode van passasierspoorweghervorming in Suid-Afrika is.

Sleutelwoorde: Passasierspoorprivatisering, Passasierspoor finansiële haalbaarheid, Passasierspoor ekonomiese haalbaarheid, Passasierspoorkoste-voordeel-analise.

Acknowledgements

I would like to use this opportunity to show my earnest gratitude towards everyone who contributed towards the completion of this study. Firstly, I would like to thank my heavenly Father for providing me with peace of mind and revelation in times of need. Without you, Lord, this would have stayed a dream.

Secondly, I would like to show my utmost appreciation towards my supervisors, Professor Stephan Krygsman and Mr Pieter Conradie, for their continued guidance, patience, and professionalism throughout this study. A special thanks for the times we could laugh together.

Thirdly, I would like to thank my fiancé, Amy Brooks, for always being willing to listen and lend a helping hand where possible. Without your optimism, love and support, the completion of this study would have been significantly more difficult.

Finally, I would like to thank my parents, Christie Kriel and Tania Kriel, for supporting me throughout my entire academic career, and making this a reality for me. I hope to, one day, support my children to the same extent when I enter fatherhood.

Table of contents

List of Figures

List of Tables

Abbreviations and Terminology

CTR&DC	Cape Town Railway and Dock Company
CBA	Cost-Benefit Analysis
CO2	Carbon Dioxide
GDP	Gross Domestic Product
ITP	Integrated Transport Plan
Km	Kilometer
MC	Marginal Cost
eNaTIS	National Traffic Information Service
NGR	Natal Government Rail
NHTS	National Household Travel Survey
NPV	Net Present Value
NRC	Natal Railway Company
OTE	Overhead Traction Equipment
PPP	Public-Private Partnerships
PRASA	Passenger Railway Agency of South Africa
RUC	Road User Cost
SAR&H	South African Railways and Harbours
SATS	South African Transport Service
SOC	State-Owned Company
VOC	Vehicle Operating Cost
WRC	Wynberg Railway Company

Chapter 1 – Introduction

1.1 Statement of purpose

Passenger railway services are widely considered to be the backbone of urban transport networks, due to its ability to function as an intermodal link, and efficiently transport large volumes of passengers over long distances (World Bank, 2017). In considering the interconnectivity of urban transport networks, it is vital that each transport mode should function at its optimal capacity, for the network to function cohesively (City of Cape Town, 2018). In the case of South Africa, however, passenger railway services have been unable to function at its optimal capacity.

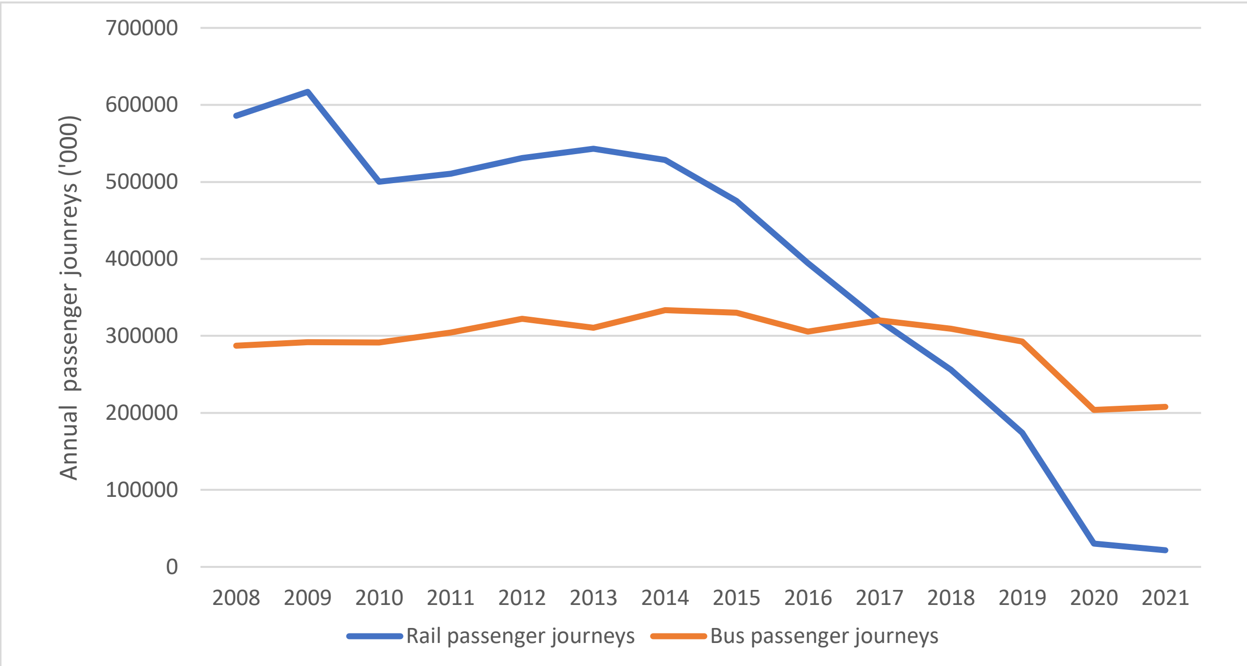


Figure 1.1: South African passenger railway journeys from 2008-2020 (Statistics South Africa, 2020a)

Figure 1.1 is constructed from the South African land transport survey and depicts the annual rail passenger journeys[1], and bus passenger journeys from 2008 to 2020. Since 2013, passenger rail journeys have been in constant decline, reaching close to zero in 2020 due to Covid-19, while bus passenger journeys have been relatively stable.

The decline in railway journeys are due to a variety of factors, including train delays, cancellations, overcrowding, safety concerns, inadequate long-term maintenance and renewal programmes, as well as vandalism, which have all caused railway services to become unreliable (PRASA, 2019a).

[1] A passenger journey is classified as the transportation of a commuter from the entrance to the exit of the given transport mode (World Bank, 2017).

Consequently, increasing numbers of South African railway commuters have diverted to other transport modes such as private vehicles, minibus taxis and busses, for their transportation needs.

In turn, these modal shifts from rail to road-based transport have other implications on the economy. Firstly, literature suggests that road-based transport modes have up to four times the economic costs of rail services due to high operating costs, increased road congestion and higher environmental impacts (Seabright, 2003). Secondly, the decline in railway journeys has caused PRASA to become increasingly financially unstable, due to declined fare revenue. In 2019, PRASA reported an all-time-high financial deficit of R1.8 billion (PRASA, 2019a).

Given the current operational performance of PRASA, and the effects of increased road-based transport use, the South African government has been in search of policy actions to improve the South African passenger railway service. In October of 2020, President Cyril Ramaphosa proposed private sector integration on certain passenger rail routes, as a method of railway reform in South Africa (BusinessTech, 2020). The purpose of this dissertation is therefore to investigate the viability of private sector participation as a method of passenger railway reform in South Africa.

1.2 Aims and research questions

This research aims to determine to which extent private sector participation is a viable method of railway reform in South Africa, from both a private and a public perspective. Firstly, financial data regarding the revenues and costs of the service are investigated to determine the short term and long term financial viability thereof. Thereafter, the economic costs of the service are compared to that of other modes to determine the economic feasibility of the service. Finally, the possible effects of private sector participation on the financial and economic feasibility of the service are determined. Based on these outcomes, conclusions are reached regarding the feasibility of private sector participation as a method of railway reform.

Research questions included:

- To what degree is the South African passenger railway service financially viable?
- To what degree is the South African passenger railway service economically viable?
- What is the feasibility of private sector participation as a method of passenger railway reform in South Africa?

1.3 Structure of dissertation

Chapter 2 contains a comprehensive literature review which is divided into four subsections. The first section (2.2) investigates the historical development of the South African railway network, in order to determine its contribution to the development of the South African economy from the 1860s until now. Section 2.3 investigates the functionality of the South African passenger railway service by investigating the trends in passenger satisfaction, modal shifts and modal investment, for both rail and road-based passenger transport modes. Section 2.4 investigates the importance of a well-functioning passenger railway system, and the possible implications that a sub-par service can have on an economy. The literature review concludes with section 2.5, in which historical implementations of passenger rail privatisation is investigated.

Chapter 3 provides the reader with the methodology and conceptual framework of the analyses, as well as the background of the case study that will be investigated. The background includes information regarding the supply and demand demographics of the proposed case study area, a demand forecast and the evaluation alternatives that will be investigated.

Chapter 4 contains a financial analysis in which the revenues, costs and capacity of the given railway line are investigated. This information, along with the demand forecast, is used to determine the profitability of the railway line with regard to each evaluation alternative.

In Chapter 5 an economic analysis of the transport services in the study area is conducted. The economic analysis compares the economic cost associated with the use of each transport mode identified in Chapter 3. The economic cost associated with each transport mode is then applied to the demand forecasts and the evaluation alternatives, to determine the implication of each evaluation alternative on the cost to the economy.

Chapter 6 contains a sensitivity analysis in which the robustness of the preliminary results are tested. Along with testing the robustness of the preliminary outcomes, the chapter investigates the financial and economic implications of private sector participation on the Southern line.

The dissertation concludes with Chapter 7, wherein the research questions are answered, and conclusions are reached regarding the feasibility of private sector participation as a method of railway reform in South Africa. The chapter concludes with the identification of research limitations and proposed future research which could further improve our knowledge regarding PPPs in the passenger railway services of South Africa.

Chapter 2 - Literature review

The following chapter aims to determine four key elements from existing literature. These elements include (1) the development of the South African railway network, (2) the trends in South African passenger journeys, modal shifts, and modal investment, (3) the importance of a well-functioning passenger railway system, and finally (4) the outcomes and implementation methods of historical PPPs in passenger rail networks.

2.1 Development of the South African railway network

South Africa's relationship with rail started in the 1860s when two railway companies began construction on railway lines in Natal and Cape Town. These companies were the Natal Railway Company and the Cape Town Railway and Dock Company.

2.1.1 Natal Railway Company

In early 1860, a newly formed private company called the Natal Railway Company (NRC) built a 3 kilometer (km) broad gauge (1,435 mm) railway line, stretching from the Durban town centre to the Natal harbour (Cottrell, 2010). Figure 2.1 shows a map of the railway line.

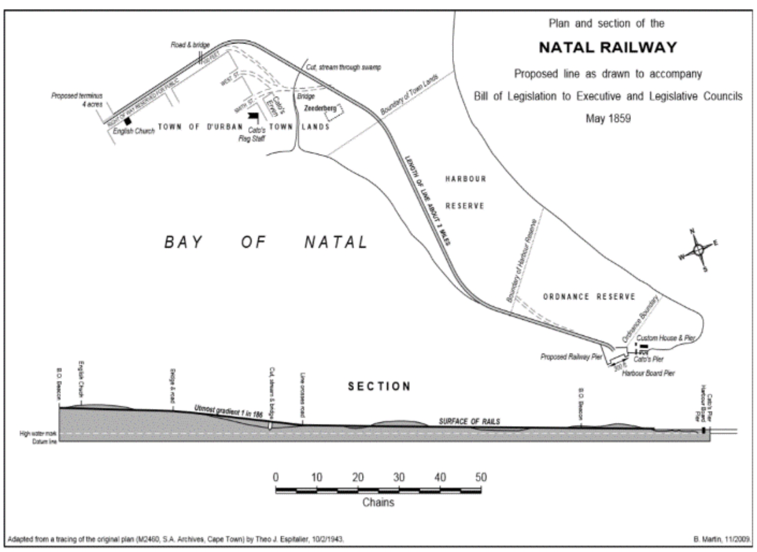


Figure 2.1: Map of the first railway line in South Africa (Cottrell, 2010)

The railway line was constructed to provide a cost-effective method of transporting primarily sugar from the Durban town centre to the Durban harbour. At the time ox-wagons were used, which proved to be expensive, slow and inefficient, due to low carrying capacity (Cottrell, 2010).

Despite the railway line transporting around 20 000 tons of imports, and 5000 tons of exports annually after completion, financial difficulty arose in 1865 (South-African-Railways, 1947). At this time, the Natal Government purchased the railway line from NRC, and extended it to connect the Durban harbour with the Umgeni River Quarry, in order to facilitate the transport of materials needed for harbour construction and upgrades (TFR, 2018). The Natal Government Railways (NGR) was established in 1877 by the Natal Government to facilitate the construction and administration of the 7km railway extension (Cottrell, 2010). After the completion of the extended railway line in January 1867, the Natal government leased the operational responsibilities of the line to NRC, as they had prior experience in the operation thereof. This was the first establishment of a South African railway public-private partnership (Cottrell, 2010).

2.1.2 Cape Town Railway and Dock Company

Shortly before the construction of the Natal railway line, a private company called Cape Town Railway and Dock Company (CTR&DC) started construction on a 70km broad gauge (1.435 mm) railway line between Cape Town and Wellington via Stellenbosch (TFR, 2018). CTR&DC was established in 1853, with a total capital amount of £600 000. This capital was divided into £20 shares, of which 5000 shares were made available to the local government, and the remaining 15 000 to the public (South-African-Railways, 1947). The company had nine directors, of whom two were South African and seven were foreign investors involved in other railway networks around the world (South-African-Railways, 1947).

The Cape Town-Wellington railway line was intended to facilitate agricultural transport as well as, to a lesser extent, passenger transport. After two years of construction, a mere 3km out of the 70km had been constructed, after which CTR&DC dismissed the project manager (Edward Pickering) and took control over the project (TFR, 2018). The Cape Town-Wellington line came to completion on 4 November 1863 (South-African-Railways, 1947). Shortly after the opening of the Wellington line, in 1964, another private railway company, the Wynberg Railway Company (WRC), constructed a railway line from Salt River to Wynberg, which is known today as the Southern line (South-African-Railways, 1947).

In 1872 the Cape government formed a new state-owned railway company called Cape Government Railways (CGR), which would proceed to buy the Cape Town-Wellington railway line from the CTR&DC, and the Saltriver-Wynberg railway line, in order to create one network that could easily be expanded (Janse van Rensburg, 1996). On 1 December 1890, the expansion of the Saltriver-Wynberg railway line, which stretched from the Cape Town city centre to Simon's Town, was completed (Boonzaaier, 2008).

2.1.3 Expansion of the railway network

From 1869, the railway network expanded significantly due to the discovery of diamonds in Kimberley (South-African-Railways, 1947). At this stage, South Africa was separated into four different provinces (Cape of Good Hope, Natal, Transvaal and the Orange Free State) with each provincial government having control over their railway networks.

Due to Kimberley's geographical position, the different provincial governments were tasked with transporting mining equipment and labourers over hundreds of kilometres at an economically viable cost. Rail was the preferred transport mode due to its ability to transport heavy and high capacity cargo over long distances at low comparative costs (World Bank, 2017). In 1872, CGR started the construction of railway lines that connected Kimberley with the three major ports in the Cape Colony in order to facilitate diamond exports (South-African-Railways, 1947). These included the Cape Town-Kimberly line, the Port Elizabeth-Kimberley line and the East London-Kimberley line, also known as the Cape Western line, the Cape Midland line and Cape Eastern line respectively. These railway lines came to completion in 1885 (TFR, 2018). Figure 2.2 illustrates the Cape Colony's railway development in 1882.

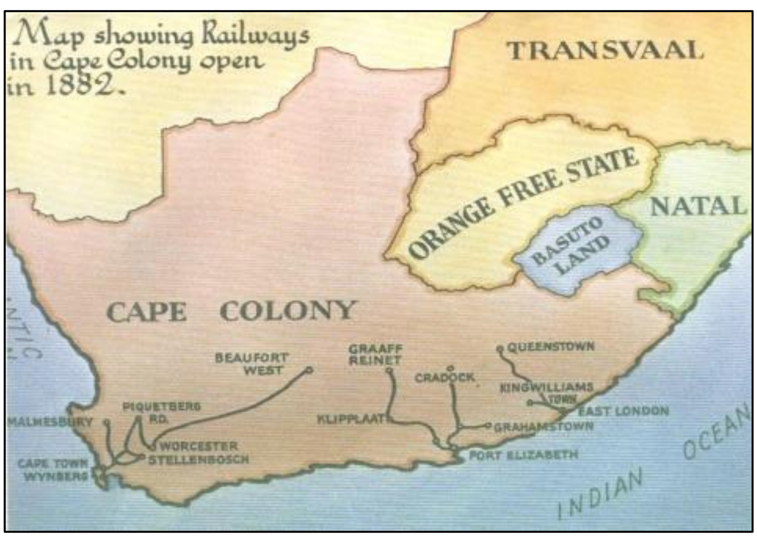


Figure 2.2: Cape Government railway network in 1882 (Wikipedia, 2021)

The Cape Town-Kimberley line was an extension of the Cape Town-Wellington line, and was thus the first railway line in South Africa to be constructed in the narrower 1065 mm (3 foot 6 inch) gauge. The narrower gauge worked better in adapting and traversing the contours of the countryside and would later become known as the Cape Gauge and would be declared as the official national gauge measure (South-African-Railways, 1947). To accommodate the Cape gauge carriages on the Cape Town-Wellington broad line, the Cape government constructed a third rail in the broad-gauge line which would allow this (Janse van Rensburg, 1996).

In 1886, a year after the three Kimberley lines had been completed, large gold deposits were discovered in the Witwatersrand (Cottrell, 2010). CGR saw an opportunity to extend the Cape Town-Kimberly line to Johannesburg to facilitate gold exports, but was restricted due to the Orange Free State owning the land (South-African-Railways, 1947). CGR came to an agreement with the Orange Free State that allowed both parties to benefit from the project. In 1890 the extended railway line reached Bloemfontein, and in 1892 the first train operated between Cape Town and Johannesburg (Cottrell, 2010).

Throughout the following 30 years, the railway network further expanded. Figure 2.3 and 2.4 illustrates the development of the South African railway network from 1892 – 1910.

Figure 2.3: South African railway network 1892 (Wikipedia, 2021)

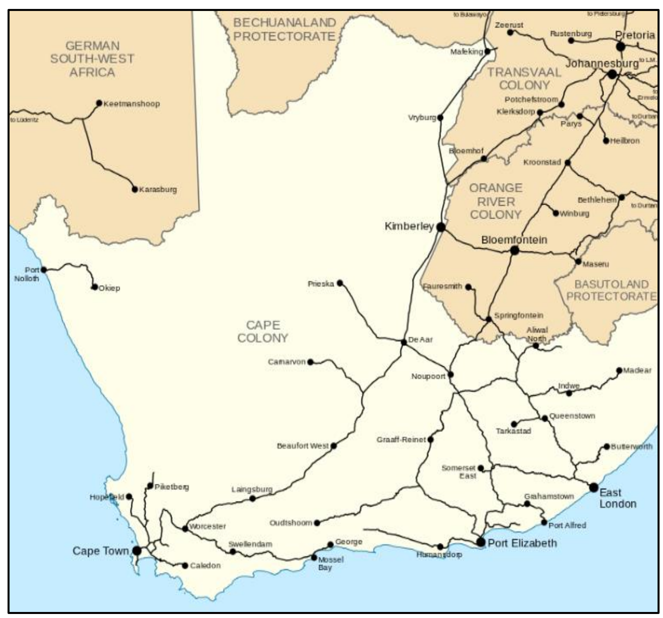


Figure 2.4: South African railway network upon the establishment of South African Railways and Harbours in 1910 (Wikipedia, 2021)

2.1.4 South African Railways and Harbours (SAR&H)

In 1910, after the end of the Second Anglo-Boer War, the Union of South Africa - under British dominion - was formed. Along with the formation of the Union, the railway networks of the four provinces merged into one national railway network (Janse van Rensburg, 1996). On 31 May

1910, the entirety of the South African railway systems was placed under the control of a newly founded state-owned enterprise called the South African Railways and Harbours (SAR&H) (TFR, 2018). The SAR&H was tasked with improving transport accessibility to the public and by 1924 had constructed 9000km of rail, as well as a functioning road-based transport system, to facilitate trade and travel in the country (Janse van Rensburg, 1996; TFR, 2018).

The control and objective of the SAR&H were described in Clause 127 of the Act of Union 1910, which read:

> *The Railways and Harbours of the Union shall be administered on business principles, due regard being paid to the agricultural and industrial development within the Union and the promotion, by means of cheap transport, of the settlement of an agricultural and industrial population in the inland portions of all provinces of the Union.*

After World War 1, in the period from 1946 – 1959, South Africa continued to grow through its strong exporting market. This lead to large infrastructure projects being undertaken to facilitate trade (TFR, 2018). The period from 1960 – 1990 brought about major technological achievements as well as major organisational change in the South African railway network. Some of the technological and operational achievements included (TFR, 2018):

- the arrival and operation of the first electric-powered locomotive in South Africa;
- the nationalisation and electrification of the Sishen-Saldanha railway line from Iscor Ltd., a private steel production company (1976);
- record-breaking train test speeds of 245 km/h (1979); and
- coal trains that spanned up to 2.65 km long.

2.1.5 South African Transport Service (SATS)

During the 1970s it was decided that the SAR&H should change its name to better reflect its multi-modal defined business operations. In 1981 the reform commenced and brought about the merger of the South African harbours, railways, roads, aviation and pipeline industries, which together were known as the South African Transport Service (SATS) (TFR, 2018).

2.1.6 Transnet Limited, PRASA, and Gautrain

In 1990 SATS became a state-owned company (SOC) and was renamed to Transnet Limited. Transnet retained ownership and control of all the departments of SATS, but compartmentalised them into Spoornet, Transnet Pipeline, Transnet Port Terminal and Transnet National Port Authority (TFR, 2018). In July 2007, Transnet separated the passenger rail services from the freight rail services and formed an independent company called the Passenger Rail Association of South Africa (PRASA). PRASA operates in the Eastern Cape, Gauteng, Kwa-Zulu Natal and the Western Cape in the form of urban transport services and inter-city services. PRASA services a total of 468 train stations throughout these provinces, with approximately 400 train sets. In 2011 the Gautrain Rapid Rail Link was opened and provided citizens with another form of rail transport. The 80km long network was constructed with the main purpose of reducing road congestion and promoting economic development.

2.1.7 Conclusion

Historically, rail transport has played a significant role in the economic development of South Africa. The development of the South African railway network was established in pursuit of exporting agricultural goods and valuable raw minerals such as coal, gold and diamonds discovered in that time. Die exportation of these goods was vital in the economic development of the South African economy and was made possible through rail transport. More recently the railway infrastructure is also being utilised for passenger transport services provided by PRASA.

It can be noted that both public and private sectors have played significant roles in the development of the South African railway network. The innovation of the private sector was necessary to initiate the construction and operation of railway networks, and the nationalisation of the network was critical in the expansion thereof.

2.2 Trends in South African passenger journeys, modal capacity and modal investment.

Since the establishment of PRASA in 2007, the state-owned enterprise has been unable to operate at a level higher than 60% of its performance targets (PRASA, 2019a). PRASA operations have become characterised by financial losses, and its dependency on government subsidisation has continued growing (PRASA, 2019a). One reason for both the dismal operational and financial results is the constant decline of passenger railway journeys.

The following section will determine the reasons for the decline in rail passenger journeys in South Africa by investigating passenger satisfaction, modal shifts and modal investment.

2.2.1 Passenger satisfaction

To determine the level of passenger satisfaction achieved by PRASA, the results of the 2013 and 2020 National Household Travel Survey (NHTS) are consulted. Table 2.1 shows the percentage of rail users that were dissatisfied with certain rail service attributes in 2013 and 2020 (Statistics South Africa, 2020b).

Attributes of the train service	RSA (per cent within RSA)	
	2013	2020
Dissatisfaction		
The level of crowding in the train	78,2	86,8
The waiting time for train	52,5	86,6
The frequency of train during peak period	46,7	81,7
The frequency of train during off-peak period	50,7	81,7
The travel time by train	50,3	73,7
Security on the walk to/from the train station	56,6	70,6
The train service overall	47,0	68,7
Security on the train	47,4	65,3
The facilities at the train station, e.g. toilets, offices	45,9	59,1
Security at the train station	32,3	57,7
The distance between the train station and your home	52,6	52,6
Safety from accident in the train	29,4	39,1
The train fare	15,3	9,6

Table 2.1: Passenger dissatisfaction – PRASA (Statistics South Africa, 2020b)

According to the 2013 NHTS, overcrowded trains (78.2% of users), the punctuality of trains (62.5% of users) and the safety of getting to the train stations (56.6% of users) were noted to be the main concerns of using PRASA services (Statistics South Africa, 2013). The 2020 NHTS survey shows that passenger dissatisfaction has further increased since 2013. In 2020, the main concerns with using passenger rail services included the overcrowding of trains (86.6% of users), the punctuality of trains (86.6% of users), and the frequency of trains (81.7% of users).

Further concerns regarding the use of passenger railway service (<50% of user concern) included:

- The distance between stations and homes (52.6%)
- Travel time by trains (73.7%)
- Safety of getting to and from the train stations (70.6%)
- Safety and security on trains (65.3%)
- Safety and security at train stations (57.7%)
- Inadequate facilities at stations (59.1%)

When passengers were asked why they have not used rail services in the past months, the four main reasons included:

- Availability of rail (44.9%)
- Preference to using minibus taxis (6.7%)
- Preference to using private transport (1.4%)
- Reasons relating to service attributes (40.2%)

It is thus clear that the majority of rail users are not satisfied with the quality and level of service as provided by PRASA. These high levels of passenger dissatisfaction also justify the constant decline in rail-related passenger journeys from 2013. Because transport is a derived demand, commuters cannot simply stop using transport in their day-to-day activities, which means that ex-rail users are using another form of transport. Section 2.2.2 investigates the growth of alternative modes of transport in order to identify which modes of transport ex-rail users are moving to.

2.2.2 Modal shift

Alternative transport modes to rail transport are all assumed to fall under road-based transport modes due to their direct competition with rail in the urban setting. Therefore, by using modal growth data from the Land Transport Survey, the growth of private vehicles, minibus taxis, and busses have been analysed to determine the modal shift of commuters in South Africa (Statistics South Africa, 2020a).

Figure 2.5 shows the annual growth rate of private vehicles, minibus taxis, and busses, using 2008 as the base year. On the secondary axis, the annual passenger rail journeys are measured and depicted by the light blue line. The vertical dotted line represents the start of the continual decline of rail passenger journeys.

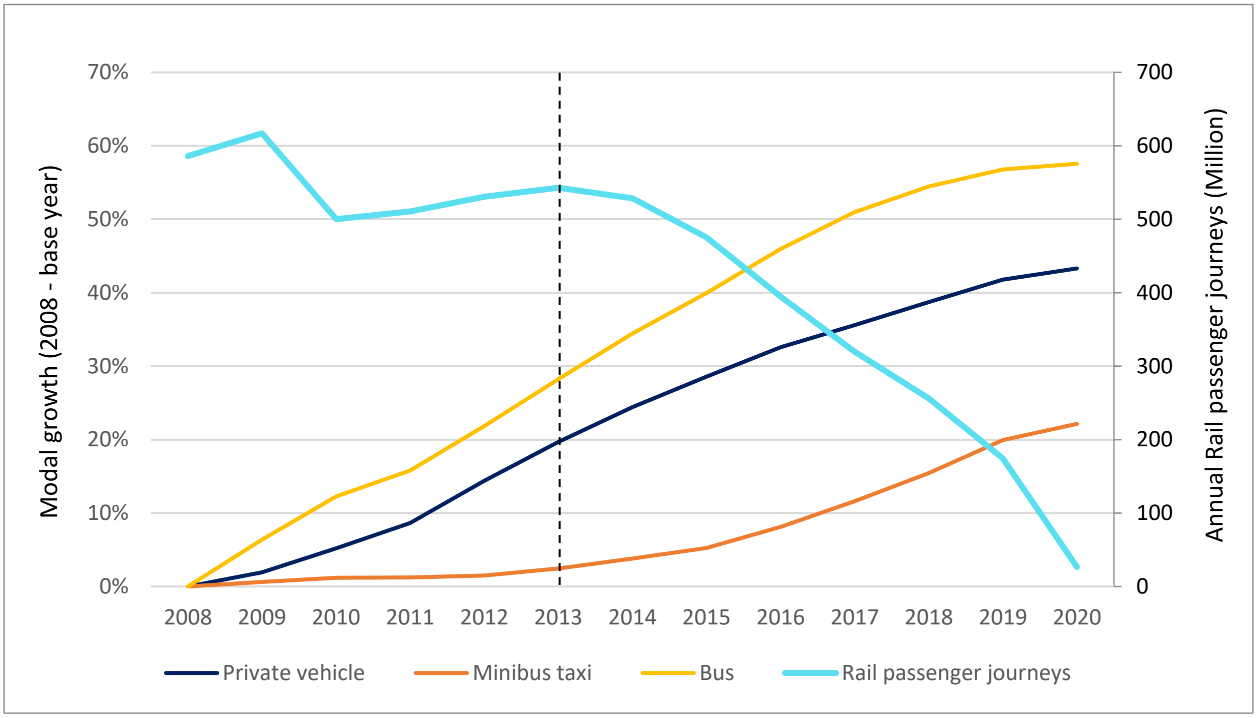


Figure 2.5: Modal growth rate and rail passenger journeys (Statistics South Africa, 2020a)

Using 2008 as a base year, it is clear that buses have had the highest growth trend, followed by private vehicles and minibus taxis. As all three modes have positive growth rates, it can also not be assumed that all rail users have moved to a single mode. By investigating the growth rates of these modes after 2013, a conclusion can be made regarding the likelihood of rail passengers moving to the use of each mode.

Even though busses have the highest growth rate of these three modes, there have been no significant changes since 2013. From 2014 to 2017 the number of busses grew at the same rate as before 2014. After 2017, however, busses have been increasing at a decreasing rate, which signifies that lost rail passengers have not significantly shifted to the use of bus transportation. Similarly, private vehicles kept a constant growth since 2013, which signifies that lost rail users are also not significantly shifting to the use of private vehicles.

The minibus taxi fleet, however, has been growing at an increasing rate since the start of the decline in rail passenger journeys. From June 2008, minibus ownership took 199 months to grow by 10% (January 2017). From January 2017, minibus ownership took only 26 months to grow another 10% (August 2019). This signifies that minibus ownership has been following a much faster growth rate than before the downturn of rail journeys, and suggests that a significant portion of lost rail passengers are now depending on minibus taxi services for their transport needs.

2.2.3 Modal investment

To understand the fast-growing road transport sector, it is necessary to reflect on the annual investment associated with road and rail transport infrastructure. Figure 2.6 has been constructed from National Treasury annual reports from 2008-2019 and shows the annual infrastructure investment of rail and road-based transport.

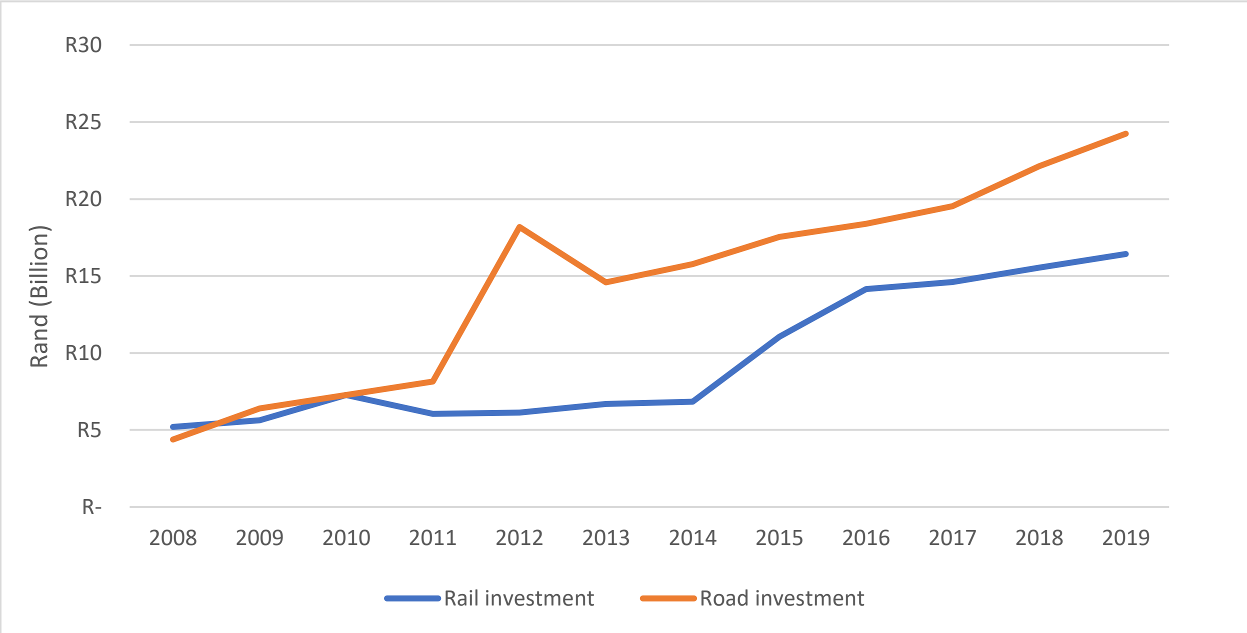


Figure 2.6: Annual road and rail infrastructure investment (National Treasury, 2008 - 2019)

Figure 2.6 indicates that infrastructure investment was, from 2008 to 2010, relatively equal for both modes. After 2011, however, road-based infrastructure investment increased significantly, while that of rail remained constant. From 2013, road infrastructure investment increased annually, while rail infrastructure investment only started increasing in 2015, and to a lesser extent than road.

