THE ECONOMIC AND TIME IMPACT OF POOR ACCESS TO PUBLIC TRANSPORT IN SOUTH AFRICAN METROPOLITAN AREAS

by

Mashumu Reginald Kgwedi

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

Supervisor: Prof, Stephan Krygsman

December 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.

December 2022

ABSTRACT

Socioeconomic changes are closely associated with transportation systems because they provide mobility for economic, educational, and social opportunities. Intra-generational equity in access to opportunities is increasingly recognised as an essential component of sustainable development and transport. The role of public transport in sustainable urban mobility can be seen as linking people to employment, social, and cultural opportunities. In South Africa, most commuters live far from their workplaces, making their travel to work expensive, since they spend about 15 to 30% of their disposable income on travel. The fares for these low-income passengers increase speedily, and the commuting hours are long. In turn, poor accessibility offered by public transport ultimately influences travel time, daily mode choice, and expenditure. Low-income households and workers, dependent on public transport, are particularly negatively impacted by the inefficient public transport system. This research aims to measure the accessibility of public transport to people who live far from work, to evaluate the multimodal and multistage character of public transport (compares travel time for the journey to work of workers for the various transport modes); to quantify travel time elements for transport users in terms of out-of-vehicle (access, egress, wait and transfer), and lastly to measure the monthly transport expenditure of different transport users in the *metros*. This will be done by comparing the 2013 and 2020 National House Travel Survey (NHTS) to give insight if the Government has been able to make progress on its stated research objectives (National Development Plan (NDP), Land Transport Policy, etc.).

Research using the data from the NHTS 2013 and 2020 illustrates the significance of public transport travel time and the impact of the multimodal, multistage nature of public transport. This is important because, unlike other modes, public transport is multimodal in nature. Multimodal trips have additional time elements including accessing the first mode, waiting, transferring, and egressing; and 'eat' into the productive time of the traveller. In the research, the Accessibility Index (AI) is used to determine the accessibility and density of public transportation at a point of interest (at home, stations, or interchanges). This is done to recognize the importance of accessibility and egress and to consider the need to understand how public transportation users use their time and money. This study shows that workers travel long distances to their workplaces and spend more time and money (disposable income) travelling. This could be because of the multiple trips and modes of transport they need to use to get home or to work. The 2013 NHTS revealed that on average, the metropolitan working population spent about 55 minutes of travelling time, while the 2020 NHTS showed an additional 2

minutes, bringing it to 57 minutes. These travel times included access, egress, waiting, and line haul time. Train users, spend more time travelling than any of the other modes in both surveys.

Unfortunately, the mobility challenges the low-income people have not improved over a decade despite some marked expansion of public transport infrastructure and urban development. This is likely to contribute to the income inequality and high unemployment rates of lower-income groups in the country since it limits their access to opportunities. This research presents some recommendations to improve the daily mobility of workers and low-income groups. This is to be done through policy and the design of infrastructure that is equitable and provides for access and egress, as well as the improved valuation of public transport capital projects.

Keywords: Public transport, multimodal, travel time, travel cost, access, egress, linehaul, transport accessibility.

ACKNOWLEDGEMENTS

First and foremost, I would like to thank the Almighty God *(Modimo wa Sione)* for the graces, and the strength He gave me to complete this research, although the journey has not been an easy one.

I would like to thank the following people for their various support and roles during my research.

I wish to express my sincere gratitude and appreciation to my research supervisor Prof. Stephan Krygsman for his supervision, the guidance and assistance from the beginning to the end. I am indebted to him for the countless hours he spent discussing and refining my ideas. *Kea leboga*

I wish to appreciate the support I received during the study, Dr. Palesa Mothapo for helping with the statistical analysis and providing a support system; the late Prof. Lukish Mamaile for his continuous support and motivation. His support and kindness will always be remembered – *May his soul rest in peace*.

Lastly, I am extremely grateful for the love, prayers, and support that my family has provided me throughout the years. The regular calls and messages kept me going, I appreciate it, and I am blessed to have you in my life. This thesis is dedicated to *makgolo* Motheo, my parents, and my late grandparents.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABBREVIATIONS AND ACRONYMS

AA – Automobile Association

AI – Accessibility Indices

BRT – Bus Rapid Transit

CV – Coefficient of Variations

DoT – Department of Transport

EA – Enumeration Area

GMA – Gautrain Management Agency

IES – Income and Expenditure Survey

IPTNs – Integrated Public Transport Networks

MTSF – Medium Term Strategic Framework

NDP – National Development Plan

NHTS – National Household Travel Survey

NMT – Non-motorised transport

NPC – National Planning Commission

PRASA – Passenger Rail Agency of South Africa

PSU – Primary Sampling Unit

PT – Public Transport

Stats SA – Statistics South Africa

GLOSSARY OF CONCEPTS AND DEFINITIONS

For the study, the ***terms*** used herein shall have the following meanings (adopted from NHTS, 2013; 2020):

Affordability – It is calculated by dividing household travel costs incurred for public transport by per capita income.

Bus – A road-based public transport vehicle that can carry more than about 18 passengers. (Including Bus Rapid Transit system)

Car – A passenger motor vehicle used by a private individual for his/her convenience.

Commuter – any person who regularly travels to and from work whether on foot or by motorised transport.

Conventional bus – A mode of transport: privately owned bus service which traditionally conveyed workers between townships and workplaces, and currently subsidised by the provincial governments.

Dwelling unit – A structure, part of a structure or group of structures that can be occupied by a household(s).

Enumerator area– The smallest geographical unit (a piece of land) into which a country is divided for enumeration purposes, census, and survey purposes; each contains between 100 and 250 households.

Formal sector – Sector of employment made up of all employing businesses that are registered in any way.

Gautrain – an 80-kilometre higher-speed commuter rail system in Gauteng Province, which links Johannesburg, Pretoria, Kempton Park and O.R. Tambo International Airport.

Household – A person or group of persons who have occupied a common dwelling unit for at least four nights in a week on average during the past four weeks prior to the NHTS interview.

Informal sector – Consists of those businesses that are not registered in any way.

Institutions – Communal places of residence for people with common characteristics such as a hospital, school hostel, prison, defence force or convent.

IPTNs – Government's new public transport initiatives in the major cities that offer dedicated roadways and stations that permit many people to board and alight quickly where demand levels merit this.

Main mode of travel – The main mode of travel is the highest mode of travel used in the following hierarchy of travel modes: Train, Bus, Taxi, Car driver, Car passenger, Walking all the way and Other

Metropolitan areas – Covers the eight metropolitan municipalities defined by the Municipal Structures Act, namely the entire jurisdictions of Cape Town, Ekurhuleni, eThekwini, Nelson Mandela Bay, Buffalo City, Mangaung, Johannesburg, and Tshwane.

Metrorail – Commuter rail division of PRASA.

Minibus taxis –Privately owned passenger-carrying motor vehicle with a seating capacity of between 8 and 16 seats, unscheduled, unsubsidised and mainly informal commuter services which first emerged in the 1980s. Most operate to or from a taxi rank.

Mode of transport/ travel – Type/means of transport used for travel purposes. For this report, one of the following six types: conventional bus, municipal bus, minibus taxi, BRT, commuter rail, and Gautrain.

Municipal bus – Bus service owned and subsidised by a metro Council, and which traditionally served white areas.

Non-motorised transport – Any mode of travel without a motor to provide the motive force for the movement of the vehicle.

Passenger trip – An individual passenger who travels between work and home each day will account for at least two passenger trips per day.

Private transport – All forms of motorised transport which were used by individuals in travel modes other than public transport. This includes car drivers, car passengers, and company vehicles.

Public transport – A transport service which may be used by members of the public: for this report, buses, trains, or minibus taxis.

Quintile – A quintile is one-fifth of 20% of a given number. The poorest per capita quintile

Quintile 1 represents households that fall into the lowest fifth or 20% of the data.

Quintile 2 represents households that fall into the second fifth (21% ─ 40%).

Quintile 3 represents households that fall into the third-fifth (41% ─ 60%).

Quintile 4 represents households that fall into the fourth fifth (61% ─ 80%).

Quintile 5 represents households that fall into the highest fifth of the data (81% ─ 100%) of the data.

Respondents – A person (or persons) responding to questions in the selected dwelling unit. The person should be a member (or members) of the household (adult) and be able to answer questions.

Rural – The settlement type is associated with commercial farming areas (rural formal) and land designated as tribal or traditional.

Total monthly household income – It is calculated by adding the monthly earnings per individual in the household as well as the total grant income for the household.

Train – A form of rail transport consisting of a series of vehicles that usually runs along a rail track to transport cargo or passengers. (Includes: Gautrain)

Travel cost – It is calculated by adding the total costs incurred for education and work-related travel. In addition, travel cost was divided by the number of individuals in the household.

Urban – All areas classified as urban formal or urban informal according to the Census geographic classification. It excludes areas classified as metropolitan by the Municipal Demarcation Board as per the 2011 classification.

Walking all the way – Walking from one point to another without any other form of transport.

Worker – In the case of the NHTS, this term applies to any person who works. No distinction is made between occupational categories or classes.

1. INTRODUCTION

1.1. Background

Intra-generational equity in access to opportunities is increasingly recognised as an essential component of sustainable development and transport. In development, intra-generational equity in transport refers to the aligning of institutional practices, policies and investments, and bureaucratic decision-making to benefit historically under-resourced communities that have been shut out of transportation decisions in the past. This includes equitable access to safe, reliable, and affordable transportation options, employment, and services (Guevarra, 2016). Transportation equity affects residents' access to economic as well as social opportunities (Saghapour, Moridpour, and Thompson, 2016). Transportation infrastructure can ensure access to markets and resources, economic opportunities, because transport systems, by the accessibility they provide, are closely related to socioeconomic changes and economic development (Rodrigue, 2020). This is because uneven accessibility levels are likely to lead to social disparities and exclusions (Rodrigue, 2020). Niedzielski and Boschmann (2014) assert that challenges in accessing activity spaces of normal everyday life, such as socio-spatial "deprivation" can lead to a reduction in quality of life.

Accessibility is linked with an array of economic and social opportunities (Rodrigue, 2020) and it is important for identifying critical areas for improvements in the connection between transport systems and urban areas (Otsuka, Delmastro, Wittowsky, Pensa and Damerau, 2019). In the fields of transport and planning, accessibility is defined as "the ease of reaching destinations or activities, or the potential for interaction, or an individual's ability to reach desired goods, services, activities and destinations" (Statistics South Africa, 2018; Rodrigue, 2020). Assessing accessibility within an urban area is a complex process because of several factors such as capacity, presence, and quality of transport modes, transport network or infrastructure, connectivity, and design of the urban environment (Otsuka *et al.*, 2019). Accessibility consists of the demand, supply, and transport system and serves as a key link between transportation and land use thus creating a spatial interaction between activities or land uses. The demand side of transport refers to individual activity needs, and the supply side is about facilities provided at various destinations to meet people's needs. Therefore, transport provides a link between demand and supply. (Otsuka *et al.*, 2019) According to Rodrigue (2020), well-developed and efficient transportation systems offer high accessibility levels when compared to less-developed ones.

Accessibility to opportunities is influenced by (1) transport modes, (2) the network and route connectivity and (3) proximity of activity locations. Public transport is one of the elements of accessibility. It is the transport mode. The other elements are proximity to locations. Low-income communities, who use public transport, live mostly far away from employment opportunities (long commute) and their neighbourhoods are generally also poorly located in terms of other amenities (shopping, culture, sport, etc.). Since these groups rely on public transport, and travel long distances, these trips take longer than normal and poor public transport makes this worse (Krygsman, 2004). Similarly, such communities often live in areas where the transport connections are less than optimal. Thus, the network connectivity (route connections) is often designed with limited public transport links and mostly with a rail link from the residential area to employment locations. Considering accessibility from the perspective of mobility, connectivity, and proximity, it is clear to note that they are dependent on good quality public transport for access (Krygsman, 2004).

This research presents a review of previous studies in the public transport environment and seeks to measure and to determine the accessibility of public transport focusing on the journey from origin to destination (access, egress, and line haul travel time). Over and above this, the impact of public transport accessibility on travel time and household expenditure in South Africa's metropolitan areas is examined. In the same light, the research seeks to quantify the time and distance penalty that people pay for using public transport and how their travel time elements influence the overall accessibility and household expenditure. Due to the different income levels, the findings proved that low-income households arguably spend more on transport than high-income households. This is likely to contribute to the income inequality in South Africa and may contribute to the high unemployment rates of lower-income groups in the country (Statistics South Africa, 2014; Treasury, 2014; Statistics South Africa, 2019c; Van der Merwe and Krygsman. 2020).

A Standard Bank Consumer Expenditure Trends (2016) report found that about 62.3% of households in South Africa fall within the poorest income bracket and earn less than R86 000 per annum (Ismail, Mkhwanazi and Silberman, 2016). With such a large percentage of people falling in the low-income group public transport is particularly important because they undoubtedly cannot afford private transport. According to Capitec Bank (2017), a "good rule of thumb is that the price of the car should be no more than 30% of your annual gross salary, and your monthly car costs no more than 10%".

This is because people can afford a car (used car) if they earn between R8000 – R12000. Below that, people are likely to rely on public transport (Capitec Bank, 2017). Unfortunately, these low-income transport users are subjected to ever-increasing public transport fares and long commuting time. In turn, this aggravates the inequity in a society where those without access to private mobility are excluded from actively participating in economic and social activities. (Tonkin, 2008; Gauteng Province Department of Roads and Transport, 2016, 2020). Government has put policies in place to address the cost of transport and improve transport accessibility.

The National Development Plan (NDP) 2030, a policy document of the South African government, has set down plans to make investments in the transport sector to improve accessibility (The National Planning Commission, 2011). The investment plans include strategies to bridge geographic distances affordably, foster reliably and safely so that all South Africans can access previously inaccessible economic opportunities, social spaces, and services. Social and economic exclusion caused by apartheid is evident as the majority of South Africans are placed far away from work, where it is difficult to access the benefits of society and participate in the economy (The National Planning Commission, 2011). For this reason, the National Planning Commission in the Presidency proposed a strategy to address spatial planning that will achieve a creative balance between spatial equity, economic competitiveness, and environmental sustainability. These strategies include inclusiveness or equity in ownership of assets, income distribution, and access to management, professions, and skilled jobs (Department of Transport, 1996; The National Planning Commission, 2011). The NDP 2030 has stated that by 2030, passenger/ public transport should be user-friendly, less environmentally damaging, more affordable, integrated, or seamless (The National Planning Commission, 2011).