2.2.4 Conclusion

According to the 2020 NHTS, PRASA is facing high levels of passenger dissatisfaction due to the low level of service quality (Statistics South Africa, 2020b). There are a variety of reasons for the low level of service quality, including the lack of infrastructure renewal, vandalism and poor management. Due to these factors, many rail commuters have moved to the use of other modes of transport, such as private cars, busses and minibus taxis. Data from the Land Transport Survey suggests that a large portion of lost rail users have moved to the use of minibus taxis. Data from the annual reports of National Treasury indicates that road infrastructure expenditure outweighs that of rail infrastructure, which aids in explaining the degrading condition of railway infrastructure.

2.3 The importance of a well-functioning passenger railway system

As per section 2.2, it is clear that the South African passenger railway service is not optimally functional. The implications of a dysfunctional transport mode have effects on the utilisation of other transport modes. Section 2.2 depicts this phenomenon by showing how the use of road-based transport modes (especially minibus taxi services) has increased due to decreasing levels of rail passenger journeys. The following section will compare the social cost associated with rail and with road-based transport modes in order to determine the importance of a well-functioning railway system. These social costs include:

- Environmental impact
- Travel time
- Accident cost

2.3.1 Energy use and environmental impact

It is common knowledge that transport activities have a negative impact on the environment. These negative impacts take on the form of harmful emissions such as carbon dioxide (CO2), nitrogen dioxide and sulphur dioxide that are released into the atmosphere when a vehicle produces energy to be propelled forward (Forkenbrock, 2001). All self-propelled transport modes exert some degree of these pollutant emissions, whether it be directly (from the vehicle) or indirectly (electricity produced by a coal/diesel power plant). It is however true that some transport modes exert less harmful emissions than others. Literature suggests that rail transport exerts fewer polluting emissions than other transport modes due to two reasons (Skrucany *et al.*, 2017).

The first reason is based on economies of scale principles. The total carbon emissions produced by a vehicle does not vary significantly with regard to the load factor thereof (Seabright, 2003). When considering the vehicle's carbon emission per capita, however, the capacity thereof becomes much more important (Seabright, 2003). A bus, for example, can carry between 60 and

80 people per journey, while a train can carry up to 2000 passengers per journey (dependent on train size and number of carriages). Even though the total emissions of the train are more than that of a bus, the per person emission is considerably less when fully utilised (Skrucany *et al.*, 2017). Thus, both the carrying capacity and the load factor of the vehicle play a significant role in its impact on the environment. In terms of the economies of scale principles of emission, rail transport trumps road transport in both carrying capacity and load factor variables, and causes rail transport to be considerably more environmentally friendly than road transport.

The second reason is based on surface resistance factors. The more resistance is present in any moving object, the more energy is required to propel that object forward. In the case of rail transport, the steel on steel configuration supplies very little resistance between the train and the railway line (World Bank, 2017). Less energy is thus required to keep the vehicle at a given speed.

Taking into consideration these factors, studies have found that rail transport is 70% more energy efficient than gasoline cars, and 50% more energy efficient than diesel cars (Skrucany *et al.*, 2017). Further studies found that rail transport consumes seven times less fuel than bus transportation, and 12 times less fuel than car transportation, when transporting the same number of passengers (Butkevičius, 2007). With regard to CO2 emissions, studies have found that rail transport emits three times less harmful emissions than road transport modes (Lingaitis and Sinkevičius, 2014).

2.3.2 Travel time

Time has monetary value, due to the possibility of that time being utilised to deliver or produce economic benefit (Wardman, 2004). Due to transport being a derived demand, the time in transit endured to get to his final demand can be considered as a cost (Lyons, Jain and Holley, 2007). For example, if an individual spends more time on an economic beneficial task, such as his career, he will receive more money and contribute to the Gross Domestic Product (GDP) of his country to a greater extent. If this individual had to travel more often, and for longer periods, he would spend less time working and would ultimately contribute less to his economy. Therefore, time spent in transit, even though it facilitates economic activity, is considered a cost to society and should be minimised as far as possible. The main challenge faced by transport modes with regard to transit time minimisation, is congestion. Congestion impairs the flow of traffic and causes travel times and travel costs to increase (Kachroo and Özbay, 2018).

There are two consequences of decreased passenger rail journeys on travel time. The first is the increased use of road-based transport modes, which lead to increased road congestion, and the second is the nature of time usage on the different modes. To understand road congestion, one first needs to understand the laws of traffic flow. The laws of traffic flow are shown by the following equation (World Bank, 2017):

$$D = \frac{V}{Q}$$

"D" represents the density of vehicles on the road and is measured by "the number of vehicles on a unit length of road at a point in time". "V" represents the speed of a vehicle and is measure by "the distance covered by the vehicles in one unit of time", and "Q" represents the flow of the vehicles and is measure by "the number of vehicles passing through a given section of the road within one unit of time". All three of these variables are dependent on one another, and changes in one variable will change the others (Kachroo and Özbay, 2018). When flow, for example, increases, density (D) would increase, and speed (V) would decrease. As shown in section 2.2, decreases in rail journeys are closely related to increases in road transport journeys. In terms of the traffic flow equation, more road transport users would increase road density by reducing speed and flow, which would ultimately increase road congestion (Kachroo and Özbay, 2018).

In South Africa, road congestion is already a noteworthy problem. Each year billions of Rands are spent on maintaining and expanding the road network (R24.25 Billion in 2019), but congestion seems to be ever-present (National Treasury, 2019). Increases in road capacity will only temporarily reduce the effects of congestion, after which the use thereof will grow until more capacity is required (Mogridge, 1997). Increasing road capacity is therefore not a sustainable solution to solving congestion problems. The use of public transport, especially rail transport, is however a sustainable solution to the problem of road congestion.

The second consequence relates to the possibilities of time usage in transit (Wardman, 2004). In most cases, time in transit cannot be used for anything else than transit itself. This is especially true for private motorcars, where the owner of the vehicle is also the driver of the vehicle (Worsley, 2020). However, in public transport modes, it is possible for the transit time to be used for other activities (Lyons, Jain and Holley, 2007). In a train, for example, commuters can use transit time to do work, or buy goods online, etc. This reduces the overall cost of transit time, as the possibility of economic activity exists.

There are definite consequences of decreased passenger rail journeys on road-based travel times. Both the increase in road congestion and the nature of time usage on transport modes impact the extent of the costs of travel times. Increased use of rail transport, however, can alleviate the extent of these costs, but can only be obtained through ensuring a functioning passenger railway service.

2.3.3 Accident costs

Accident costs are considered to be the monetary value of fatalities, injuries and damages to property due to transport-related activity (RTMC, 2015). In terms of accident cost, the consequences of decreased passenger rail journeys are very similar to those discussed in time savings.

Studies suggest that accident costs originating from road-based transport modes are significantly more than that of other transport modes (Seabright, 2003). Road transport accidents occur more often than other modal accidents due to the following reasons:

1. There are significantly more vehicles present, at one time, on the transport infrastructure than other transport modes.
2. Generally, road transport has a significant number of licensed drivers, while in other modes only a few individuals are qualified to operate the vehicle. This increases their responsibility and ability to drive the vehicle.
3. Road transport does not have a fixed right of way, meaning that all vehicles on the road have control over their trajectory.

These factors, in combination with irresponsible behaviour of individuals - such as driving under the influence of alcohol - cause around one million road accidents per year in South Africa (Labuschagne *et al.*, 2017). From these accidents, 13 591 individuals died, 62 520 individuals were seriously injured and another 202 509 were slightly injured. The total cost of road accidents in 2015 was estimated to be R142.95 billion, which equates to 3.4% of South Africa's GDP (Labuschagne *et al.*, 2017). The deaths, injuries and damages to property caused by road accidents are costly to an economy and should be minimised as far as possible (Partheeban, Arunbabu and Hemamalini, 2008).

With increases in road use, more accidents occur and the cost of accidents increases. Passenger rail transport, although not accident-free, has a much lower accident rate and thus contributes less to the accident cost of a country.

2.3.4 Conclusion

In 1995, a comprehensive study was conducted regarding the externalities of different transport modes. The study found that rail transport has the lowest social cost compared to that of private vehicles, busses and aviation. The total social cost of using rail transport was less than a quarter than that of private vehicle transport and less than half of aviation transport (Seabright, 2003). The results of this study are still being used in practice today, as the French government instituted a law stating that all domestic flights, having a duration of less than two and a half hours, will be substituted by rail transport to reduce transport externalities (BBC, 2021). Rail transport, therefore, has significant social benefits over road transport modes. These benefits, however, are only validated in the case of a well-functioning passenger railway network with high load factors.

2.4 Case study review

The declining market share of passenger rail services has been a common occurrence in a variety of countries. In reaction to this trend, many countries commenced with private sector integration as a method of structural reform within their national passenger railway services. The following section will investigate the success and implementation methods of six of these counties, including Britain, Japan and New Zealand (developed countries), and Cameroon, Cote d'Ivoire and Argentina (developing countries).

2.4.1 Methods of private sector integration

Two broad methods of integrating private sector participation into railway networks have been found in literature.

The first entails the vertical privatisation of an entire railway network. This policy structure is complex to implement, as it requires the privatisation of all the divisions in a railway network - which include operations, infrastructure, maintenance, signalling and management (World Bank, 2003). This form of integration transfers all business-related risk and asset ownership onto the private sector (World Bank, 2003). Britain, Japan and New Zealand make use of this policy structure.

The second policy structure is called concessionary policy regimes. A concession is a public-private partnership (PPP) that is different from privatisation in that the risks and responsibilities of the railway network are shared between the consignee (i.e. the private firm) and the government (World Bank, 2003). Generally, the state retains ownership of the railway infrastructure, while the private sector upholds operating responsibilities, infrastructure maintenance responsibilities, commercial risk, investment risk, and operating risk (World Bank, 2003). Cameroon, Cote d'Ivoire and Argentina make use of this policy structure.

2.4.2 Failure of railway networks

Prior to the 1990s, railway networks around the world went through a process of nationalisation, wherein control and ownership of railway industries were transferred from private enterprises to national governance.

Prior to nationalisation, the majority of existing railway networks were under the control and ownership of different private firms. In Britain, for example, 123 different private railway firms were merged to create British Rail in 1932 (Bradshaw, 1996). As in South Africa, these private railway networks were small in size and constructed to satisfy freight-related demand (Thompson and Kopicki, 1995). The short nature of the railway lines, the lack of integration between them, and the specific commercial focus thereof caused these railway lines to have a lack of economies of scale and scope in their operation. Due to the extensive fixed costs faced by railway infrastructure development, the need for economies of scale and scope is a critical component in providing a financially sustainable railway service (Bereskin, 2012; World Bank, 2017). This caused many of these small private railway firms to go bankrupt. Governments, however, saw the potential of rail transport to be a cost-effective method of both passenger and freight transport, which prompted the era of railway nationalisation.

The notion of nationalising these railway industries was based on the benefits of one extensive network that would greatly benefit from economies of scale, scope and density. Nationalisation thus prompted drastic network expansion in many countries, due to the access to national budgetary capital.

Even though nationalisation contributed significantly to the expansion of railway networks, the after-effects of railway nationalisation were mainly negative. In the case of Japan, Britain, New Zealand, Cameroon, Cote d'Ivoire and Argentina, the aftereffects of nationalisation were bankruptcy and vast amounts of debt. There are a variety of reasons for the financial difficulty of these nationalised railway networks:

1. A combination of stagnation in innovation and the emergence of road transport caused the demand for rail transport to fall significantly in these countries. Road transport provided an alternative to both freight- and passenger transport and proved to be more affordable and flexible than rail transport. Much of the freight sector, which represented the largest source of revenue for rail transport, shifted to the use of road transport, hampering the profitability of rail operations. In Japan, for example, the market share of rail and road transport shifted from 55% and 15% in 1955 to 20% and 65% in 1991 (Mizutani, 1999). Over the same period, the market share for rail transport in Britain decreased from 17% to a mere 5% in 1991 (Thompson and Kopicki, 1995). Similar situations occurred in New Zealand, Cote d'Ivoire and Argentina (Thompson and Kopicki, 1995; Ramamurti, 1997; Mitchell and Budin, 1998).
2. Long periods of uninterrupted monopolistic power over the market, as well as a lack of incentive among management to improve the functionality of the system, caused the service quality of railway services to deteriorate over time. Decreasing rail service quality was one of the main causes of the modal shift from rail to road transport (Thompson and Kopicki, 1995).
3. A lack of well-structured management and investment programmes resulted in considerable neglect in the maintenance of the railway infrastructure. In many cases, the railway infrastructure had deteriorated to the extent that speed restrictions and trip cancellations were often necessitated, resulting in unreliable services. In Cameroon, for example, the extensive expansion of the railway network after nationalisation caused the downfall of the network, due to a lack of finances to adequately maintain the network (Bullock, 2005). As in Cameroon, the neglect of infrastructure investment also caused financial difficulty in Cote d'Ivoire and Argentina (Thompson and Kopicki, 1995; Thompson and Budin, 1997).

Nationalisation was successful in the expansion of railway networks, due to access to national capital, but was not successful in fostering financial sustainability within railway networks. With growing amounts of debt, diminishing market influence, and the continual deterioration of railway infrastructure, many governments began investigating structural reform options aimed at improving railway financial sustainability - often resulting in reprivatisation.

2.4.3 Incentive for private integration

These countries concluded that private sector participation can address most of these failures. Firstly, the integration of private firms provides the railway network with much-needed motivation to innovate and remain profitable in a competitive environment. Due to nationalised railways having long periods of monopolistic power over both passenger and freight transport, innovation in both their strategic focus and managerial operations had stagnated. These companies were focused on production attributes, as opposed to adopting a customer-orientated approach. Thus, when alternative transport modes arose, the market quickly shifted.

Secondly, private integration can lead to increased financial sustainability through strict budget cuts. Nationalised railway companies were, in many cases, used as political and macro-economic tools for governments to use at will. Governments regularly used railways as a source of employment to improve their countries' economic status. Japan, New Zealand, Cote d'Ivoire and Argentina had significant over-staffing problems, which had to be reduced in order for private railway operators to become profitable. In Japan, a total of 93 000 former employees were retrenched after privatisation, and in New Zealand total employment decreased by 75% after privatisation (Thompson and Kopicki, 1995; Mizutani, 1999). Overstaffing problems not only caused low labour productivity, but also lead to disproportionately high wage bills. Driven by the objective of profit maximisation, private firms could have the incentive to curtail unnecessary expenditures and improve their financial viability.

Thirdly, private sector involvement can bring about a much-needed capital injection into the network. Privatisation often arose as a last-ditch effort to save failing railways that have accumulated large amounts of debt. This was the case in Japan, New Zealand and Argentina. Before privatisation, Japan National Rail had accumulated $300 billion debt, and New Zealand and Argentina were facing annual losses of $50-60 million and $1.3 billion respectively (Thompson and Kopicki, 1995). High amounts of debt often also meant that the likelihood of overdue infrastructure maintenance backlog was high, and that critical maintenance or replacement would be necessary. The capital injection from the private sector plays a vital role in financing the reform process.

2.4.4 Implementation of private sector participation

2.4.4.1 Policy and Intermediate institutions

The first step of integrating private participation in a country's national railway network is the formation of an intermediate institution. An intermediate institution is an organisation, formed by the government, which is placed in charge of the reform process (Thompson and Kopicki, 1995). This organisation consists of a group of professionals who perform managerial and consulting tasks and are responsible for implementing public policies and guiding the reform process towards achieving its stipulated objectives. In the case of Japan and Britain, new institutions were formed (JNR Settlement Corporations and Railtrack) as intermediate institutions, and in the case of the other countries, negotiations were done directly with governments or with the national railway corporations.

For an intermediate institution to work effectively, three prerequisites should be met, including (1) integrity, (2) technical expertise, and (3) credibility (Thompson and Kopicki, 1995). Integrity is paramount, as political intervention and external incentives can lead to intermediate institutions making ungrounded decisions regarding reform policies and implementation techniques. To ensure the integrity of the intermediate institution and the deterrence of government intervention, some governments decided to outsource the responsibilities of intermediate institutions to external consulting teams. This was the case in Cote d'Ivoire (Bullock, 2005).

The intermediate institution is responsible for making major decisions about the reform process, which includes the reallocation of assets, the reassignment of liabilities, the renegotiation of employment, the articulation of reform objectives, the assignment and abandonment of routes, the creation of competition, the creation of a regulatory body and private sector performance management (Thompson and Kopicki, 1995). It is crucial that the intermediate institution possesses the required technical skills to undertake these tasks with distinction, otherwise the reform process will likely fail.

The perceived credibility of the intermediate institution from the perspective of the general public is another vital component of the success of the reform process. Intermediate institutions are required to make decisions that will lead to the successful implementation of privatisation and a profitable railway network. In many cases, though, these decisions do not align with the public's perceived interests, such as the case with retrenching employees.

2.4.4.2 Subsidisation

Increased financial sustainability by railway networks is a major driving factor for the implementation of private sector involvement in the countries investigated. Even though this is the case, many of the privately owned or operated railway networks in the case studies still rely heavily on government subsidisation for survival. This is the case for Britain, New Zealand, Cameroon and Argentina (Thompson and Budin, 1997; Martin, 2002; Bullock, 2005; Bowman, 2015). For example, after nearly ten years of private sector involvement, the Argentinian government was still responsible for paying annual subsidies of USD 400 million, over and above the USD 6 billion infrastructure investment over the period of 20 years (Martin, 2002). In Cameroon, the private railway operator, Camrail, received annual subsidies of 40-50% of ticket sale revenues per year (Bullock, 2005).

The reason behind the constant need for government subsidisation in the passenger railway service is its objective to maximise social welfare. To maximise social welfare, which is classified as total revenue minus total cost plus consumer surplus, the optimal subsidy must be granted to the operator of the transport network (Mattson and Ripplinger, 2012). A subsidy must be granted, as the price which the operator would usually set is higher than marginal cost (MC), and where MC is equal to price (P), social welfare is maximised.

2.4.5 The restructuring process

In the cases investigated, rail restructuring processes were focused on four key variables. These variables included infrastructure and asset reform, liability redistribution, workforce renegotiation and strategic focus reforms. Each variable will be discussed in the following section.

2.4.5.1 Railway asset and infrastructure reform

There are a variety of methods in which railway assets and infrastructure have been restructured to incorporate private sector participation. Even though each country’s strategy was different, many similarities occurred between them, and two dominant directions were identified.

The first is used under vertical privatisation and entails the separation of the railway infrastructure and assets between private parties with the help of the intermediate institution. Under this method, full operational and ownership rights are rewarded to private firm(s). The extent to which assets - such as rolling stock - are awarded to private firms, is determined by the intermediate institution and is based on the extent of the operating area or net tonnage/passenger-km of the area. In some cases, such as in Britain and Japan, the private companies had ownership of the railway line, but not of the rolling stock. The rolling stock would be leased to the private company through the intermediate institution or a newly formed rolling stock leasing company (Bradshaw, 1996; Mizutani, 1999). In New Zealand, the entirety of the railway network, including all infrastructure, was sold to the private company (Clark, Manager and Scotland, 2010).

The second form of infrastructure and asset reform is used under concessionary policies, and differs from the first method in that the government retains ownership of most of the infrastructure. This method is used when government wants to retain a degree of power in the railway industry. The consignee usually owns little to none of the infrastructure, but rather leases the infrastructure from the government for several years. These leasing contracts are usually between eight and 15 years for rolling stock and between ten and 20 years for fixed railway assets such as railway lines and stations. Even though the private firms do not take ownership of the rolling stock, they are responsible for routine maintenance and infrastructure upgrades undertaken during the leasing period.

In Cameroon, the government retained ownership of all fixed assets, including railway lines, railway stations and real estate, and rolling stock would be acquired through eight-year leasing contracts from government (Bullock, 2005). In Cote d'Ivoire, the consignee did not own any infrastructure but was granted the power to decide on the quantity, timing and area of infrastructure investment, via the railway asset management companies, to incorporate profitable private sector decision making (Thompson and Budin, 1997). In Argentina, government also retained the ownership of all infrastructure and leased it to the consignee. Infrastructure maintenance and renewals, however, was the responsibility of the consignee (Thompson and Kopicki, 1995; Thompson and Budin, 1997).

2.4.5.2 Railway liabilities

Within the investigated countries, the liabilities accrued by state-owned railways prior to privatisation remained the responsibility of the government, as the debt was oftentimes too large for private firms to bear. The debt was administered by intermediate institutions and was financed through two main revenue streams. The first was income gained from the private sector's participation in the market through infrastructure leasing fees or shares of income that were allocated to debt, and the second was revenue obtained through the sale of excess assets, such as real estate and rolling stock (Thompson and Kopicki, 1995).

In Japan, the JNR Settlement Corporation (JNRSC) was formed to reduce the debt created by the national railway corporation (JNR). After the distribution of assets to the private railway companies, excess assets (including real estate) were liquidated to compensate, as far as possible, for the accrued liabilities of the JNR (Thompson and Kopicki, 1995). In Argentina and Cameroon, costly railway renewal and maintenance was also the responsibility of the private railway companies.

Even though the debt remained the responsibility of the state, the effects of insolvent railway companies, such as infrastructure neglect, was a financial burden on the private railway companies. In New Zealand, for example, the private railway company (Tranzrail) invested four times the purchasing price of the network into infrastructure renewal (Bullock, Greig and Wallis, 2005).

2.4.5.3 Railway workforce

Workforce renegotiation plays a significant role in the political support towards the reform process, which is essential for successful implementation. Due to significant overstaffing prior to private participation, the intermediate institutions are tasked with reducing the size of the workforce to ensure that the private firms are financially sustainable. This usually necessitates a series of negotiations between the intermediate institution and railway labour unions to agree upon terms under which the reduction would take place. These terms could include early retirement packages for employees over the age of 55, additional retrenchment funds and assistance with finding new employment opportunities for retrenched employees. After these negotiations have been completed, the private firms would be required to retain a stipulated number of employees from the state-owned railway company. In Cote d'Ivoire, for example, Sitarail was obligated to employ 1815 of the 3470 employees previously working under the government railways, and in Cameroon 3000 of the 3400 employees were to be reappointed (Mitchell and Budin, 1998; Bullock, 2005). In Japan, the retrenchment process was alleviated, to an extent, through providing packages such as early retirement to individuals older than 55, and helping individuals find new job opportunities (Thompson and Kopicki, 1995).

2.4.5.4 Strategic focus

The strategic focus of state-owned railways and that of private railways differs. State-owned railway companies usually operate the railway network from a service provision perspective - focussing on providing a service and keeping the costs thereof as low as possible (World Bank, 2017). This viewpoint causes a lack of incentive to innovate and improve, and generally causes the service quality of most nationally-operated railway companies to deteriorate over time. Private participation shifted the focus to customer satisfaction which, in turn, leads to improvements in the service quality of rail - resulting in subsequent increases in ridership.

2.4.6 Outcomes of private integration

For some countries (Japan, Cameroon, Argentina) the outcomes of private sector participation were positive, while for others (Britain, New Zealand, Cote d'Ivoire) it was not. In Argentina, for example, the network went from a concessionary system to a nationalised system, and back to a concession system, due to the failure of the nationalised system. In New Zealand, however, the country went from a nationalised system to a privatised system, only to go back to a nationalised system due to the failure of the privatised system. It is thus difficult to guarantee a successful outcome from integrating private sector participation into a national railway network. It is, however, possible to highlight the main positive and negative trends from this policy action.

The most prominent positive outcomes of private sector integration in these countries were improvements in service quality and rail usage. These improvements related to factors such as punctuality, reliability, trip frequencies, comfort and the quality of station facilities. In Argentina, passenger-kilometres increased by 30-40% in the first month of concession. A survey conducted four years after private integration showed that 91-96% of Argentinian railway commuters agreed that the service quality and reliability of the service had improved significantly since concessioning (Martin, 2002). The customer-orientated managerial practices followed by private firms seemed to be more successful than the production-focused practices of many nationally operated railways. This heightened demand for rail transport ultimately elevated the market position of rail services to the level of road transport industries - resulting in improved competitiveness and financial viability. Many of the railways were, in fact, able to move from a position of fiscal deficits to one of profitability as a result of the reform process. For example, within 10 years of private integration, the Cameroon railway network was able to regain the total debt of USD20 million incurred by the national operator, and contributed another USD12.7 million to the economy

(Bullock, 2005). In Japan, net profits increased from negative USD16.8 billion in 1985 to negative USD2.7 billion in 1991 within six years of private integration (Thompson and Kopicki, 1995; Mizutani, 1997)

The second positive trend relating to private sector integration was the increase in both labour- and asset productivity. In the interest of profit maximisation, assets and employees were utilised significantly more efficiently by the private sector. In Japan, labour productivity increased by 150% within the first five years of private integration (Thompson and Kopicki, 1995).

Negative outcomes of railway privatisation were also identified during the investigation of the case studies, the most prominent of which was the reduction in employment. Privatisation necessitated that railways were to reduce their workforce drastically to become profitable. Even though achieving a workforce reduction was an essential component of privatisation’s success, the process was not a positive one in public opinion. The second negative outcome realised was the increasing of railway rates and subsidy requirements. In Britain, New Zealand, Cameroon and Argentina private firms were heavily reliant on government subsidisation to be profitable, even with increases in rail usage. Along with increased subsidy requirements, many countries were subject to increased travel fares over time.

2.5 Conclusion

Historically, the South African railway network was constructed as a form of hinterland transport, to facilitate the export of raw materials and agricultural goods. The railway network was initiated by the private sector, after which control and ownership were transferred to the various provinces of the country, and finally nationalised in 1910. Both national and private parties played significant roles in the development of the South African railway network, which aided in forming the strong foreign trade sector that South Africa benefits from today.

Currently, however, the South African railway network is not performing at its optimal capacity. Since the establishment of PRASA in 2007, the passenger rail network has been unable to operate at a level higher than 60% of its performance targets. Passenger satisfaction and rail passenger journeys have declined significantly since 2013, while the use and total capacity of road transport modes have increased. Data collected from the land-transport survey suggests that ex-rail users have diverted to road-based transport modes, especially minibus taxis.

Literature suggests that rail-based transport has significantly lower economic costs compared to road-based transport modes. Taking into consideration environmental impacts, accident costs and travel times, studies suggest that rail is up to four times less costly than private vehicles. The shift from rail to road-based modes, therefore, has consequences for the total economic cost of travel in an economy.

Because of this, many countries have invested significant amounts of capital and time into improving their degrading passenger railway services. One method of reform among these countries was the integration of private sector participation in their passenger railway industries. There are a variety of methods of implementing this strategy, and outcomes vary from country to country, but significant benefits such as increased rail use, increased asset and labour productivity, as well as increased financial sustainability, have been realised by many countries.

Chapter 3 – Evaluation background

The literature review revealed the importance of a well-functioning passenger railway service, and the overall positive outcomes of the historic implementations of PPPs as a method of railway reform. The following chapter aims to provide the foundation of the evaluation chapters that follow, regarding the case of South African passenger railway services. Firstly, the chapter clarifies the methodology used and the evaluation alternatives considered in the financial and economic analysis, after which the demographic features of the study area are discussed. These demographic features include land use, supply of transport infrastructure, population characteristics, and travel behaviour. The chapter concludes with a demand forecast that will be used in the analysis chapters.

3.1 Methodology and evaluation alternatives

To determine the financial and economic viability of the South African railway network, the study considered the Cape Town Southern line as a case study. The Southern line was one of the first railway lines to be constructed in South Africa, and today accounts for the greatest portion of passenger rail journeys in the Cape Town district.

The financial and economic analysis take the shape of an adjusted Cost-Benefit Analysis (CBA). The analysis is considered as adjusted, due to no new construction of infrastructure being considered as in conventional CBAs. Instead, the analysis assumed differences in the utilisation of the Southern line, as well as changes in modal use in the market, to determine the financial and economic feasibility of the line in different scenarios.

The study considers three evaluation alternatives, each differing with regard to the assumed increases in load factor of the Southern line brought about by PPPs. As increases in ridership are not accurately predictable, both an optimistic (A1) and pessimistic (A2) alternative is considered. Each alternative is considered over a period of 20 years and discounted at a real discount rate of 5%. The three evaluation alternatives include:

- **A0 – BASE ALTERNATIVE:** A0 is the “do nothing” alternative and will be used to compare with the results of the other alternatives. This alternative assumes that the current operational attributes of the Southern line will continue over the 20-year analysis period.

- **A1 – 80% UTILISATION AT YEAR 12:** A1 assumes that the market share of rail increases incrementally over the 20-year analysis period. More specifically, the alternative assumes that the Southern line will reach 80% of capacity in year 12 of the analysis, after which the load factor will stay constant at 80% over the remaining eight years.
- **A2 – 50% UTILISATION AT YEAR 10:** Similar to A1, this alternative assumes that the utilisation of the Southern line will incrementally increase over the 20-year analysis period. However, this alternative assumes that the line will reach 50% utilisation on the 10^{th} year of the analysis, after which the load factor will stay constant at 50% over the remaining ten years.

The financial analysis utilises two financial analysis tools, namely revenue and cost analysis, and financial modelling, to determine the financial sustainability of the Southern line. Through using primary data regarding ticket sales and financial expenditure, the financial analysis investigates the revenues and costs of the Southern line in order to determine its short-run and long-run profitability. The short-run profitability of the Southern line is investigated by considering the most recent annual income statement of the Southern line, while long-run profitability is investigated by considering the growth of cost and revenue elements using multiple historic annual income statements. Furthermore, the financial analysis determines the costs and revenue associated with one passenger journey, in order to determine the effectiveness of the current pricing strategies as well as possible improvements that should be implemented in order to increase the financial feasibility of the service. The chapter concludes by investigating the effects of increased rail use on the financial feasibility of the Southern line.

The economic analysis considers the total economic costs of the different transport modes in the study area. These modes include minibus taxis, busses, private vehicles and rail transport, and the total economic costs of each mode consist of Vehicle Operating Costs (VOC), travel time and accident costs. The total economic cost of each mode is presented in a cost-per-km format and applied to data regarding the average trip distance and load factor per mode, to obtain the cost-per-passenger-journey for each mode, within the study area. These costs are then applied to the demand forecast and the evaluation alternatives to determine the economic implication of each evaluation alternative. This chapter will determine which transport modes are the most economically cost-effective in the study area, as well as the economic implications of increased rail use over the 20-year analysis period.

After the financial and economic viability of the Southern line have been determined, a sensitivity analysis is conducted. Within the sensitivity analysis, the financial and economic models will be subjected to different discount rates to determine the robustness of the outcomes. Thereafter, further implications of private sector participation, as seen from international experience, are integrated into the financial and economic analysis in order to determine the possible effects thereof on the overall feasibility of the Southern line.

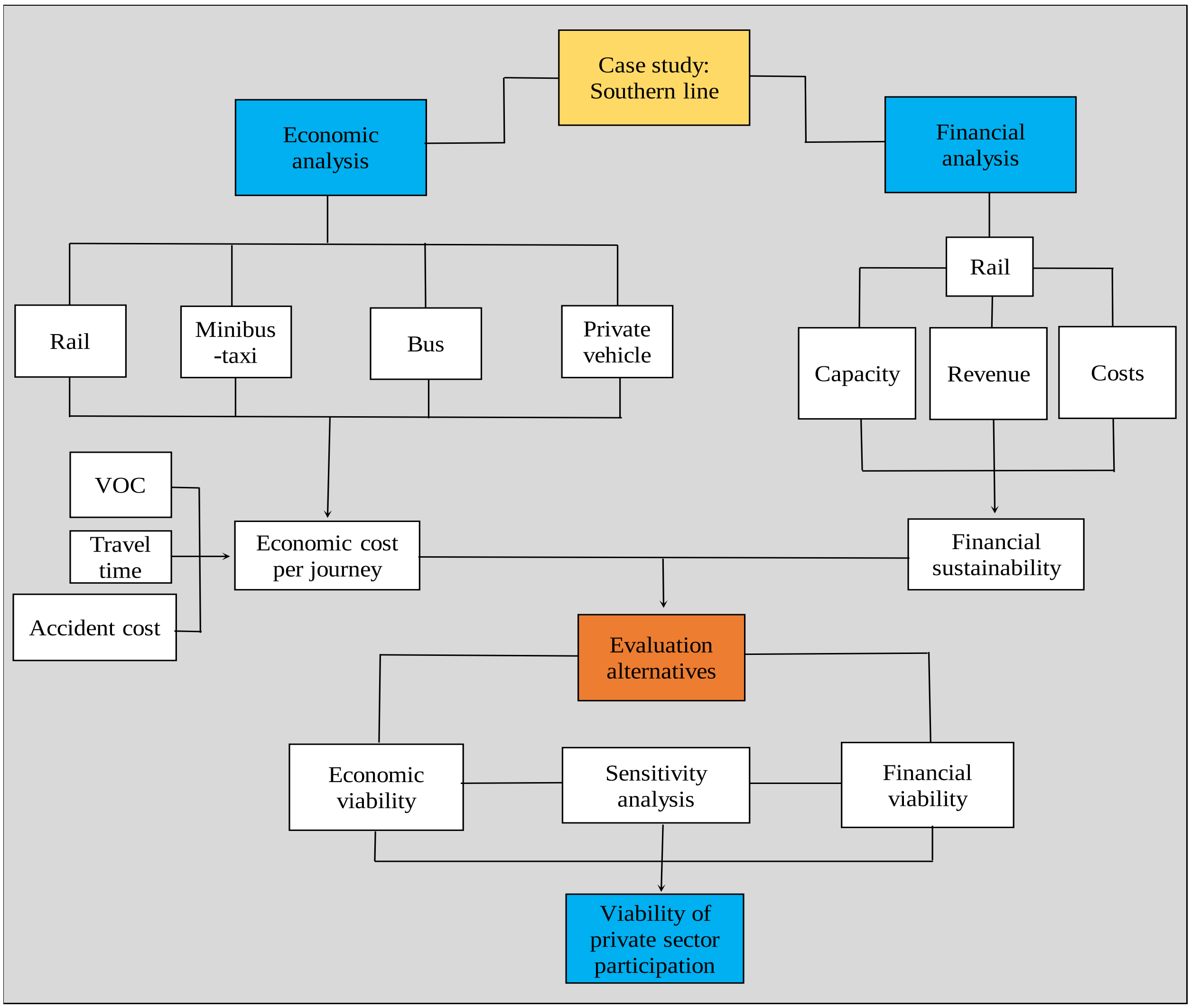


Figure 3.1: Conceptual framework

Figure 3.1 provides a conceptual framework of the study that follows. Based on the findings of the financial and economic analysis, the feasibility of integrating private sector participation in the national passenger railway service of South Africa can be determined. Recommendations will be made regarding the feasibility of PPPs, from both a private and public perspective, along with the level of performance required, in order to ensure the feasibility of the service.

3.2 Study area demographics

3.2.1 Study area identification and land use

The passenger rail network of Cape Town consists of nine routes originating from Cape Town, of which the Southern Suburbs line, the Cape Flats line, the Central Line, the Malmesbury Worcester line and the Northern line are the most prominent (City of Cape Town and TDA, 2017). The Southern line operates over two districts of the Cape Town area, which include the Southern Suburbs and the Cape Peninsula. The study area is mainly utilised for residential purposes, as seen in Figure 3.2, and houses large areas of mixed land use zones where a combination of residential and small retail stores are situated (Krygsman, de Jong and Verkoren, 2013; City of Cape Town, 2018).

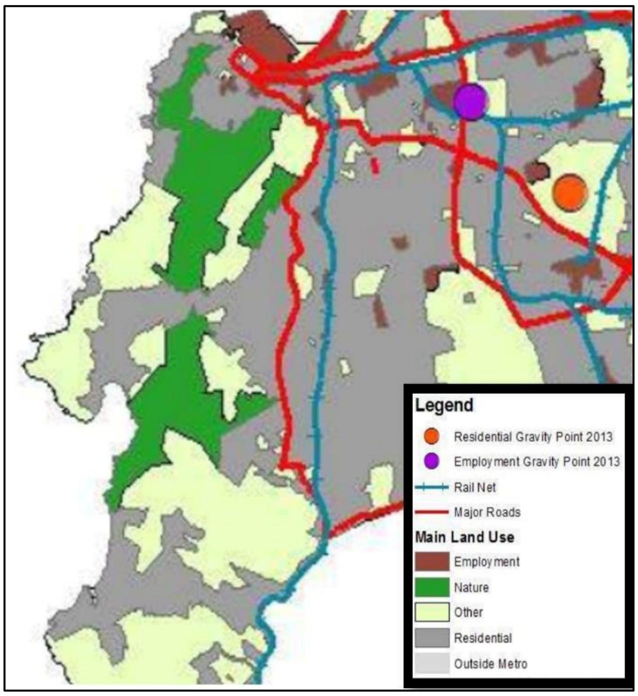


Figure 3.2: Land use – Southern Suburbs (Krygsman, de Jong and Verkoren, 2013)

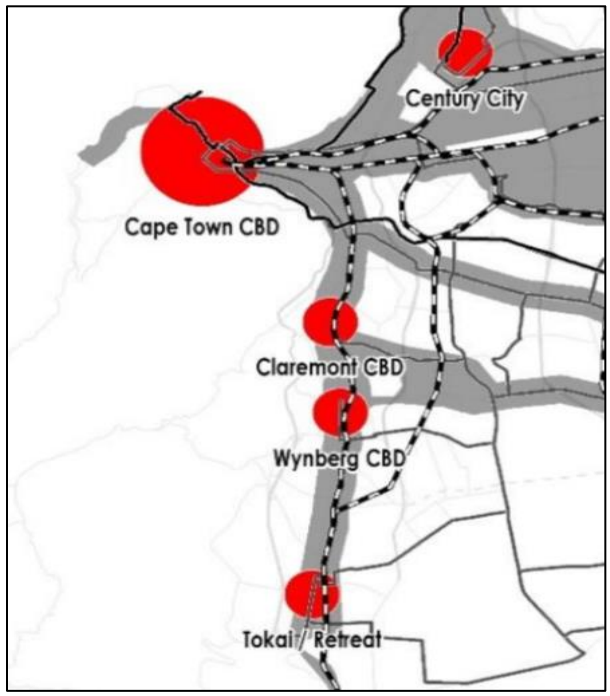


Figure 3.3: Population and employment nodes – Southern Suburbs (City of Cape Town, 2018)

3.2.2 Transport modes and infrastructure

The Southern Suburbs houses four main employment and population nodes which are situated in Cape Town CBD, Claremont CBD, Wynberg CBD and Tokai/Retreat (City of Cape Town, 2018). Figure 3.3 illustrates each node as well as the size thereof.

The area is well serviced by road and rail transport infrastructure. Rail transport services are provided by the Southern line and road transport services are provided by private vehicles, bus services and minibus taxi services. Road transport is supported by the M3 and the M4. The M3 freeway originates in Cape Town central and runs through the western side of the Southern Suburbs through Newlands and Constantia and ends in Westlake. The M4, also classified as the main road, runs through the Southern Suburbs to the City centre, and is serviced by the Golden Arrow bus service and minibus taxis (City of Cape Town and TDA, 2017).

The Southern line is a 66km long (round trip), Cape Gauge, railway line that runs from Cape Town central to Simon's Town. The railway line is powered by a 3000V DC overhead catenary electricity system and has a total of 26 train stations. The line is operated by 16 train sets, which include five 5M2A's and eleven 10M3s (Asakhe-Consulting-Engineers, 2007). Each train set pulls eight carriages (eight metro coaches, eight metro plus coaches), which provide a total capacity of 1280 passengers per train set (HaskoningDHV, 2013).

Figure 3.4 shows a map of the Cape Town railway network. The red line indicates the path of the Southern line which stems in Cape Town central and extends eastward through Woodstock and Salt River on a line shared between the Cape Flats, Bonteheuwel and Bellville railway lines.

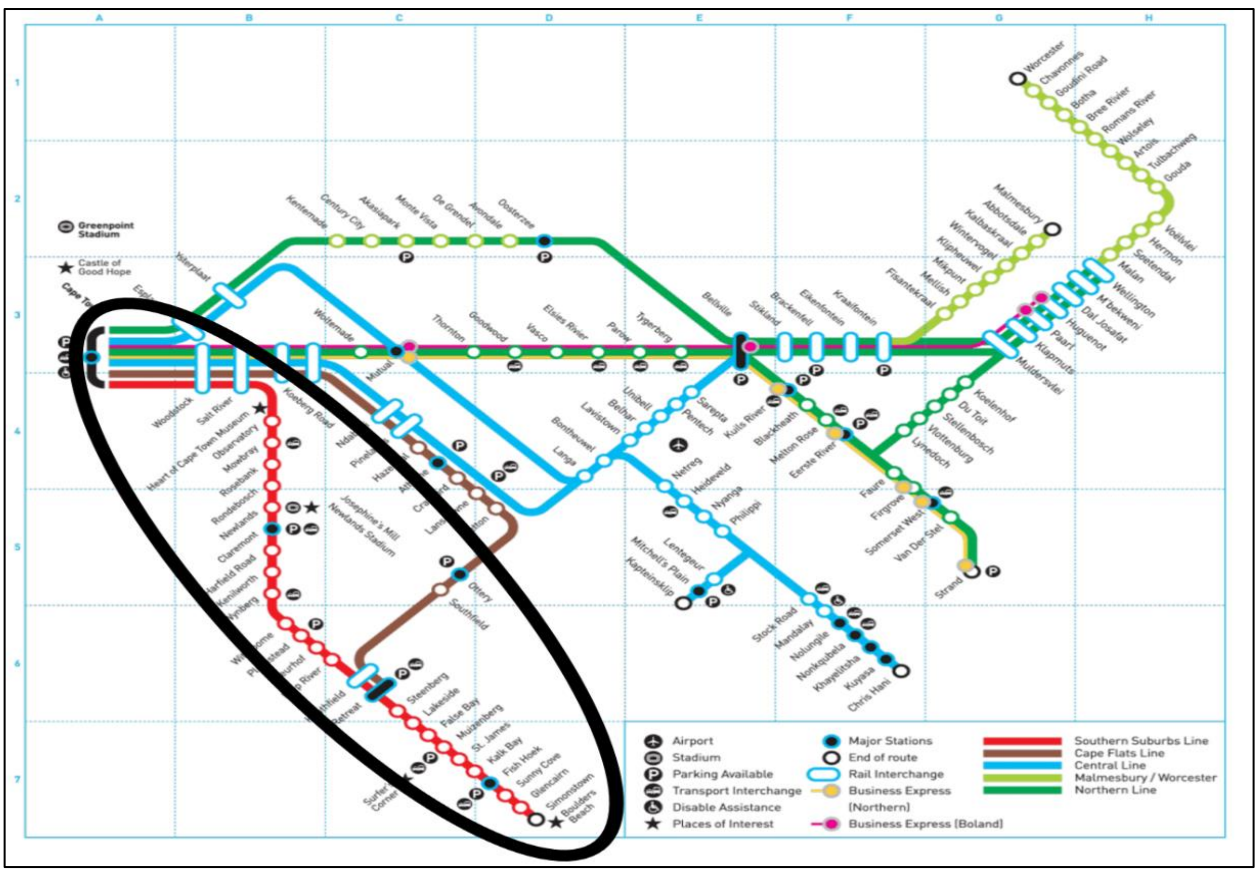


Figure 3.4: Cape Town passenger railway network (City of Cape Town, 2018)

Thereafter the line diverges southwards and passes through Observatory, after which it continues to Heathfield and Retreat, where it again connects with the Cape Flats line. Some trains operating on the Southern line terminates at this point, but most continue through Muizenberg to Fish Hoek where the double track ends. A single-track runs from Fish Hoek to Simon’s Town.

According to Google Maps, the average distance between each suburb in the study area and the closest train station is approximately 2.4km. Table 3.1 shows the proximity between the suburbs in the study area and the closest train station.

Km from nearest train station		
x<1km	**1km<x<3km**	**x>3km**
17%	45%	38%

Table 3.1: Proximity to train station – Southern Suburbs

Seventeen per cent (17%) of the suburbs is equal to, or less than, one km from the nearest train station; 45% is between two and three km away from the nearest station, and 38% of the suburbs is three km or more from the nearest train station. Other studies conducted regarding the average travel distance to the closest railway station in Cape Town found a similar result of 2.13km (Hitge and Vanderschuren, 2015). These results are thus considered to be accurate.

3.2.3 Population attributes

The following population size and income data was gathered from the 2011 South African Census and used to determine the population attributes of the study area.

Suburb	Area size (km²)	Population	Households	Population per km²	Household per km²	Average annual household income
Observatory	3,10	9207	3060	2970,0	987,1	R 115 100,00
Mowbray	2,79	4726	1621	1693,9	581,0	R 115 100,00
Rosebank	1,10	4963	1343	4511,8	1220,9	R 115 100,00
University of Cape Town	0,43	471	0	1095,3	0,0	R 230 700,00
Rondebosch	6,42	14591	5649	2272,7	879,9	R 230 700,00
Newlands	3,48	5100	2032	1465,5	583,9	R 230 700,00
Claremont	5,21	17198	7364	3301,0	1413,4	R 230 700,00
Kenilworth	3,46	10872	5158	3142,2	1490,8	R 230 700,00
Bishopscourt	2,31	1603	544	693,9	235,5	R 230 700,00
Constantia	22,67	9814	3165	432,9	139,6	R 230 700,00
Wynberg	5,06	14472	5127	2860,1	1013,2	R 230 700,00
Plumstead	4,58	20178	7079	4405,7	1545,6	R 230 700,00
Diep River	0,75	2515	965	3353,3	1286,7	R 230 700,00
Bergvliet	2,5	4428	1481	1771,2	592,4	R 230 700,00
Sweet valley	0,51	311	108	609,8	211,8	R 230 700,00
Dennendal	0,59	878	318	1488,1	539,0	R 230 700,00
Tokai	0,1	217	111	2170,0	1110,0	R 230 700,00
Heathfield	1,11	4649	1541	4188,3	1388,3	R 115 100,00
Elfindale	1,59	2577	838	1620,8	527,0	R 230 700,00
Retreat	5,27	25745	6234	4885,2	1182,9	R 115 100,00
Dreyersdal	1,59	2130	1115	1339,6	701,3	R 230 700,00
Pollsmoor	1,25	2161	240	1728,8	192,0	R 230 700,00
Steenberg	0,9	4168	1060	4631,1	1177,8	R 230 700,00
Steenberg Estate	3,91	796	294	203,6	75,2	R 230 700,00
Kirstenhof	1,52	4515	1665	2970,4	1095,4	R 230 700,00
Westlake	2,02	6452	2076	3194,1	1027,7	R 230 700,00
Lakeside	1,07	2226	934	2080,4	872,9	R 230 700,00
Cafda Village	0,89	9964	2081	11195,5	2338,2	R 57 300,00
Coniston Park	0,31	1833	441	5912,9	1422,6	R 29 400,00
Seawind	0,47	6700	1392	14255,3	2961,7	R 29 400,00
Sheraton park	0,31	3111	841	10035,5	2712,9	R 29 400,00
Lavender Hill	1,63	25897	5113	15887,7	3136,8	R 29 400,00
Vrygrond	0,82	13222	5942	16124,4	7246,3	R 29 400,00
Marina da'gama	2,96	4969	2016	1678,7	681,1	R 230 700,00
Costa Da Gama	0,51	2638	96	5172,5	188,2	R 230 700,00
Stonehurst Mountain Estate	0,5	678	217	1356,0	434,0	R 230 700,00
Capricorn	1,07	1821	656	1701,9	613,1	R 230 700,00
Muizenberg SP2	2,43	5537	1977	2278,6	813,6	R 230 700,00
St James	0,37	491	244	1327,0	659,5	R 230 700,00
Kalk bay	0,32	700	254	2187,5	793,8	R 230 700,00
Fish hoek	13,45	11890	4852	884,0	360,7	R 230 700,00
Simons town	19,81	6569	2317	331,6	117,0	R 115 100,00
Total	**131,14**	**272983**	**89561**			
Average	**3,12**	**6500**	**2132**	**3700**	**1108**	**R 186 093**

Table 3.2: Population attributes – Southern Suburbs (Statistics South Africa, 2011)

Table 3.2 depicts the 42 different suburbs that are part of the designated study area, as well as the area size, population size, number of households and average annual household income of each suburb. The data indicates that a total of 272 983 individuals live in the designated 42 suburbs (131.14 km²), which make up 89 561 households, and 6.8% of the Cape Town population in 2011. The average population density of the area is 3700 people per km², and the average household density is 1108.4 households per km².

Some areas appear to be much more densely populated than others, while also having the lowest average household income bracket of the area. These areas are situated to the south of the study area and include Cafda Village (11 195 persons per km²), Coniston Park (5912 persons per km²), Seawind (14 255 persons per km²), Sheraton Park (10 035 persons per km²), Lavender Hill (15 887 persons per km²) and Vrygrond (16 124 persons per km²). These areas have an average household income of R34 050 per annum.

The average annual household income of the study area is R186 092, which is significantly higher than that of the Western Cape average (R57 000) and the national average (R29 400) (Statistics South Africa, 2011). This signifies that the area houses a high concentration of wealthy individuals. When analysing the data, three general levels of income are present, including areas of high income (R230 700), areas of middle-range income (R115 100) and areas of low income (R29 400). The high-income areas collectively contribute to 57% of the total population and are situated to the west of the railway line, the middle-income areas contribute to 20% of the population and are situated closer to the city centre, and the low-income areas collectively contribute to 23% of the total population and are situated to the southeast in the Muizenberg area.

3.2.4 Travel behaviour

To investigate the travel behaviour in the study area, data from the 2006, 2011, 2016 and the 2019 Integrated Transport Plan (ITP) of Cape Town is used (City of Cape Town, 2019). The data illustrates the number of passenger journeys undertaken between specific location points (nodes) throughout Cape Town in the am-peak[2] period. The route from one of these nodes to another is referred to as a “desire line”, and the frequency of operation on these desire lines are indicated per mode of transport.

[2] Am peak: 06:00 - 09:00

For the purposes of investigating travel behaviour in the Southern Suburbs, three nodes, as well as the desire lines connecting them, were investigated. These nodes include Cape Town CBD (1), Muizenberg (25) and Claremont (15). The travel data between these nodes was analysed for each year mentioned earlier, in order to determine the modal split and travel behaviour within the study area. Figure 3.5 illustrates the am peak modal split within the study area from 2006 to 2019.

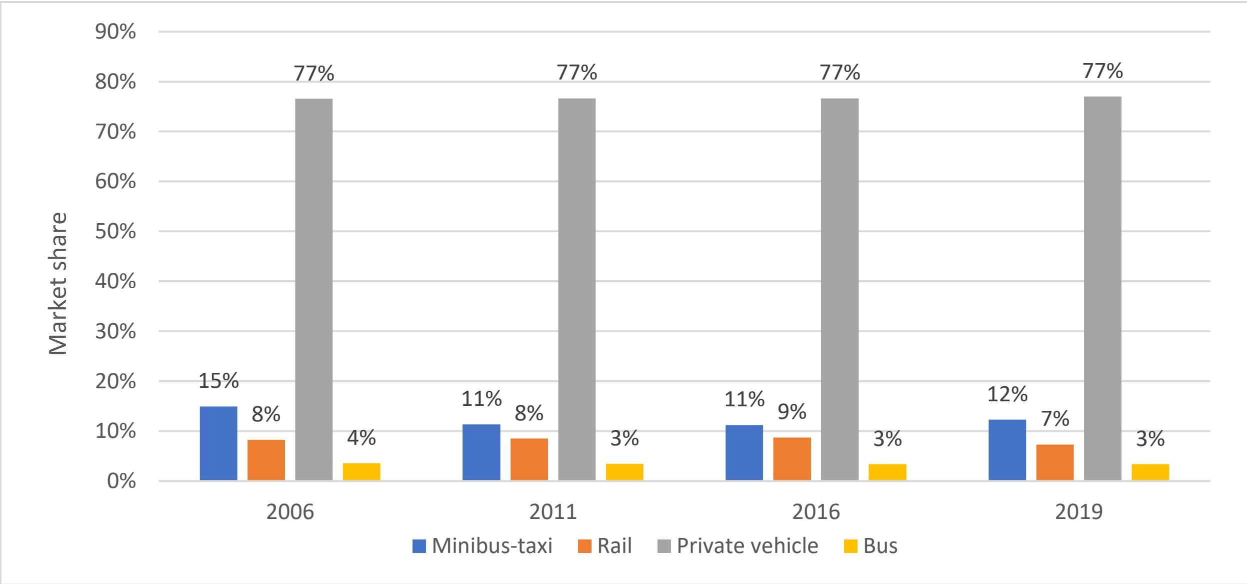


Figure 3.5: Am peak modal distribution - Southern Suburbs (City of Cape Town, 2019)

Between 2006 and 2019, the am peak modal distribution in the study area stayed relatively unchanged. The use of private vehicles took the majority of the market share, with a constant 77% over the period. Minibus taxis had the second biggest market share with an average of 12%, rail transport had an average market share of 7%, and bus transport had a market share of 3%.

Figure 3.6 shows the am peak desire lines per mode in the Southern Suburbs. The thickness of the lines on the graphs represents the intensity of demand for that mode, and the four graphs show the desire lines for minibus taxi, rail, private vehicle and bus transport, respectively. When considering the three location nodes of the Southern Suburbs (1, 5 and 25), the dominance of private vehicle use can once again be noted. When considering the destination of travel in the study area, Figure 3.6 indicates that a large portion of journeys flow to the CBD and other surrounding suburbs to the east, such as Bellville, Somerset-West, and Strand.

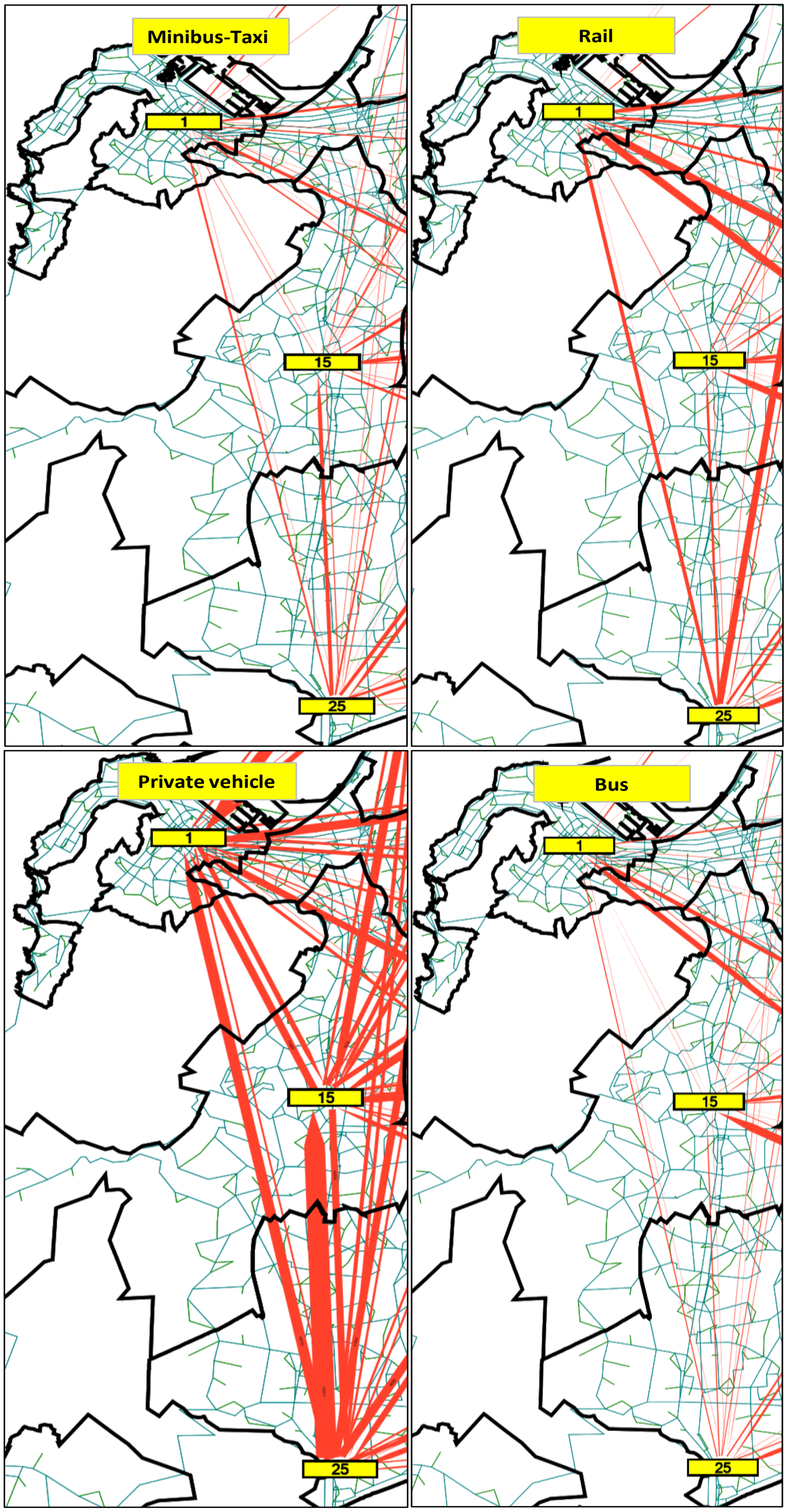


Figure 3.6: Am peak travel behaviour – Southern Suburbs (City of Cape Town, 2019)

3.3 Demand forecast

Now that the modal split and origin-destination travel behaviour in the study area have been identified, the demand forecast can be conducted. Based on the historic traffic growth data from the ITP of Cape Town, the average traffic growth for the study area could be calculated and used to forecast the traffic demand. Figure 3.7 shows the total am peak passenger journeys between the three location nodes identified in the previous section, from 2006 to 2019.

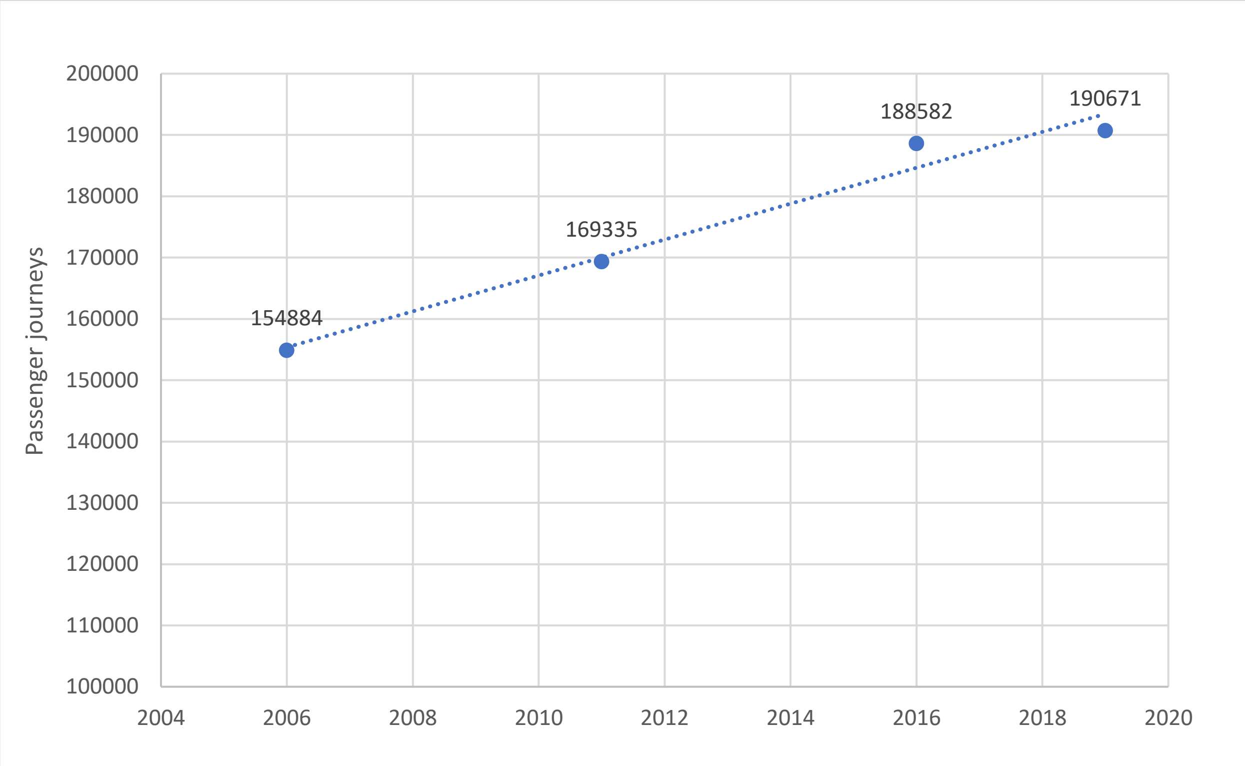


Figure 3.7: Total Am peak traffic - Southern Suburbs (City of Cape Town, 2019)

Using these data points, the geometric growth rate of each period could be calculated on a yearly basis. In the first period (2006-2011), a yearly traffic growth of 1.87% was calculated. In the second period (2011-2016), the growth rate increased to 2.27%, and in the final period (2016-2019) the growth rate decreased to 0.37% per year[3]. The average of these periodic geometric growth rates was calculated to be 1.68% per annum. These outcomes are in line with population growth forecasts conducted by the United Nations, which estimate that Cape Town will have a growth rate of 1.8% annually, until 2030 (United Nations, Department of Economic and Social Affairs, 2018).

[3] The growth rate of the 2019 ITP are noted to be unusually low in comparison to the prior rates.

Taking into consideration the unusually low growth rate indicated by the 2019 ITP, the analysis assumes that passenger journeys will grow by 2% annually in the first 10 years of the analysis, after which the growth will decline to 1% for the remainder of the analysis. The reduced growth rate in the second period is based on the historic decline of population growth rates of Cape Town. Prior to the latest census (2011), the growth rate of Cape Town was as high as 2.57%, indicating significant reductions in growth in comparison to more recent data (World Population Review, 2021).

In order to calculate the number of annual passenger trips, the am peak traffic data first had to be converted into daily journeys. This was done using data from the 2013 rail census, which suggested that the weekday am peak rail journeys accounted for 37% of the daily passenger trips (HaskoningDHV, 2013). Based on the assumption that this distribution has stayed constant, the total daily rail journeys could be calculated and was found to be 37 730 per day. If we then assume that the modal distribution of daily journeys is constant to that of the am peak period, we know that daily rail journeys (37 730) are equal to 7% of the daily journeys. Based on this, the total journeys for all modes (100%) could be calculated and was found to be 515 340 journeys per day.

Further assumptions should then be made regarding Saturdays and Sundays, as the demand for transport is generally less on these days. On Saturdays and Sundays, the supply of trains is reduced to 43% and 36% of weekday supply respectively. If we assume that the demand for passenger journeys reduce with the same margins in the road transport modes, the total number of weekly and yearly passenger journeys can be calculated. Table 3.3 below shows the total demand for passenger journeys, per mode, in the study area per day, week, and year for 2019.

Total demand for passenger journeys						
	Share	**Total weekday**	**Total Saturday**	**Total Sunday**	**Total week**	**Total year**
Minibus taxi	12%	63302	27220	22789	366516	19058844
Rail	7%	37731	16224	13583	218461	11359953
Private vehicle	77%	396767	170610	142836	2297279	119458532
Bus	3%	17541	7543	6315	101562	5281239
Total		**515340**	**221596**	**185522**	**2983819**	**155158567**

***Table 3.3: Total daily, weekly, and yearly journeys per mode – Southern Suburbs* (City of Cape Town, 2019)**

Table 3.3 indicates that the study area has a total annual demand of 155 158 567 passenger journeys. This is the calculated number of yearly passenger journeys in the base year of the evaluation (2019). The annual passenger journeys of 2019 are then applied to the assumed traffic growth rates mentioned earlier to obtain the annual passenger journeys per year of the 20-year analysis period. In year 20 of the analysis, the total annual passenger journeys will be 208 925 387.

3.4 Conclusion

Chapter 3 has indicated that the area under study is mainly utilised for residential housing purposes and is largely inhabited by a relatively high-income population. The area is mainly serviced by private vehicles, which account for 77% of journeys undertaken. Twenty-three per cent (23%) of the journeys are serviced by public transport modes, of which rail services account for 7%, minibus taxis for 12%, and busses for 3%. Rail services require a high load factor in order to be financially and economically viable, which implies that, for rail service to increase its utilisation, a large portion of the current private vehicle users will need to convert to rail use.

In investigating the flow and growth of traffic within the study area, data from the ITP suggests that travel mainly occurs between the residential areas within the study area and the Cape Town CBD. The flow of rail traffic is relatively weak in this corridor, while the flow of private vehicle use is strong. This suggests that rail transport is a viable alternative mode of transport for private vehicle users, since the Southern line operates on the same origin-destination points as private vehicles.

The average annual traffic growth in the area was found to be 1.68%. The annual passenger journeys undertaken by all modes in the study area amounted to 155 million in 2019. According to this data, the demand forecast suggests that total journeys will grow to 208 million in year 20 of the analysis.