The revised South African White Paper on National Transport Policy (2017) advocates for a "safe, reliable, effective, efficient, coordinated, integrated and environmentally friendly public transport system by developing norms and standards as well as regulations and legislation to guide the development of public transport for rural and urban passengers; and to make public transport competitive with the private car to provide a viable alternative mode". The policy further envisioned "a transport system that provides equitable and reliable access for all in an economically and environmentally sustainable manner to advance inclusive growth and competitiveness of the country"

(Department of Transport, 2017). Despite the policy's goal of *a transport system that provides equitable and reliable access for all in an economically and environmentally sustainable manner to advance inclusive growth and competitiveness of the country*, South African cities are still characterised by relatively inequitable, long commuting and unreliable public transport systems that inhibit access to economic activities.

Large numbers of the working population reside far from employment opportunities and travel long distances to and from work leading to high transport costs and long commuting times (Statistics South Africa, 2014). Commuting refers to a regular or recurring journey between locations (i.e., one's place of residence and place of work, study, or even when not work-related) (Statistics South Africa, 2014). In a recent study about *Transit-based job accessibility and urban spatial structure*, van der Merwe and Krygsman (2020) argued that transport is a representation of friction between where people are and where they want to be, which is often measured in terms of travel costs and travel time, and possibly convenience, comfort, and safety of travel. In South Africa, most low-income commuters live far from their workplaces, which makes their travel expensive, long, and inconvenient.

Many of South Africa's poor households spend 15 to 30% of their disposal income on transport (Statistics South Africa, 2014). This is more than double the national benchmark hence inconsistent with the South African White Paper on Transport Policy (1996). This in turn limits and reduces transport expenditure to less than 10% of disposable household income to measure the affordability of public transport, (Department of Transport, 1996, 2017). The Gauteng Province National House Travel Survey of 2014 highlighted that the proportion of household income spent on public transport increased significantly because of the ever-increasing fares. This study also highlighted that 55% of the households spent more than the policy maximum target of 10% of their income on public transport thus increasing the statistics to 60% of these households in 2019/20 (Gauteng Province Department of Roads and Transport, 2020).

The disposable income spent on transport adds up to other challenges experienced by public transport users such as travel time. The National House Travel Survey (NHTS) 2013 found that most households identified travel time and cost of travel as the biggest determinants of transport modal choice (Statistics South Africa, 2014). Subsequently, the NHTS 2020 survey found that these two factors are still the biggest determinants of modal choice amongst transport users (Statistics South

Africa, 2020). This means that long commute times and transport costs inhibit workers from fully participating in the economic, social, and family maintenance activities as they spend a larger fraction of their incomes and daily time getting to and from work. This implies that less time and income are spent on childcare, home maintenance, and general social activities. The long travel time is mostly exacerbated by other travel time elements or trip stages such as access, egress, waiting and transfers times. Access and egress stages, together with waiting and transfers are the weakest part of a multimodal public transport chain if not well integrated into the total trip and their contribution to the total travel disutility is often substantial (Krygsman, 2004; Krygsman, Dijst, and Arentze, 2004). Therefore, not only do people spend a lot of time on public transport trips, but the disutility of the various time elements aggravates the experience, convenience, and contributes towards poor accessibility. The time and cost elements are caused by fact that workers live too far from economic activities which has subsequently led to rural-urban migration.

In recent years, there has been rural-urban migration because of the growing recognition that urban environments reduce transaction and transport costs, foster entrepreneurial dynamism, facilitate more intense trading between enterprises, and stimulate stronger collaboration between firms and other economic agents (Turok, 2015; United Nations Department of Economic and Social Affairs, 2018). The concentration of people, infrastructure, institutions, and economic activity in cities means that resources of all kinds are used more efficiently and creatively, thereby saving costs, promoting innovation, and improving productivity. This concentration or clustering also boosts the competitiveness of the local and national economy as well as enables the population access to participate efficiently in the economic activities (Glaeser and Joshi-Ghani, 2013; Turok, 2015). Glaeser and Joshi-Ghani (2013), argue that cities remove the physical spaces between people and firms, because of proximity which makes connections easier. People can participate in economic activities when there is connection and link between transport systems, social and economic opportunities. From the findings of this research, the stated vison and goals of these policy documents have not been met. The following section will provide an overview of the challenges relating to poor public transport accessibility.

1.2. **Problem statement**

Poor access to employment, social and cultural opportunities is one of the most challenging issues that South Africa has been facing. South African cities are characterized by an unbalanced spatial structure, with lower-income communities located on the periphery, far away from employment opportunities and other amenities (Statistics South Africa, 2014; Treasury, 2014; van der Merwe and Krygsman, 2020). The origins of this challenge lie in the legacy of apartheid's spatial planning and the failure of the current system to address this spatial layout and urban form. The result of this spatial layout is long commutes, higher transport costs, lower labour productivity, and overall unproductive cities. Over and above this, the inequity in a society where those without access to private mobility are reliant on public transport means they will be excluded from participating in economic activities (Tonkin, 2008; Statistics South Africa, 2014; Treasury, 2014; Hitge and Vanderschuren, 2015; van der Merwe and Krygsman, 2020).

It goes without saying that mobility is one of the fundamental components of the economic benefits of transportation. This is because it enables social, cultural, political, and economic activities to take place (Rodrigue, 2020). Similarly, it illustrates that an individual having access to a car has a more significant commuting range than an individual without a car; in turn access to more opportunities, a range of commercial and personal interactions than those relying on public transport. The network configuration and public transport limits the level of accessibility to the opportunities or amenities that are typically available for car owners which can access all roads and streets (Rodrigue, 2020). Resultantly, an individual without a car is very likely to rely on a public transport.

Public transport plays a prominent role in sustainable urban mobility because it links people to employment, social and cultural opportunities (Krygsman, Dijst, and Arentze, 2004). Cities have put less effort into improving and investing in public transport, especially on the access and egress which includes modes such as walking and cycling as feeder and distributor. It is required by policies (The National Planning Commission, 2011) that cities develop public transport for sustainable urban mobility to address mobility gaps. Government traditionally provides public transport mainly for the line haul (main mode) and does not consider other stages of the trip, i.e., the first and last mile services (access and egress). Typically, the bigger and more spread-out cities become the more important the other stages (access and egress) are in a public transport trip.

The Constitution of South Africa (108 of 1996) identifies the legislative responsibilities of different spheres of government regarding transport infrastructure, road traffic management, and public transport. Public transport planning happens within the Local or Provincial level and is funded by the National government through the National Treasury and Department of Transport. It is however important to note that funding is often for line-haul and not for access and egress. So, it is important that funding is adequate and covers the entire system. Transport is a concurrent function that is legislated and executed at the three levels of government, i.e., National, Provincial, and Local government levels (Schedule 5 of the Constitution, 1996). Although public transport is assumed to be a hop-in and go to your destination, this is not the case.

Once on the system, users seldom use one mode to travel from origin to destination. The interconnectivity or transfers between modes becomes an issue as well as the travel time and cost. Most users must use many modes of transport from the point of origin to the destination, involving one or more transfers. These factors contribute to the long travel time and high cost of transport as money must be exchanged at each transfer and interchange of transport mode, from and to the point of origin. Further, the mode of transport often drops or leaves users not close to their destination or workplaces. This then requires them to use other modes of transport to reach their destinations. For many, this means walking to the destination. While there is a consideration for the main mode, there is less or no attention to other modes (access and egress) including the collection of travel data on the full trip. This collection of data is important because, unlike other modes, public transport is multimodal in nature (Krygsman, 2004). Other modes such as private vehicles are unimodal trips, which are a move from the origin (home) to destination (activity). A unimodal trip is always based on the shortest route, measured in time and distance. This is because transport is inherently associated with a negative disutility, where users will minimise the trip (time) and maximise the activity. Multimodal public transport is never so direct. The time elements, i.e., access to the first mode, wait, transfer, egress are all additional time elements on multimodal trips. These other time elements and stages 'eat' into or takes away the productive time of the traveller because public transport users are located far from the modes of transport.

In the context of South Africa, public transport users must access the system from their homes, which are often far from the first point of access to the system. Access is influenced by many factors such

as distance, operations, and frequency, as well as routes that are used, (Krygsman, 2004; Hitge and Vanderschuren, 2015). Proximity makes connections easier; it enables people and firms to compare, compete and collaborate (Glaeser and Joshi-Ghani, 2013; Turok, 2015). On the other hand, cities remove the physical spaces between people and firms, because of proximity. Therefore, the proximity of public transport becomes a problem if cities are dysfunctional (Turok, 2015). There is limited understanding of the multistage or multimodal trip since most studies consider mainly the line-haul or in-vehicle travel time. They do not look at all stages of the trips, which include access, egress, waiting, and transfer times. Some studies are limited to measuring accessibility, i.e., how far are people away from work, school or other activity locations, there is less about how people 'give up' (opportunity cost) other productive time to use public transport, and all these time elements of public transport add up. This research seeks to address this gap by illustrating the impact of the poor accessibility offered by the multimodal, multistage stage character of public transport as well as the additional expenditure.

1.3. **Research aims**

The time and distance penalties inherent in the dysfunctional public transport system severely impact low-income South Africans. Poor accessibility offered by public transport ultimately influences travel time, and household expenditure. Low-income households, dependent on public transport, are particularly negatively impacted by poor public transport. Therefore, the overall aim of the research is to evaluate the multimodal and multistage character of public transport on household, daily travel time, and household expenditure and compare the 2013 and 2020 NHTS to give insight of whether the government has made progress on their stated research objectives as contained in the policies such as NDP and the Land Transport Policy. This comparison will illustrate the access and overall monetary penalty imposed on users of public transport compared to normal vehicle users.

1.4. **Research objectives**

The following objectives will be addressed in this research:

a. To determine the transport profile of commuters who use different modes of transport namely, public (train, bus, and minibus) and private transport.

i. To compare the travel times of workers who use various transport modes in *metropolitan areas*.
ii. To determine and quantify the travel time elements for public transport users in terms of out-of-vehicle (access, egress, wait and transfer) and relate this time to the journey to work.

b. To compare the monthly transport expenditures between public transport users and private transport users.
c. To compare objectives (a) and (b) in light of the 2013 and 2020 NHTS.

1.5. **Limitations**

The National Household Travel Survey (NHTS) is an initiative of the National Department of Transport and Statistics South Africa was used to conduct this research. In 2003, the first household travel survey was conducted and was followed by the second survey in 2013 by Statistics South Africa (Stats SA). Thereafter, the third survey was conducted and was released in March 2021. Therefore, the NHTS gives strategic insight into the travel patterns and transport problems in the country, for research, planning, and policy formulation purposes. In South Africa, transport data is generally very difficult to obtain because separate municipalities collect data for their area only in a form of Integrated Transport Plans (ITPs). The main source of transport data on a national level is Statistics South Africa through NHTS because it is the only source that is available on a national level. While the NHTS survey data is useful in analysing general transport trends and general levels of access, it is less suitable to model individual accessibility. Additionally, this dataset is limited in that, it does not give detail the distance travelled but only travel time. The NHTS only collect trip data and less on activity data.

1.6. **Significance of the research**

In the quest for knowledge, this research contributes to the existing body of knowledge and the expansion of academic literature. The research will certainly increase the existing body of knowledge and make specific contributions to the subject field of public transport travel behaviour. Furthermore, the evaluation of the multimodal and multistage character of public transport on household, daily travel time, and household expenditure will be carried out. This is important because, unlike other modes, public transport is multimodal and multistage in nature. Other modes such as private vehicles

are unimodal trips, which are a move from the origin (home) to the destination (activity). This research will hopefully advance an understanding of the time and distance penalty that people pay as well as the total monetary cost of relying on public transport. It compares the NHTS data for 2013 and 2020, to determine if the government has met any of its objectives. Furthermore, the research aims to illustrate the impact of poor accessibility offered by the multimodal, multistage stage character of public transport and the time and expenditure deficit due to this.

In addition, this research is pertinent when one considers the current urban transport challenges, development plans, and policies. Much of the discussion on the urban development of cities and improving sustainability has largely been around greening the environment to reduce problems associated with air pollution and traffic congestion, encouraging the use of more mobility friendly solutions such as designated bus, taxi, and bicycle lanes to improve traffic flow among other things. Thus, it is important to assess the current impact of poor access to effective public transportation on the working-class population.

The public transport journey is a multimodal, multistage journey that includes various modes as well as transfers while the private car journey is a single-stage, single-mode journey. This makes public transport so incredibly difficult to plan. Another problem is that poor public transport planning leads to long times, high cost, poor accessibility, and overall, an inefficient urban system. An inefficient urban system has implications for the productivity of urban areas. This then influences employment creation. Policymakers need to understand these out-of-vehicle time elements as they are added to the normal in-vehicle time. There is very little that public transport users can do during out-of-vehicle times because they are very unproductive (time spent waiting for a bus is unproductive). So, it is important that the government or policymakers understand these different stages of a (public) transport journey, and plan to eliminate them. It is important to understand that the focus should not only be on the line haul stage. It should be on the other stages as well and on the interchange. This increases policy complexity and makes it difficult to plan the multimodal/multistage character of public transport than to plan for private transport.

While considering this, areas of improvement must be understood. It is likely that the working population who work far from home, must use a large portion of their income on transport and spend more time commuting, which means these users are likely to be trapped in poverty and less time for

their families. This is likely going to have a very negative impact on the family structure, health, and well-being of the working class. While some might fare better than others, it is likely that the poorest and those earning on the lowest scale are the most impacted. This research seeks to uncover some of these aspects that are not widely discussed when planning cities and introducing new modes of public transport. Over and above this, it may encourage future research in the field of public transport.

If public transport is planned poorly, the government will find it difficult to create employment. In the same manner if people spend too much money on public transport, this means less money is available to spend on other, more deserving activities. Transport expenditure is not really a very productive expense because it does not really generate a lot of employment. Also, if people travel too long, they have less time available to spend on other activities, such as working, social, etc. Both long travel time and high expenditure leads to poor economic environments and hampers government policies directed to economic growth and development (Krygsman, 2004).

1.7. **Chapter overview**

This dissertation presents the findings of the topic: "*the economic and time impact of poor access to public transport in South African metropolitan areas".* The dissertation has six (6) chapters, described as follows:

Chapter 1: Introduction

Chapter 1 provides the background, problem statements, aim, and objectives as well as the limitations and significance of the research. It also provides an outline and summary for each of the chapters making up this dissertation.

Chapter 2: Review of Literature

Chapter 2 provides a foundation upon which the research is built and acts as a basis for discussing results and interpretations. The literature review articles and reports on studies, policies, and theories that discuss public transport and addresses the following themes; (a) accessibility and the roles of the various modes in how we measure accessibility; (b) the role of the various time elements and how we measure them and include them in our calculation of accessibility; (c) the cost of (public) transport; and (d) the background and enabling transport legislative and policy framework in South Africa with

regards to public transport. It examines the accessibility and focuses on the journey from origin to destination (access, egress, and line haul travel time), as well as the impact of public transport accessibility on the metros. The literature seeks to unpack the impact of the poor accessibility offered by the multimodal, multistage stage character of public transport and the expenditure.

Chapter 3: Methodology

Chapter 3 consists of the research design and methodology, which was organised according to the stages of the research process, such as identifying and selecting data sources, their validity and reliability as well as editing; analysing data; and interpreting NHTS 2013 and 2020 data using the IBM SPSS version 25 and Statistica statistical analysis software. The subset data of the working population of the survey (NHTS data) was used to reach the findings in the research. The focus was placed on the metropolitan areas.

Chapter 4, and 5: Results of the research

The fourth (transport profile of commuters, and travel time elements for the journey to work for the various transport modes in metros), and fifth chapters (expenditure profile of commuters) discuss and present the results and findings of the research. In these chapters, the research compares both the 2013 and 2020 NHTS data to give insight if the government has been successful in making progress on the stated research objectives (NDP, Land Transport Policy, etc.).

Chapter 6: Conclusions and recommendations

In this final chapter, the implications of the research findings and future research are discussed. Conclusions and recommendations justified and supported by the analysis performed are presented herein.

2. LITERATURE REVIEW

2.1. Public transport in South Africa

The South African Constitution (108 of 1996) describes public transport as a concurrent Schedule 4A function between the national and provincial spheres of government. On the other hand, the municipal public transport is a Schedule 4B concurrent function falling within the sphere of local government (South African Government, 1996; Treasury, 2014). Additionally, the responsibilities of provinces and municipalities in planning and management of land transport are defined in the National Land Transport Act (5 of 2009) (hereinafter the NLTA) (Republic of South Africa Government, 2009). The NLTA requires that both spheres of Government prepare transport plans in line with the framework developed by the National Department of Transport. In the same manner, the NLTA provides for the establishment of local transport authorities by municipalities to improve local transport service delivery. Planning authorities are expected to develop transport plans and oversee their implementation, develop local land transport policy, and perform financial planning and management for land transport functions. These duties include transport planning, infrastructure, operations, services, maintenance, monitoring, and administration (South African Government, 1996; Republic of South Africa Government, 2009).

Public transport implies land-based public passenger transport (Department of Transport, 2016; Competition Commission South Africa, 2021). The South African public transport system comprises three popular modes of urban or public transport: buses, minibus taxis, and trains (Metrorail and Gautrain). Other modes include provincially contracted buses, unsubsidised buses, municipal buses, metered taxis, e-hailing operators, and Shosholoza Meyl. This study focuses on minibus taxis, buses (including contracted buses, Bus Rapid Transit (BRT), municipal buses), and trains (Gautrain and Metrorail). These modes of transport provide a basic mobility service to people (Krygsman, 2004). Krygsman, (2004) states that public transport trip involves access, line-haul, egress, and requires some connectivity from origin to destination. This includes the use of more than one mode to complete a trip (Rietveld, 2000a; Krygsman, 2004). The modes of transport mentioned above have been characterised by negative experiences by members of the society, with descriptions such as infrequency, inadequacy, poor maintenance, overcrowding, unsheltered terminuses, rude staff, and increasing cost of public bus and train services (Perlnah, 1984; Pirie, 1987; Khosa, 1998). Of all South Africa's public transport modes, taxis transport about 67% to 70% of passengers, raise 71% of the

total revenue and receive 0% of subsidies. In comparison, trains, particularly Gautrain, transport 1% of public transport users, raises 7% of the total revenue, and receives 15% of subsidies. Similarly, Metrorail carries 21% of the passengers, raises 10% of the total revenue, and receives receive 29% of operating subsidies. Buses on the other hand (conventional, municipal, and BRT) transport 11% of passengers, raising 12% of total revenue and receive 56% of operating subsidies. [The expenditure and performance review prepared for the Presidency, (Treasury, 2014; Competition Commission South Africa, 2021)].

Nearly two decades after the publication of the White Paper on National Transport Policy in 1996, passenger transport in South Africa is still fragmented and suffers from operational and institutional inefficiencies (Statistics South Africa, 2014; Competition Commission South Africa, 2021). The Competition Commission Land-Based Passenger Transport Sector market inquiry report highlighted that public transport is still not adequately focused on the customer in terms of accessibility, reliability, affordability, and safety (Commission South Africa, 2021). The NDP 2030 has stated that by 2030 passenger transport should be user-friendly, less environmentally damaging, more affordable, integrated and seamless (The National Planning Commission, 2011). In terms of the reviews above, unhealthy competition among different modes of transport makes it difficult to foster partnership in the passenger transport sector. This, in turn, results in an unfortunate downward cycle of poor quality services, minimal investment in services, poor market perception, and an increase in the use of private vehicles (Statistics South Africa, 2014; Competition Commission South Africa, 2021). These factors, including the unavailability of public transport (i.e., distance from home or destinations) and the disutility (or inconvenience) associated with the non-seamless stages and connections are the cause of the declining public transport market share (Krygsman, Dijst, and Arentze, 2004).

The Apartheid's Native (Urban) Areas Act (21 of 1923) and the Group Areas Act (41 of 1950) through the race-zoning policies brought about the separation between the place of residence and place of work for most of the black South African population (Khosa, 1998). As a result, most of the black South Africans were marginalised and segregated. This segregation led to them residing in the periphery of the city, resulting in long and expensive commuting (Khosa, 1998). Evidence shows that most white workers generally lived no more than 7 km from their place of work while black workers

lived more than 15 km on average, from their place of work, with many travelling 100 km and more (Khosa, 1998; McCaul, 1991). This result is supported by the National House Travel Survey 2013, which shows that much has not changed in terms of the spatial design of cities in South Africa (Statistics South Africa, 2014).

The average distance travelled by commuters by rail was 21 km, while by bus it was 37 km (McCaul, 1992). According to Statistics South Africa (2018), most of the workers who used trains (65,0%) travel for more than an hour to get to their destination compared to other public transport users. The comparative figures for public transport are 53,2% for buses and 26,% for taxis. In contrast, it is only 33% of private transport users (car drivers and passengers) who travel for more than an hour. Those who walk from home to work had the lowest percentage of 8,8% (Statistics South Africa, 2018). Unlike the other public transport modes, taxis registered the lowest proportion of workers who left their homes before 06:00 (26,0%). The distribution of walking time from home to the first transport by the main mode of transport shows that mainly train and bus users are disadvantaged were about 34,5% of train users had the highest percentage of workers who walked for more than 15 minutes to get to their first transport, followed by those who used buses (15,6%). These findings by Statistics South Africa clearly show the convenience of private transport (Statistics South Africa, 2018). As expected, more than fifty-five percent (55,7%) of workers who changed transport on their way to work are more likely to experience longer travel times (more than an hour) compared to those who did not change transport (Statistics South Africa, 2018).

According to the NHTS, South Africans have become more mobile and more dependent on private transport over time as the use patterns of public transport have changed significantly between 2003 and 2013 (Statistics South Africa, 2014), and as more economic opportunities in the cities increased. There has been a general increase in the percentage of households who used taxis (from 59,0% to 69,0%), buses (16,6% to 20,2%) and trains (5,7% to 9,9%) in the 2013 NHTS survey (Statistics South Africa, 2014). It is not surprising therefore that in the National Development Plan (NDP), Medium Term Strategic Framework (MTSF), and more recently the Sustainable Development Goals (SDGs), access to safe, affordable, accessible, and sustainable transport is high on the agenda. To address the spatial divisions of the past, the government plans to improve public transport by making it quicker,

safer, and more affordable for people to access work opportunities through initiatives such as the BRT system.

In 2014, of the 15,3 million workers in South Africa, approximately 11,1 million households used public transport as their mode of travel, with nearly 4 million using private transport all the way to work. Most of those households using public transport are in metropolitan areas (4,4 million), followed by those households in rural areas (3,9 million) and 2,8 million from urban areas. Across all geographic locations, taxis constituted the largest proportion (3.7 million) as a mode of travel, followed by buses and trains. A further 3 million walked to work, and approximately 1 million used buses as their main mode (Statistics South Africa, 2014).

The 2014 Gauteng Household Travel Survey (GHTS) is a province-wide primary data collection project that collects and analyses information about household travel patterns to provide an improved understanding of the interaction between households and transport service delivery. It provides a snapshot of the perceptions and travel experiences of residents in the province and assists with evidence-led transport planning in both the province and municipalities within the province. A survey was conducted between 2014\16. The 2014\16 survey was administered to a random stratified sample of 29 779 households in all metropolitan and district municipalities that make up the province, resulting in a weighted total number of households of 3 910 754. The datasets comprise data about (i) households, (ii) persons in households, (iii) trips undertaken by individuals in households, and (iv) commuters' attitudes towards transport service (Gauteng Province Department of Roads and Transport, 2016).

The survey revealed that Gauteng residents are more reliant on private cars for daily travelling and commuting rather than public transport; the modes of transport for daily commuting from home to work are private cars (48.4%), minibus taxis (29.3%), walking to work (11.1%), bus (2.9%), train (2.4%), lift club (1.7%), and other (4.2%). The survey also points out that the share of public transport has not increased substantially despite the large investments made in the last decade in the improvement of public transport infrastructure. What is equally worrying is that the average travel time for daily commuting has increased markedly and almost doubled in the last few years, which has implications for economic productivity and personal and family time (Gauteng Province Department of Roads and Transport, 2016). Travel times are particularly high for public transport trips and have deteriorated markedly for buses. The survey pointed out that the principal

reason why residents are not using higher capacity public transport modes is its accessibility across the city region (Gauteng Province Department of Roads and Transport, 2016).

In 2019/20 the Gauteng Department of Roads and Transport together with Council for Scientific and Industrial Research (CSIR) conducted its third province-wide survey with 31 311 households in Gauteng. According to one of the main findings of the 2019/20 Gauteng Household Transport Survey (GHTS), low capacity transport modes, such as minibus taxis and private cars, have become the backbone of the transport network in the Gauteng province, as opposed to high-capacity modes, such as trains and buses. The minibus taxis account for 23% of all peak-period trips in the province, with private cars at 22%. Buses and trains account for 5% of all trips, (Gauteng Province Department of Roads and Transport, 2020). This is against the vision set out in the province's 25-year Integrated Transport Management Plan, which views trains as the backbone of the province's transport network. It is also against what the NDP has envisaged in terms of access to public transport. The survey shows that average travel time has also increased 17% from 46 minutes in 2014 to 57 minutes in 2019/20. Average travel time over the past 18 years has almost doubled. Travel times are particularly high for public transport trips and have deteriorated markedly for buses. As a result, many people choose to travel either earlier or later to avoid peak times.

2.2. **Policy in public transport**

2.2.1. Introduction

The policy is defined as the "formulation of rules, norms, and prescriptions intended to govern the subsequent decisions and actions of government" (Richard and Baldwin, 1976:122). Brooks, (1986) further expands this concept by defining public policy "as the broad framework of ideas and values within which decisions are taken and actions, or inaction, is pursued by governments about some issue or problem". Hanekom (1987:7) argues that policy is an indication of "a goal, a specific purpose, and a programme of action that has been decided upon. Public policy is therefore a formally articulated goal that the legislator intends pursuing with society or with a societal group" (Hanekom (1987:7). In a broader view, it provides a guideline for decision-making by those charged with the responsibility of operating the organisation or government as a system.

Policy formulation means a strategic planning process leading to a general concept. In terms of transport policy, it usually results in a "Transport Masterplan", a political decision (Sandra Hanzl, Meschik, and Sammer, 2003). It includes a set of measures aimed at future developments of the transport system. Strategic policies in transport cover a larger area and include long-term strategies, which consequently need to be implemented (Hanzl, Meschik and Sammer, 2001). Hanzl, Meschik, and Sammer (2001) submit that it is essential that implementation of policy also comprises of the analysis of social and political acceptability of measures and the sensibility of citizens, politicians, journalists, and experts for objectives and programmes before, during, and after implementing transport measures. This section presents a consolidated picture of national policies within the transport sector in South Africa

2.2.2. Transport policy framework in South Africa

The Department of Transport is the custodian of the public transport policy matters (plays a facilitative and regulatory role) in South Africa. It develops the policy and legislative framework, which is implemented through provincial departments, local government, and public entities. According to Treasury (2014), there are three official policy documents and two important pieces of legislation on public transport since 1994. A summary of transport policies and legislation for South Africa about public transport and non-motorised transport are discussed below. These provide a framework guiding the planning, design, and safety of public transport and non-motorised transport (NMT) facilities and activities.

a) White Paper on National Transport Policy (1996) and Draft White Paper on National Transport Policy (2017)
b) National Transport Master Plan (NATMAP) 2050
c) National Development Plan, 2012
d) National Road Traffic Act, 1996 (93 of 1996
e) Public Transport Strategy and Action Plan (2007)
f) National Land Transport Act (5 of 2009)
g) Taxi Recapitalisation Policy, 2009
h) Municipal By-Laws

2.2.2.1. White Paper on National Transport Policy (1996) and Draft White Paper on National Transport Policy (2017)

The White Paper on National Transport Policy is the key transport policy document in South Africa because it guides all transport legislation and planning (Department of Transport 1996). The 1996 and the revised 2017 White Paper on National Transport Policy (2017) advocates for a "safe, reliable, effective, efficient, coordinated, integrated and environmentally friendly public transport system by developing norms and standards as well as regulations and legislation to guide the development of public transport for rural and urban passengers; and to make public transport competitive with the private car to provide a viable alternative mode". The policy further envisioned "a transport system that provides equitable and reliable access for all in an economically and environmentally sustainable manner to advance inclusive growth and competitiveness of the country" (Department of Transport, 2017; 1996). Despite the policy's goal as articulated above, South African cities are still characterised by relatively inequitable, long commuting and unreliable public transport systems that inhibit access to economic activities. To this end, the policy is divided into two key areas – infrastructure and operations and control. Public transport is nested within the broad area of operations and control under the heading "land passenger transport". The Department of Transport's mission regarding land transport is:

To support this vision, the White Paper objectives are broadly outlined as:

- Spatial development principles must support passenger transport policy.
- The principle of devolution of public passenger transport functions to the lowest appropriate level of government.
- The application of funds to transport improvements should be self-sustaining and replicable. To encourage this, the users of urban transport facilities should pay for all or most of the costs incurred within the limits of affordability.