Chapter 4 – Financial analysis

Now that the supply and demand demographics of the case study area have been identified, and the demand forecast has been conducted, the financial analysis can commence. This chapter aims to determine the financial feasibility of the Southern railway line by using two financial analysis tools, including revenue and cost analysis, and financial modelling. The revenue and costs analysis aims to understand the structure of the Southern lines revenues and costs, in order to determine its short term profitability, the effectiveness of its pricing strategy, and its distribution of fixed and variable costs (World Bank, 2017). The financial modelling tool uses income statement data provided by PRASA, in order to forecast the long-term profitability of the Southern line over the analysis period. The chapter concludes by investigating the effects of increased rail use on the financial feasibility of the Southern line.

4.1 Revenue

The revenue structure of a passenger railway line comprises three main components, namely fare revenue, government subsidies and auxiliary revenue (World Bank, 2017). A significant portion of PRASA's income is generated from operational and capital subsidies. More specifically, of the R16 billion obtained in 2020, R12.4 billion (77.5%) came from subsidy payments, around R1 billion (6.25%) from fare revenue, and the remaining R2.6 billion (16.25%) was generated through other activities such as rental income, interest received and actuarial gains (PRASA, 2020).

PRASA income statements do not specify the exact revenue generated by each line, but group together the various railway lines based on the district they abide in. The Southern line forms part of the Cape Town district and - according to ticket sales data provided by PRASA for 2019/20 - contributes 26% of the fare revenue in this district. To determine the three revenue elements of the Southern line, these proportions have been used.

4.1.1 Fare revenue

Fare revenue is obtained through ticket sales and is the primary revenue source of passenger railway services. On the Southern line, fare revenue has decreased from R164 million in 2013 to R42.8 million in 2020. Fare revenue is determined by the demand for the service, the pricing strategy and revenue collection (World Bank, 2017).

4.1.1.1 Level of demand

Since the level of demand directly affects the number of ticket sales, it also affects fare revenue levels. Figure 4.1 shows the passenger rail journeys undertaken from 2008 to 2020. The figure indicates that the level of demand for passenger rail journeys in South Africa has been decreasing since 2013. As mentioned in the literature review, the demand for rail transport - on a national level - has been in decline due to multiple reasons, and rail commuters have gradually shifted to the use of other transport modes such as minibus taxis.

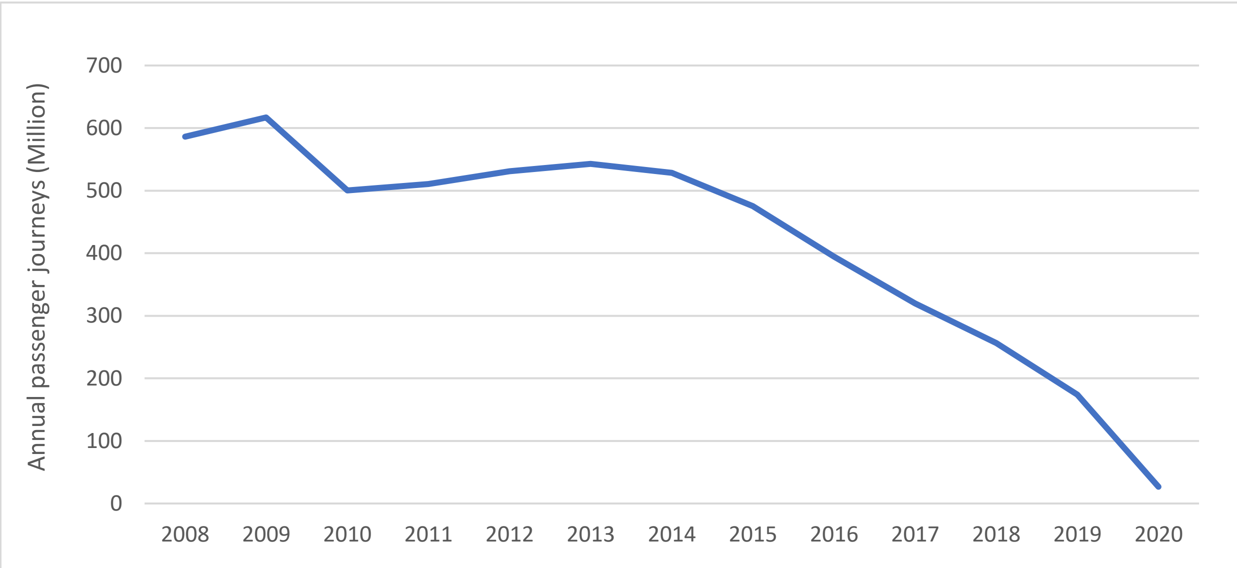


Figure 4.1: National traffic density – Passenger rail (Statistics South Africa, 2020a)

4.1.1.2 Pricing strategy

Along with the level of demand, ticket pricing is an important variable of revenue levels. The pricing strategies implemented by passenger railway networks should consider the level of cost recovery required for the railway line to be profitable. Economic theory suggests that passenger railway lines should price above the marginal variable cost, taking into consideration the elasticity of demand for its given market, in order to maximise its cost recovery (World Bank, 2017). Passenger railway services generally use four pricing strategies, which include differing ticket types in terms of distance (zones), peak load pricing, ticket duration validity, and differing ticket classes.

In terms of distance-based pricing, PRASA has six different zones which are divided based on the trip distance undertaken. For each zone, a certain ticket price is allocated, based on the nature of the ticket (single, return, weekly, monthly), and ticket prices increase as the distance of each zones increases. Zones include 1-10km, 11-19km, 20-30km, 31-40km, 41-135km, and 136-200km (Metrorail, 2020). Ticket prices have not increased since 2015, and do not differ in peak and off-peak periods (Metrorail, 2020).

Four different ticket types are available, which include a one-way ticket, a round-trip ticket, a weekly ticket, and a monthly ticket. Holders of weekly and monthly tickets can use the service for the designated zone as much as desired while the ticket is valid. The tickets allow significant savings to the users, as weekly tickets cost equally to 6.5 trips, but allow 14 trips, and monthly tickets amount to the cost of three weeks' worth of travel, but allow four weeks. Along with savings to the commuters, weekly and monthly tickets create an obligation for the holder of the ticket to use rail instead of other transport modes for a certain amount of time, which increases ridership.

Figure 4.2 has been constructed from ticket sales data of the Southern line provided by PRASA for the financial year 2019-2020. PRASA assumes that a round-trip ticket accounts for two journeys, weekly tickets for 14 journeys, and monthly tickets for 60 journeys. Figure 4.2 shows the annual trips undertaken on the Southern line based on the ticket types used. It is clear that the majority (62%) of trips undertaken is from monthly ticket holders, and that an obligation on the side of the ticket holder is created to maximise his/her use of the service.

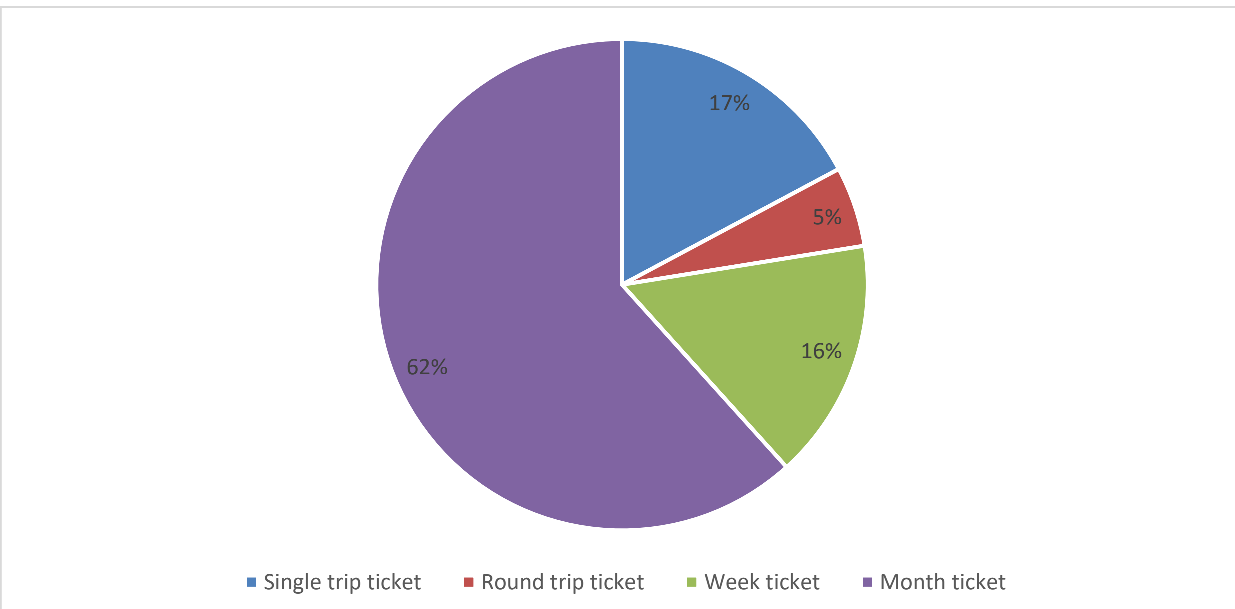


Figure 4.2: Passenger trips per ticket type - Southern line (PRASA, 2019c)

Figure 4.3 shows the percentage of total fare revenue generated by each ticket type on the Southern line. Ticket sales from the Southern line in the 2019-2020 financial year were used to construct this figure. Monthly and single-trip tickets contribute to the highest portions of fare revenue, at 41% and 34% respectively.

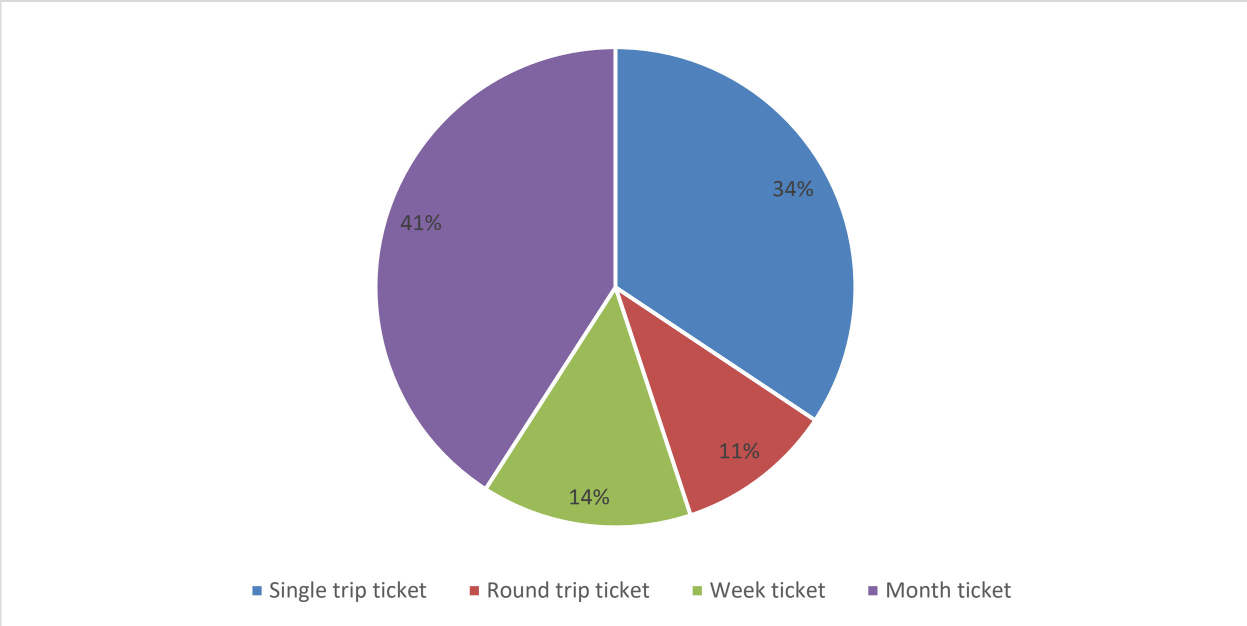


Figure 4.3: Fare revenue per ticket type – Southern line (PRASA, 2019c)

The Southern line also provides different ticket classes and services. These classes include metro (second class), metro plus (first class), metro plus express, business express, and tourism tickets. In 2019, 92% of tickets sold were metro class, while the remaining 8% were metro plus tickets. The remaining ticket classes only contributed to 0.02% of total ticket sales. Metro plus tickets contributed to 13% of total revenue, while metro class contributed to 87%.

4.1.1.3 Revenue collection

The last determinant of fare revenue is based on the operator's ability to collect revenue. Revenue collection and the problem of fare evasion is a common issue in passenger railway services around the world. PRASA is no exception to this problem. Metrorail estimates that fare evasion levels are between 40-50% of ticket sales (EWN, 2018).

4.1.2 Government subsidisation

The second revenue source of passenger railway services is government subsidies (World Bank, 2017). In South Africa, rail subsidisation takes the form of operational and capital subsidies. Figure 4.4 illustrates the operational and capital subsidies paid to PRASA from 2008 to 2020 (National treasury, 2020).

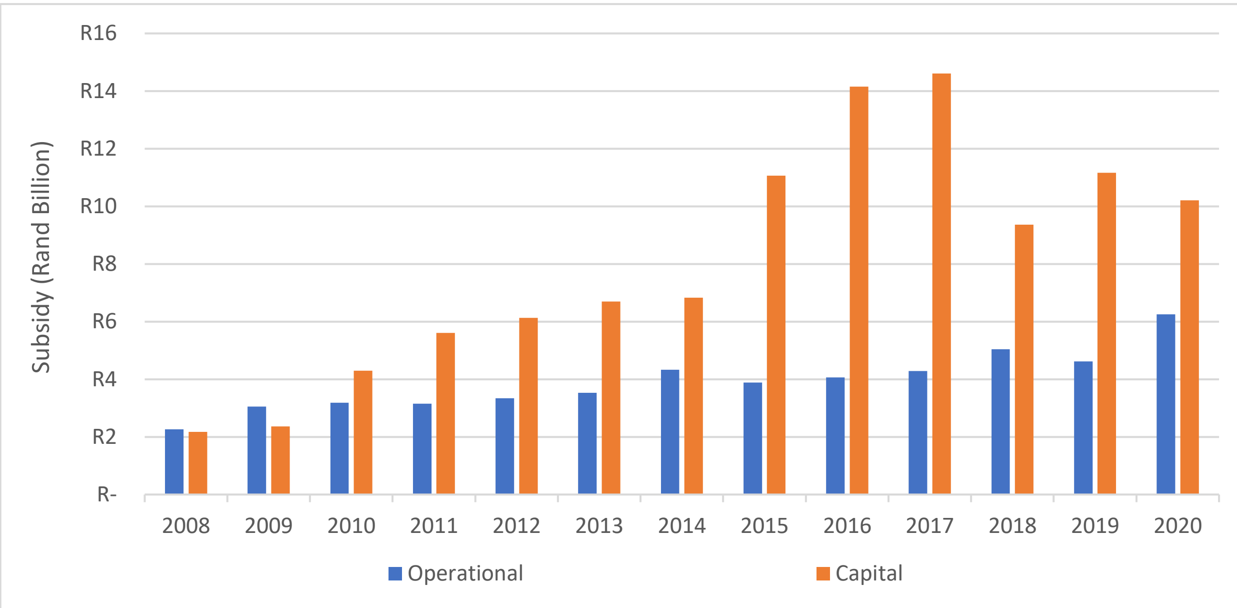


Figure 4.4: National subsidy payments - PRASA (National treasury, 2020)

Operation and capital subsidies have had an average annual growth of 10% and 17% respectively, outweighing the average inflation rate over this period (5.5%). Total operation and capital subsidies have grown by 300% and 500% respectively since 2008.

The increases in capital subsidisation are mainly due to PRASA's capital programmes, in which outdated infrastructure and assets such as signalling, Overhead Traction Equipment (OTE) and rolling stock are renewed (PRASA, 2020). Operational subsidies, however, have been increasing due to the lower levels of fare revenue collected. Based on the Cape Town district income statements of PRASA, the estimated subsidies of the Southern line have increased from R116 million in 2012/13 to R247 million in 2019/20.

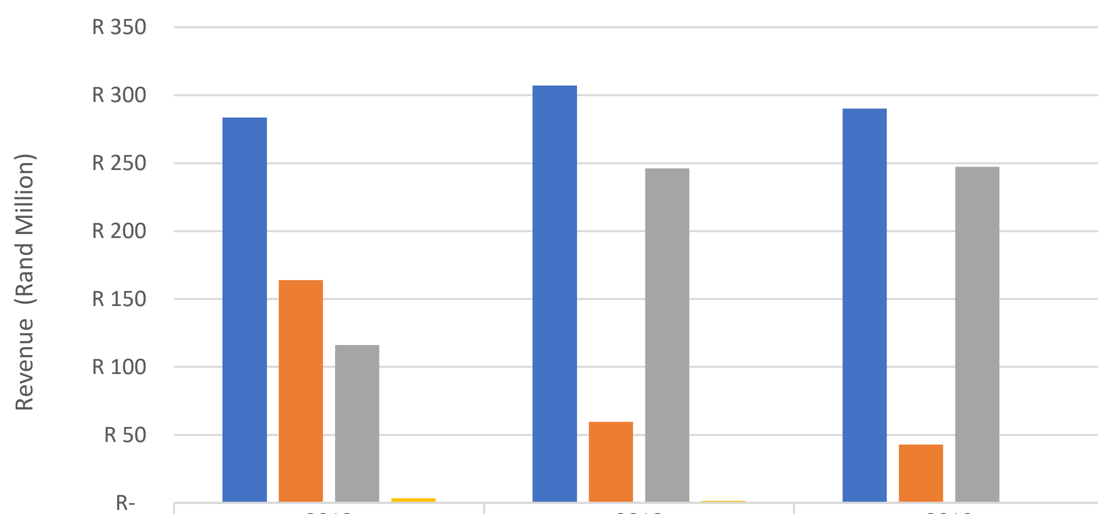
4.1.3 Auxiliary revenue

Auxiliary revenue is defined as the revenue generated from goods and services other than a company's primary offering. In the passenger rail industry, auxiliary revenues take the form of rental income (station facilities and rail infrastructure), interest income, sales of goods on board trains, traction workshop services to third party rail companies, and advanced booking (World Bank, 2017). These revenues can lead to much-needed sources of income when utilised correctly, especially when ticket sales are in decline - as is the case with PRASA.

PRASA generates auxiliary revenue mainly through rental income and interest received. In 2020, rental income generated R726 million, and interest received accounted for over R1.5 billion (PRASA, 2020). Based on the Cape Town district income statements of PRASA, the estimated auxiliary revenue of the Southern line was R3.3 million in 2013, and R1.3 million in 2018.

4.1.4 Southern line revenue

Figure 4.5 illustrates the allocation of revenue to the Southern line in 2013, 2018 and 2019. In 2013, fare revenue generated the highest portion of income for the Southern line, followed by government subsidies. In more recent years, however, fare revenue has decreased significantly, and government subsidisation now accounts for the highest portion of revenue. Auxiliary revenue has played a relatively insignificant role throughout the entire period.



	2013	2018	2019
Total revenue	R 283	R 307	R 290
Fare revenue	R 164	R 60	R 43
Government Subsidy	R 116	R 246	R 247
Auxiliary revenue	R 3	R 1	R-

Total revenue   Fare revenue   Government Subsidy   Auxiliary revenue

Figure 4.5: Revenue allocation – Southern line (PRASA, 2019c)

4.2 Costs

The cost structure of railway operations is complex and hard to define. Due to the vast amount of cost elements, and a large degree of joint[4] and common[5] costs associated with rail operations, it is difficult to determine the exact costs per scheduled train. As per PRASA's income statements, rail cost elements are separated into three categories, including operational costs, overhead costs, and other costs.

Similar to the revenue elements, the costs of the Southern line form part of the Cape Town district income statements. In the 2019/20 financial year, the Southern line accounted for 21.1% of train kilometres in the Cape Town district. To determine the costs of the Southern line from the income statements of the Cape Town district, this proportion is used.

4.2.1 Operating costs

Operating costs are classified as costs that are directly related to the operations of the service. Rail operating costs include traction (energy) costs, depreciation, maintenance, materials and employee costs (Gattuso and Restuccia, 2014). These cost elements each have many subdivisions, but for illustration purposes, the total of each cost element is portrayed. Materials, for example, include materials used for lighting, traction equipment, tracks, cleaning facilities and electrical grids.

Based on the Cape Town district income statements and the proportions mentioned earlier, the annual operating costs of the Southern line could be calculated. In 2013 and 2019, the total operating costs of the Southern line amounted to R318 million and R413 million respectively (PRASA, 2019b). The main element under operating costs is personnel costs, which accounts for 65-75% of total operating costs throughout the investigated period.

[4] Joint costs occur when the production of one transport service (one-way trip), leads to the production of another transport service (return trip). Joint costs are the costs shared by these two transport services (World Bank, 2017).

[5] Common costs occur when the facilities used to produce one transport service are also used to produce another transport service (World Bank, 2017). Common costs are largely associated with fixed infrastructure such as railway tracks, signalling systems, and OTE. Common costs often occur between freight and passenger railway companies, as they use the same infrastructure, but have different transport services (Transnet and PRASA).

4.2.2 Overhead costs

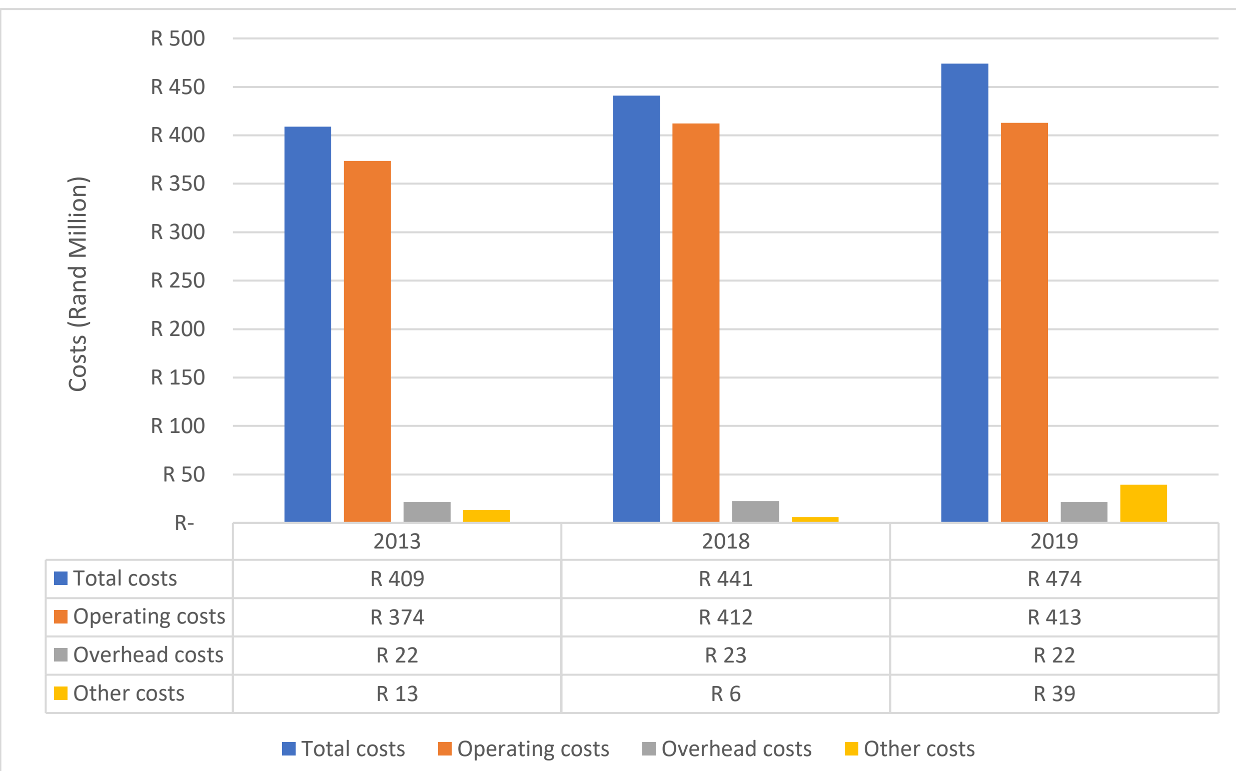
As with any business, rail operators have some extent of overhead costs. The elements within overhead costs are not directly associated with train operations, but are business expenses that are necessary for operations to occur. These costs include elements like training of employees, office expenses, computer expenses and professional services, and amounted to approximately R21 million throughout the period investigated (PRASA, 2019b).

4.2.3 Other costs

Other costs include costs that are not associated with train operations. These include interest paid to creditors, losses on disposal of assets and impaired losses. The main contributing element within ‘other costs’ are losses on the disposal of assets, which amounted to R13.7 million and R38.7 million in 2013 and 2019 respectively (PRASA, 2019b).

4.2.4 Southern line costs

Figure 4.6 illustrates the allocation of costs on the Southern line. Unlike the revenue sources of the Southern line, the costs have stayed relatively constant with regard to its distribution.



	2013	2018	2019
Total costs	R 409	R 441	R 474
Operating costs	R 374	R 412	R 413
Overhead costs	R 22	R 23	R 22
Other costs	R 13	R 6	R 39

Figure 4.6: Cost allocation – Southern line (PRASA, 2019b)

In each financial year, operating costs contributed to the majority of the costs investigated, followed by overhead costs, and other costs.

4.3 Capacity

Before the revenues and costs of the Southern line can be applied to the 20-year transport forecast, the capacity of the Southern line needs to be determined in order to determine the total revenue generated at different utilisation levels.

The capacity of a railway line is defined as the maximum number of passengers that can be transported past a fixed point in one direction, during one hour (Gattuso and Restuccia, 2014). Transport capacity calculations are built on three main parameters, which include vehicle capacity, number of vehicles, and vehicle headway[6] (Vuchic, 2005). To calculate the capacity of the Southern line, these principles are applied to the latest publicly available timetable for the Southern line.

4.4.1 Southern line service attributes

A total of 15 trainsets [7]operate on the Southern line, each consisting of one locomotive and eight carriages. Each trainset has a carrying capacity of 1280 passengers (160 passengers per carriage) (HaskoningDHV, 2013). The Southern line has a total of 26 train stations, of which 23 are on double track and 3 are on single-track (after Fish Hoek). Operating hours are from 5 am until 10 pm on weekdays, and from 5 am to 8 pm on weekends.

4.4.2 Capacity calculation

The 2018 train schedule was used as a baseline for the capacity calculations and was separated into “outbound journeys” (from Cape Town to Simon’s Town), and “inbound journeys” (from Simon’s Town to Cape Town). Two stations, namely Plumstead and Fish Hoek, were chosen as points from which hourly trains were measured, and the average of these points were used for the capacity calculation. To ensure accuracy, two methods were used to calculate the capacity of the Southern line.

[6] Headway is the amount of time separating two vehicles.
[7] A trainset is a locomotive with a given number of carriages. For example, one locomotive and eight carriages.

As per the 2018 schedule, a total of 63 trains passed through Plumstead towards Simon's Town on a normal weekday, with a maximum of seven trains per hour in peak times, and a minimum of two trains per hour in off-peak times. On average 3.71 trains passed Plumstead towards Simon's Town per hour. In Fish Hoek, a total of 53 trains passed through the station towards Simon's Town on a normal weekday, with a maximum of six trains per hour in peak times, and a minimum of one train per hour in off-peak times. On average 3.12 trains passed Fish Hoek towards Simon's Town per hour.

On weekends (Saturday and Sunday) scheduled trains are fewer, due to lower demand. On Saturdays and Sundays the total number of trains passing through both stations in both directions decreased to 27 and 19 respectively. The average per hour train passing through both stations towards Simon's Town decreased to 1.59 on Saturdays and 1.12 on Sundays. From weekdays to Saturdays and Sundays the headway between scheduled trains increased from 13 minutes to 30 and 43 minutes respectively.

The difference between the average hourly trains in Plumstead and Fish Hoek was due to some trains having their turn-around point before reaching Fish Hoek. To account for this variation, the average of the two points would be used to calculate the capacity. Thus, the total hourly capacity of the Southern line at a specific point is (as per the 2018 schedule) equal to the average train per hour (6.82), times the total capacity per train (1280), which equates to 8730 passengers. The total capacity per week-day would, therefore, be equal to 8730 passengers, times the operating hours (16 hours per day), which equates to 139 680 passengers journeys per day. The same calculation would be applied to Saturdays and Sundays, which equates to 56 922 and 40 056 per day respectively. Consequently, the weekly and yearly capacity of the Southern line are equal to 795 708 and 41 376 828 passenger journeys respectively.

Another method of calculating the capacity of a railway line is by considering the total daily scheduled trains. In 2018, the Southern line had an average of 54 scheduled outbound trains and a daily average of 53 scheduled inbound trains. In that year, the total daily scheduled trains were thus equal to 107 trains. Therefore, the daily capacity of the Southern line was equal to the total scheduled trains (107) times the capacity of each train set (1280), which equates to a total capacity of 138 240 passengers per day. On Saturdays and Sundays, the inbound and outbound journeys reduced to 58 and 32 respectively, and the daily capacity thus reduced to 74 240 and 40 960 respectively. Based on these numbers, the total weekly capacity equated to 793 600 passenger journeys, and the total yearly capacity would be 41 267 200 passenger journeys.

For the analysis, the average of these two calculations was used, which equated to a total of 41 322 014 passenger journeys annually.

4.4 Southern line cost structure and distribution

Table 4.1 shows the income statements of the Southern line for 2013, 2018 and 2019, as derived from the Cape Town district income statements. Table 4.1 indicates that the Southern line has been operating at a financial deficit, which has been increasing since 2013.

Southern line						
		2013		2018		2019
Revenue	**R**	**283 457 309**	**R**	**307 107 728**	**R**	**290 179 101**
Fare revenue	R	164 007 240	R	59 714 935	R	42 824 243
Government Subsidy	R	116 117 337	R	246 055 807	R	247 354 858
Sundry income	R	3 332 732	R	1 336 985	R	-
Operating costs	**-R**	**317 887 191**	**-R**	**412 359 252**	**-R**	**412 857 037**
Personnel	-R	236 806 290	-R	259 961 891	-R	267 065 363
Maintenance	-R	1 781 922	-R	5 660 516	-R	6 543 977
Material	-R	12 249 459	-R	10 135 263	-R	5 347 938
Security	-R	26 932 005	-R	38 539 653	-R	41 018 260
Other operating costs	-R	152 186	-R	72 186	-R	81 353
Energy	-R	35 737 112	-R	28 958 669	-R	32 104 637
Depreciation	-R	4 228 219	-R	69 031 073	-R	60 695 510
Overhead costs	**-R**	**21 707 819**	**-R**	**22 639 703**	**-R**	**21 623 063**
Training	-R	1 036 940	-R	628 167	-R	229 148
Auxiliary transport	-R	3 220 315	-R	2 313 670	-R	71 568
Communication	-R	2 716 274	-R	3 888 035	-R	3 202 697
Computer Expenses	-R	1 174 448	-R	7 151 894	-R	7 091 218
Health and Risk	-R	561 695	-R	774 091	-R	643 503
Insurance claims	-R	3 179	R	718 991	R	212 517
Leases	-R	7 309 682	-R	2 962 826	-R	2 772 348
Office expenditure	-R	163 910	-R	94 858	-R	156 666
Professional services	-R	4 209 839	-R	214 149	-R	35 602
TCO	R	-	-R	4 566 202	-R	4 619 150
Publications, printing and marketing	-R	317 162	-R	589 935	-R	232 203
Travel and accommodation	-R	894 284	-R	174 867	-R	103 111
Projects	R	9 062	R	-	-R	2 678 366
Bank charges and penalties	-R	109 152	R	-	R	-
Other costs	**-R**	**13 386 985**	**-R**	**6 098 224**	**-R**	**39 324 552**
Finance costs	-R	106 800	-R	186 227	-R	587 139
Losses on disposal of assets	-R	13 762 529	-R	5 711 752	-R	38 737 413
Impaired losses	R	482 344	-R	200 244	R	-
Total costs	**-R**	**352 981 996**	**-R**	**441 097 179**	**-R**	**473 804 652**
Total loss	**-R**	**69 524 686**	**-R**	**133 989 451**	**-R**	**183 625 551**

Table 4.1: Derived income statements - Southern line (PRASA, 2019b)

With regard to the annual revenue of the Southern line, no significant changes had been realised between 2013 and 2019. When investigating the elements of total revenue, however, the distribution of revenue changed dramatically over the period. Fare revenue levels declined by 74% since 2013, from R165 million to R43 million in 2019. These large cuts in fare revenue did not affect total revenue levels, due to significant increases in government subsidisation. From 2013 to 2019 government subsidisation increased by 113% from R117 million to R249 million. Regardless of the fare revenue, total revenue during that period equated to around R293 million per year.