It is evident from the above objectives that the White Paper considers the provision of public transport as critical to improving mobility and accessibility and that it should be provided efficiently, affordably, and effectively. In terms of infrastructure for public transport, the White Paper provides that there should be efficiency in the provision, maintenance, and operation of the primary economic road infrastructure network. Against this background, the White Paper promises to offer financial and technical assistance to the minibus taxis to 'improve their financial viability (South Africa 1996: 24). In the same manner, it also recommends 'regulated competition' to the bus operations. Further that

the rail infrastructure for commuter transport should be determined by a combination of market needs and social considerations. Since the 1940s, the bus industry has been dominated by a few monopolies in South Africa. For example, Public Utility Transport Corporation (PUTCO) has been a recipient of up to 45% of the annual R815 million bus subsidies, with some 35 bus companies sharing the rest (Department of Transport 1996; Khosa 1998; Department of Transport, 2014). One of the policy principles of the White Paper is "to encourage, promote and plan for the use of non-motorised transport where appropriate" (Land Passenger Transport Chapter, Strategic Objectives). Therefore, one can infer that the objectives of the White Paper on Transport Policy have not been achieved as envisaged, because the mobility needs of the population have not been met. Public transport is still not accessible and affordable for the majority.

2.2.2.2. National Transport Master Plan (NATMAP) 2050

The need to develop a transport master plan was identified by government in an effort to seek to improve the efficiency and effectiveness of a multimodal transport system that is well regulated and well managed within a multisectoral sphere of effective coordination. As a result, the National Transport Master Plan (NATMAP) derives its main goal from the need for a multi-modal transport planning framework which is dynamic, long-term and in line with future transport infrastructure supply facilities. The NATMAP 2050, therefore, aims to achieve: "an integrated, smart and efficient transport system supporting a thriving economy that promotes sustainable economic growth, supports a healthier lifestyle, provides safe and accessible mobility options, socially includes all communities and preserves the environment."

2.2.2.3. National Development Plan (2012)

The NDP presented a long-term strategy, which considered a variety of factors that influence the South African economy and society, including transport. Investments in transport infrastructure and improving public transport are viewed as key development areas that are imperative in achieving the 2030 objectives. The NDP recognises specific strategy objectives, which are related to public transport and are intended to address and eradicate poverty and reduce inequality in South Africa. These are listed below:

- Investments in public transport, which will benefit low-income households by facilitating mobility.

- Investments in the transport sector must 'bridge geographical distances affordably, foster reliably and safely so that all South Africans can access previously inaccessible economic opportunities, social spaces, and services".
- Improving mobility and economic accessibility will increase social and economic access and alleviate poverty (The National Planning Commission, 2011)

The NDP (primarily from Chapter 4 – Economic Infrastructure and Chapter 8 – Transforming Human Settlements) identifies several public transport policies and planning priorities, including:

- Increasing public transport investment: attracting private-sector investments that are focused on extending bus services, refurbishing commuter trains, and linking high-volume corridors to develop an integrated and effective
- Resolving the problems with bus rapid transport (BRT) systems.
- Devolving transport management to local governments and ensuring that institutions are strengthened, and legislation, policy, and practice are aligned.
- Providing subsidies for low-income commuters will increase the affordability of public transport (The National Planning Commission, 2011).

It has been 10 years since the NDP was developed, most of these objectives have not been met highlighting the mismatch of policy and implementation. There is still much that needs to be implemented to achieve the above stated objectives.

2.2.2.4. National Road Traffic Act, 1996 (93 of 1996)

The NRTA contains various provisions that impact on NMT and its associated facilities, such as public roads used by bicycles, pedestrians, and animal-drawn carts, amongst other issues. They provide that no one may drive a vehicle on a sidewalk. The definition of "vehicle" includes bicycles. This could be a limiting factor in promoting NMT since bicycles are part of NMT. A sidewalk is defined as that portion of a verge intended for the exclusive use of pedestrians. "Verge" is defined as that portion of a road, street or thoroughfare, including the sidewalk, which is not the roadway or the shoulder. There are some challenges in the interpretation of this Act, which needs to be addressed for the benefit of all road users. The promotion of NMT is critical because of its role in the first and last mile service as articulated in the Public Transport Strategy and plan 2017 in the next section. Lack of

inclusion for this mode in the planning and provision of infrastructure exacerbate the challenges of access and egress. It is important that the safety element is also incorporated and covered thoroughly.

2.2.2.5. Public Transport Strategy and Action Plan, 2007

The Public Transport Strategy aims to radically accelerate the improvement in public transport by focusing on modal upgrading and establishment of Integrated Public Transport Networks (IPTN), which introduced Priority Rail Corridors and Bus Rapid Transit in South African cities. The strategy is supported by the Public Transport Action Plan, which focuses on the implementation, in a phased and incremental approach. This is a central policy document on public transport, highlighting the creation of integrated public transport networks (IPTN), wherein NMT is the key aspect of the 'first mile' and 'last mile' of a trip. The intention of Action Plan is to introduce public transport that would reduce unacceptable walking distances and improve NMT links to public transport. The Strategy also discusses "high-quality non-motorised transport networks". It provides further that NMT, particularly walking and cycling, should serve as an important mode of transport in the proposed IPTN. It provides that actions to improve NMT linkages fall into typical infrastructure development categories of planning, design, implementation, and maintenance (Department of Transport, 2014).

2.2.2.6. The National Land Transport Act

The National Land Transport Act NLTA (5 of 2009) provides that the Minister of Transport must facilitate the increased use of public transport and, in taking measures relating to public transport, must promote the safety of passengers, promote a strategic and integrated approach to the provision of public transport and promote the efficient use of energy resources and limit adverse environmental impacts about land transport. Section 36 provides that every municipality must produce an Integrated Transport Plan (ITP). In doing so, they must comply with the Minimum Requirements for Integrated Transport Plans which require the larger municipalities to produce a Comprehensive Integrated Transport Plan (CITP) including a Transport Needs Assessment that must give due attention to NMT. CITP must also include an NMT strategy. Municipal ITPs are binding on everyone, including organs of state, and can be used as a tool to enforce the provision and maintenance of NMT infrastructure. They must be updated annually and "overhauled" every five years. Furthermore, Section 35 of the NLTA provides that each province must produce a Provincial Land Transport Framework (PLTF). The Framework must in turn provide that in preparing the PLTF, non-motorised forms of transport

must be considered. In the same manner, they provide that the PLTFs must contain a chapter on "non-motorised and environmentally sustainable transport" including, amongst others: the integration of NMT planning with land transport and land use planning. These include the improvement and expansion of pedestrian sidewalks and dedicated public space to interlink public transport stations and ranks, (Department of Transport, 2014).

2.2.2.7. Taxi Recapitalisation Policy, 2009

The Taxi Recapitalisation Policy (TRP) is an intervention by government to bring about safe, effective, reliable, affordable, and accessible taxi operations by introducing New Taxi Vehicles (NTVs) designed to undertake public transport functions in the taxi industry. Through this project, the government seeks to challenge the problem of an ageing fleet within the transportation system. The TRP represents a comprehensive re-engineering of the taxi industry to introduce safe and comfortable vehicles for taxi commuters.

2.2.2.8. Municipal By-Laws

Section 156 (2) of the Constitution, read with the Local Government: Municipal Systems Act (32 of 2000), empowers municipalities to make bylaws on any issue over which they have a responsibility, such as municipal roads, municipal planning, traffic, and parking, among others. Some South African cities are drafting by-laws impacting public transport and NMT users. There is a need for legislation in all three spheres of government to address public transport and NMT specifically, infrastructure. Some legislation, e.g., the National Road Traffic Regulations, have provisions that could hamper the introduction or promotion of NMT. In terms of the regulations, cities should encourage by-laws that promote public transport and NMT friendly developments, (South African Government, 1996).

Transport policy is spelled out in the 1996 White Paper on National Transport Policy. The National Land Transport Act (22 of 2009) (NLTA) sets out a framework for integrated land transport planning and service delivery across provinces and local government, (Republic of South Africa Government, 2009). The approach which has emerged, especially in the Public Transport Strategy and Action Plan (hereinafter the Strategy) and the National Land Transport Act (2009), envisage an active role for the public sector in the management of city-wide networks, with city governments playing the leading

role. In the same light, the Strategy is intended "to shift public transport service delivery away from operator controlled, commuter based, uni-modal routes to user-oriented, publicly controlled, fully integrated, mass rapid public transport networks" (Treasury, 2014).

Some of the key components as summarised in the Strategy are as follows:

- 85% of all residents within 1km of IPT Network by 2020
- Extended hours of operations (16-24 hours)
- Peak frequencies (5-10 min) – Off-peak frequencies (10-30 min)
- Electronic fare integration when making transfers.
- Integrated feeder services including walking/cycling and taxi networks.
- Car competitive public transport option – enables strict peak period car use management (Treasury, 2014).

Several agencies within the Department of Transport are mandated to deliver transport infrastructure and oversee transport regulation. These include among others, the South African National Roads Agency Limited (SANRAL) which manages the construction of roads. The agency responsible for services and regulation of rail transport is the Passenger Rail Agency of South Africa (PRASA). Other regulatory bodies include the Road Traffic Management Corporation (RTMC), which is expected to enhance cooperation between the three spheres of Government on road traffic management and law enforcement, (Treasury, 2014). They are responsible for traffic management and road safety in terms of section 52 of the Road and Traffic Acts (93 of 1996) (Treasury, 2003; Treasury, 2014).

The White Paper on National Transport Policy (1996, 2017), and more recently, the National Development Plan 2030, describes public transport policy in South Africa in directing the implementation of government plans in transport development, for example, the development of the Bus Rapid Transit (BRT) came into effect through such policies (Department of Transport, 1996; The National Planning Commission, 2011). As highlighted above policy will further provide guidelines to other spheres of government such as provinces and local governments. For example, the Department of Transport (2008) requires that NMT be developed and integrated into the Provincial Land Transport Framework (PLTF) and Integrated Transport Plan (ITP) of local government. This provides and serves as guidelines for the attainments of the provincial and municipal transport plans respectively. A guideline which requires implementation mostly from low levels of government has

been provided by the PLTF. PLTF) is a strategic document whose purpose is to inform all transport and land use related provincial decision-making concerning transport infrastructure development, management, and investment, public transport, NMT, freight transport, land transport safety, as well as guide district-wide and local ITP, (Department of Transport, 2009). The purpose of the ITP is to communicate to citizens and other stakeholders such as the provinces and the National Department of Transport how cities intend to plan, implement, and operate transport in a transparent and accountable manner, to improve the transport system for the benefit of all its citizens (Department of Transport, 2009).

The NMT Facility Guidelines were prepared in 2014 by the Department of Transport. It provides guidelines for practitioners to carry out planning, design, and implementation of NMT facilities, maintenance programmes, and implementation of standards. The guidelines should be used in conjunction with other guidelines and standards for road design, such as the South African Road Traffic Signs Manual (SARTSM, Manual) and others. The Non-Motorised Transport Facility Guidelines prescribes the need to promote NMT as a feeder mode to other modes of transport, especially public transport. However, there is a backlog of infrastructure provision for the integration of these modes and more importantly to accommodate first and last-mile services. The first and last mile service infrastructure is essential to complement the entire public transport system. In the context of urban transport, the term “first and last mile” finds relevance in public transport systems where it is referred to as both the initial and final leg (access and egress) of delivering connectivity – from origin to transit nodes and from transit nodes to destination, (The National Planning Commission, 2011; Chidambara, 2014).

2.2.3. Conclusion: transport policies in South Africa

The poor population usually resides away from job opportunities and amenities, and this burdens them with enormous travel distances to their places of employment and commercial centres and this contributes to excessive costs. As a result, this exposes commuters to vast walking distances and insecure rail travel; fails to regulate the taxi industry adequately; largely ignores the country’s outrageous road safety record (Republic of South Africa, 1994). Government officials need comprehensive urban access data to address the policy objective of maximizing urban access. Urban access time indicators need to be developed at the urban area level and between small zones within urban areas for the various public and private modes of travel. In proceeding with mass transit

improvements, transport policies must focus on outputs (objectives) to produce more favourable urban access than focusing on inputs (regulatory systems and service provision alternatives) (Gordon and Lee, 2015). Urban transport systems (collective and personal) that maximize access in the cities would likely improve the potential for addressing the challenge of eradicating poverty and facilitating greater economic growth (Carruthers, Dick and Saurkar, 2005; The World Bank, 2009; Lall, Henderson and Venables, 2017). The overall transport policies should aim to develop new transport infrastructure which supports economic development, reduces the cost of transport, travel times and inequality.

Within the context of South Africa, it is necessary to tackle the spatial distribution of South African cities holistically and pragmatically. Sustainable service provision can be possible once transport, land use, and services planning are fully integrated to enhance the functioning and efficiency of cities. that the role of NMT, walking in particular as well as public transport has been emphasised, it is vital to encourage investment of NMT and public transport infrastructure for the benefit of integration, social inclusion, and sustainability in transport and other areas of social activity. Policy directives can play a huge role in promoting investment towards these modes in order to improve the level of accessibility. The Department of Transport, in addressing its constitutional and legislative mandate, remains critical for the achievement of socio-economic goals of society. It exists to ensure the provision of safe, reliable, effective, efficient, affordable, and integrated transport services that best meet the needs of passenger as stipulated in the 1996 White Paper on Transport Policy. Policy plays a major role in advocating for infrastructure development, maintenance, and strategic expansion of its network. This will in turn contribute to high level of accessibility of the transport system.

2.3. **Modes of public transport**

2.3.1. Bus Transport

Bus transport covers the municipal buses, bus rapid transit (BRT), and commuter buses (public and private). The control of bus services is exercised at the central government level by the Department of Transport (DoT), which grants operating permits and approves fares and transport service levels, (Khosa, 1998). Conventional bus services are provided by large and well-established private companies on contracts issued by provincial governments. The conventional bus (i.e., provincially subsidised) services arose during the apartheid period in response to the long travel distances between

newly established black townships and places of work (Khosa, 1998; Treasury, 2014). Municipal bus services originated as services within white-dominated areas. They serviced the shorter routes within the core city, while the longer routes to and from the black townships were left to the provincially subsidised buses. The bus industry has been faced with a variety of challenges, which resulted in the market share for buses deteriorating substantially. Some of the factors that contributed to the deterioration are because bus services operate at inconsistent frequencies during the peak and off-peak, lack of service information for users e.g., poor route information and poor fleet management. As a result of these factors, there has been an increased incidences of accidents and breakdowns (Khosa, 1998; Treasury, 2014; Statistics South Africa, 2015b).

The need for bus-fare subsidies was closely associated with the inability of most black people to pay their transport fares because of their location on the outskirts of urban areas (Pirie, 1987; Khosa, 1998; The National Planning Commission, 2011; Jennings, 2015). Interestingly, a government commission established in the 1940s to investigate transport in Pretoria, Witwatersrand, and Vereeniging concluded that: "transport charges about workers' wages, or even to the total family income, are beyond the capacity of the African workers to pay. They certainly cannot afford to pay anything more in the direction except by reducing further their hunger diet" (South Africa 1944: p263 in Khosa, 1998).

According to the Expenditure & Performance Review Draft report prepared for Treasury, there are about 44 subsidised bus contracts in South Africa (Treasury, 2014). These subsidised bus services are characterised by long journey distances between township origin and workplace destination (and the reverse in the afternoon). Operations have therefore been designed to allow buses to make one inward journey during the morning peak, to park during the day, and to make one journey back in the afternoon peak (Treasury, 2014). The subsidy system is designed to support regular workers in that it offers a stipulated number of trips that can be taken per week or month. Subsidies for this service have not increased in recent years other than to compensate for the ongoing economic inflation. There has been a limited expansion of the public transport (bus) service despite significant urban growth. This appears to be because of uncertainty as to whether and how the bus service should be developed (Treasury, 2014). Khosa (1998) argues that the operational legacy of the bus system remains in place. This has also been highlighted in the 2011 National Development Plan (The National Planning Commission, 2011). When compared to provincially subsidised conventional buses, operating costs tend to be higher, load factors are lower, and trip lengths are shorter. Unlike subsidised conventional

buses, a relatively large fraction of their care services is provided to pensioners and scholars on their way to and from school, accounting for significantly lower fare revenue. Municipal bus services on the other hand absorb higher operating subsidies than conventional bus services, according to Khosa (1998).

The Public Transport Strategy and Action Plan 2007 (Treasury, 2014) implicitly lends support to extensive implementation of what is referred to as BRT. In line with the Public Transport Strategy and Action Plan, most of South Africa's metros and a few secondary cities are rolling out BRT projects with substantial government support through the National Department of Transport.

2.3.2. Bus Rapid Transit system

Bus transport includes the BRT systems which were introduced in South Africa during the past decade. The BRT model was developed in Latin America, but is now being implemented all over the world, especially in China and other parts of Asia, and is widely regarded as the best practice for modernising road-based urban public transport services. BRT has got key sets of operational design features which are intended to increase speeds, and thus, improve customer service while reducing costs through reducing cycle times (Treasury, 2014). BRT systems make use of modern buses and stations, equipped with access for the disabled, operating on dedicated bus lanes with a comprehensive system of trunk and feeder routes, enabling riders, in many cases, to board or alight nearer to their residences or places of work (Cervero, 2013; Frieslaar *et al.*, 2015; Maggie and Niclesse, 2016). Although the BRT system has proven itself to connect workers with commerce in a comparatively cost-effective and flexible manner, the infrastructure takes many years to build. Cervero (2013) asserts that BRT systems have gained favour in developing countries. This is evidenced by the fact that they have been implemented in over 150 cities globally, transporting about 28 million passengers each weekday. Cities such as Curitiba (Brazil) implemented the BRT system mainly because they were more affordable than light rail transit (LRT), while others, such as Seoul, Mexico City, and Bangkok, have invested in BRT systems to supplement pre-existing urban rail systems. In cities like Lagos and Jakarta, BRT has provided the backbone for a new public transport system because there were no viable public transport systems in place (Cervero, 2013; Maggie and Niclesse, 2016).

The need to improve mobility and accessibility levels necessitated the investment of the BRT system in South African cities. This were intended to transform the urban space to provide more inclusive, sustainable, and productive cities (Maggie and Niclesse, 2016). Although detailed statistics for BRT are not readily available, because they are private companies, it is common knowledge that they are subsidised by the different municipalities to a substantial extent either in the form of operating subsidy or in the form of capital sums paid out to taxi owners for surrendering their operating licences and leaving the industry altogether. Now in its thirteenth year of operation, the Johannesburg BRT service consists of only about 45km of dedicated road, a "growth rate" of less than four (4) km per year (Automobile Association (AA), 2021). Johannesburg introduced a BRT system named "Rea Vaya." Its journeys are charged by length on a sliding scale, with fees capped for trips over 35km and are paid for by a pre-loaded smartcard used by boarders to tap in and out of a trip. Interestingly, the prices are competitive with taxi fares over these distances.

Another example of a BRT system is "MyCiti" in Cape Town, which link three nodes of economic potential – namely Atlantis, Epping and Paarden Eiland, and the Cape Town CBD. Although other cities in South Africa have commenced BRT operations there have been many allegations of corruption in the awarding of tenders in Harambee scheme in Ekurhuleni (Germiston). While in the Go!Durban scheme in eThekwini millions of rands have been spent without any actual services in operation (Automobile Association (AA), 2021).

2.3.3. Minibus taxis

The minibus taxi industry is a dominant form of public transport in South Africa because it transports more than 70% of all motorised trips. Their fleet consists mainly of 15-seater taxis and about 1% being the midi-bus taxis. While the minibus-taxi industry remains an informal one, it has a high share of the transport market (Walters, 2014; Fobosi, 2019). It is the most available, convenient, and affordable mode of public transport, and serves largely the urban poor (Transport Education Training Authority (TETA), 2018; Fobosi, 2019). Minibus taxis currently provide two-thirds of all public transport in metro areas and carry more than one-third of daily passengers in motorised transport in the metropolitan areas (i.e., not including walking, cycling or 'other') (Fobosi, 2013, 2019; Statistics South Africa, 2014; TETA, 2018). Since the 1980s, the number of minibus taxis has grown to some 130 000 minibus taxis in South Africa in 1996 (Race Relations Survey 1986-1996), which highlights the importance of the industry in the public transport space. According to the SANTACO 2014 report,

an estimated 200,000 to 250,000 minibus taxis are currently operating in South Africa. Further, some estimates suggest that the industry has an annual turnover of nearly R40 billion per annum and employs 600,000 people. (SANTACO, 2014; TETA, 2016).

The significance of the minibus taxis industry is highlighted in the Expenditure & Performance Review Draft report (Treasury, 2014). It has proven remarkably efficient in providing public transport services, particularly over shorter routes where the subsidy advantage benefitting competing services is not as pronounced. A notable feature of this industry is that it has no operational subsidy, unlike the other transport modes. The efficiencies of the minibus taxi system are rooted in:

- their informality, including informal working conditions, which permit a very low-cost structure, and minimal enforced regulation.
- their use of mass vehicle technology, which is cheap and reliable.
- their flexibility, which enables them to respond quickly to market demands.
- their small vehicle size, which means that they can profitably serve relatively low demand routes at acceptable headways (Treasury, 2014).

All provinces have now established democratically elected taxi councils (Treasury, 2014). The democratisation process was concluded with the election of members of the South African Taxi Council (SANTACO) in September 2001 and later the National Taxi Alliance (NTA) (Transport Education Training Authority (TETA), 2018). These organisations represent the interests of the industry in business meetings with various stakeholders at national level. Khosa (1998) summarises this by stating that:

“The efficiency of the minibus taxi sector and the current scale of operations combined with the marginal nature of many individual businesses, as well as the problems arising from lack of regulation is resulting in demands to both subsidise the sector beyond the current taxi recapitalisation programme. Subsidisation of the sector is seen by some as offering a mechanism to both formalise the sector and strengthen its regulation, and thus achieve higher safety levels, better working conditions, and better management of the competition. While better regulation and management of competition could yield very significant positive results, there is also a danger that doing so will run the risk of increasing costs with minimal or no concomitant improvement in output” (Khosa, 1998; Treasury, 2014).

Provinces have adopted the National Land Transport Act (5 of 2009) (NLTA) requirements for formalising and regulating the taxi industry. The formalisation process included registration of associations and non-members through the Office of the Registrar, and democratisation, which involves establishing minibus taxi leadership through elections at the regional and national level, (Khosa, 1998; Treasury, 2014). However, minibus taxi operations are not subsidised, but there is a taxi recapitalisation programme that pays an incentive when older, smaller taxis are scrapped, as well as a grant to purchase newer taxis. (Treasury, 2014).

2.3.4. Rail services

Rail plays a crucial part in the public transport space in South Africa, and it is regarded as the safest land transport when compared to other forms of transport. It is affordable and is the cheapest form of public transport on corridors with more than 40 000 one-way passengers, (Treasury, 2014). However, it is often less flexible and more capital intensive than road transport when lower traffic levels are considered (Johannesburg Inner City Traffic & Transportation (JICTT), 2010; Treasury, 2014). A majority of commuter rail lines in South Africa are operated by a parastatal, Metrorail (a division of PRASA). The exception is the Gautrain Rapid Rail Link, the first phase of which came into operation at the end of 2010. It is operated on behalf of the Gauteng Province under a 20-year concession contract by the Bombela Consortium (The Gautrain Development Agency, 2013; Treasury, 2014; Gautrain Management Agency, 2015). This project was developed as a "Public-Private Partnership (PPP) contract and was registered in terms of the Public Financial Management Act (1 of 1999) (hereinafter the PFMA) as a PPP project with National Treasury in 2001. The approved concession period entailed 54 months of development (construction) and 15 years of operations, to March 2026. The complete system as designed has been in full operation for 10 years. During this period, there has been an average 2.6% monthly increase in rail passengers, a total of 76.7% growth over 30 months.

Metrorail (PRASA) is a State-Owned Enterprise (SOE) under the auspices of the Department of Transport and is South Africa's biggest provider of passenger and commuter rail services (Metrorail, 2007). It is responsible for the provision of commuter rail services in the six (6) metropolitan areas. The commuter rail services include traditional commuter services (Metro and MetroPlus), as well as

the newer Business Express services (MetroPlus Express), which has two services serving Johannesburg and Tshwane. The train has a seating capacity of 520 passengers with an average travel time of 90 minutes. PRASA also has other types of rail services being offered, including Intercity services by Shosholoza Meyl, the exclusive Blue Train, and Pride of Africa (Rovos Rail) tourist services (Metrorail, 2007; PRASA, 2019). Therefore, the research only focuses on the commuter rail service, not the intercity and tourist services.

According to Treasury, the rail services in cities are experiencing operational and infrastructure challenges such as the need to upgrade track capacity, rolling stock, and stations (Treasury, 2014). If additional capacity and accessibility of the rail network are being expanded along specific corridors, it could stimulate higher density and transport-oriented developments in a long run. This includes the improvement and integration with other modes of transport and mixed land-use and transit-oriented developments (TOD) (Treasury, 2014).

The Gautrain Rapid Rail System is worthy of mention because, as stated above, it is not operated in terms of the Metrorail system. It is a public-private partnership (PPP) project developed to meet the demands of Gauteng's strategic development, and to strategically move Gauteng's economy and its people forward through transport infrastructure development. In the same manner, the National Development Plan 2030 enshrines a broad socio-economic policy document that guides development in South Africa and identifies PPPs as a core vehicle for service delivery and infrastructure development (The National Planning Commission, 2011). This is because PPP is based on a design-build-finance-operate-transfer (DBFOT) agreement (The Gautrain Development Agency, 2013; Chikagwa, 2014; Treasury, 2014; The Gautrain Management Agency, 2015).

Gautrain was necessitated by the increased levels of congestion in the Gauteng City Region, which needed alternative modes of transport to be sought, i.e., the introduction of a rapid transit railway between Johannesburg and Pretoria to alleviate the traffic congestion on the N1 freeway (Gautrain Management Agency, 2013). The 80-kilometer rapid rail link comprises of 10 train stations that connect Johannesburg and Pretoria and Johannesburg and OR Tambo International Airport. There is direct coordination with Metrorail Services at Johannesburg Park Station, Pretoria main station, Hatfield and Kempton Park, and physical interfaces with taxis and buses at Park Station (The Gautrain Development Agency, 2013; Gautrain Management Agency, 2015).

2.3.5. Non-motorised transport, as part of access and egress trips

In this section, the role of non-motorised transport (NMT) in connecting commuters (access and egress) to transit systems and economic activities is discussed. NMT forms part of people's daily lives in the cities and communities as a means of mobility to access places of amenities. NMT refers to walking, cycling, and variants such as a wheelchair, scooter, handcart use as well as associated infrastructure. It is a preferred mode of transport for short distances, provides basic mobility, affordable transport, access to motorized modes, physical fitness, and enjoyment (Litman, 2005; Department of Transport, 2008). A larger portion of the society makes use of it daily as their main mode of transport (PRASA, 2008; Statistics South Africa, 2014). For some, it is not a matter of choice but a necessity to move from point A to B. For these reasons, walking is an essential mode and a travel mode used by many as a primary way of getting around, and virtually all people walk as part of trips made by private cars or public transport (Lah, 2015).

In 2014, about 3 million workers (21, 1%) walked all the way to work in South Africa with the majority of those that walked all the way to work found in the rural areas (Statistics South Africa, 2014). Interestingly, there was a massive increase in terms of the latest 2020 NHTS survey (Statistics South Africa, 2020) which found that about 17,4 million South Africans walked to their destination. The 2020 NHTS revealed that walking (59,4%) was the primary method used by all learners (school-going and higher education) in all nine provinces in 2020 (Statistics South Africa, 2020). It also accounts for a large share of urban trips to the cities of developing Africa, including South African cities. Sturgis, (2015) states that the share of walking trips in sub-Saharan Africa is higher than in any other region of the world. Nonetheless, Commuters must contend with potholed tarmac, open manhole covers, running sewage, and dirt roads turning to mud baths when it rains (Shearlaw, 2015). This leaves the safety of commuters exposed to danger.

Woldeamanuel and Kent (2016) argue that walking presents health benefits to the public as the major transit access mode while presenting planners with the challenge of overcoming walk-accessibility costs which deter mass-transit use. Ligege and Nyarirangwe (2015) believe that the role being played by NMT, walking in meeting the daily mobility and accessibility needs, among the middle to low-income households, cannot be overemphasized. Walking as a preferred mode of transport for short

distances has proved to be essential in the urban transport system as alluded by the 2013 NHTS that nearly 3 million people walked to their place of employment (Statistics South Africa, 2014). Despite the evidence that walkability has always been an important part of transport mode, it is still not considered to be part of the urban transport system since it is deemed as an insufficient investment in non-motorised infrastructure (International Energy Agency, 2013). The literature indicates sidewalk quality, availability, and street network connectedness are crucial access factors in walking to transit stations and in other instances as the main mode from origin to destination. Hence, there are still many barriers preventing market acceptance of NMT (IEA, 2013). These barriers include but are not limited to:

- Lack of necessary policy and incentive programmes to encourage early market take-off and first movers.
- Lack of the necessary supporting infrastructure to develop sustainable alternative forms of transportation. The growth of non-motorized transport, in particular cycling, has been very low in almost all developing countries due to a large extent to lacking infrastructure. (IEA, 2013)

The Gauteng province Household Travel Survey has found that walking is still the predominant mode of travel in the province. It accounts for 70% of the travellers and commuters' trips. This demands that facilities for non-motorised transport should receive priority as well as walking times to access the first public. They use this mode of transport daily as a feeder service to the public transport stations and stops, some as their primary mode to travel from home to work, school, and shops (Gauteng Province Department of Roads and Transport, 2013). The Gauteng Province Household Travel Survey also revealed that public transport users tend to walk longer to access the first public transport mode than to access their destination from their last public transport stop (Gauteng Department of Roads and transport, 2016). Furthermore, the 2019/ 2020 Gauteng Household Travel Survey (GHTS) found that over 29% of trips in the peak period are "walking all the way".