The operating costs of the Southern line account for 87% of the total costs. From 2013 to 2019 operating costs increased by 30%, from R317 million to R412 million. Cumulatively, operating costs grew by 7% more than inflation. The growth in operating costs was due to increases in personnel costs, maintenance costs and security costs, but were mainly attributable to the difference in depreciation between 2013 and 2019. In 2013 total depreciation accounted for R4.2 million, while in 2018 and 2019 it accounted for more than R60 million. The reason for this is likely due to differences in accounting methods between these financial years. If the 2013 depreciation is assumed equal to that of the other years (R60 million), total operating costs for 2013 were R373.6 million, which signifies that operating costs grew by R39 million from 2013 to 2019.

Other costs seemed to be volatile over the three financial years, mainly due to variations in losses on disposal of assets. Losses on the disposal of assets are the difference between the net disposal proceeds of an asset, and its carrying value, and could vary due to differing levels of asset disposals in a particular year. In order to accommodate for the variations in costs such as losses on disposals of assets and depreciation, the financial model considers the average of

Total costs	R	**476 069 250**
Operating costs	R	434 475 801
Personnel costs	R	254 611 181
Maintenance	R	39 512 852
Material	R	9 244 220
Security	R	35 496 639
Other operating costs	R	101 908
Energy	R	32 266 806
Depreciation	R	63 242 194
Overhead costs	R	21 990 195
Training	R	631 418
Auxiliary transport	R	1 868 518
Communication	R	3 269 002
Computer Expenses	R	5 139 187
Health and Risk	R	659 763
Insurance claims	-R	309 443
Leases	R	4 348 285
Office expenditure	R	138 478
Professional services	R	1 486 530
TCO	R	3 061 784
Publications, printing and marketing	R	379 767
Travel and accommodation	R	390 754
Projects	R	889 768
Bank charges and penalties	R	36 384
Other costs	R	19 603 254
Finance costs	R	293 389
Losses on disposal of assets	R	19 403 898
Impaired losses	-R	94 033

Table 4.2: Average annual costs – Southern line

these costs over the three financial years. Table 4.2 illustrates the average annual costs of the Southern line.

The results in Table 4.2 include adjustments to outliers such as the 2013 depreciation and additional costs that fall under national network income statements, including R35 million in maintenance costs.

Out of the R476 million annual expenditure, six cost elements make up 93% of total expenditure. Figure 4.7 illustrates the distribution of costs on the Southern line and shows that personnel costs account for 53% of total expenditure.

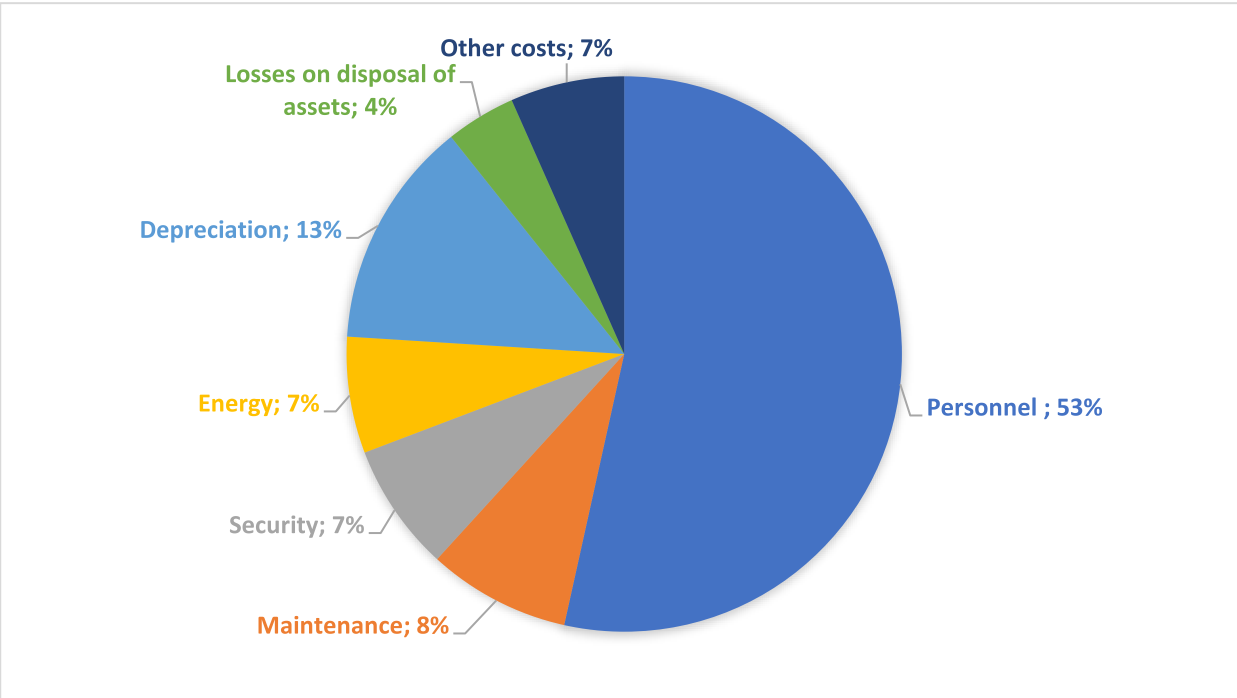


Figure 4.7: Cost distribution – Southern line

Table 4.3 shows each cost element of the Southern line, as well as the extent to which they are fixed and variable. These assumptions are purely estimates and are made to determine the extent to which rail-related costs are fixed and variable. The assumptions are made based on the extent to which costs vary with increased operations in the short term. Energy costs, for example, are mainly variable as the use of energy is directly related to the operation of trains, but are also fixed to an extent as some energy costs would occur even without operating trains. The outcomes of Table 4.3 indicate that fixed and variable costs account for 84% and 16% respectively. These outcomes are in line with existing literature that suggests that fixed costs within rail operations are rarely below 70% of total costs (World Bank, 2017). Based on these assumptions, the total fixed and variable costs of the Southern line in 2019 were equal to R401.8 million and R74.3 million respectively.

Cost element	Fixed proportion	Variable proportion
Personnel	100%	0%
Maintenance	30%	70%
Security	80%	20%
Energy	30%	70%
Depreciation	100%	0%
Losses on disposal of assets	100%	0%
Material	20%	80%
Other operating costs	0%	100%
Training	100%	0%
Auxiliary transport	30%	70%
Communication	10%	90%
Computer Expenses	100%	0%
Health and Risk	30%	70%
Insurance claims	0%	100%
Leases	10%	90%
Office expenditure	100%	0%
Proffessional services	20%	80%
TCO	100%	0%
Publications,printing and marketing	100%	0%
Travel and accommodation	100%	0%
Projects	100%	0%
Bank charges and penalties	100%	0%
Finance costs	100%	0%

Table 4.3: Fixed and variable cost proportions

Figure 4.8 illustrates the fixed and variable costs of the Southern line with changes in load factor. On the secondary axis, the unit cost per passenger journey is measured and illustrated by the grey line. The unit cost per trip is calculated by dividing the total costs of operations (variable and fixed costs) by the number of trips undertaken. Changes in operating costs and unit costs are determined by changes in assumed traffic volume, which is depicted by the load factor.

The fixed costs (blue area) stay constant as load factors increase. The variable costs (orange area), however, increase as ridership increases. The variable cost per passenger journey is calculated by dividing the total variable cost in 2019 (R74.3 million) by the annual passenger journeys undertaken in 2019 (10 184 927), which equates to R7.20 per passenger journey. As the load factor increases, the variable cost per passenger journey (R7.20) is multiplied by the ridership associated with each load factor to simulate the increase in total variable cost (orange area). As the load factor increases, the unit cost per passenger journey (grey line) decreases due to the high proportion of fixed costs. Even though total costs are the highest at 100% load factor, the unit cost per passenger journey is the lowest. It is under these circumstances, where passenger rail service can benefit from its economies of scale factors, that it becomes profitable. Without high load factors, however, the unit cost per passenger journey becomes too high to cover from fare revenue alone.

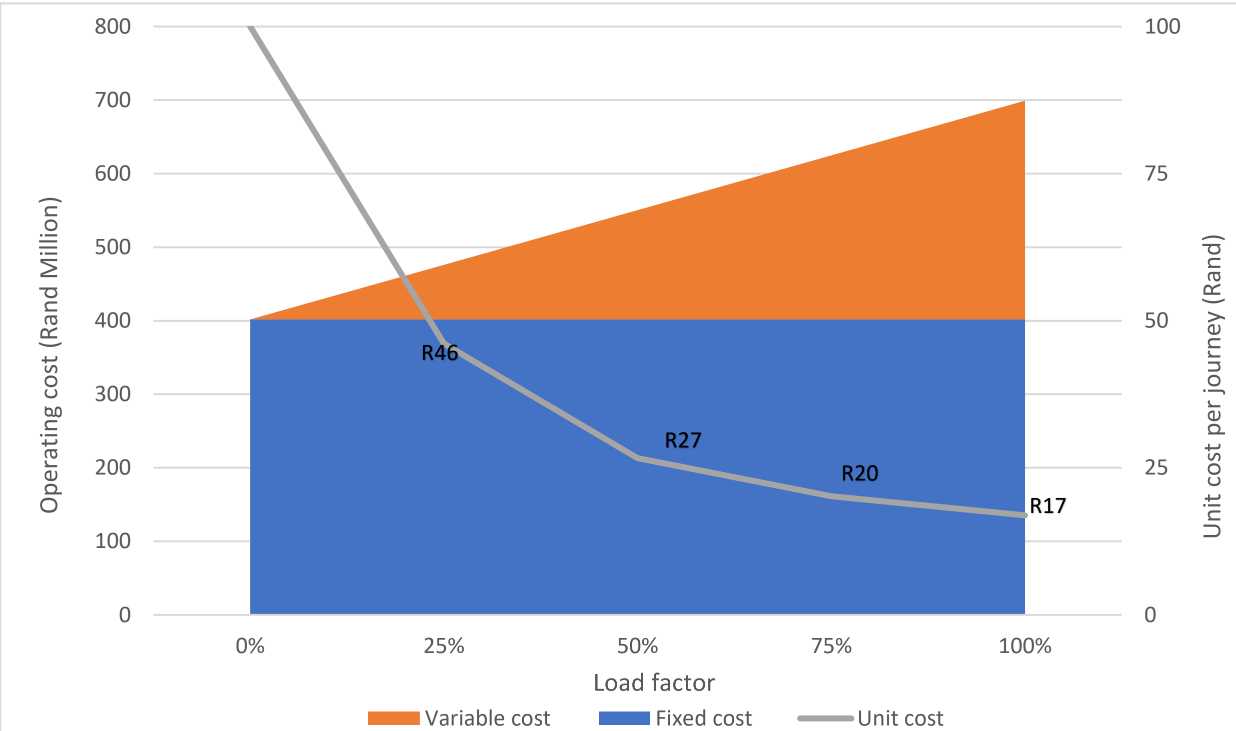


Figure 4.8: Cost distribution and unit costs per load factor – Southern line

Figure 4.8 also indicates the level of pricing that should be followed, at a given load factor, in order for the operator to be profitable. In 2019, the Southern line was operating at a load factor of 27%, which indicates that each ticket sold should be priced at R45 to break even. By considering the total fare revenue, and total passenger journeys on the Southern line, the total revenue per journey equated to R4.20 in 2019. Therefore, for the Southern line to break even in 2019, a subsidy per passenger journey of R40.80 was required. At these price levels, government subsidisation would still be required under 100% load factor, as the unit cost only declines to R17 per passenger journey.

4.5 Evaluation alternatives – Financial analysis

Now that all information regarding the revenue, costs and capacity of the Southern line has been considered, the long-term financial feasibility of the Southern line can be determined using financial modelling. Financial modelling involves forecasting the revenues and costs of the Southern line over the analysis period, in order to determine its long-term profitability (World Bank, 2017). After the revenues and costs have been forecasted over the study period, they are discounted to year zero in order to determine the Net Present Value (NPV) of each evaluation alternative. For the purposes of this study, a 20-year study period is utilised, with a real discount rate of 5%.

To determine the revenue generated through ticket sales in each alternative, the total forecasted journeys for rail are separated into the four ticket groups, discussed in Chapter 3. The division is made based on the proportions provided in Chapter 3, namely that 17% of trips are undertaken by single-trip tickets, 5% by round-trip tickets, 16% by weekly tickets, and 62% by monthly tickets. After the railway journeys undertaken have been assigned to a ticket type, the total sales per ticket type could be calculated, and the sum of revenue generated by those sales equals the total revenue of each alternative. Table 4.4 indicates the average price per ticket type on the Southern line. The average ticket price per ticket type is used, since other factors such as travel zones, and ticket classes, cause the prices per ticket type to vary.

Year		2019
Average single ticket price	R	8,40
Average round ticket price	R	16,90
Average weekly ticket price	R	52,64
Average monthly ticket price	R	167,24

Table 4.4: Average ticket price – Southern line (PRASA, 2019c)

To determine the costs associated with each alternative, distinctions are made between fixed and variable costs. The fixed costs are considered constant at R401.8 million annually in each alternative, while the variable costs depend on the utilisation of the service in the given year. Therefore, with each additional railway journey, variable costs increase by R7.20, as per Section 4.4. The total discounted cost of each alternative is the sum of the discounted fixed and variable costs over the 20-year analysis period. Finally, the profitability of each alternative is determined by the difference between total discounted revenue and total discounted costs over the 20-year analysis period.

4.5.1 A0 – Do nothing

The first alternative assumes that the current (2019) operating conditions stay constant over the 20-year analysis period. This means that the market share of rail will stay proportionally constant to what it was in 2019 (7% of the market) throughout the 20-year analysis period. Based on the demand forecast, the total journeys undertaken by rail in the base year is 11 359 953. In years 10 and 20 of the analysis, the total rail journeys will increase to 13 847 719 and 15 296 497 respectively, due to the normal population and traffic growth. Since the market share of rail is assumed to stay constant at 7%, the Southern line is assumed to have a load factor of 37% in year 20 of the analysis.

Because of the increase in load factor, an increase in annual revenue is noted. More specifically, annual revenue increases from R47.7 million in the base year, to R64.3 million in year 20. The total discounted revenue over the 20-year analysis period amounts to R699.1 million.

The annual fixed cost of the Southern line is equal to R401.8 million annually, which equates to a total discounted fixed cost of R5 billion over the 20-year analysis period. The annual variable costs of the Southern line increase from R83.4 million in year one, to R110.1 million in year 20, which equates to a total discounted variable cost of R1.19 billion over the 20-year analysis period. The total discounted costs of the base alternative amount to R6.2 billion.

Item	**Net present value**	
Revenue	R	699 167 217
Costs	R	6 204 754 226
Profit/loss	**-R**	**5 505 587 009**

Table 4.5: NPV - A0

In comparing the discounted revenue to the discounted costs of the base alternative, a significant financial deficit is realised. Over the 20-year analysis period, a total financial loss of R5.5 billion will be incurred. According to the demand forecast, a total of 273 million rail passenger journeys will occur throughout this alternative, which equates to a average load factor of 33%, and an average annual unit cost (cost per passenger journey) of R37.

4.5.2 A1 - 80% Utilisation at year-12

Alternative one is the optimistic alternative, in which the assumption is made that rail use will increase until it reaches 80% of its capacity in year 12 of the analysis. The market share of rail will increase from 7% in the base year to 17% in year 12. To achieve this growth, rail will need to gain a market share of roughly 1% annually, until year 12.

Rail passenger journeys increase from 11 359 953 in the base year to 33 057 611 in year 12 of the analysis. In each year after year 12, the number of rail journeys stay constant at 33 057 611. By calculating the revenue in the same method as A0, the annual revenue is found to increase from R47.7 million in the base year to R139 million in year 20. The total discounted revenue over the 20-year analysis period amounts to R1.3 billion.

As in A0, the total discounted fixed costs amount to R5 billion over the 20-year period. The annual variable costs of the Southern line increase from R92.7 million in year one, to R238 million in year 20, which equates to a total discounted variable cost of R2.2 billion over the 20-year analysis period. The total discounted costs of alternative one amount to R7.2 billion.

Item	Net present value	
Revenue	R	1 303 060 209
Costs	R	7 238 849 867
Profit/loss	**-R**	**5 935 789 657**

Table 4.6: NPV – A1

As per Table 4.6, a total financial deficit of R5.9 billion is realised over the 20-year period. In comparison to the base alternative, the total loss has increased. This can be explained by the degree to which marginal revenue[8] and marginal variable cost[9] change in reaction to increased utilisation. At the given ticket pricing levels, the marginal revenue per trip is equal to R4.20. Furthermore, the marginal variable cost per passenger journey equates to R7.20, as indicated in section 4.4. Therefore, at current pricing levels, the marginal variable cost outweighs the marginal revenue by 71%, which causes the service to become more unprofitable as utilisation increases. Therefore, in order for the Southern line to cover its marginal variable cost, and to benefit from increased utilisation, prices will need to increase by 71%. If these pricing levels are reached, economies of scale benefits are realised from reduced per-unit cost. The per-unit cost of A1 shows a reduction of R13 per unit, in comparison to the base alternative.

4.5.3 A2 – 50% Utilisation at year-10

Alternative two is the pessimistic alternative, in which the assumption is made that rail use will increase to 50% of its capacity in year 10 of the analysis, after which it will stay constant at 50% until year 20. The market share of rail will increase from 7% in the base year to 11% in year 10. To achieve this growth, rail will need to gain a market share of roughly 0.4% annually until year 10.

Rail passenger journeys are thus assumed to increase from 11 359 953 in the base year to 20 661 007 in year 10 of the analysis. In each year, after year 10, rail is assumed to have 20 661 007

[8] The additional revenue generated from one extra passenger journey.
[9] The additional variable cost incurred from one extra passenger journey.

journeys. By calculating the revenue in the same method as A0, the annual revenue is found to increase from R47.7 million in the base year to R86.8 million in year 20. The total discounted revenue over the 20-year analysis period amounts to R926 million.

As in A0, the total discounted fixed costs amount to R5 billion over the 20-year period. The annual variable costs of the Southern line increase from R87.5 million in year one, to R148 million in year 20, which equates to a total discounted variable cost of R1.5 billion over the 20-year analysis period. The total discounted costs of alternative two amount to R6.59 billion.

Item	**Net present value**	
Revenue	R	926 275 116
Costs	R	6 593 649 761
Profit/loss	**-R**	**5 667 374 645**

Table 4.7: NPV - A2

As per Table 4.7, a total financial deficit of R5.6 billion is realised over the 20-year period. Similar to the outcomes of A1, the financial loss of A2 is greater than that of A0, due to the marginal revenue being lower than the marginal variable cost. The average per-unit costs of rail passenger journeys for A2 are equal to R30, which is R7 less than that of the base alternative.

4.6 Conclusion

It is clear from the financial analysis that the Southern line is unprofitable in both the short and long term. In 2019 the costs incurred outweighed the revenue by R441 million before subsidy payments, and the base alternative indicated an total financial deficit of R5.5 billion over the 20-year analysis period.

A variety of factors are causing the Southern line to be financially unfeasible. These include:

1. Low load factors – In 2019 the load factor of the Southern line was 27%, which amounted to a cost per passenger journey of R45. As load factors increase, the unit cost costs per passenger journey decrease due to the high proportion of fixed costs associated with rail. At 80% load factor, for example, the unit cost per passenger journey amounts to approximately R19, which enables the railway line to recover a greater portion of its costs from its primary revenue.
2. Low revenue – Low revenue levels are caused by two factors. The first is the inadequate pricing levels implemented. As stated in section 4.1.1.2, passenger rail operators should price at a level higher than their marginal variable cost (World Bank, 2017). The marginal

revenue generated from one additional journey on the Southern line in 2019 equated to R4.20, while the marginal variable cost equated to R7.20. In order for the Southern line to cover its marginal variable cost, and benefit from increased utilisation and economies of scale, pricing levels should increase by 71%. Along with inadequate pricing strategies, and high levels of fare evasion, the Southern line is unable to effectively utilise secondary sources of income from auxiliary revenues. Auxiliary revenue is generated from services such as rental income and sales of goods on board trains, and have internationally played a significant role in revenue generation of passenger railway services. In 2018, auxiliary revenues amounted to a mere R1.3 million, which is insignificant compared to other revenue sources.

3. High costs – In 2019, personnel costs (R267 million) accounted for 53% of the Southern line's total expenditure. As seen in the case studies in Chapter 2, the reduction of personnel costs is one of the first steps taken to increase the financial feasibility of railway services. In many cases, including Japan, New Zealand and Cote d'Ivoire, personnel costs were more than halved after privatisation.

Overall, the conclusion is reached that the Southern line is not currently viable, and will also not be viable with increased ridership. Therefore, a private operator will need to do more than focus on increasing load factors to be profitable. Focus should be placed on maximising revenue by means of increasing ticket prices, lowering fare evasion, generating greater auxiliary revenues, as well as minimising costs by cutting large cost items such as personnel costs.

Chapter 5 - Economic analysis

The financial analysis aimed to determine the financial sustainability of the Southern line, by investigating the financial costs and benefits associated with its operations. The economic analysis expands on the financial analysis by investigating the non-financial externalities associated with its operations (World Bank, 2017). Unlike the financial analysis, the economic analysis excludes distorting financial factors such as taxes and subsidies, in order to reflect the effects of policies recommendations from a social perspective (European Commission, 2014).

The cost of commuting can be classified into two main groups, namely Vehicle-User-Costs (VUC), and Road-User-Costs (RUC) (Qin and Cutler, 2013). The VUC includes all the direct costs of travel, such as fuel and depreciation, while RUC takes into consideration the direct and indirect costs of travel. RUC is defined as the sum of Vehicle-Operating-Costs (VOC), travel time costs, and accident costs (Qin and Cutler, 2013). The following section will investigate the economic feasibility of the Southern line, by comparing the RUC thereof with that of alternative transport modes. The purpose of this chapter is therefore to determine whether increased rail use would lead to savings in the total economic cost of commuting.

5.1 Vehicle-Operating-Costs (VOC)

The costs of operating any type of vehicle are known as VOC, and include costs such as replacement costs, depreciation, finance costs, insurance, licensing, maintenance, fuel and lubrication costs. VOC is important to be considered when conducting an economic analysis, as it represents the direct costs of commuting, and therefore directly affects the disposable income of commuters. As the VOC increases, the disposable income of commuters decreases, and less money is spent on economic sectors that contribute to economic growth. It is therefore essential to minimize the VOC of commuting.

To calculate the VOC of road-based modes, each mode is assigned to one vehicle type. Based on other assumptions, including the average travel distance per mode type, the VOC per km is calculated. The VOC of rail services is calculated by considering the operating kilometres and expenses of the Southern line.

5.1.1 VOC assumptions

Tables 5.1 to 5.3 show the assumptions made regarding the VOC of private vehicles, minibus taxis and busses respectively. Assumptions regarding replacement values, depreciation periods, residual values, tyre prices, tyre lifetimes, maintenance costs, fuel costs and annual kilometres driven are based on public information, to which the sources refer. Costs that vary from user to user, including finance costs, insurance costs and fixed maintenance costs, are held constant at a percentage of total costs. Variable maintenance costs are considered per km and are obtained from VOC calculati ons conducted by Arrive Alive (Arrive Alive, 2021c). Fuel and diesel prices are considered at R17.59 and R14.47 per litre, according to coastal prices in August 2021 (Arrive Alive, 2021a).

VEHICLE	Toyota corolla Quest 1,6		
	ASSUMPTIONS		
Capital	Replacement cost	(R)	278400
	Finance cost	(%)	10,0%
	Depreciation	(Yrs)	5
	Residual value	(%)	30,0%
Insurance	Insurance (% of cost)	(%)	8%
Licensing	Licence (1000-1250kg - Tarra)	(R)	800
Tyres	Number of tyres	(No)	4
	Price per tyre: New	(R)	900
	Number of tyres (front)	(No)	2
	Number of tyres (rear)	(No)	2
	Tyre life: (front)	(Km)	50000
	Tyre life: (rear)	(Km)	50000
Overhead cost	% of fixed cost	(%)	10,00%
Maintenance	Fixed - % of Fixed cost	(%)	10,00%
	Variable	(c/km)	19,55
Fuel	Usage (l/100km)	(l/100km)	7
	Cost per litre (Petrol)	(c)	1759
Lubrication	% of fuel cost	(%)	2,50%
Annual use	Yearly km driven	(Km)	16630

Table 5.1: VOC assumptions - Private vehicle

VEHICLE	Toyota Sesfikile 2,7 16s		
	ASSUMPTIONS		
Capital	Replacement cost	(R)	468300
	Finance cost	(%)	10,0%
	Depreciation	(Yrs)	5
	Residual value	(%)	25,0%
Insurance	Insurance: Total (Rand/yr)	(R)	8%
Licensing	Licence (1250-1500kg -Tarra)	(R)	1750
Tyres	Number of tyres	(No)	4
	Price per tyre: New	(R)	2000
	Number of tyres (front)	(No)	2
	Number of tyres (rear)	(No)	2
	Tyre life: (front)	(Km)	50000
	Tyre life: (rear)	(Km)	50000
Drivers	Number of	(No)	1
	Monthly salary of driver	(R)	10100
Assisstants	Number of	(No)	1
	Monthly salary of assistant	(R)	5000
Overhead cost	% of fixed cost	(%)	10,00%
Maintenance	Fixed - % of Fixed cost	(%)	10,00%
	Variable	(c/km)	120,00
Fuel	Usage (l/100km)	(l/100km)	14,3
	Cost per litre (Petrol)	(c)	1759
Lubrication	% of fuel cost	(%)	2,50%
Annual use	Yearly km driven	(Km)	76000

Table 5.2: VOC assumptions - Minibus taxi

According to Toyota South Africa, the Toyota Corolla Quest 1.6 retails for R278 400 (Toyota SA, 2021a). The vehicle is assumed to depreciate over five years with a residual value of 30%. According to Dunlop South Africa, new tyres for this vehicle retail at R900 per tyre, with a lifespan of 50 000km (Dunlop, 2021). Overhead costs are assumed to be 10% of total fixed costs, which include all additional costs of vehicle operations such as parking, tolls, cleaning and storage costs. The Quest consumes seven litres per 100km driven (Toyota SA, 2021a), and according to a study conducted by UCT in 2012, the average annual mileage of a private vehicle is 16 630km (Merven *et al.*, 2012).

According to Toyota South Africa, a new Toyota Sesfikile 2.7l retails for R468 300 (Toyota SA, 2021b). Minibus taxis are assumed to depreciate over 5 years, with a residual value of 25%. According to Bridgestone South Africa, minibus taxi tyres retail at R2000 per tyre, with a lifetime of 50 000km (Bridgestone, 2021). Salary Explore South Africa states that the average minibus taxi driver earns a monthly income of R10 100, and assistant drivers are assumed to earn R5000 (Salaryexplore, 2021b). The overhead costs of minibus taxis and busses are assumed to be higher than that of private vehicles (15% of fixed costs), due to their commercial operations. The Toyota Sisfikile consumes 14.3 litres per 100km driven (Toyota SA, 2021b), and the average minibus taxi in South Africa travels around 76 000km per annum (Transaction capital, 2019).

VEHICLE	New GABS bus (60 seater)		
ASSUMPTIONS			
Capital	Replacement cost	(R)	2600000
	Finance cost	(%)	10,0%
	Depreciation	(Yrs)	13
	Residual value	(%)	10,0%
Insurance	Insurance (% of cost)	(%)	8%
Licensing	Licence (8500-9000kg - Tarra)	(R)	12500
Tyres	Number of tyres	(No)	6
	Price per tyre: (front)	(R)	7000
	Price per tyre: (rear)	(R)	5500
	Number of tyres (front)	(No)	2
	Number of tyres (rear)	(No)	4
	Tyre life: (front)	(Km)	80000
	Tyre life: (rear)	(Km)	80000
Drivers	Number of	(No)	1
	Monthly salary of driver	(R)	12000
Overhead cost	% of fixed cost	(%)	15,00%
Maintenance	% of Fixed cost	(%)	10,00%
	Variable maintenance cost	(c/km)	279,00
Fuel	Usage (l/100km)	(l/100km)	40
	Cost per litre (Diesel)	(c)	1447
Lubrication	% of fuel cost	(%)	2,50%
Annual use	Yearly km driven	(Km)	65000

Table 5.3: VOC assumptions - Bus

According to MAN South Africa, a new 60-seater bus retails for R2.6 million. The MAN bus is assumed to depreciate over 13 years with a residual value of 10% (Cooper, E., E. Kenney and X. Li, 2019). The MAN bus has two front tyres which cost R7000 each, and 4 rear tyres which retail for R5500 each (TyreMall, 2021). According to Salary Explore South Africa, the average bus driver earns R12 000 per month (Salaryexplore, 2021a). The MAN 60-seater bus consumes 40l of diesel per 100km driven, and according to Golden Arrow bus services, the average commercial bus travels around 65 000km per annum.

5.1.2 VOC per mode

The VOC per mode is a function of the assumptions in Tables 5.1 to 5.3. Tables 5.4, 5.5 and 5.6 indicate costs of private vehicles, minibus taxis and busses respectively. For each mode, the cost elements are depicted as annual costs and per km costs. Busses have the highest annual cost of

R1 669 459, followed by minibus taxis with R689 900, and private vehicles with R117 759. The cost per km dri ven was found to be R7.08 for private vehicles, R9.07 for minibus taxis and R25.68 for busses.

	(R/yr)	(C/KM)	(%)	(%)
Fixed Cost				
Cost of Capital	13 920	83,7	15,08%	11,82%
Depreciation	38 256	230,0	41,44%	32,49%
Insurance	20 880	125,6	22,62%	17,73%
License	800	4,8	0,87%	0,68%
Fixed maintenance	9 232	55,5	10,00%	7,84%
Overhead Cost	9 232	55,5	10,00%	7,84%
Total Fixed Cost R/yr)	**92 320**	**555,1**	**100,0%**	**78,4%**
Variable cost				
Fuel	20 477	123,1	80,50%	17,39%
Lubrication	512	3,1	2,01%	0,43%
Variable Maintenance	3 251	19,6	12,78%	2,76%
Tyres	1 197	7,20	4,71%	1,02%
Total Variable Cost (c/km)	**25 437**	**153,0**	**100,0%**	**21,6%**
TOTAL COST	**117 757**	**708,1**		**100%**

Table 5.4: Private vehicle VOC

	(R/yr)	(C/KM)	(%)	(%)
Fixed Cost				
Cost of Capital	23 415	30,8	5,99%	3,39%
Depreciation	68 645	90,3	17,57%	9,95%
Insurance	37 464	49,3	9,59%	5,43%
Vehicle personnel	181 200	238,4	46,39%	26,26%
License	1 750	2,3	0,45%	0,25%
Fixed maintenance	39 059	51,4	10,00%	5,66%
Overhead Cost	39 059	51,4	10,00%	5,66%
Total Fixed Cost R/yr)	**390 593**	**513,9**	**100,0%**	56,62%
Variable cost				
Fuel	191 168	251,5	63,87%	27,71%
Lubrication	4 779	6,3	1,60%	0,69%
Variable Maintenance	91 200	120,0	30,47%	13,22%
Tyres	12 160	16,00	4,06%	1,76%
Total Variable Cost (c/km)	**299 307**	**393,8**	**100,0%**	**43,4%**
TOTAL COST	**689 900**	**907,8**		**100%**

Table 5.5: Minibus taxi VOC

	(R/yr)	(C/KM)	(%)	(%)
Fixed Cost				
Cost of Capital	260 000	400,0	24,34%	15,57%
Depreciation	176 769	272,0	16,55%	10,59%
Insurance	208 000	320,0	19,47%	12,46%
Vehicle personnel	144 000	221,5	13,48%	8,63%
License	12 500	19,2	1,17%	0,75%
Fixed maintenance	106 836	164,4	10,00%	6,40%
Overhead Cost	160 254	246,5	15,00%	9,60%
Total Fixed Cost R/yr)	**1 068 359**	**1643,6**	**100,0%**	**64,0%**
Variable cost				
Fuel	376 220	578,8	62,59%	22,54%
Lubrication	9 406	14,5	1,56%	0,56%
Variable Maintenance	181 350	279,0	30,17%	10,86%
Tyres	34 125	52,50	5,68%	2,04%
Total Variable Cost (c/km)	**601 101**	**924,8**	**100,0%**	**36,0%**
TOTAL COST	**1 669 459**	**2568,4**		**100%**

Table 5.6 – Bus VOC

Figures 5.1, 5.2 and 5.3 show the distribution of costs within the operation of private vehicles, minibus taxis, and busses respectively.