African cities are fragmented or disconnected, because of this, standard of living and commuting costs are high (The World Bank, 2009; Lall, Henderson and Venables, 2017). The Statistics South Africa's Quarterly Labour Force Survey (QLFS) reveals that most people are discouraged from looking for jobs because there are no jobs in their area while others lack money to commute (Statistics

South Africa, 2019c). These job seekers can only reach to areas where they can walk, which limits their chances of getting employment. Benn (2004) argues that though walking is the most sustainable form of urban travel, it cannot provide access to the broader employment opportunities that exist throughout cities. The cities of developing Africa, with their large urban footprints, are not walking cities. Lack of access to employment opportunities throughout most of the urban area restricts household incomes and is likely to retard economic growth while increasing unemployment and poverty (Salon and Gulyani, 2010). Some cities of developing countries may have long since become too spatially large for walking to suffice as a principal mode of access without hobbling economic growth and ingraining high levels of poverty (Cox, 2012). Many walked long distances to the Metro, which was strained to beyond its capacity. The system required considerably more in government operating subsidies than had been foreseen (Muñoz, Ortuzar and Gschwender, 2008). Some existing studies have argued that despite a recognised need to "rebalance" movement systems to better respond to a wide range of travel needs, NMT is still not incorporated in all aspects of planning, but an emphasis on motorised transport (Parkin, Ryley, and Jones, 2007; Jennings, 2011; Mullan, 2013; Sturgeon Consulting, 2015).

Ligege and Nyarirangwe (2015) argue that there is little to no provision of the NMT infrastructure in the South African townships and cities even though it plays a huge role in the economic development, empowering marginalized groups, and alleviating poverty. PRASA (2008) indicates that many commuters walk to reach the origin station, when the disembark at the destination and back home for access and egress trips. The new infrastructure developments prioritize the provision of motorized vehicles with less attention given to NMT infrastructure (Ligege and Nyarirangwe, 2015). However, the provision of NMT infrastructure is starting to be discussed by various interest groups to correct these injustices. In South Africa, those who walk do not choose to do so but are compelled by socio-economic factors. Therefore, the inclusion of NMT infrastructure in the road design and built environment can contribute to connecting people to opportunities and other transport modes and nodes, especially poor communities. These poor households do not have the opportunity to own private cars and their only options are walking or cycling. As asserted by Mabe (2015) the South African working-class population is essentially the walking class it would be beneficial to begin to shift towards the inclusion of NMT into the public transport system. Good access and egress which is mainly fulfilled by walking have a significant role to play in making public transport accessible.

2.4. **Key challenges and issues faced by the passenger transport sector**

Nearly two decades after the publication of the White Paper on National Transport Policy in 1996, passenger transport in South Africa is still fragmented and suffers from operational and institutional inefficiencies. It is not adequately focused on the customer in terms of accessibility, reliability, affordability, and safety. Despite introducing Integrated Public Transport Network (IPTNs) and other plans and policies supporting the integration modes, the roll-out of improved and integrated passenger transport is still lacking (Von Der Heyden *et al.*, 2015; Competition Commission, 2017; 2021). The passenger transport industry is still faced with a variety of challenges, among others are:

- The public transport system is still fragmented between passenger transport modes despite the positive intentions behind the rolling-out of IPTN.
- There is a lack of maintenance and underinvestment on current passenger transport facilities, and this results in poor passenger facilities.
- BRT system funding models are expensive because they are implemented without considering their appropriateness as compared to other modes/ technology choices given to passenger numbers, business case support, and other developmental and transformation objectives. ().
- There is competition between passenger transport modes and this, results in friction between operators (e.g., bus/BRT/taxi), which, in turn, hinders cooperation.
- The provision of public transport services will continue to be inequitable, inefficient, ineffective, and uneconomical without an operational subsidy policy.
- The low densities, new low-cost housing developments on the peripheries of cities or towns adds to urban sprawl, result in long travel time and inefficient use of passenger transport.
- There is a lack of integrated ticketing, information systems, safety, and operational compliance standards for public transport.
- There is no reliable or updated public transport data and this results in uninformed and ineffective passenger transport planning (Von Der Heyden *et al.*, 2015; Competition Commission South Africa, 2017; 2021).

2.5. **Public Transport Subsidies**

As stated above, South Africa's public transport system comprises of three modes namely, bus, train, and the minibus taxi (MBT) industry. According to an expenditure and performance review prepared for the presidency (Treasury, 2014; Statistics South Africa, 2020), the MBT transports about 70% of

public transport passengers, raises 71% of the total revenue, and yet receives 0% of subsidies. In comparison, the Gautrain transports 1% of public transport users, raises 7% of the total revenue, and receives 15% of subsidies. In the same manner, the commuter rail (Metrorail) carries 21% of the passengers, raises 10% of the total revenue, and receives 29% of operating subsidies; while buses (Conventional, Municipal and Bus Rapid Transit (BRT) transport 11% of passengers, raises 12% of total revenue and receives 56% of operating subsidies. Based on this analysis, it is evident that the MBT industry is dominant in the public transport system.

Transport subsidy is defined as "the difference between the economic fare and what the commuter pays (Lipman 1993). Transport subsidies (for buses and trains) are only applicable to weekly or monthly tickets. A subsidy amount of R185 million supports some 815 000 passenger trips per day in South Africa" (Department of Transport 1996). Khosa (1990), states that although the state has been providing transport subsidies to black workers since the 1950s, transport subsidies do not cover all classes of labour, nor the unemployed. "The subsidy system is designed to support regular workers in that it offers a set number of trips that can be taken per week or month. Subsidies for this service have generally not been increased in recent years other than to compensate for inflation; there has been a limited expansion of the service despite significant urban growth. This appears to be because of uncertainty as to whether and how the service should be developed" (Treasury, 2014). Van der Merwe and Krygsman (2020) are in agreement with a study in the USA by Phillips (2014) which showed that direct transport subsidy reduces transport costs when searching for work, and significantly increases their job search intensity. This goes to show that public transport subsidies play a significant role for those who are mostly in the lower-income level It also keeps them encouraged to search for work compared with the group that did not receive a subsidy (Van der Merwe and Krygsman, 2020).

The National Land Transport Act (5 of 2009) (NLTA) also sets out the mechanisms on how to transform the transport subsidy system, as well as how to formalise the taxi industry. The reform seeks to develop many current bus subsidies since they come from past arrangements and do not reflect new public transport priorities. Although provinces assist in administering payments of these bus subsidies, this duty rests on the state through the National Department of Transport which retains the right to make all final approvals in the procurement of bus services. Therefore, the aim of NLTA

is to devolve this function to provinces and municipalities after the process of transformation and restructuring of the transport subsidy system is completed (Republic of South Africa Government, 2009). Although to a limited degree, the NLTA has achieved this goal since the municipalities are now responsible for planning and regulating municipal public transport and many run their bus services (Republic of South Africa Government, 2009).

2.6. **Affordability of public transport for South African households**

The 1996 White Paper on National Transport Policy has set a benchmark of 10% of disposable income to measure the affordability of public transport. One of the strategic objectives of the policy document mention that public transport should be affordable for all commuters in relation to their disposable income (Department of Transport, 1996, 2017). This may either be the percentage of household income or the percentage of the personal income of commuters. Both the 2014/16 and 2020 Gauteng Province Household Travel Surveys also found that the proportion of household income spent on public transport has increased significantly. This is inconsistent with both the national and provincial policies of reducing household public transport cost to less than 10% of disposable household income (Department of Transport, 1996; Gauteng Province Department of Roads and Transport, 2016). As defined by Carruthers, Dick, and Saurkar (2005), the concept of affordability refers to "the extent to which the financial cost of journeys put an individual or household in the position of having to make sacrifices to travel or the extent to which they can afford to travel when they want to". The affordability measure is calculated by dividing household per capita travel cost incurred for public transport by per capita income (Statistics South Africa, 2015b).

The distance between the place of residence and place of work has been aggravated in South Africa by the race-zoning policies and legislation highlighted above (the Native (Urban) Areas Act 21 of 1923 and the Group Areas Act 41 of 1950) (Khosa, 1998). A significant portion of the black population in South Africa is still affected by poor accessibility and mobility. This is even after the country has invested so much in the improvement of the public transport systems such as the Gautrain, Bus Rapid Transits (BRT) to provide for mobility and accessibility. The cost of public transport and the distances involved prevent the poor from taking full advantage of opportunities offered by cities, and such exclusion contributes to high unemployment rates (The National Planning Commission, 2011). Moreover, public transport consumed between 5 and 20% of the black working-class incomes

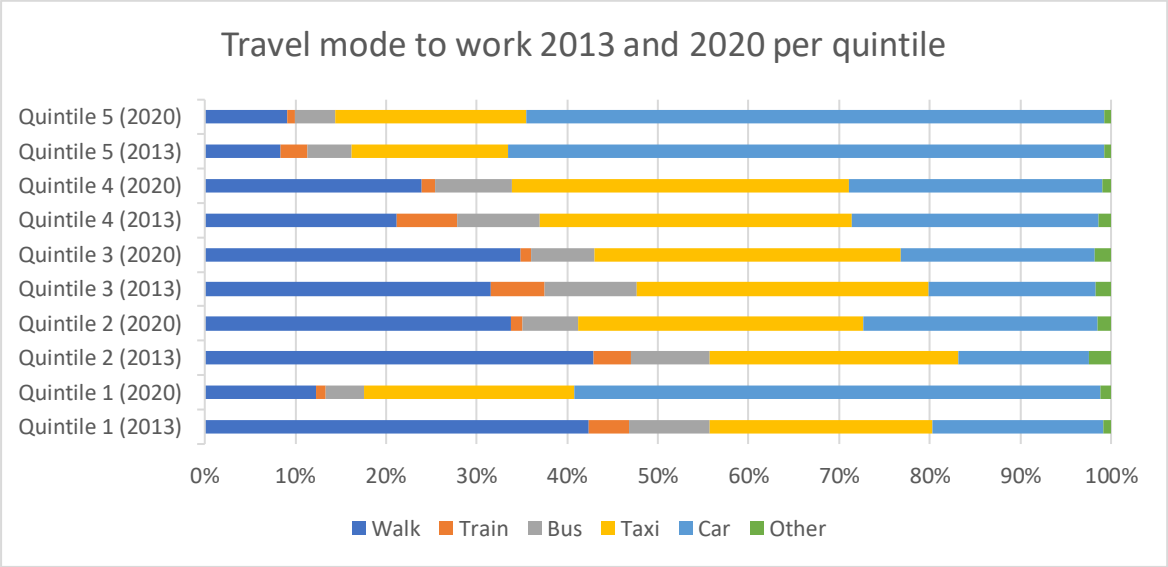
(van der Reis 1993) in metropolitan areas compared to other races who spend an average of 7-6% of their incomes on travel, which is still the case in 2020, as the Gauteng House Travel Survey found (Gauteng Province Department of Roads and Transport, 2020). Transport is often the second major expense in the family budget after food.

Van der Merwe and Krygsman (2020) and Kerr (2015) argue that public transport costs are a significant driver of inequality in South Africa. For this reason, lower-income workers find it difficult to 'transfer' the cost of commuting to their employer and to allocate a significant percentage of their salaries to transport compared with higher-earning individuals. Kerr (2015) compared the commuting times for commuters of different income groups using different transport modes and found that commuters who use the three main modes of public transport (bus, train, and minibus taxi) spent a significantly higher percentage of their income on transport than private vehicle users. This finding is also highlighted in both the 2013 and 2020 National House Travel Survey reports (Statistics South Africa, 2014).

Likewise, Statistics South Africa (2014) found that of the 5,3 million households who used public transport, about 2,2 million households spend less than 10% of their monthly household income per capita on public transport and about 1.5 million households who spend between 10% and 20% (Statistics South Africa, 2014). Regarding monthly household earnings, more than 60% of the low-income households earning R500 or less per month spend more than 20% of their monthly household income per capita on public transport, whereas 90% of households earning more than R6 000 indicated that they spend less than 10% of their monthly household income per capita on public transport (Statistics South Africa, 2015). For these reasons, Statistics South Africa (2015) found that taxis are the most expensive mode of travel with an average per capita monthly cost of R561, followed by travelling by buses which cost R502 and finally trains which operate at R402 per month. It also found that more than two-thirds of (66,6%) households who fall in the lowest income quintile spent a higher proportion of their income (more than 20% of their monthly household income per capita) on public transport compared to households from the highest income quintile. This highlights the reliance of the lower-income quintile households on inefficient public transport. (Statistics South Africa, 2014).

According to (Statistics South Africa, 2015a), households in urban areas (18,66%) and rural areas (18,65%) have a higher proportion of expenditure on transport compared to the other settlement types (such as metros), which is also higher than the national percentage of 16,29%. This is attributed to the fact that these households (in rural areas and to some extent in urban areas) are located far from shopping centres and malls. As a result, people residing in rural areas are likely to spend more on transport as the distance increases. Metropolitan or urban formal areas have got infrastructure within their proximity and stand to benefit more compared to rural areas. Infrastructure programmes are more likely to be developed in metros and urban formal areas compared to the rural formal ones (Statistics South Africa, 2015a). Statistics South Africa's 2014/2015 Living Conditions Survey further contends that consumption expenditure on operational costs for privately owned vehicles is higher (R6 157) compared to expenditure on the use of public or hired transport (R3 844) for most of the population groups. However, this is not the case for Black households, who recorded a lower percentage because they spent more on public transport. For these reasons, it can be inferred that Black households have a higher proportion of their expenditure dedicated to transport (17,21%), followed by coloured-headed households (16,03%). This is high given the fact that these groups are in the lowest brackets when it comes to the level of income as compared to their White and Indian counterparts. (Statistics South Africa, 2015a).

Figure 2.1 provides insight into the main modes used to travel to work in relation to monthly income. The NHTS of 2013 and 2020 provide income categories per month in 5 quintiles (5=highest and 1=lowest). A quintile is one-fifth of 20% of a given number. The table shows that high-income earners travelling to work do so mainly by private cars (66%), whereas low-income earners do so predominantly on foot (42%) and by taxi (25%). The results show a shift away from walking, rail and bus to taxi and private vehicles. This shift shows a move away from energy-efficient modes to fuel-intensive modes. In turn, this leads to higher emissions, more problems with costs and ultimately a community that is not resilient to fuel price shocks, such as the case in South Africa. There is significant decrease of people who walk, from 2013 (42,4%) to 2020 (12,2%) for quintile one (1). And a significant increase for private cars from 18,8% in 2013 to 58,1% in 2020. This is unusual because this group depends heavily on public transport and walking because of their income level.