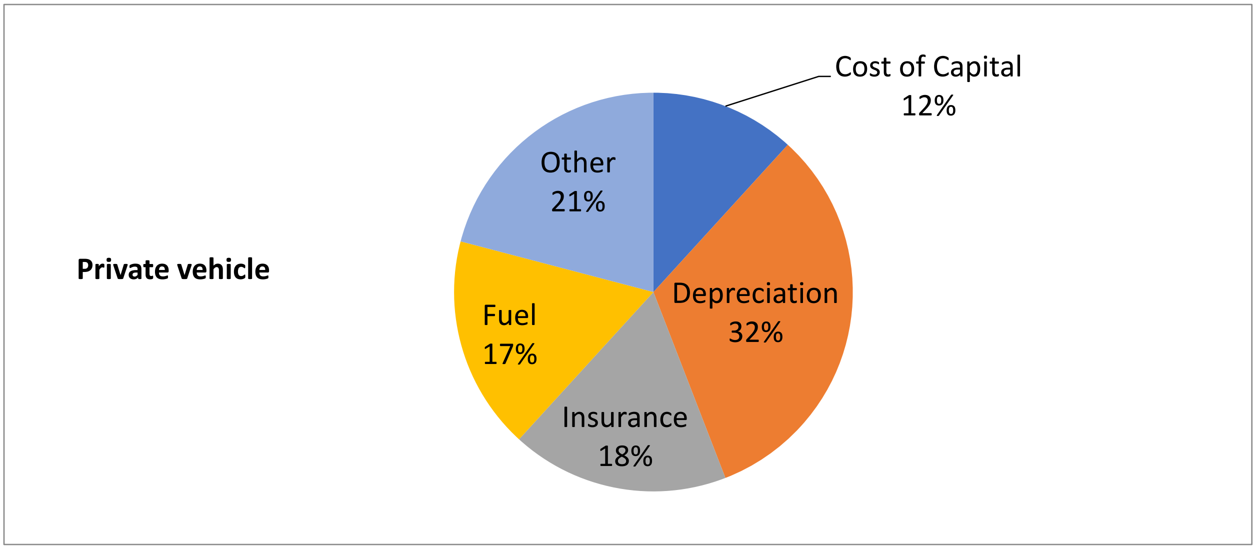


Figure 5.1: Private vehicle cost distribution

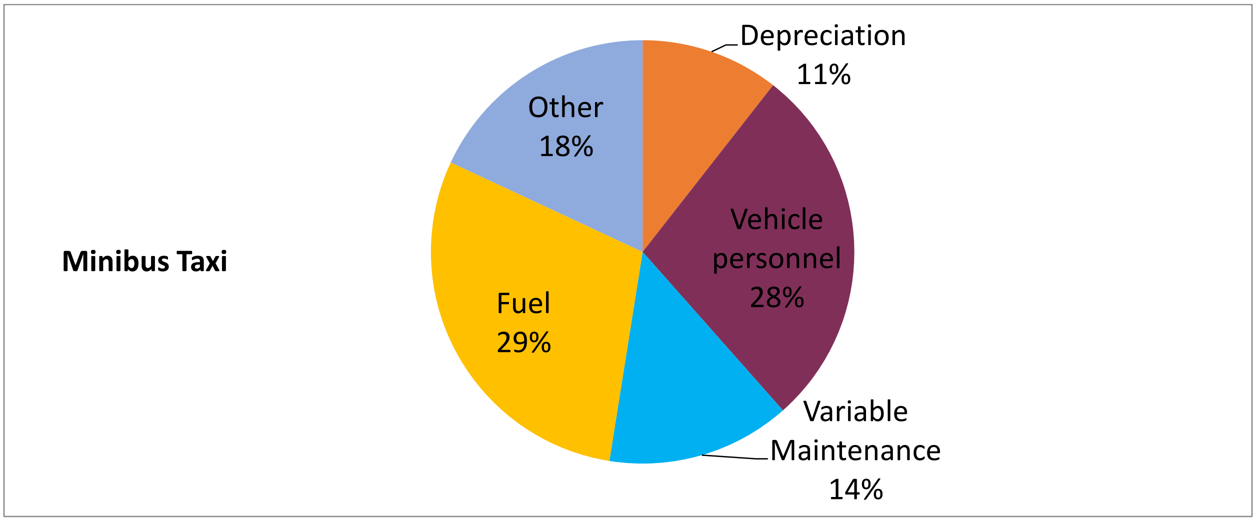


Figure 5.2: Minibus taxi cost distribution

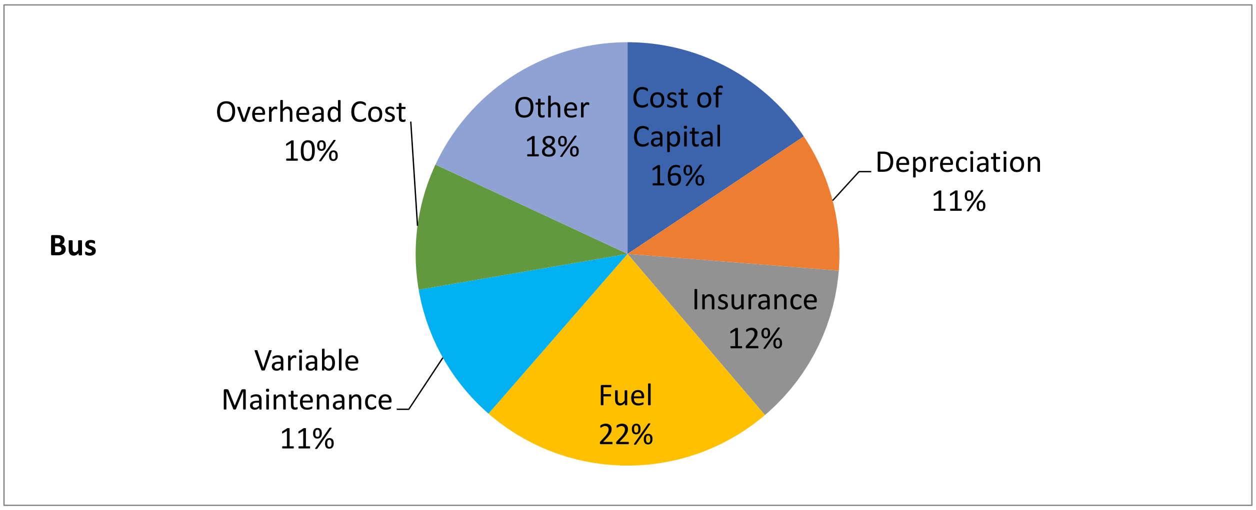


Figure 5.3: Bus cost distribution

The main cost components of a private vehicle are depreciation, insurance and fuel costs, which collectively contribute to 67% of total annual costs. For minibus taxis, personnel costs (26.6%), fuel costs (27.7%) and variable maintenance costs collectively contribute to 71% of total annual costs. Under bus operations, costs are dispersed over more elements, and the three main cost elements are fuel costs, cost of capital and insurance costs, which collectively contribute to 50% of total annual costs.

The cost distribution figures show that the main cost elements of each mode differ. For private vehicles, for example, depreciation plays a much bigger role than in minibus taxis and bus operations. Personnel costs seem to be much higher for minibus taxis than for bus operations, and insurance costs seem to be more prominent under the bus and private vehicle operations.

Due to the high degree of joint and common costs within rail operations, the per km VOC for rail follows a different approach. According to the World Bank, railway operating costs are divided into personnel costs, maintenance costs, depreciation, materials, energy, terminal operations and commercial costs (World Bank, 2017). To calculate the per km VOC of rail, these costs were considered from the Cape district income statement, after which the costs of the Southern line were obtained per the proportion of kilometres operated in the district.

As per Table 5.7, the total operating costs of the Southern line amounted to R399 million in 2019 (PRASA, 2019b). In the same year, the Southern line had a total of 21 943 scheduled trains[10], which collectively operated 651 268km throughout the year. Using this information, the VOC per scheduled train and train km could be calculated and was found to be R18 183 and R613 respectively.

Operating cost	**R**	**398 979 162**
Personnel	R	254 611 181
Maintenance	R	39 512 852
Material	R	9 244 220
Other operating costs	R	101 908
Energy	R	32 266 806
Depreciation	R	63 242 194
Cost per scheduled train	**R**	**18 183**
Cost per km	**R**	**613**

Table 5.7: Rail VOC (PRASA, 2019b)

[10] A train running from its origin to its turn-around point. On the Southern line a scheduled train runs predominantly between Cape Town and Fish Hoek, or Cape Town and Simon's Town.

Figure 5.4 shows the fixed and variable cost distribution for each transport mode. Chapter 4 revealed that the fixed and variable cost proportion of rail is 84% for fixed costs and 16% for variable costs. The fixed and variable cost distributions for the road-based modes are collected from Tables 5.4, 5.5 and 5.6. Figure 5.4 reveals that rail has the highest fixed cost of 84%, followed by private vehicles with 78%, busses with 64%, and minibus taxis with 57%. It is interesting to note the difference in distribution between the different public transport modes. The fact that rail has a much higher fixed cost proportion, increases its ability to benefit from economies of scale, given high load factors.

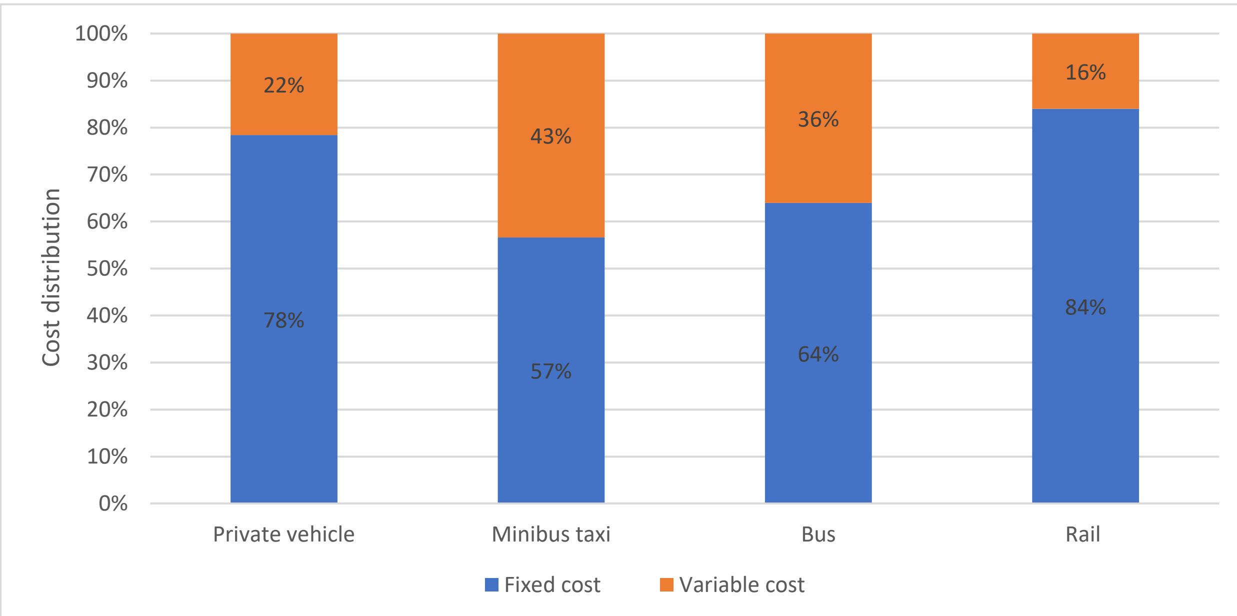


Figure 5.4: Fixed and variable cost proportions per mode

5.1.3 VOC per load factor

It is important to consider the capacity of each vehicle in order to reliably compare the VOC per passenger-km. Private vehicles are assumed to have a capacity of 5 passengers, minibus taxis 16 passengers, busses 60 passengers, and trains 1280 passengers. Figure 5.5 shows the VOC per passenger-km of each mode, with variations in load factor.

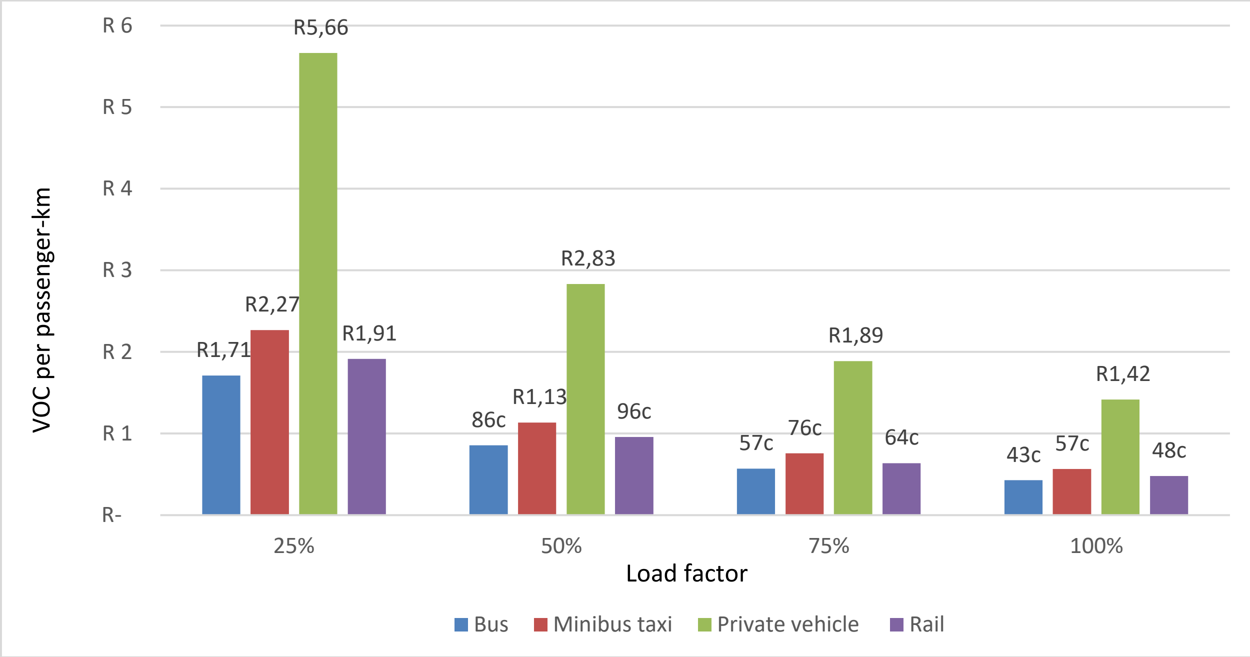


Figure 5.5: VOC per passenger-km and load factor

As the vehicle load factors increase, the VOC per passenger-km decreases. Figure 5.5 indicates that private vehicles have a significantly higher VOC per passenger-km than the other modes. Minibus taxis have the second highest VOC per passenger-km, followed by rail, and then busses.

5.2 Travel time

Travel time is the second component of RUC and is considered a cost due to its unproductive nature. When the travel time of an individual increases, less time is available for that individual to participate in other economic activities such as work or leisure. Therefore, to maximise economic activity, travel time must be minimised.

To obtain the total cost of travel for each mode, two steps are followed. Firstly, the total travel time of each mode is determined over a certain route, after which the travel time is multiplied by the value of time of commuters.

5.2.1 Travel time per mode

Total travel time comprises of three stages, including the access stage, the line haul stage and the egress stage (Krygsman, Dijst and Arentze, 2004). The access stage includes the time taken to access the transport mode from the commuter's place of origin. With regard to public transport modes, the access stage includes the walking time from one's home to the transport mode, as well as the waiting time for the mode to arrive. Private vehicles are assumed to have no access time, due to the vehicle residing at the commuter’s home.

Walking time is calculated by multiplying the average distance from the nearest station with the average walking speed. A study conducted on the travel time of commuters in Cape Town revealed that the average walking speed of commuters is 16.5 minutes per km (Hitge and Vanderschuren, 2015). Furthermore, the study found that the average walking distance to a railway station, bus station and minibus taxi rank was 2.13km, 1.43km and 1.14km respectively.

Walking time	Average (km)	Walking speed (min/km)	Time
Rail	2,13	16,5	35
Bus	1,43	16,5	24
Minibus taxi	1,14	16,5	19

Table 5.8: Walking time per mode (Hitge and Vanderschuren, 2015)

Table 5.8 shows the average walking time per mode of transport. Walking to the nearest railway station in Cape Town takes, on average, 35 minutes. Walking to minibus taxi stops seems to have the shortest duration, which could be due to minibus taxis stopping wherever it suits them best. According to Google Maps, as mentioned in Chapter 3, the average distance from the closest train station is 2.4km, which increases walking time to railway stations to 40 minutes. With regard to the analysis, the average walking time of bus and minibus taxi services will be kept constant to the Cape Town averages, while that of rail services will be specific to the study area.

The second component of the access stage is waiting time, and it considers the time that commuters wait for the mode to arrive. For public transport users, this is the time spent at the station awaiting the next bus, minibus taxi or train. Table 5.9 shows the average waiting time per mode of transport in Cape Town.

Waiting time	Average (min)
Rail	31
Bus	33
Minibus taxi	22

Table 5.9: Waiting time per mode (Hitge and Vanderschuren, 2015)

On average, the waiting time for bus transport is the highest, namely 33 minutes, followed by rail transport at 31 minutes. Minibus taxis seem to have the lowest waiting time, which could be due to the higher frequency of minibus taxi service resulting in lower waiting times.

The second stage of travel time is the line haul stage. The line haul stage includes the time spent in the vehicle, and is dependent on the distance of the journey as well as the speed of the vehicle. Table 5.10 illustrates the average speed per mode in Cape Town for am-peak and off-peak periods.

Speed (km/h)	AM	Off
Private vehicle	29,9	38,4
Rail	22,6	28
Bus	21,5	20,6
Minibus taxi	27,9	33,8

Table 5.10: Average speed per mode (Hitge and Vanderschuren, 2015)

Private vehicles have the fastest average speed in the am peak, namely 29.9km/h, followed by minibus taxis with 27.9km/h. Rail services have the second slowest average speed of 22.6km/h. Suburban railway lines usually operate at a speed of 50km/h or higher, but the railway networks in Cape Town are currently facing speed restrictions and operating delays, due to vandalism and outdated signalling systems (PRASA, 2019a; Wikipedia, 2019).

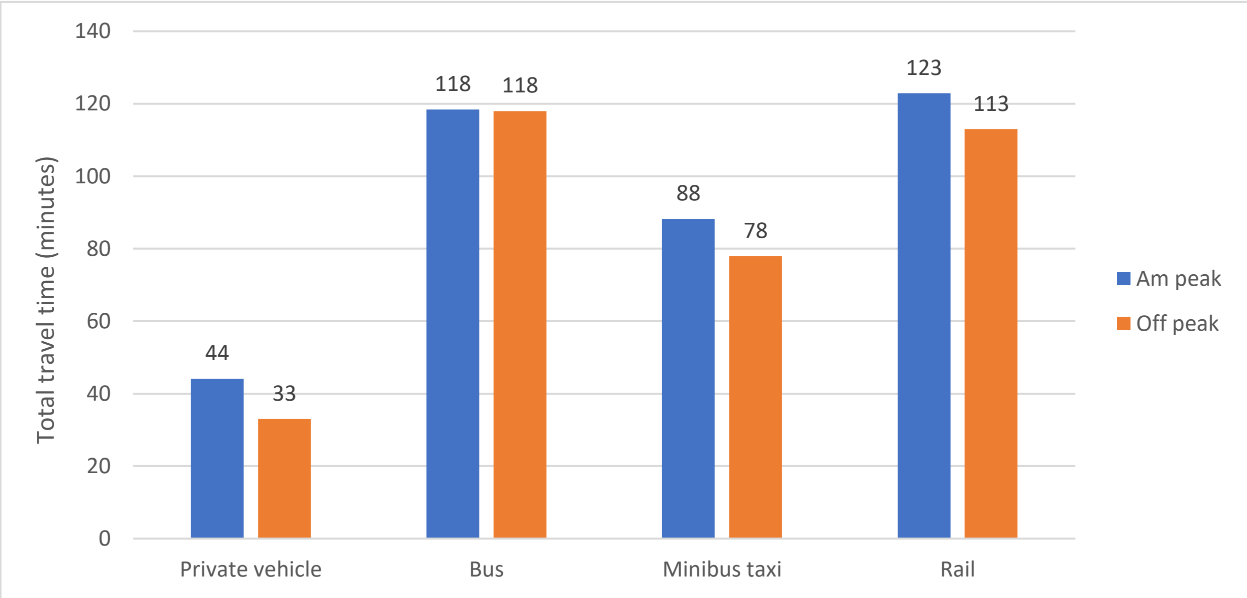


Figure 5.6: Total travel time per mode

Figure 5.6 illustrates the total travel time of each mode, assuming a trip of 20km. Over the assumed distance, private vehicles have the lowest travel time, followed by minibus taxis, busses, and finally rail. Rail services have the longest total travel time, at close to three times the duration of private vehicle users. The 2020 NHTS confirms these outcomes by mentioning that commuters using rail services have the longest travel time of 107 minutes per journey, followed by bus users with 84 minutes, and minibus taxis with 63 minutes (Statistics South Africa, 2020b).

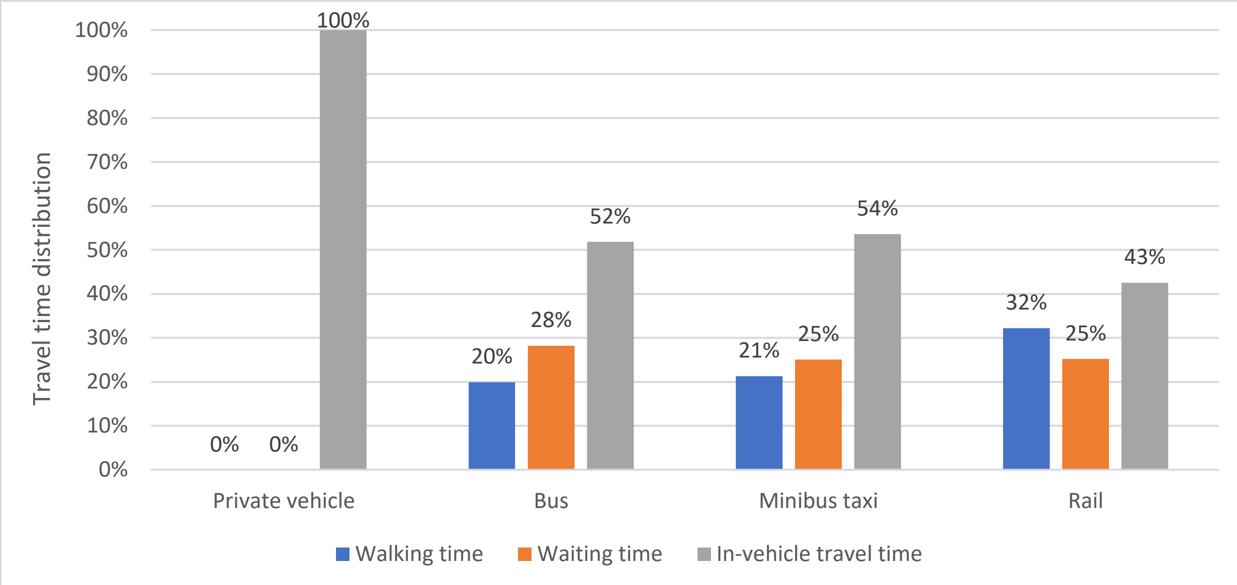


Figure 5.7: Components of travel time per mode

Figure 5.7 illustrates the proportion of each time component with regard to total travel time, and indicates that the main competitive edge of private vehicles is zero walking and waiting time. Rail transport, on the other hand, has a total waiting and walking time of 71 minutes per journey, which equates to 1.3 times that of its in-vehicle travel time.

5.2.2 Value of time

According to the 2011 census, the average income of an individual living in the study area was R186 092 per annum (Statistics South Africa, 2011). To illustrate 2019 values, this income has been adjusted for inflation - which indicates that the average income of an individual is R281 675 per annum. If the assumption is made that all working individuals in the study area work eight hours per day and 22 days per month, the time value of an hour for each individual is equal to R133.

5.3 Accident costs

Accident costs are the third and final component of RUC, and are classified as all costs associated with an incident in transit. According to the Road Traffic Management Corporation (RTMC), road incidents are categorised into human casualty costs, vehicle costs and incident costs (RTMC, 2015). Human casualty costs take into consideration all costs associated with death, permanent damage to the body, loss of productivity, pain and suffering, medical treatment, funerals and workplace reoccupation. In 2015 the total human casualty costs were R99 billion and accounted for 69.3% of accident costs (RTMC, 2015).

Vehicle costs take into account all costs associated with the damage and repair of vehicles. In 2015 these costs accounted for 14.9% of total accident costs, which equates to R21.3 billion (RTMC, 2015).

Incident costs take into consideration other costs associated with accidents, such as emergency response units, legal services, infrastructure damage and impacts on congestion. These costs accounted for 15.8% of South African costs of road accidents in 2015, with a total of R22.6 billion. In 2015, a total of 832 431 road accidents accounted for R142.9 billion in costs (RTMC, 2015).

Rail related accidents are recorded by the Railway Safety Regulator (RSR) of South Africa and annually reported on in the State of Safety report. Railway accidents/incidents consist of two main categories, namely operational incidents and security-related incidents. Operation incidents include occurrences such as train collisions, derailments, level crossings, people struck by trains and platform-train interchange (PTI), while security-related incidents include incidents such as theft, vandalism and threats to the safety of commuters. In 2019/20, PRASA reported a total of 1356 operational incidents, of which the main contributors were people being hit by trains (327 incidents) and PTIs (456 incidents). Even though PRASA has contributed to 322% fewer train km than in 2010/11, train collisions have increased by 19% (RSR, 2020).

A total of 4658 security-related incidents were recorded in 2019/20, of which theft of assets (2906 incidents), vandalism (985 incidents), and personal safety on trains (382 incidents) had the majority share (RSR, 2020). Security-related incidents accounted for 77% of incidents recorded by PRASA.

5.3.1 Accident costs per mode

Specific accident costs relating to the study area do not exist. Therefore, accident costs per mode for the Western Cape have been used in the analysis and assumed equal to the study area. According to a study conducted by Vanderchuren and Roux, the total road accident costs for the Western Cape amounted to R14.5 billion in 2017 (Vanderschuren and Roux, 2017). Adjusted for inflation, the total cost of crashes in 2019 amounted to R15.8 billion.

Specific data regarding the cost of crashes per road-based mode does not exist, but data regarding fatal crashes per mode does. 49.9% of fatal crashes in the Western Cape are caused by private vehicles, while 11.2% are caused by public transport vehicles (Vanderschuren and Roux, 2017). According to Arrive Alive, three out of 36 individuals who lose their lives in road accidents per day, are in minibus taxis (Arrive Alive, 2021b). Minibus taxis, therefore, contribute to 8.3% of fatal crashes, which means that fatalities from bus services contribute to 2.9% of fatal crashes (11.2% - 8.3%).

If the assumption is made that the portion of fatal crashes per mode is equal to that of the total incidents, the contribution of each mode to the total cost of crashes of the Western Cape can be calculated. As per Table 5.11, private vehicles contribute to the largest portion of accident costs, with a total of R7.8 billion per annum, followed by minibus taxis and bus transport at R1.3 billion and R452 million respectively.

	Cost of crashes	Registered vehicles	Average distance covered	Cost of crashes per km
Minibus taxi	R 1 314 731 917	38039	76000	R 0,45
Bus	R 452 267 779	7267	65000	R 0,96
Private vehicle	R 7 793 730 802	1306988	16630	R 0,36

Table 5.11: Accident cost per mode-km – Western Cape

Table 5.11 indicates the number of registered vehicles per mode and the average travel distance per vehicle. The number of registered vehicles for 2019 was obtained through the National Traffic Information System (NaTIS) and the RTMC, while the average travel distance was assumed to be equal to that used in the VOC calculations (NaTIS, 2019). By dividing the cost of crashes of each mode with the number of registered vehicles, and the average distance covered per year, the costs of crashes per mode can be calculated for each km driven. Table 5.11 shows that private vehicles have the lowest per km accident cost (R0.36), and bus transport has the highest per km accident cost (R0.96).

The latest available data regarding rail-related incidents and accident costs are from the 2017 State of Safety report. The report states that the Cape Town PRASA district had an incident cost of R1008 per 1000 passenger journeys in 2017 (RSR, 2017). Adjusted for inflation, the total incident cost per 1000 journeys in 2019 would be R1097.

In 2019, the Southern line had a total of 10 184 927 passenger journeys. The total incident costs are therefore the total journeys (1000s) times the incident cost per 1000 journeys, which equate to R10.2 million per annum. By dividing the total costs of incidents on the Southern line by the total distance covered on the Southern line in 2019 (651 268km), the accident cost per km is calculated to be R15.80.

5.3.2 Accident costs per load factor

Again, it is important to consider the capacity of each mode to reliably compare the accident cost per passenger journey. Figure 5.8 illustrates the accident cost per passenger-km, with variations in load factor. Vehicle capacities are assumed equal to that of the VOC calculations.

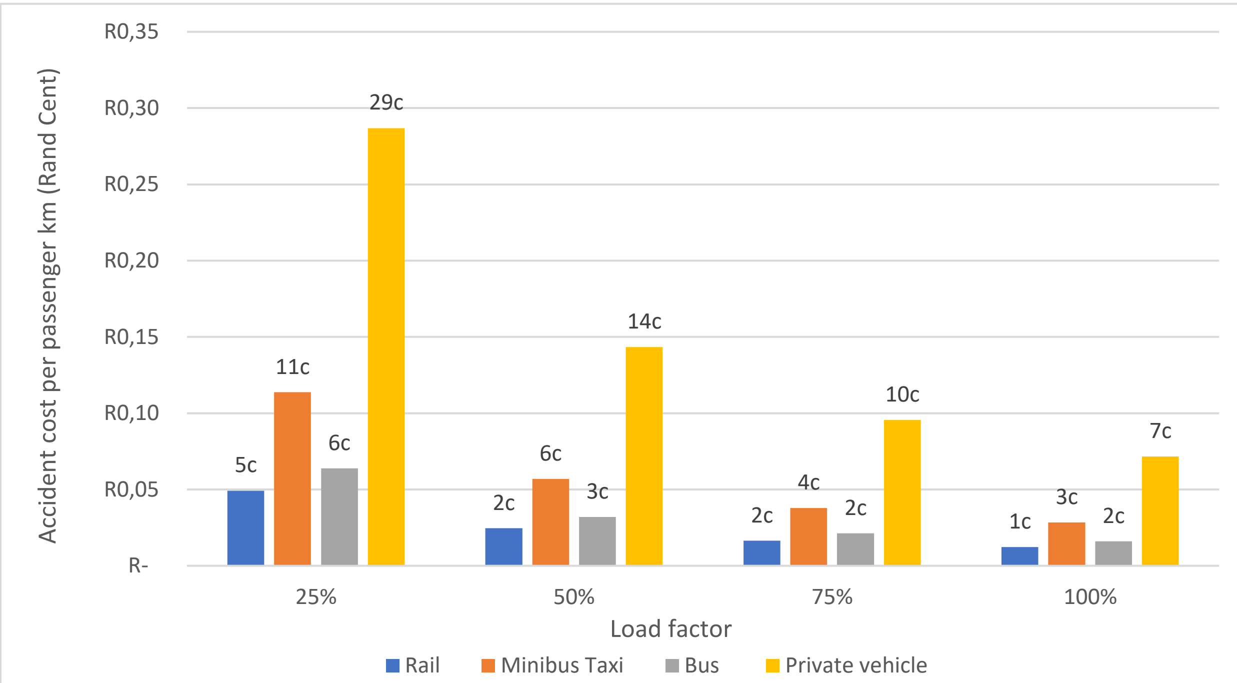


Figure 5.8: Accident cost per passenger-km per load factor

As in the case of the VOC, the proportions of costs stay constant relative to one another as the load factor increases. Figure 5.4 illustrates that private vehicles have the highest passenger-km accident cost, followed by minibus taxis, busses and rail respectively.

5.4 Total economic cost per journey

Now that the VOC, travel time costs, and accident costs per passenger journey for each mode have been calculated, the RUC cost per journey in the study area can be determined. In order to calculate the RUC per journey, the average travel distance of commuters in the study area has to be calculated, and the average load factor per mode needs to be considered.

With regard to the trip distance, the average passenger journey length in 2019 is considered. According to ticket sales data provided by PRASA, the average trip distance on the Southern line was 19.7km in 2019. Google Maps reveals that a 19.7km trip from Cape Town Central by rail reaches Retreat railway station. The same trip undertaken by road-based modes equates to 22km, due to rails designated right of way. Therefore, in the analysis, each railway journey equates to 19.7km, while that of the road-based modes equate to 22km.

According to the ITP, the average private vehicle in Cape Town has a load factor of 25%, or 1.2 persons per vehicle (City of Cape Town, 2018). According to a study conducted on the vehicle occupancy of vehicles in South Africa, the average load factor of minibus taxis and busses are 75% and 65% respectively (European Environment Agency, 2010). And finally, ticket sales data provided by PRASA reveals the load factor of the Southern line to be 27% (PRASA, 2019c).

5.4.1 VOC per journey

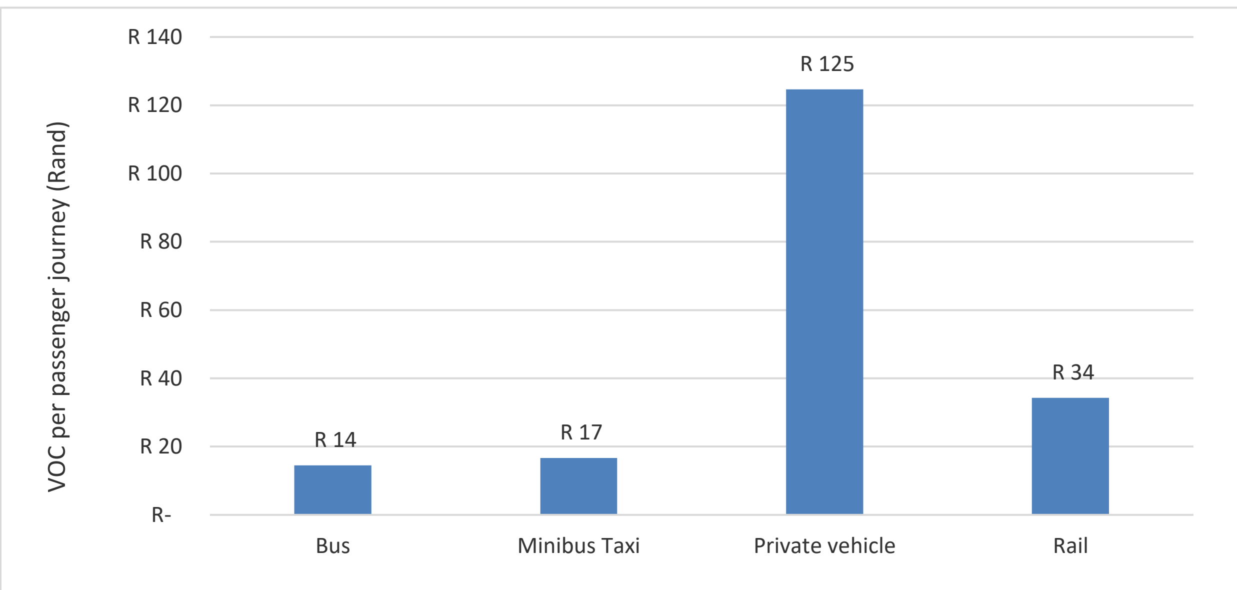


Figure 5.9: VOC per journey

Figure 5.9 illustrates the VOC per passenger journey over the assumed trip distance and vehicle load factors. Private vehicles have the highest VOC per passenger journey, namely R125. The public transport modes have a considerably lower VOC per passenger journey, due to higher load factors resulting from greater capacities. Bus services have the lowest VOC per passenger, followed by minibus taxis, and then by rail.

5.4.2 Travel time costs per journey

By taking into consideration the average travel time per mode over the assumed trip distance, and multiplying it with the value of time calculated in section 5.2, the travel time cost associated with each mode can be calculated. Figure 5.10 illustrates the time costs of commuting by each mode type.

Private vehicles have the lowest time costs of all the modes. The public transport modes have significantly higher time costs, due to long waiting and walking times. In the am-peak, rail has the highest time cost of R273 per journey, followed by bus services with R263. Minibus taxis have a lower travel time cost of R196 per journey, but is still significantly more than that of private vehicles.

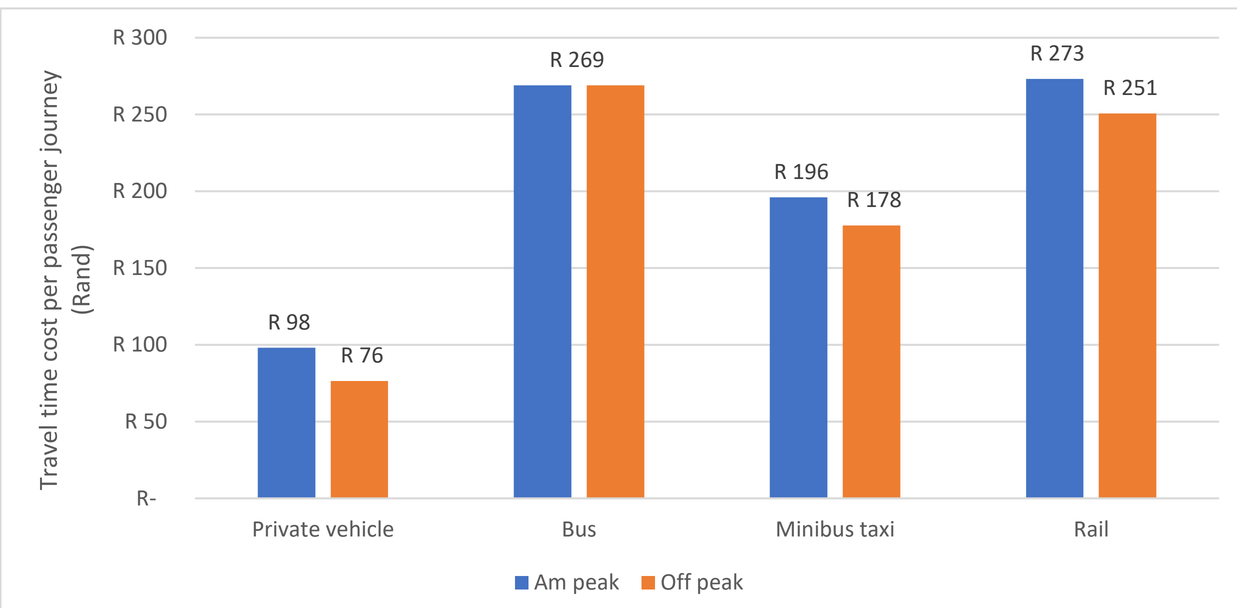


Figure 5.10: Travel time cost per journey

Generally, the income of private vehicle users is higher than that of public transport users. Therefore, in practice, it is probable that the travel time costs of private vehicle users would be higher, and that of public transport users would be lower than the indicated amounts. For the purposes of this study, however, the average income of the area was used, due to a lack of income data.

5.4.3 Accident costs per journey

Figure 5.11 illustrates the accident cost per passenger journey over the assumed trip distance. Private vehicles have the highest accident cost per passenger journey, namely R6.31. Accident costs relating to the use of public transport modes are significantly less than that of private vehicles.

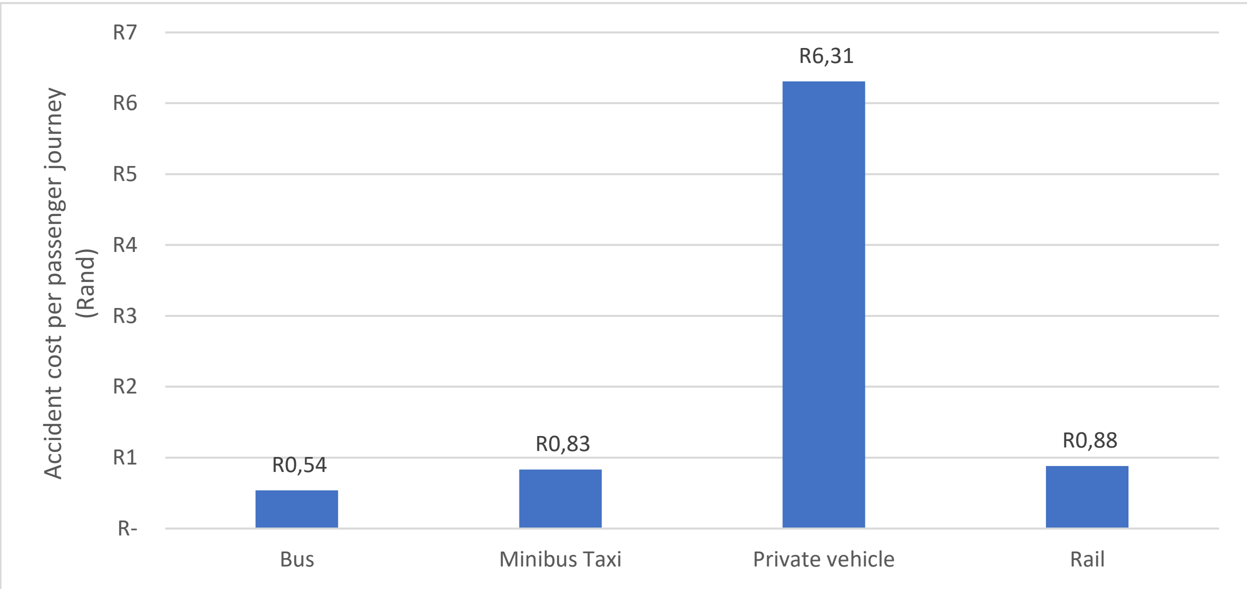


Figure 5.11: Accident cost per journey

5.4.4 Total economic costs per journey

Figure 5.8 illustrates the combined economic costs per passenger journey over the assumed trip distance and load factors. A journey by rail has the largest economic costs, with a total of R308 per passenger journey, and bus journeys have the second-largest economic costs of R278 per passenger journey. Private vehicles have a total economic cost of R229 per passenger journey, and minibus taxis have the lowest economic costs per passenger journey of R214.

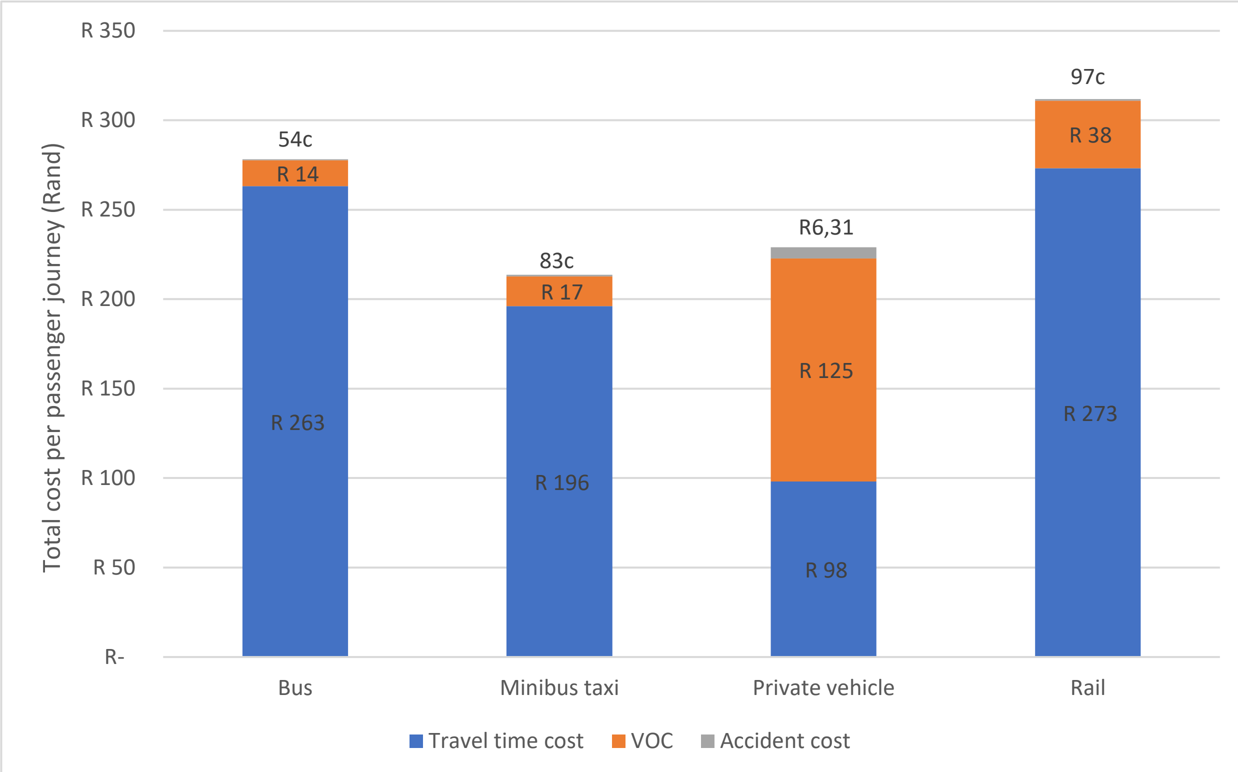


Figure 5.12: Economic costs per passenger journey

Journeys associated with the public transport modes are mainly made up of travel time costs. This is due to the high walking and waiting times associated with the use of public transport in Cape Town. Other variables such as speed restrictions on the railway line also prevent rail from operating at its optimal speed (Hitge and Vanderschuren, 2015). The VOC and accident costs associated with the public transport modes, play a small part in contributing to the total economic cost thereof.

Private vehicles have a much larger VOC than public transport modes. VOC makes up the majority of the economic costs associated with private vehicle use, since the time costs thereof are relatively small. Even though the VOC and accident costs of private vehicles are significantly higher than that of the other modes, 77% of the market still prefers to use private vehicles due to its lower travel time.

5.5 Evaluation alternatives – Economic analysis

Now that the economic costs per trip have been calculated, the cost implications of each evaluation alternative can be considered. The economic costs of bus, minibus taxis, and private vehicles per passenger journey will be held constant, as no changes in the load factor of these modes are assumed. For rail transport, however, the VOC and accident costs per passenger journey will decrease as the load factor increases.

In addition to the three evaluation alternatives, further assumptions can be made regarding the distribution of modal shifts. Since only 15% inhabitants of the study area make use of bus and minibus taxi services collectively, the analysis assumes that all increases in rail journeys originate from private vehicle users. The economic analysis thus assumes that the market share of minibus taxis and busses will stay constant at 12% and 3% respectively, while that of private vehicles will decrease as rail use increases. The cost implications of these shifts from private vehicles to rail transport over the 20-year period will be calculated by subtracting the economic costs of rail and private vehicles from one another and discounting it back to present values.

5.5.1 A0 – Do nothing

In the base alternative, the current (2019) operating conditions are assumed to stay constant over the 20-year analysis period. Figure 5.13 indicates the growth in passenger journeys of rail and private vehicles over the 20-year analysis period in Alternative 0. The market share of all modes are assumed to stay constant to that of 2019. Thus, the growth indicated in Figure 5.13 is due to the traffic and population growth in the area.

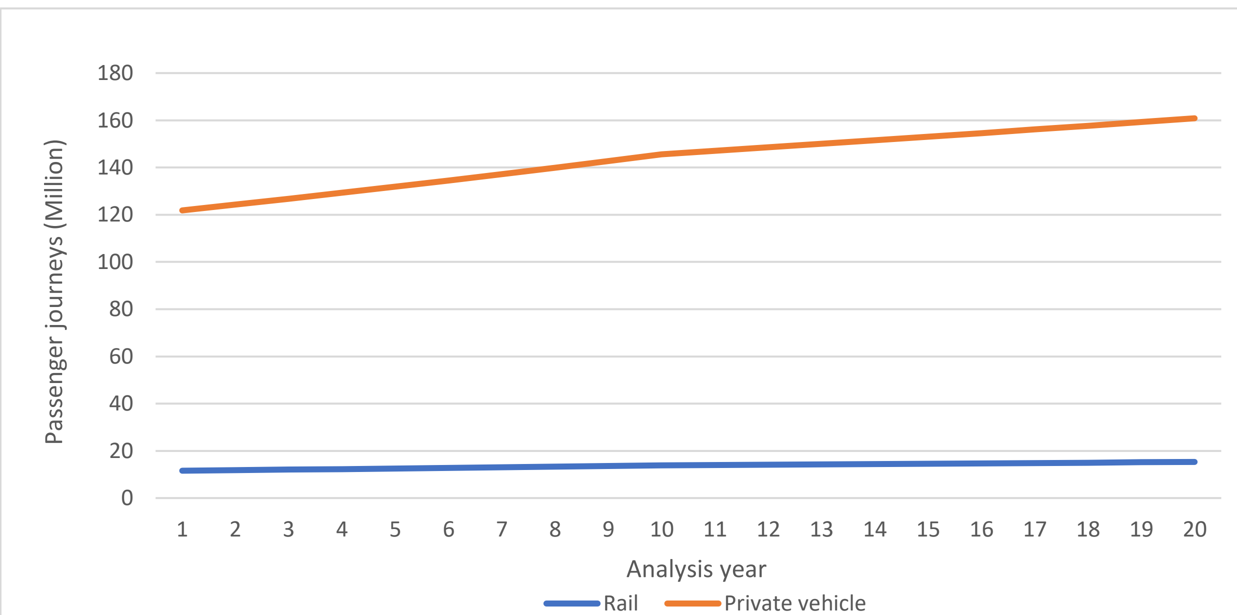


Figure 5.13: Passenger journeys growth per mode (Alternative 0)

The purpose of this alternative is to obtain a baseline to compare the results of other alternatives. The economic costs of private vehicle journeys stay constant at R229 per journey, as calculated in section 5.4. The economic costs of rail journeys start at R308 per journey and decrease as load factors increase, due to the economies of scale factors associated with VOC and accident costs. In year 20 of the analysis, the economic costs of a rail journey are estimated to be R299, assuming that the load factor is 37%.

Over the 20-year analysis period, the total discounted economic costs of private vehicles amount to R400.5 billion, and the discounted economic costs of rail amount to R50.3 billion. Therefore, the sum of the discounted economic costs of private vehicle and rail journeys amount to R450.9 billion.

5.5.2 A1 - 80% Utilisation at year-12

Alternative 1 assumes the load factor of the Southern line to increase to 80% in year 12 of the analysis and to stay at 80% until year 20. Figure 5.14 indicates the growth of private vehicles and rail journeys over the 20-year analysis period of Alternative 1.

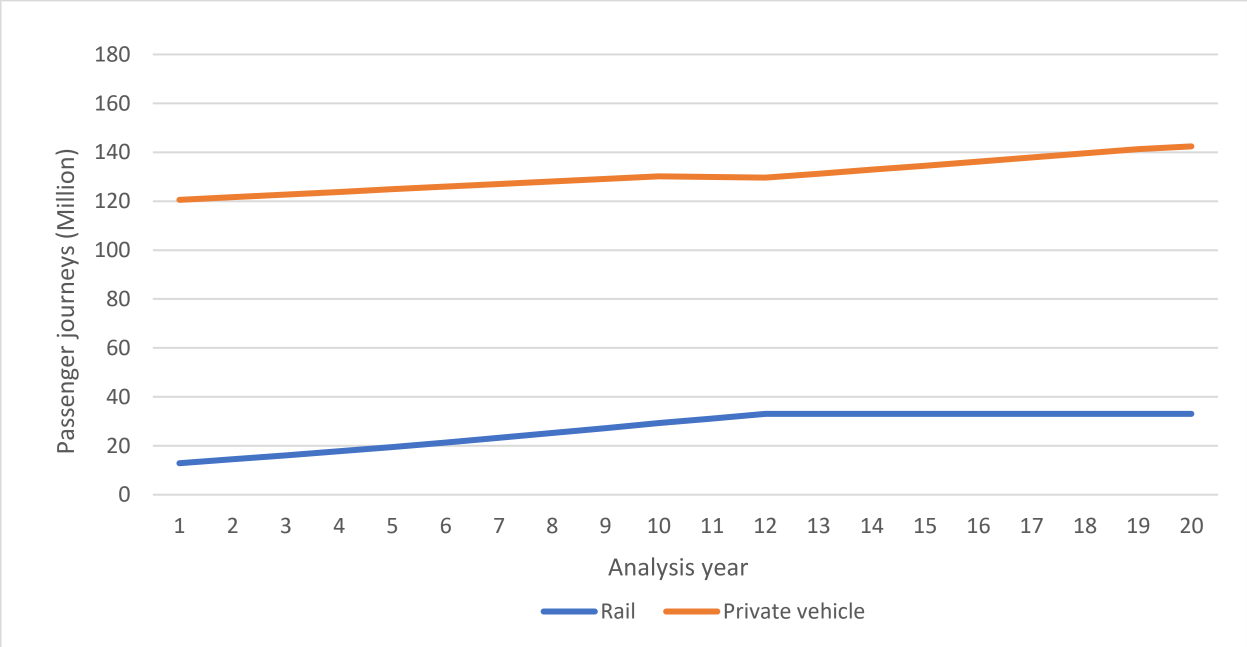


Figure 5.14: Passenger journeys growth per mode (Alternative 1)

In comparison to the base alternative, rail journeys are seen to increase fast until year 12, after which it stays constant until year 20. Private vehicle journeys grow slower, due to greater shifts to rail use, and reach a maximum of 140 million in year 20, compared to 160 million in the base alternative.

The same economic costs concerning rail and private vehicle use apply to this alternative. The economic costs of rail journeys start at R308 per journey in the base year, and decline to R299 in year 20, assuming that the load factor is 80%. Since increases in load factors only decrease VOC and accident costs per journey, the economic costs per journey do not differ significantly from the base alternative.

The total discounted economic costs of private vehicle and rail use amount to R 367.5 billion, and R461.1 billion, respectively, over the 20-year period. The sum of the total discounted economic costs of rail and private vehicles amounts to R461.1 billion, which indicates an increase of R10.2 billion in comparison to the base alternative. This is due to the economic costs of rail journeys exceeding the economic costs of private vehicle journeys.

5.5.3 A2 - 50% Utilisation at year-10

Alternative 2 assumes that rail usage will increase until it reaches 50% load factor in year 10 of the analysis, after which the load factor stays constant at 50% until year 20. Figure 5.15 indicates the growth of private vehicle and rail journeys over the 20-year analysis period of Alternative 2.

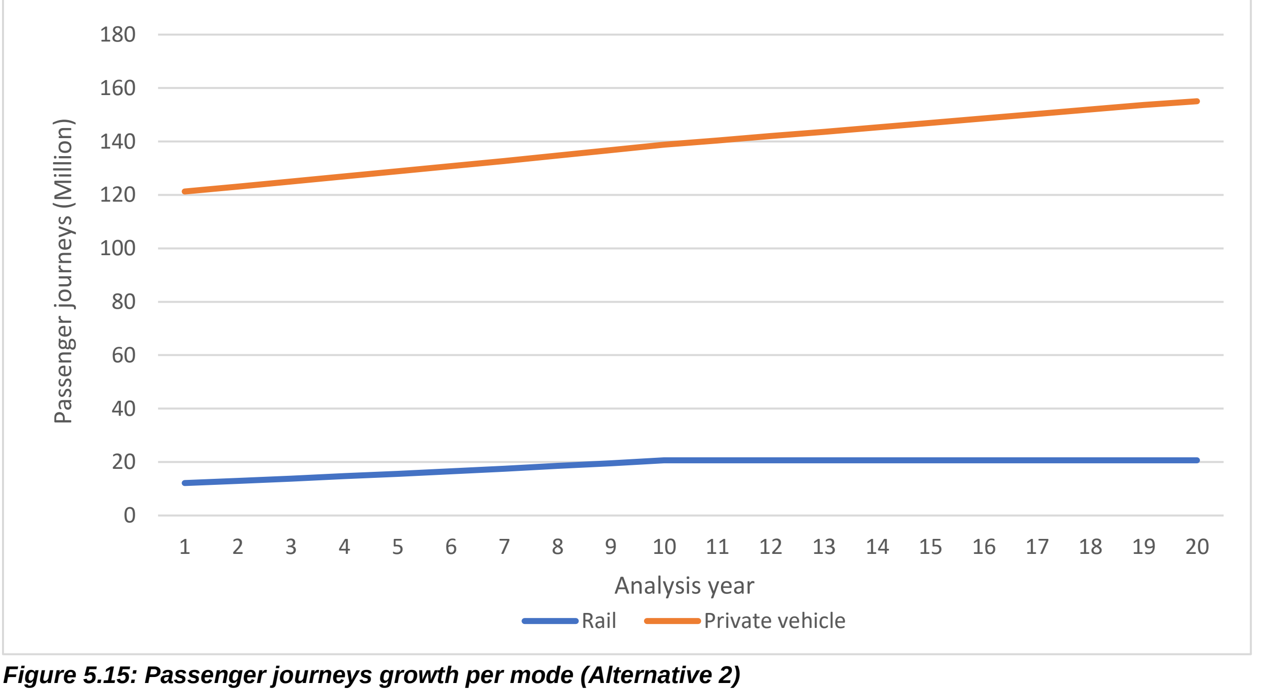


Figure 5.15: Passenger journeys growth per mode (Alternative 2)

As suggested, rail journeys increase in the first 10 years of the analysis, after which it stagnates in growth until year 20. Private vehicles have a more constant growth rate than in Alternative 1, due to fewer commuters shifting to rail transport. Again, the economic costs of private vehicles are considered as R229 per journey. Rail journeys start with an economic cost of R308 per journey, and decrease to R299 per journey in year 20, assuming the load factor increases to 50%.

The total discounted economic costs of private vehicle and rail use amount to R388.1 billion, and R66.6 billion, respectively. The sum of the discounted economic costs of private vehicles and rail amount to R454.7 billion, which indicates a total increase of R3.8 billion in comparison to A0.

5.6 Conclusion

After investigating the RUC (VOC, accident costs and travel time cost) of each mode of transport over an assumed trip distance and load factors, the analysis indicates that minibus taxis have the lowest economic cost per passenger journey, followed by private vehicles, busses, and lastly by rail.

The analysis found that the majority of the economic costs per passenger journey were attributable to travel time costs, which were especially prevalent under the public transport modes, due to high access-stage and line haul travel times. Private vehicles, in contrary, were found to have much lower travel time costs, but a significantly higher VOC. Nevertheless, even with high VOCs, private vehicles are less expensive than rail and bus services, due to faster travel times. The relatively high-income levels in this area suggest that individuals would rather pay a bigger “out-of-pocket” fee for the use of private vehicles and save on travel time. Furthermore, accident costs seem to contribute to a relatively small portion of the economic costs per journey, especially under public transport modes.

Since a significant portion of the transport market in the study area is made up of private vehicle users, the evaluation alternative assumes that all increases in rail journeys originate from private vehicles users. Since rail journeys have the highest economic cost of the four transport modes, each alternative found that increased rail use would increase the economic costs of transport in the study area over the 20-year analysis. More specifically, Alternative 1 indicated an increase of R10.2 billion over the base alternative, and Alternative 2 indicated an increase of R3.8 billion over the base alternative. Therefore, the conclusion can be made that, under current operating conditions, rail services are not economically viable, and significant improvements would have to be made regarding travel times in order for rail services to become economically competitive against private vehicles.

Chapter 6 - Sensitivity analysis

The financial and economic analysis indicated that the Southern line is not financially or economically viable. Financially, the annual costs of the Southern line far outweigh that of the revenue generated, and economically, the Southern line was found to have the highest economic cost per passenger journey of all the modes investigated.

The purpose of the sensitivity analysis is to test how robust the outcomes of the financial and economic analysis are, with changes in given variables (Belli and Tan, 1998). The changes in variables are depicted as scenarios of which the NPV are compared to the preliminary outcomes[11], to determine the effects thereof on the financial and economic feasibility outcomes. For the purposes of this study, the scenarios are based on the changes in operating performance given private sector participation. The sensitivity analysis will determine both the robustness of the preliminary outcomes and the possible financial and economic feasibility of the Southern line, given private sector participation.

6.1 Discount rate sensitivity

The discount rate represents the time value of resources and is therefore vital to be tested with variations, as the future value of resources are unpredictable (Belli and Tan, 1998). To account for possible variations in the time value of resources, the discount rate sensitivity considers three discount rates. The primary analysis uses a discount rate of 5%, therefore a lower discount rate (2%) and a higher discount rate (8%) are considered for each alternative. If the outcomes of the alternative discount rates are similar to that of the preliminary outcomes, the results are classified as robust.

Discount rate	A0		A1		A2	
2%	-R	7 232 981 714	-R	7 844 643 448	-R	7 458 644 183
5%	-R	5 505 587 009	-R	5 935 789 657	-R	5 667 374 645
8%	-R	4 332 303 184	-R	4 643 761 513	-R	4 451 615 664

Table 6.1: Financial discount rate sensitivity

Table 6.1 indicates the NPV of the base alternative (A0), Alternative 1 (A1), and Alternative 2 (A2) in the financial analysis, with variations in the discount rates. The outcomes indicate that each alternative concludes with a financial deficit, regardless of the discount rate used. When the discount rate decreases, the subsidy requirements (financial loss) increase, and vice versa. Since

[11] The financial and economic feasibility outcomes from Chapters 4 and 5.

these results correspond to that of the primary analysis, the outcomes of the financial analysis can be classified as robust.

Discount rate	A0	A1	A2
2%	R 599 887 618 139	R 614 412 387 025	R 605 226 659 849
5%	R 450 922 582 043	R 461 191 998 378	R 454 776 581 786
8%	R 350 611 454 286	R 358 083 967 888	R 353 471 485 408

Table 6.2: Economic discount rate sensitivity

Table 6.2 indicates the total discounted economic cost of transport in each alternative, with variations in the discount rates. Within each discount rate considered, A0 has a lower economic cost than that of A1 or A2, which confirms the outcomes of the primary economic evaluation, and can therefore be regarded as robust.

6.2 Financial sensitivity

Chapter 4 indicated that three main elements are currently causing the Southern line to be financially infeasible. These elements include low utilisation, low revenue levels and high operating costs. According to the literature review, historic implementations of private sector participation have commonly lead to increased utilisation, increased revenue and reduced costs of passenger railway networks. The following section will investigate the possible implications of private sector participation on the financial feasibility of the Southern line.

Private sector participation commonly leads to increases in the revenue levels of passenger rail services through increased ticket prices, increased auxiliary revenue, and reduced fare evasion. Therefore, the following variables are altered to simulate the feasibility of the Southern line, given private sector participation:

- Ticket prices on the Southern line increase by 71%, in real terms, in order to cover marginal variable cost.
- Auxiliary revenue increases from R1.3 million per annum to R10 million per annum, based on the ability of the private firm to exploit revenues from station facilities such as the shop rentals, and from train services such as Wi-Fi and on-board shops.
- Fare evasion is reduced by 30% by improving surveillance and passenger control infrastructure.

Along with increasing revenue levels, the literature suggests that private sector participation leads to reductions in operating costs. More specifically, the case studies have revealed that drastic cuts in personnel costs are a common occurrence under passenger rail privatisation. Given that personnel costs currently account for the majority of expenditure on the Southern line, the financial sensitivity assumes that personnel costs are reduced by 50% from year one of the analysis.

Scenario	Variable	Change
1	Ticket prices	71%
2	Auxiliary revenue	R10 000 000
3	Fare evasion	-30%
4	Personnel cost	-50%
5	All	-

Table 6.3: Financial sensitivity scenarios

Table 6.3 shows the changes in variables that are assumed with private sector participation, as discussed above. Each variable change is assigned to a scenario in which that change is applied to the financial analysis. For example, in Scenario 3 the assumption that fare evasion is reduced by 30% is applied to the model, after which the NPV is recalculated and indicated for each alternative. Scenario 5 is labelled as "All" and includes all the variable changes from Scenarios 1 – 4. Scenario 5 thus demonstrates the overall effect of private sector participation on the financial feasibility of the Southern line.

		Scenario				
Alternative	Preliminary results	S1 (Ticket prices)	S2 (Auxiliary revenue)	S3 (Fare evasion)	S4 (Personnel cost)	S5 (All)
A0	-R 5 505 587 009	-	-	-	-	-
A1	-R 5 935 789 659	-R 5 010 616 911	-R 5 811 167 556	-R 5 544 871 597	-R 4 349 280 613	-R 2 593 629 242
A2	-R 5 667 374 647	-R 5 009 719 315	-R 5 542 752 544	-R 5 389 492 112	-R 4 080 865 601	-R 2 786 022 399

Table 6.4: NPV of financial sensitivity scenarios

Table 6.4 illustrates the NPV of A0, A1 and A2 in each scenario. To recall from Chapter 4, the NPV of each alternative is negative due to the annual costs outweighing the annual revenue of the service.

S1 to S5 depict the NPVs of each alternative, given the specific change in the variable indicated in Table 6.3. In comparing the NPV of each scenario with the preliminary results of that alternative, the following conclusions have been reached:

- By increasing the ticket prices, the NPV of A1 and A2 increase by approximately R925 million and R658 million respectively.
- Increases in auxiliary revenue increase the NPV of A1 and A2 by R124 million.

- Reductions in fare evasion increase the NPV of A1 and A2 by R391 million and R278 million respectively.
- Reductions in personnel costs have an especially large impact on the NPV of both alternatives. Reductions in personnel costs increase the NPV of both A1 and A2 by R1.5 billion.
- Finally, if all these variable changes are grouped together, Scenario 5 indicates that the NPV of A1 and A2 increase by R3.3 billion and R2.8 billion respectively.