Quintile	Walk	Train	Bus	Taxi	Car	Other
Quintile 1 (2013)	42,4	4,4	8,9	24,6	18,8	0,9
Quintile 1 (2020)	12,3	1,1	4,2	23,2	58,1	1,2
Quintile 2 (2013)	42,9	4,1	8,7	27,5	14,4	2,4
Quintile 2 (2020)	33,8	1,2	6,2	31,4	25,8	1,5
Quintile 3 (2013)	31,6	5,9	10,2	32,2	18,4	1,7
Quintile 3 (2020)	34,8	1,2	7	33,8	21,4	1,8
Quintile 4 (2013)	21,2	6,7	9,1	34,4	27,2	1,4
Quintile 4 (2020)	23,9	1,5	8,5	37,2	27,9	1
Quintile 5 (2013)	8,4	2,9	4,9	17,3	65,8	0,7
Quintile 5 (2020)	9,1	0,8	4,5	21,1	63,8	0,7

Figure 2.1: Main modes used to travel to work in relation to monthly income for 2013 and 2020.
Source: Statistics South Africa, 2013a; 2013b and 2020)

2.7. **Barriers to mobility (public transport)**

Rodrigue (2020) assents that mobility is one of the fundamental components of the economic benefits of transportation since it enables social, cultural, political, and economic activities to take place. Transport and land-use policies call for more public transport services so that the low-income groups, unemployed, and car-less people can access employment locations and other welfare services. There are a variety of factors that influence household travel choices. The 2013 National House Travel Survey found that nationally, travel *time* was identified as the biggest determinant of modal choice by 30% of the surveyed households. The *cost* of travel came second (28%) in terms of the determinant of modal choice (Statistics South Africa, 2014). In the latest 2020 NHTS survey, travel cost (30,8%)

surpassed travel time (23,3%) as the biggest factor influencing the modal choice of households. Summarily, this buttresses the fact that both travel time and cost are the main factors influencing the modal choice of households as found by both the surveys. This finding cuts across all modes identified in the surveys. Other factors include safety, security from crime, flexibility, accessibility, and reliability, however, these recorded a marginal influence. The surveys have shown that both the long travel time and high cost of public transport are still part of the challenges faced by public transport users making mobility difficult.

It goes without saying that public transport represents a means to overcome employment accessibility and mobility problems of low-income workers (Sanchez, Shen, and Peng, 2004). However, other studies dismiss public transport as a viable link between urban residents and employment locations. Their argument is that public transport access does not translate into access to employment. Likewise, some studies found little or no relationship between public transport access to employment locations and employment participation (Sanchez, 1999; Robert Cervero, Sandoval, and Landis, 2002; Sanchez, Shen, and Peng, 2004). The employment accessibility measure used by Sanchez, Shen, and Peng, (2004) focused on the home-jobs connection, but it does not fully account for the wide range of accessibility effects of transit. This is appalling because a significant amount of research has dealt with the relationship between labour force participation and the spatial separation of jobs and houses. Nonetheless, most analyses concentrate on commuting time or distance as a function of automobile accessibility. It is only a few studies that address the relative impacts of employment accessibility resulting from public transport services (Sanchez, Shen, and Peng, 2004).

Waller (2005) outlined opportunity costs experienced by transit-dependent poor households and concluded that when all costs are considered along with benefits of private vehicles, it makes sense to press for more assistance and policies that reduce car ownership costs for poor workers. Some research quantifies the additional money required to own and operate personal vehicles, as compared to the lower cost of travelling on public transit, but this overlooks the fact that owning a car enables people to search for or accept a better-paying job even at the far outskirts of their residential spaces (Sanchez, Shen and Peng, 2004). This means and illustrates that an individual who has access to a car has a more significant commuting range than an individual without it, implying access to more opportunities, and an increased range of commercial and personal interactions than those relying on

public transport (Waller, 2005; Cheng and Bertolini, 2013; Rodrigue, 2020). An individual without a car is very likely to rely on a public transport that is commonly shaped along corridors, and this limits the level of accessibility to the same opportunities or amenities available for car owners (Rodrigue, 2020). Most poor households seek access to a car as the sprawling nature of many metropolitan areas, workplaces, and residences virtually require private vehicle to increase access. However, having access to a vehicle in the household does not mean all adults of working age have reliable access to the car (Waller, 2005). Some members in the household will still rely on public transport for commuting.

In the same manner, Waller (2005) concurs that transit-dependent low-income households often pay a high price for going without a personal vehicle as transit often fails to meet their needs. Transit-dependent users still require other means of transport such as a car, a bicycle, or walking to take them from the train stop/ stations in the access and egress trips. In addition, Waller, (2005) asserts that most public transport systems use flat fares, rather than distance fares that adjust to reflect distance travelled. This implies that low-income public transport users who travel shorter distances will still pay more per kilometre than higher-income riders, subsidizing the commute of those with higher incomes (Waller, 2005). Wallers (2005) also argues that while car ownership increases transportation expenditures, there should be a true accounting of costs of the benefits of car ownership and the opportunity costs of going without a car because public transit has not achieved the goal of linking jobs and workers. It is still unreliable, infrequent, crowded, or requires lengthy commutes (Waller, 2005). Studies reviewing transportation expenditure data fail to take the cost of travel time into account. He insists further that low-income households are prepared to pay more for commuting to have shorter trips than having lower fares. This is also supported by the NHTS 2013 where travel time and cost were the main factors influencing trip choice in South Africa (Statistics South Africa, 2014, 2020).

These high costs relative to household budgets lead to travel patterns dominated by walking, greatly limiting access to economic opportunities (Lall, Henderson and Venables, 2017). The cost per passenger kilometre increases with distance from the central business district because density declines (Eskeland and Lall 2015; Lall, Henderson and Venables, 2017). This means that larger vehicles are more efficient in high-density areas if they are filled to capacity. Private cars have the flattest curve because they carry only a few passengers. Generously assuming that pedestrians can travel at an average of 4 kilometres an hour in a straight line, a large share of city residents can access

opportunities only within a 50 square kilometre area of where they live by walking for an hour (Lall, Henderson and Venables, 2017). Hence, there is a need to develop public transport systems that are affordable and accessible to cater for most of the low-income groups who rely heavily on public transport for their day-to-day activities.

2.8. **Accessibility of public transport to work**

Public transportation provides a vital link for workers to the labour market. Most workers commute outside their neighbourhoods to get to their workplaces. However, the challenge of access to reliable forms of public transportation remains. This makes job accessibility considerably lower for public transport users than for private car users (Kawabata and Shen, 2006). Kawabata and Shen (2006) found that commuting by public transport takes up to 12 times more time than driving in countries like the USA. This means long travel time for public transport users and limited access to opportunities compared to those with access to a private car. Huang (2020) argues that accessibility comprises three fundamental elements i.e., people (population), transportation, and job opportunities, which is measured by the time travelled. He describes people by race, car ownership, income, age; transportation represented by the spatial layout of the system and level of services; and the job is represented by location, employment capacity, and industry. The spatial layout of these elements and the relationships between them determine the urban land use and spatial structure. Based on the distributions of these elements, different accessibility patterns can be expected. The spatial distribution of activity centres and their relative proximity to one another shape urban travel patterns (Horner, 2004). Proper urban transportation and land-use policies depend on the understanding of the spatial structure of cities. Time, along with distance, is often used as a cost in many accessibility models for multimodal transportation (Kawabata and Shen, 2006; Cheng and Bertolini, 2013). When public transport is the primary transportation mode, travel time is an essential part of accessibility (Tribby and Zandbergen, 2012).

According to Krygsman (2004), public transport trips consist of three stages: *feeder* (referred to as access modes) – *line-haul* (main modes) – *distribution* (referred to as egress modes) as shown in Figure 2.2). This also includes the transfers between modes and stages which take place at *transfer nodes*, i.e., bus stops, train stations, parks, and ride facilities.

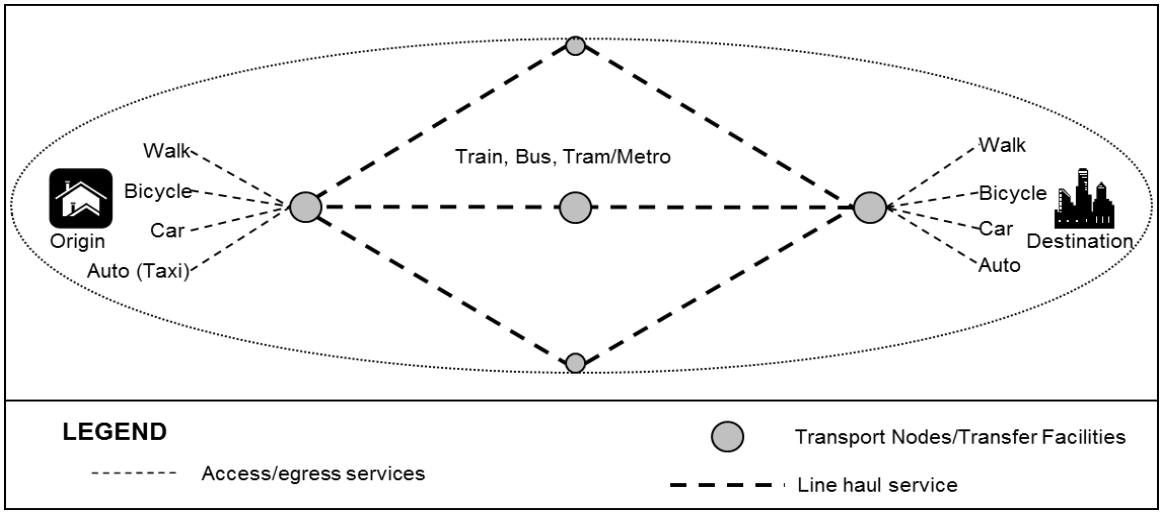


Figure 2.2. Conceptual public transport trips (Source: Krygsman, 2004)

The access, egress, line-haul stages, and transfer locations are referred to as the *structuring elements* of multimodal public transport as they structure, in time and space, the movement of the individual. However, the multimodal public transport system imposes some unique time-space constraints on travel, and influences travel demand, as compared to private cars (Krygsman, 2004). The demand of individuals for public transport is largely determined by three interrelated demand characteristics of the public transport system, i.e. (i) the *availability* of multimodal public transport at origins and destinations, (ii) the *travel time* required to reach destinations, and (iii) the *accessibility (flexibility)* provided by the public transport system and network (Krygsman, 2004). Access and egress, being the weakest links in multimodal public transport chains, determine to a large extent the availability of the system and whether people can use it. To use the public transport system, users need to *access* the system and *egress* to the destination from the boarding/alighting transfer station (Keijer and Rietveld, 2000; Rietveld, 2000b; Krygsman, 2004). This could lead to a decrease in public transport usage because of the effort required to access the public transport system.

Ridership of any public transport system is highly dependent on the time people spend during its access and egress parts, and the level and quality of access (Murray *et al.*, 1998; Murray, 2001; Givoni and Rietveld, 2007). Goel and Tiwari, (2016) assert that multinomial logistic regression models are used to determine the factors associated with the choice of access–egress modes, and the different factors which influence the choice of access mode. They found that trip length, vehicle ownership, location of the metro station and population density around the metro station have statistically significant associations with the choice of access/egress modes (Goel and Tiwari, 2016).

Equally, *Proximity* to the transfer location is a major determinant of the access and egress travel times and will determine the absolute 'availability' of public transport as a transport alternative (Murray *et al.*, 1998; Murray, 2001). If proximity becomes easy, users are more likely to use the system. If difficult, then users might forgo the trip by public transport and opt for another mode, typically their private cars. If the user is a *captive public transport user*, he or she might forgo the trip entirely (and therefore the activity). No matter how effective or good the line-haul system is, if the user cannot gain access to (or egress from) the transfer location (or destination) public transport may be perceived as providing unacceptable accessibility. The access and egress *catchment* can therefore be a major determinant of public transport use. This is supported by Krygsman's (2004) argument that should the access and egress exceed an absolute threshold time (or distance) people will be hesitant to use the system, the result of which will be a cancellation of subsequent activities. Another factor that can inhibit public transport use is the relative contribution to total trip time. Krygsman (2004) argues further that, the current public transport systems have not kept pace with their changing land-use and economic trends. This has resulted in the loss of connectivity because public transport trips have to include some level of transfers through different modes of public transport. Resultantly, the transfers bring about a time penalty and add discomfort in the trip (Krygsman, 2004).

As Levinson (1998) rightly argues, the interaction between two locations declines with increasing disutility (distance, time, and cost) between them, but is positively associated with the amount of activity at each location. Therefore, these indices will provide insight into how easy it is to get from an origin to a specific destination by using different travel modes. All locations are not equal because some are more accessible than others, which implies inequalities. Thus, accessibility is a proxy for spatial inequalities (Rodrigue, 2020). Rodrigue (2020) presents two core concepts about accessibility, i.e., *location* and *distance*, which are derived from the physical separation between locations. The distance can only exist when there is a possibility to link two locations through transportation. Commonly, the friction of distance is expressed in units such as kilometres or time. However, variables such as cost or energy spent to arrive at a destination can also be used (Rodrigue, 2020).

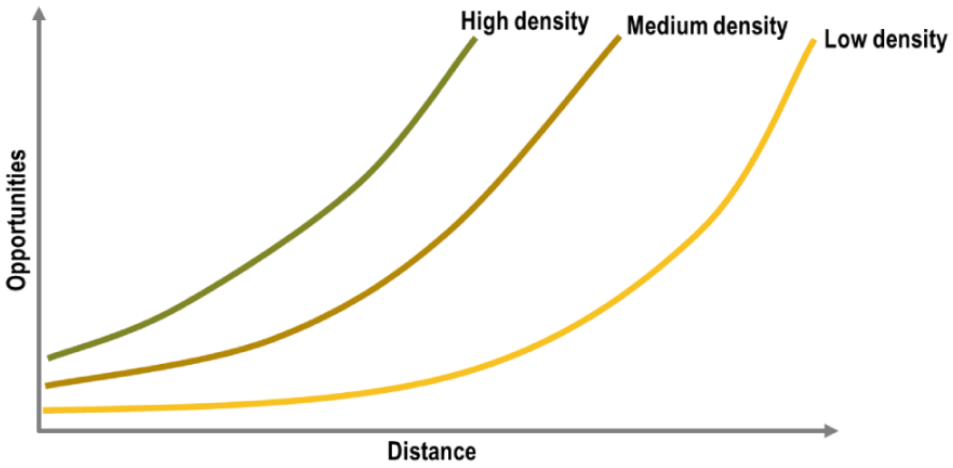


Figure 2.3: Relationship between Distance and Opportunities (Source: Rodrigue, 2020)

Public transport confronts many challenges in South Africa, some include the infrequency, inadequacy, poor maintenance, overcrowding, unsheltered terminuses, lack of integration with other modes (information, ticketing), and increasing cost of public transport (Human Awareness Programme 1982, Perlman 1984, Pirie 1992, Khosa, 1998; JICTT, 2010). Most workers and the poor still live in the outskirts, dormitory townships distant from places of work and other amenities. They still rely heavily on public transport and non-motorised transport, which is fragmented and in other areas not available (Kerr, 2015). As a result, the cost of mobility and time spent commuting between homes and the workplace is draining and difficult to sustain. Workers using several modes of transport have their hourly wage reduced by 40% or more because of transport costs. As argued by Krygsman (2004). these transfers bring about a time penalty and add discomfort to the public transport trip.