Overall, the results of the financial sensitivity analysis indicate that the Southern line would still be financially infeasible under private control. However, the results also indicate that, from private sector participation, the financial deficit of the Southern line decreases significantly compared to the base alternative (A0). If the outcomes of Scenario 5 are compared to the preliminary outcomes of A0, a total savings of up to R2.9 billion is realised over the 20-year analysis period. Therefore, the conclusion can be made that private sector participation would not make the Southern line financially feasible, but it would reduce its subsidy requirements significantly over the analysis period.

6.3 Economic sensitivity

Chapter 5 indicated that rail transport had the highest economic cost of all modes investigated in the study area, with travel time contributing to the largest portion of economic cost. As in the financial sensitivity investigation, the economic costs of transport will be reinvestigated, taking into account different scenarios. The first scenario assumes improvements in operating standards of the Southern line, brought about by private participation. The improvements in operating standards reduce the travel time associated with rail use. The second scenario does not take into account travel time costs and accident costs per journey, in order to reflect the "out-of-pocket" costs of commuting. This scenario will determine the effects of increased rail use on the disposable income of commuters. Table 6.5 illustrates the two scenarios, as well as the changes associated with each.

Scenario	Variable	Change
1	Rail - Travel time	Reduced waiting time
		Increased vehicle speed
2	Out-of-pocket costs	No travel time cost
		No accident cost

Table 6.5: Economic sensitivity scenarios

Currently, the operating standards of the Southern line are not optimal. The average waiting time for a train in Cape Town is 31 minutes, and the average vehicle speed of rail (22.6km/h) is slower than that of a private vehicle (30km/h). Scenario 1 assumes that private participation will lead to improvements in waiting times and in-vehicle travel times of trains. More specifically, the waiting time for a train is assumed to decrease to 10 minutes, and the average travel speed of trains is assumed to increase to 40km/h. These assumptions are based on the ability of the private firm to increase the frequency of trains and improve the infrastructure that is currently causing slow travel speeds (signalling systems and track). In fact, within passenger rail concession policies, a minimum supply of trains is usually stipulated by the government in the process of negotiations. This was the case in Japan and Argentina, and lead to significant increases in operating standards and customer satisfaction (Thompson and Kopicki, 1995).

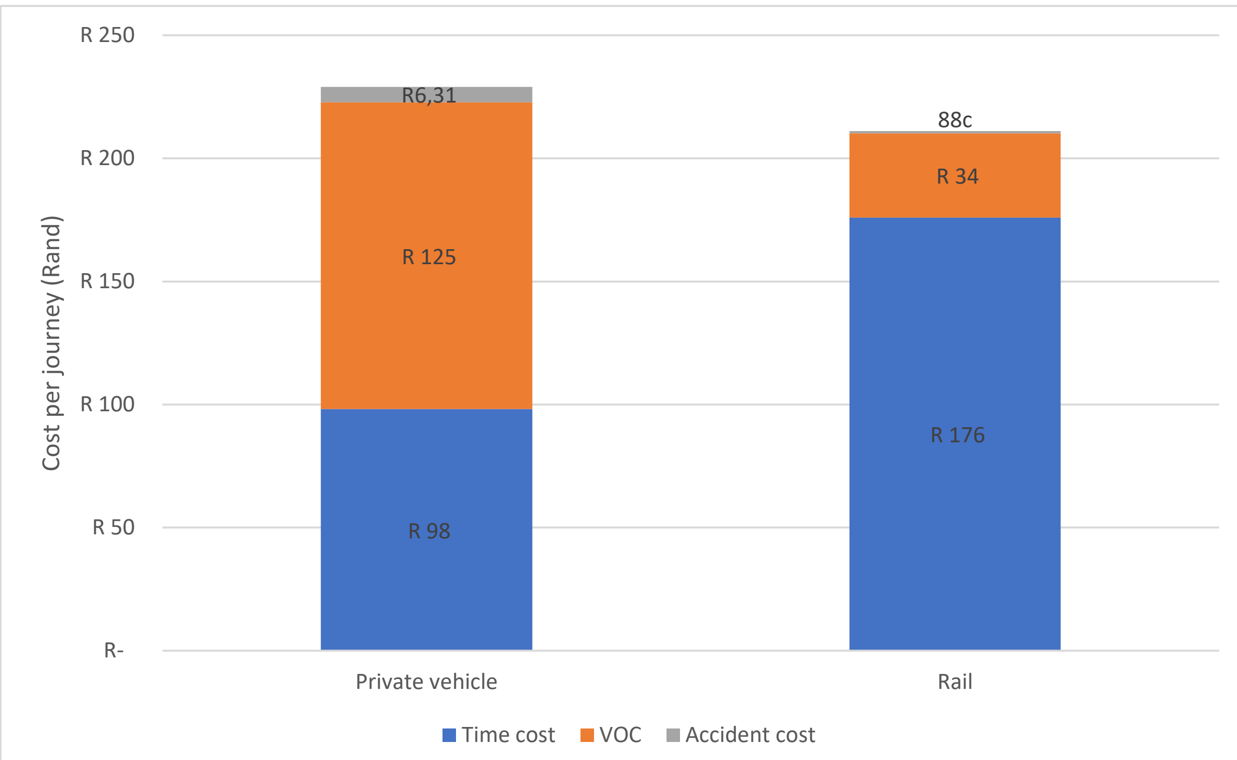


Figure 6.1: Adjusted economic cost per passenger journey

Figure 6.1 shows the economic cost per passenger journey for private vehicles and rail in the Southern Suburbs, with the additional assumptions regarding operating standards. Due to the improvements in operating standards, rail's travel time costs reduce from R273 to R176 per journey. Even though rail still has a higher travel time cost, the high VOC of private vehicles causes it to have a higher economic cost per journey than rail. Overall, the cost of a railway journey amounts to R211, while that of a private vehicle amounts to R229.

In calculating the out-of-pocket costs of commuting, only the VOC of each journey is considered. Therefore, the out-of-pocket costs associated with a private vehicle and a rail journey amount to R125 and R34 respectively. It is important to mention that the VOC per passenger journey of rail decreases as the load factor increases, while that of private vehicles stays relatively constant due to limited capacity.

		Scenario	
Alternative	**Preliminary results**	**S1 (Rail - Travel time)**	**S2 (Out-of-pocket costs)**
A0	**R 450 922 582 043**	**-**	**R 222 775 296 912**
A1	R 461 249 652 631	R 431 130 928 144	R 205 439 672 690
A2	R 454 817 565 080	R 433 407 790 747	R 216 652 717 052

Table 6.6: NPV of economic sensitivity scenarios

Table 6.6 indicates the discounted economic costs of travel (for private vehicles and rail) over the 20-year analysis period for A0, A1 and A2. The preliminary results incorporate no changes in variables, while each scenario's results incorporate the specific changes in variables, mentioned in Table 6.5.

The preliminary results show that increased rail usage leads to increased total economic costs, due to the economic costs of a railway journey being greater than that of a private vehicle. In Table 6.6 the preliminary results of A0 are lower than that of A1 and A2, indicating that increased rail use leads to increased economic costs.

When considering Scenario 1 (improvements in travel time of rail), the results indicate that both A1 and A2 have smaller discounted economic costs in comparison to the preliminary results of A0. This is due to the economic costs of a rail journey being lower than that of a private vehicle journey, under improved operating standards, and indicates that rail becomes economically feasible under these conditions. In A1 and A2 a total saving in economic costs of R30 billion and R21 billion respectively is accounted for over the 20-year analysis period.

Scenario 2 indicates the NPV of the sum of direct costs (out of pocket costs) associated with rail and private vehicle journeys over the 20-year analysis period. The out of pocket costs of A0 amount to R222.7 billion, while that of A1 and A2 amount to R205.4 billion and R216.6 billion. The outcomes show that total discounted direct costs decline as rail use increases. This is due to the VOC of rail journeys being less than that of private vehicle journeys. Under increased rail use A1 and A2 hold savings of R22 billion and R6 billion in disposable income, in comparison to the base alternative.

6.4 Conclusion

In considering the variations in discount rates, the outcomes of both the financial and economic analyses have been found to correspond with the preliminary outcomes in Chapters 4 and 5, signifying that the results are robust.

The financial sensitivity considered five scenarios, each reflecting possible changes in operations brought about by private sector participation. The results indicate that the Southern line will still be financially infeasible under private control. Even though the Southern line would still rely heavily on government subsidisation, the results indicate that the subsidy requirements are significantly lower under private control than in the base alternative. The results indicate that, under private control, subsidy requirements would decrease by approximately R2 billion over the 20-year analysis period. From a government perspective, it is thus financially feasible to propose private sector participation, and from a private perspective it could also be feasible given the right amount of subsidisation is received.

The economic sensitivity considered two scenarios, of which one tested the economic feasibility of rail with improved operating standards, and the other testing the effects of increased rail use on the disposable income of commuters. The results indicate that the economic costs per rail journey decrease below that of private vehicles, given that waiting times and train speeds improve. Therefore, given the improvements in operating standards, the Southern line becomes economically feasible and leads to savings of approximately R30 billion and R21 billion in A1 and A2 respectively. In considering the effect of increased rail use on the disposable income of commuters, the results indicate that significant savings could arise due to the VOC of private vehicle journeys being significantly larger than that of rail journeys. Savings in disposable income of R22 billion and R6 billion are accounted for in A1 and A2. From an economic perspective, it is therefore feasible to propose private sector participation, as it leads to both the economic feasibility of the service and the significant savings in the disposable income of commuters.

Chapter 7 - Conclusion

7.1 Conclusions and recommendations

This dissertation investigated the financial and economic feasibility of the South African passenger railway service, in order to determine the feasibility of private sector participation as a method of passenger railway reform in South Africa. The Cape Town Southern line was appointed as a case study, after which the conclusion was reached that the service is financially and economically not feasible. Under private sector participation, however, the service was found to be economically viable, and financially more sustainable than under national control.

The literature review revealed that cooperation between private and public entities has been present in the South African railway industry since its establishment in the mid-1860s. Private firms played an important role in the initiation and construction of railway lines, while the public sector was involved in expanding and connecting the national railway network. More recently, the South African passenger railway network has been placed under public ownership, and the functionality of the system has deteriorated.

Many countries have gone through the same deteriorating cycle, and have opted for private sector integration as a method of reform. From international experience, private sector integration follows different levels of intensity (from full privatisation to concessionary policies) and different methods of implementation, but are generally found to increase utilisation, improve productivity, and increase the financial sustainability of the railway service. Disadvantages of the reform policy take the shape of reduced employment, increased ticket prices, and continual reliance on government subsidisation. Even though government subsidisation is regularly required under private control, the privatised systems are frequently more financially sustainable than the public-operated system due to improvements in service quality and the adoption of commercial focus.

The case study area, i.e. the Cape Town Southern Suburbs, is largely inhabited by a relatively high-income population. Data from the ITP suggests that the majority of the population, 77%, utilise private vehicles for their transport needs, while 15% make use of minibus taxis and busses, and only 7% make use of rail. Since the public transport market in the area is relatively small, the conclusion was reached that rail services would need to compete against private vehicles to increase its utilisation. The origin-destination data for private vehicle journeys suggests a strong flow along the path of the Southern line. Therefore, rail transport can be considered a viable alternative mode of transport for private vehicle users. For private vehicle users to shift to rail use, however, the operating standards of the service would have to increase drastically.

Through investigating the financial feasibility of the Southern line, a general trend of unprofitability was noted. As per Chapter 4, the Southern line incurred a financial deficit of R441 million in 2019. If no reform policies are implemented, the fiscal deficit is estimated to amount to R5.5 billion over the 20-year analysis period. The financial infeasibility of the Southern line is attributable to three main components.

The first component pertains to low load factors. The Southern line had a load factor of 27% in 2019, which equated to a total cost per passenger journey of R45. Due to low utilisation, the Southern line is unable to benefit from economies of scale, and is therefore unable to cover its total costs.

The second factor pertains to low revenue levels. The Southern line is heavily dependent on government subsidisation to cover its costs. Its reliance on subsidisation is due to declining fare revenue levels, inadequate pricing strategies, and the inability of the Southern line to generate secondary sources of income. Fare revenue levels have declined by 74% from 2013 to 2019, while government subsidisation has increased by 114% over the same period. Chapter 4 indicated that the marginal variable cost per journey outweighed the marginal revenue per journey by 71%. Therefore, due to inadequate pricing, the Southern line is unable to recover the entirety of its variable cost, or any of its fixed costs, which lead to increased financial deficits as the utilisation of the service increases. Lastly, auxiliary revenue accounted for an insignificant portion of total revenue throughout the study period, further strengthening the dependence of the Southern line on government subsidisation.

The third factor contributing to the financial infeasibility of the Southern line pertains to high costs. In 2019, six cost elements collectively contributed to 93% of total expenditure, of which personnel costs contributed to 53%. These high costs further limit the ability of the Southern line to cover its fixed and variable costs through its primary sources of income.

Even under the assumption of increased ridership, the Southern line was still found to be financially not feasible. Therefore, the conclusion is made that any private stakeholder, considering involvement in the Southern line, would not only need to focus on increasing the utilisation of the service, but also on increasing revenue levels and reducing costs.

From international experience, the revenue levels of passenger rail services commonly increase under private sector participation, due to increased ticket prices, increased auxiliary revenue, and reduced fare evasion. On the cost side, private sector participation frequently involves extensive reductions in large operating costs, such as personnel costs. To determine the effects of private sector participation on the financial feasibility of the Southern line, these increases in revenues and reductions in costs were integrated into the model, after which the analysis revealed that the service would remain unprofitable under private participation.

Even though government subsidisation would still be required under private sector participation, the subsidy requirements are found to be significantly lower than that of the do-nothing alternative. Thus, the Southern line is not financially feasible and is unlikely to be feasible under a PPP, but in the interest of reducing government subsidies, improving service quality, and increasing utilisation thereof, private sector participation is recommended as a feasible method of railway reform in South Africa.

In contrary to theory regarding the economic cost of different transport modes, Chapter 5 found the Southern line to have the highest economic cost per passenger journey out of all modes investigated. The high cost of rail journeys are mainly attributable to comparatively large travel time costs. In comparison to the economic cost of private vehicles, rail journeys were noted to have lower VOC and accident costs, but had a significantly larger travel time cost due to long access, and line haul stages travel times. Overall, the total economic costs of a private vehicle journey (R229) were less than that of a rail journey (R308), which indicate that the total economic cost of travel would ultimately increase if the utilisation of rail were to increase. Under current conditions, therefore, the Southern line was classified as economically not feasible.

International experience suggests that rail operations improve significantly under private management, which leads to increased operating frequency and consequently reduced travel times. The economic sensitivity analysis considers these improvements in the form of reduced waiting times, and reduced in-vehicle travel times associated with rail journeys. The results indicate that the cost of rail journeys decline from R308 per journey to R211 per journey. Under these conditions, the economic cost of rail journeys are lower than that of private vehicles, and results in savings of more than R21 billion over the 20-year analysis period, depending on the degree of growth in rail utilisation. In investigating the effects of increased rail use on the disposable income of commuters, the sensitivity analysis found that commuters would save up to R22 billion over the 20-year analysis period due to the relatively high out-of-pocket cost of private vehicle use. Overall, the results of the study indicate that the Southern line is currently economically not feasible, but by taking into consideration improvements in operating standards brought about by private sector participation, the Southern line is found to be economically feasible. Therefore, from an economic viewpoint, private participation is considered a feasible method of passenger railway reform in South Africa.

Based on the outcomes of the case study analysis, the South African passenger railway service is considered financially and economically not viable under its current operating conditions. With the integration of private sector participation, and the improvements in utilisation, financial management and operating standards that come along with it, the service is found to be economically viable and financially less costly than following no reform policy. Therefore, the study recommends that the integration of private sector participation within passenger railway services in South Africa is feasible, as it leads to reduced government subsidisation, reduced economic cost of travel, and increased disposable income of commuters.

7.2 Limitations and future research

The limitations regarding the case study approach are acknowledged. Each passenger railway line has a unique set of characteristics regarding its market structure and operational conditions. Therefore, the outcomes of the study could differ if another railway line is used as a case study. Future research should be conducted regarding the feasibility of private sector participation on additional passenger railway lines in South Africa, before it is recommended as a policy action in that specific corridor.

The limitations regarding the assumptions that accompany the financial and economic analysis are recognised. Exclusive financial data regarding the Southern line does not exist. Therefore the revenues and costs of the Southern line were derived from district income statements by using line-specific ticket sales data and operating kilometres. In practice, the specific financial values might differ. Since no line-specific income statements exist, future research should be conducted in developing a methodology to obtain line-specific financial information from district network income statements.

No concrete data exists regarding the exact distribution of fixed and variable costs within railway operations. Therefore assumptions were made to distribute these costs. Future research should be conducted regarding the distribution of fixed and variable costs within each cost element in railway operations. Furthermore, data regarding the aspects of RUC, including VOC, travel time and accident costs were calculated by using district averages. Some of these averages, such as the income of the given population, were obtained from the 2011 South African census, and could be considered outdated. Therefore, future research is proposed on collecting and analysing primary data regarding population income, the value of time, accident rates and average vehicle speeds in the given study area.

The outcomes of the study heavily rely on the assumption that private sector participation would lead to increased use of rail service, due to improved service quality. Due to the limited market size of the case study area, private vehicle users are assumed to be willing to shift to rail use, given improved operating standards. In practice, however, this assumption might be unrealistic, since private vehicle users are generally fixed regarding their travel behaviour. Therefore, future research should be conducted on the willingness of private vehicle users to shift to rail use, given improved operating standards.

Finally, the research experienced limitations regarding data collection, due to the start of the global pandemic in March 2020. Before Covid-19, an existing data collection methodology utilising cellphone tracking technology would have been utilised to obtain accurate and sufficient passenger transport data (Krygsman and Nel, 2008). After Covid-19, however, train operations came to a halt and no primary data could be collected. The latest passenger data available came from the 2013 rail census, which was considered the last resort.

References

Arrive Alive (2021a) *Fuel Pricing*. Available at: https://aa.co.za/fuel-pricing/.

Arrive Alive (2021b) *Minibus Taxis and Road Safety*. Available at: https://www.arrivealive.co.za/Minibus-Taxis-and-Road-Safety.

Arrive Alive (2021c) *Vehicle rate calculator*. Available at: https://aa.co.za/vehicle-rates-calculator/.

Asakhe-Consulting-Engineers (2007) '2007 Rail Census Report'. Western Cape, pp. 1–120.

BBC (2021) *France moves to ban short-haul domestic flights*, *BBC NEWS*. Available at: https://www.bbc.com/news/world-europe-56716708.

Belli, P. and Tan, J. (1998) 'Handbook on Economic analysis of Investment Operations'.

Bereskin, C. G. (2012) 'Railroad Economies of Scale, Scope, and Density Revisited', *Journal of the Transportation Research Forum*, 48(2). doi: 10.5399/osu/jtrf.48.2.2261.

Boonzaaier, B. (2008) *Tracks Across the Veld*. 1st edn. JNC Boonzaaier. Available at: https://store.saice.org.za/book-store/tracks-across-the-veld.

Bowman, A. (2015) 'An illusion of success: The consequences of British rail privatisation', *Accounting Forum*. Elsevier Ltd, 39(1), pp. 51–63. doi: 10.1016/j.accfor.2014.10.001.

Bradshaw, B. (1996) 'The Privatization of Railways in Britain', (April), pp. 15–21. Available at: http://www.ejrcf.or.jp/jrtr/jrtr08/pdf/f15_bra.pdf.

Bridgestone (2021) *Taxi & Light Delivery Vehicle Tyres*. Available at: https://www.bridgestone.co.za/products/commercial_tyres/taxi.

Bullock, R. (2005) 'Results of Railway Privatization in Africa', p. Transport Papers TP-8. Available at: https://openknowledge.worldbank.org/handle/10986/17415.

Bullock, R., Greig, D. and Wallis, I. (2005) 'Results of Railway Privatization in Australia and New Zealand', *World Bank*, p. Transport Papers TP-8.

BusinessTech (2020) *New plan to privatise train routes in South Africa*. Available at: https://businesstech.co.za/news/government/441516/new-plan-to-privatise-train-routes-in-south-africa/.

Butkevičius, J. (2007) 'Development of passenger transportation by railroad from Lithuania to European States', *Transport*, 22(2), pp. 73–79. doi: 10.1080/16484142.2007.9638102.

City of Cape Town (2018) 'Comprehensive integrated transport plan 2018 – 2023', *Intergrated Transport Plan*, (December 2018), p. 566. Available at: http://resource.capetown.gov.za/documentcentre/Documents/City strategies, plans and frameworks/Comprehensive Integrated Transport Plan.pdf.

City of Cape Town (2019) *Intergrated transport plan*.

City of Cape Town and TDA (2017) 'City of Cape Town 2017 Municipal Spatial Development Framework'.

Clark, R., Manager, R. P. and Scotland, T. (2010) 'Full circle: rail industry privatisation in New Zealand, and a new theory of its fundamental conceptual weaknesses 1'. Available at: https://ideas.repec.org/p/vuw/vuwcsr/4077.html.

Cooper, E., E. Kenney, J. M. V. and X. Li, (2019) 'Costs and Emissions Appraisal Tool for Transit Buses', (March), pp. 1–22. Available at: www.wri.org/%0Apublication/transit-buses-tool.

Cottrell, M. (2010) 'The first public railway in South Africa: The Point to Durban railway of 1860', *Natalia*, 40, pp. 20–31. Available at: http://natalia.org.za/Files/40/Natalia 40 2010 Railway 150 pp 20-31.pdf.

Dunlop (2021) *High Performance HTRV5*. Available at: https://www.dunloptyres.co.za/Tyre-Range/Passenger/HTRV5?site=dunlop.

European Commission (2014) *Guide to Cost-benefit Analysis of Investment Projects: Economic appraisal tool for Cohesion Policy 2014-2020*, *Publications Office of the European Union*. doi: 10.2776/97516.

European Environment Agency (2010) 'Passenger transport - increase in vehicle occupancy', p. 1. Available at: http://sa2050pathways.environment.gov.za/assets/onepage/za_vehicle_occupancy.pdf.

EWN (2018) *Fare evation a major problem, says Metrorail*. Available at: https://ewn.co.za/2018/05/29/fare-evasion-a-major-problem-says-metrorail.

Forkenbrock, D. J. (2001) 'Comparison of external costs of rail and truck freight transportation', 35. Available at: https://www.researchgate.net/publication/222302046_Comparison_of_external_costs_of_rail_and_truck_freight_transportation.

Gattuso, D. and Restuccia, A. (2014) 'A Tool for Railway Transport Cost Evaluation', *Procedia - Social and Behavioral Sciences*. Elsevier B.V., 111, pp. 549–558. doi: 10.1016/j.sbspro.2014.01.088.

Royal HaskoningDHV, (2013) 'PRASA - 2013 - Metrorail Census'.

Hitge, G. and Vanderschuren, M. (2015) 'Comparison of travel time between private car and public transport in Cape Town', *Journal of the South African Institution of Civil Engineering*, 57(3), pp. 35–43. doi: 10.17159/2309-8775/2015/v57n3a5.

Janse van Rensburg, R. A. J. (1996) 'The History of the Rail Transport Regulatory Environment in South Africa', p. 22. Available at: http://hdl.handle.net/10019.1/85556.

Kachroo, P. and Özbay, K. M. A. (2018) 'Traffic flow theory', *Advances in Industrial Control*, (9783319692296), pp. 57–87. doi: 10.1007/978-3-319-69231-9_3.

Krygsman, S., Dijst, M. and Arentze, T. (2004) 'Multimodal public transport: An analysis of travel time elements and the interconnectivity ratio', *Transport Policy*, 11(3), pp. 265–275. doi: 10.1016/j.tranpol.2003.12.001.

Krygsman, S., de Jong, T. and Verkoren, O. (2013) 'CAPE TOWN AND ITS EMPLOYMENT CENTRES: MONOCENTRIC, POLYCENTRIC OR SOMEWHERE INBETWEEN?', *Society of South African Geographers*, (September), pp. 25–28.

Krygsman, S. and Nel, J. (2008) 'Deriving transport data with cellphones: Methodological lessons from South Africa', *International conference on survey methods in transport*.

Labuschagne, F. *et al.* (2017) 'The cost of crashes in South Africa 2016', 2004 (July), pp. 474–485.

Lingaitis, V. and Sinkevičius, G. (2014) 'Passenger Transport by Railway: Evaluation of Economic and Social Phenomenon', *Procedia - Social and Behavioral Sciences*. Elsevier B.V., 110, pp. 549–559. doi: 10.1016/j.sbspro.2013.12.899.

Lyons, G., Jain, J. and Holley, D. (2007) 'The use of travel time by rail passengers in Great Britain', 41, pp. 107–120. doi: 10.1016/j.tra.2006.05.012.

Martin, B. (2002) 'Railway privatisation through concessions: The origins and effects of the experience in Latin America', *International Transport Workers' Federation*.

Mattson, J. and Ripplinger, D. (2012) 'Marginal cost pricing and subsidy of small urban transit', *Transportation Research Record*, (2274), pp. 77–83. doi: 10.3141/2274-08.

Merven, B. *et al.* (2012) 'Quantifying the energy needs of the transport sector for South Africa : A bottom - up model', (June).

Metrorail (2020) *Metrorail - Fares*. Available at: http://www.metrorail.co.za/Newfares.html.

Mitchell, B. and Budin, K. (1998) 'The Abidjan-Ouagadougou Railway Concession', *Africa Transport Technical Note*, 13, pp. 1–4.

Mizutani, F. (1997) 'Accademia Editoriale PPrivatisation fo the Japan national rail : Overview of performance changes. Author (s): F . MIZUTANI and K . NAKAMURA Source : International Journal of Transport Economics / Rivista internazionale di economia dei trasporti , Vol .', *Accademia Editoriale*.

Mizutani, F. (1999) 'An assessment of the japan railway companies since privatization: Performance, local rail service and debts', *Transport Reviews*, 19(2), pp. 117–139.

Mogridge, M. J. H. (1997) 'The self-defeating nature of urban road capacity policy: A review of theories, disputes and available evidence', *Transport Policy*, 4(1), pp. 5–23.

National Treasury (2019) ‘National treasury Annual report’. Available at: https://www.gov.za/documents/national-treasury-annual-report-20192020-2-feb-2021-0000.

NaTIS (2019) *New vehicle registrations 2019*. Available at: https://www.natis.gov.za/index.php/statistics/new-vehicle-registrations/new-vehicle-registrations-2019.

Partheeban, P., Arunbabu, E. and Hemamalini, R. R. (2008) ‘Road accident cost prediction model using systems dynamics approach’, *Transport*, 23(1), pp. 59–66.

PRASA (2019a) *Annual report 2018/19*, *Annual report*. Available at: https://www.prasa.com/Annual Reports/Prasa Annual Report 2018-19.pdf.

PRASA (2019b) *Cape District income statement*.

PRASA (2019c) ‘Ticket Sales - Southern line’.

PRASA (2020) ‘Prasa 2019/20 annual report’, pp. 1–180. Available at: https://static.pmg.org.za/PRASACBRTARTMCRAF_and_Ports_Regulator_PRASA_Annual_Report_2020_FINAL_16_Nov.pdf.

Qin, X. and Cutler, C. E. (2013) ‘Review of Road User Costs and Methods’, (July), p. 124.

Ramamurti, R. (1997) ‘Testing the limits of privatisation: Argentine railroads’, *World Development*, 25(12), pp. 1973–1993. doi: 10.1016/S0305-750X(97)00092-2.

RSR (2017) ‘State of Safety Report’. Available at: https://www.rsr.org.za/wp-content/uploads/2020/05/RSR-State-of-Safety-Report-2016-2017.pdf.

RSR (2020) *State of Safery report*. Available at: https://www.railwaysafrica.com/assets/docs/RSR-StateofSafety2019-20.pdf.

RTMC (2015) *Cost of Crashes*. Available at: https://www.rtmc.co.za/index.php/publications/reports/cost-of-crashes.

Salaryexplore (2021a) *Bus Driver Average Salary in South Africa 2021*. Available at: http://www.salaryexplorer.com/salary-survey.php?loc=201&loctype=1&job=226&jobtype=3.

Salaryexplore (2021b) *Taxi Driver Average Salary in South Africa 2021*. Available at: http://www.salaryexplorer.com/salary-survey.php?loc=201&loctype=1&job=236&jobtype=3.

Seabright, P. (Ed) (2003) ‘The economics of passenger rail transport - A Survey’, (January), p. 123. Available at: http://publications.ut-capitole.fr/1728/1/report_idei_1.pdf.

Skrucany, T. *et al.* (2017) ‘Comparison of Chosen Environmental Aspects in Individual Road Transport and Railway Passenger Transport’, *Procedia Engineering*. The Author(s), 192, pp. 806–811. doi: 10.1016/j.proeng.2017.06.139.

South-African-Railways (1947) ‘The South African Railways: History, scope and organisation’.

Available at:
https://books.google.co.za/books/about/The_South_African_Railways.html?id=5G6GAAAAIAAJ
.

Statistics South Africa (2011) *Census South Africa*, *Census 2011*. Available at: https://census2011.adrianfrith.com/place/199.

Statistics South Africa (2013) ‘National Household Travel Survey 2013 statistical release’, *National household travel survey*, pp. 1–179.

Statistics South Africa (2020a) ‘Land transport survey’. Available at: http://www.statssa.gov.za/?s=land+transport+survey&sitem=publications.

Statistics South Africa (2020b) ‘National Households Travel Survey 2020 Statistical release’, *National household travel survey*. Available at: http://www.statssa.gov.za/publications/P0320/P03202020.pdf.

TFR (2018) ‘150 Years of Rail in South Africa’, *Heritage*, p. 22. Available at: https://www.transnetfreightrail-tfr.net/Heritage/150years/150YearsRail.pdf.

Thompson, L. S. and Budin, K.-J. (1997) ‘Global Trend to Railway Concessions Delivering Positive Results’, *Viewpoint*, (134), p. 8. Available at: https://openknowledge.worldbank.org/handle/10986/11563?locale-attribute=en.

Thompson, L. S. and Kopicki, R. (1995) ‘Best Methods of Railway Restructuring Privatization Ron Kopicki’, *World Bank*, (111). Available at: http://documents.worldbank.org/curated/en/761811468761126588/Best-methods-of-railway-restructuring-and-privatization.

Toyota SA (2021a) *Toyota Corolla Quest*. Available at: https://www.toyota.co.za/ranges/corolla-quest.

Toyota SA (2021b) *Toyota Sesfikile*. Available at: https://www.toyota.co.za/ranges/hiace-sesfikile.

Transaction capital (2019) *Transaction capital results*. Available at: https://www.transactioncapital.co.za/downloads/home/TCP_HY19_Results analysis booklet_FINAL.pdf.

TyreMall (2021) *DUNLOP 12R22.5 SP391 16PR 152/148L*. Available at: https://www.thetyremall.co.za/product/dunlop-12r22-5-sp391-16pr-152-148l/?campaign=11003218280&content=460768474996&keyword=&gclid=CjwKCAjwndCKBhAkEiwAgSDKQV4ptsexd5ycOAWfLBu3VxylrwylHD3keD002dHBcO6ApLcSuhDdvhoCUE4QAvD_BwE.

United Nations, Department of Economic and Social Affairs, P. D. (2018) ‘The World ’s Cities in 2018’, *The World’s Cities in 2018 - Data Booklet (ST/ESA/ SER.A/417)*, p. 34.

Vanderschuren, M. and Roux, D. (2017) ‘Road safety comparison in South Africa – How do the different provinces compare?', *Southern African Transport Conference, 6-9 July 2019*, (August).

Vuchic, V. R. (2005) *Urban transport : Operations, Planning and Economics*. Canada: John Wiley & Sons.

Wardman, M. (2004) 'Public transport values of time', *Transport Policy*, 11(4), pp. 363–377. doi: 10.1016/j.tranpol.2004.05.001.

Wikipedia (2019) *Commuter rail*. Available at: https://en.wikipedia.org/wiki/Commuter_rail#Inter-city_rail.

Wikipedia (2021) *Rail transport in South Africa*, *Wikipedia*. Available at: https://en.wikipedia.org/wiki/Rail_transport_in_South_Africa.

World Bank (2003) 'A Railway Concessioning Toolkit', (74). Available at: https://www.ssatp.org/sites/ssatp/files/publications/SSATP-WorkingPapers/SSATPWP74.pdf.

World Bank (2017) 'Railway Reform: Toolkit for Improving Rail Sector Performance', (June, 2017), pp. 1–428. Available at: https://olc.worldbank.org/system/files/RR Toolkit EN New 2017 10 19.pdf.

World Population Review (2021) *Cape Town Population*. Available at: https://worldpopulationreview.com/world-cities/cape-town-population.

Worsley, T. (2020) 'Comparing Road and Rail Investment in Cost-Benefit Analysis', *International transport forum*. Available at: https://www.itf-oecd.org/sites/default/files/docs/comparing-road-rail-investment-cost-benefit-analysis.pdf.