Saghapour, Moridpour, and Thompson, (2016), argue that the average walk time to and from home and station for buses and trams is 10 min or 800 m and the maximum walking time for trains is 15 min or 1200 m. The calculation done by Keijer and Rietveld (2000) using the Dutch National Travel Survey (1994) has found that 50% of people are willing to walk ±550 m or cycle 1.8 km to the station (i.e., access). This is assuming a mean access/egress speed of 4 and 12 km/h for walking and cycling, respectively. The respective distances on the egress side are 600 m and 2.4 km. The benchmark with The Netherlands (Dutch National Travel Survey) is because they have infrastructure in place for access and egress modes, which makes it reasonable to measure. Krygsman (2004) assents that access

and egress travel time is of similar absolute magnitude (i.e., a mean of ±9 –10 min), they reveal both similar and dissimilar coefficients. Overall, it seems that access and egress are a function of transport variables (mode, transfers, line-haul time, etc.), with socio-demographic variables being less important in explaining travel time. He further states that, should access and egress exceed an absolute maximum threshold, users will not use the public transport system because access and egress modes determine the catchment of public transport stops and the intensity of use within catchments. Arguably, if the proportion of trip time spent on the access and egress stages is considerable, public transport trips will be considered a less suitable choice as these stages involve much physical effort (Krygsman, 2004). When public transport is considered less suitable, this affects the daily activities of those who rely on it, thereby increasing the barriers to participate in other activities.

2.9. **Public transport travel time**

Travel time is described as the single most significant factor explaining the demand for a transport mode and is arguably the biggest existing contributor to the public's aversion to public transport (Bovy and Jansen., 1991; Ortúzar and Willumsen, 2002; Krygsman, 2004). According to Litman (2009), other than sleep and work, a major share of people's time is devoted to transport. People around the world tend to devote 60-90 daily minutes to personal travel (Litman, 2016). One of the key factors that define accessibility is the travel time between home and activities, or opportunities. Several frameworks have been developed to determine the level of service indicators for the effectiveness of public transportation systems (Cervero, 2013; Hassan, Hawas, and Ahmed, 2013). Spending excessive amounts of time in travel (particularly congested commuting) seems to reduce life satisfaction and takes away family time (Litman, 2016; Clark, Chatterjee, Martin, and Davis, 2019).

Travel time is one of the largest categories of transport costs, and its savings are often the primary justification for transportation infrastructure improvements. According to Statistics South Africa (2013; 2020), travel time was confirmed to be important to the transport users in South Africa in determining transport modal choice both in 2013 and 2020 surveys. Hitge and Vanderschuren (2015) found the average travel time in Cape Town, for all modes was about 90 minutes in 2013. This is above the global range, which averages around 70 minutes per person per day (Schafer and Victor, 2000). While travel time can have both discomforts and positive utilities, this depends on several

factors, such as origin-destination distance, and the transport system used (Hitge and Vanderschuren 2015). Among urban transport modes, public transport has three distinguishing features that make the assessment of travel impedance difficult. First, public transport journeys require access and egress legs with another mode, typically walking. Second, public transport is a scheduled service that offers connections between stops only at specific intervals. Third, public transport provides services through a network on spatial coverage. These three structuring elements increase the out-of-vehicle time for public transport trips.

2.9.1. Out of Vehicle Time (OVT)

The public transport travel time includes out-of-vehicle time (OVT) which includes waiting, transfer, access, and egress time elements. OVT is *weighed* more onerously than the line-haul time (the in-vehicle-time (IVT)). The value of OVT time may be set at a rate higher than the value of IVT since this includes some time spent standing around and being exposed to warm, cold, or rainy weather (Small, 1998; Krygsman, 2004; Litman, 2016); i.e., a high disutility as the individual derives no benefit (or space benefit). According to Litman (2016) and Small (1998), travel time costs are a large component of transport economic impacts, so how they are evaluated significantly affects planning decisions. Travel time unit costs vary depending on the type of trip, travel conditions, and traveller preferences. For example, time spent relaxing on a comfortable seat tends to impose less cost than the same amount of time spent driving in congestion or standing on a crowded bus. Walking, cycling, waiting, and travelling as a passenger or driver may each have different unit costs which vary depending on travel conditions, needs, and user preferences. Travel time unreliability (uncertainty of how long a trip will take, and unexpected delays) imposes additional costs (Litman, 2016; Victoria Transportation Policy Institute, 2020).

2.9.2. Transport travel time ratio

Commuting trips also tend to be more schedule-sensitive than personal travel, and hence there is a need to consider the costs of travel time variability. Personal travel refers to non-work trips i.e., travel for shopping, personal business, social, and recreational purposes. These trips can have a lower time value than commuting trips (Mackie *et al.*, 2003). As a result, travel time (and thus interaction costs) by public transport proves to be longer than travel time by private cars for the same origin and destination. Public transport users spend more time travelling than they would by a private car. In

Cape Town, it takes 110 minutes to travel by public transport than by private cars (70 minutes). This highlights a greater significance in the discrepancy between modes in the levels of spending on infrastructure for the two largely separate sub-systems of private and public transport networks (Hitge and Vanderschuren, 2015).

The competitiveness of public transport relative to the private car or time differential between public and private transport trips is usually calculated or captured by the *travel time ratio*, defined as the travel time by public transport divided by travel by private car between the same origin and destination (Krygsman, 2004; Ortúzar and Willumsen, 1996; Rietveld et al., 1996; Keijer and Rietveld, 2000). Krygsman (2004) states that the travel time ratio fluctuates from 1 to 5 for most trips and, the larger the ratio, the less competitive public transport is. For example, evidence from other studies shows that for a travel time ratio of up to 1.5, the share of public transport is 50% to 70%. Bovy and Van Den Waard. (1991) in their study, found that if the ratio of total travel time between rail and the other modes is greater than 2, the probability that people will choose rail is small. According to Hitge and Vanderschuren (2015), Cape Town has a travel time ratio of 1.81, which is evidence that public transport is not competitive with private cars since it loses most of its competitiveness when the travel time ratio exceeds about 1.5 (Hitge and Vanderschuren, 2015).

Likewise, Krygsman (2004), states that people benefit by trading temporal elements (time) for spatial elements (distance) when they travel. The non-movement elements in public transport entail a high disutility as the individual derives no benefit (or space benefit) from waiting and transfer. As highlighted above (section 2.9) public transport travel time comprises OVT and it is *weighed* more onerously than the IVT. The value of OVT has a higher rate than the value of IVT. Estimates of the weight of OVT compared to IVT range between 1.2 and 5 (Bovy and Jansen, 1979; Krygsman, 2004). As the public transport trip always contains OVT elements, the disutility associated with public travel time will almost always outweigh the disutility of private car travel time. As with access and egress time, it is not only the absolute contribution of OVT but also the relative contribution to total travel time that is an important indicator of transport level-of-service (Krygsman, 2004).

The ratio *OVT/IVT* is frequently used not only as the level-of-service indicator for public transport trips but also to assess demand elasticity (Wardman and Tyler, 2000). The larger the ratio, the less attractive public transport becomes as an alternative (Krygsman, 2004). Public transport travel time

unit costs can vary depending on travel conditions, with significantly higher values if walking, waiting, and travel conditions are uncomfortable (crowded, dirty, too hot, or cold, insecure, etc.). Waiting time unit costs tend to decline if passengers have accurate real-time bus and train arrival information, so they know how many minutes they must wait (Dziekan and Kottenhoff, 2007)

2.9.3. Interconnectivity ratio

The interconnectivity ratio as defined by Krygsman, Dijst, and Arentze, (2004) refers to the proportion of access and egress time to total trip travel time (access–main–egress). According to Krygsman, Dijst, and Arentze, (2004), the ratio always falls between 0 and 1 which differs from other ratios in transport planning (such as the OVT over IVT or public transport time over private transport time) as it represents that part of the trip time that the user is physically occupied or willing to 'sacrifice', to reach the public transport system and their final destination. Though wait and transfer times are important time elements in public transport trips, they are not considered to be part of access/egress. This is because the wait and transfer time do not involve physical exertion and are very much determined by the service frequency of the line-haul mode (Krygsman, Dijst and Arentze, 2004).

Interconnectivity ratio formula:

$$Interconnectivity\ Ratio = \frac{Access\ time + Egress\ time}{Total\ travel\ time}$$

Goel and Tiwari, (2016) also calculated the interconnectivity ratio for each respondent as the ratio of access and egress time to the total trip time access, egress, and IVT as discussed in Krygsman, Dijst, and Arentze, (2004). They further calculated the interconnectivity ratio for each respondent, using access and egress time, and estimated time using average travel speed of 32 km/h of main haul trip for metro. They excluded transfer time at interchange stations in the total trip time and respondents who did not mention their egress time. They found the average interconnectivity ratio to be 0.38 ± 0.01 with up to 88% of trips having the ratio between 0.2 and 0.5.

3. RESEARCH METHODOLOGY AND DATA

3.1. Introduction

This chapter discusses the design and methodology undertaken in the research. The data variables explored are travel time and cost, population group, geographical location, the main mode of transport, household income quantile, and gender. These themes are chosen because the form the basis of this research. The primary data used in this research was drawn from the National House Travel Survey (NHTS). The NHTS is a sample household travel survey which was first conducted in 2003, followed by the second survey in 2013 and recently in 2020 by Statistics South Africa. The NHTS gives strategic insight into the travel patterns and transport problems in the country, for research, planning, and policy formulation purposes. The NHTS 2013 dataset is the primary highlight of this research, however NHTS 2020 will be used to compare the results and give insights to show whether there was a significant change from the 2013 survey. The NHTS data is publicly available and is chosen because it is a representation of South Africa's travel patterns.

The target population of the NHTS consists of all private households in all nine (9) provinces of South Africa and residents in workers' hostels. The survey does not cover other collective living quarters such as students' hostels, old-age homes, hospitals, prisons, and military barracks, and is therefore only representative of non-institutionalised and non-military persons or households in South Africa. The NHTS (2013 and 2020) provides a snapshot of the perceptions and travel experiences of South Africans. Such perceptions and experiences provide critical data to the government for future transport planning and highlight what is working well in the public transport system and what should be transformed (Statistics South Africa, 2014). This research used only the dataset of the working population in both formal and informal sectors and excluded the unemployed population. This is because the research focuses on working or employed population. The novelty of the methodology is that the study recognises the importance of access and egress and considers the need to understand travel time and cost for public transport users.

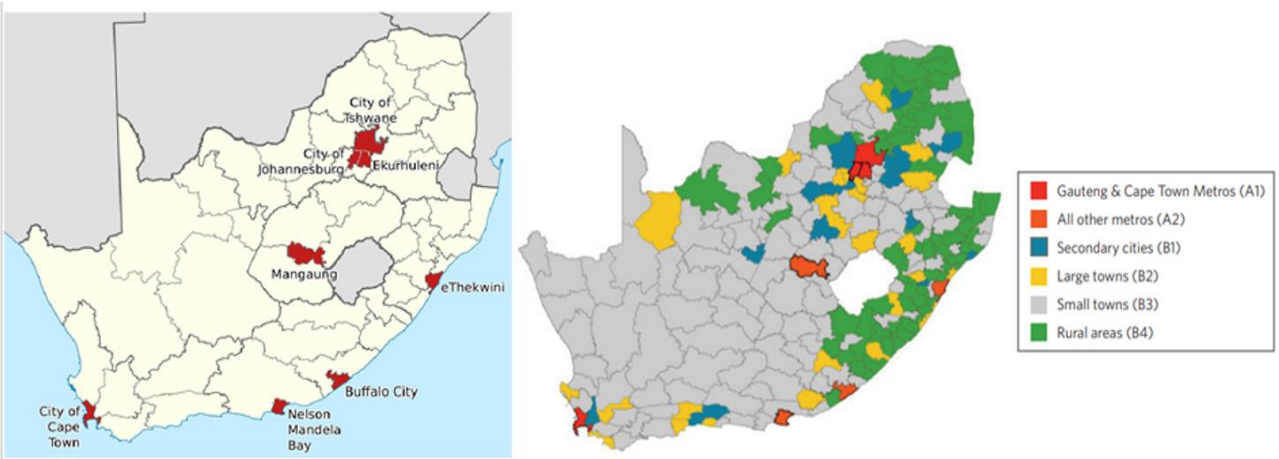
3.2. **Research Area**

3.2.1. Metro Areas

The research used the work-related travel patterns subset of the 2013 and 2020 NHTS data, which comprises of the working population in both formal and informal sectors. The focus of the research is on South African metropolitan areas as shown from Figure 3.1 below. A Metropolitan refers to a formal local government area comprising the urban area as a whole and its primary commuter areas. This may comprise of a large concentration of people or a population of at least 100 000 (UNICEF, 2012). Additionally, metropolitans include both the surrounding territory with urban levels of residential density and some additional lower-density areas adjacent to and linked to the city (e.g., through frequent transport, road linkages, or commuting facilities). For these reasons, metropolitan councils have their own n budgets, common property ratings and service-tariff systems, and single-employer bodies. South Africa has eight metropolitan municipalities, namely:

- Buffalo City (East London)
- City of Cape Town
- Ekurhuleni Metropolitan Municipality (East Rand)
- City of eThekwini (Durban)
- City of Johannesburg
- Mangaung Municipality (Bloemfontein)
- Nelson Mandela Metropolitan Municipality (Port Elizabeth)
- City of Tshwane (Pretoria).

Metropolitan councils may decentralise powers and functions. However, all original municipal, legislative, and executive powers are vested in the metropolitan council. It is important to note that metros generate a huge share of the Gross Domestic Product (GDP) because of so many economic activities, (Republic of South Africa Government, 1996, 2018).



Source: Turok, & Borel-Saladin, (2014)

Source: Arndt, Davies and Thurlow, (2018)

Figure 3.1: Map of South Africa showing the 8 metropolitan municipalities and classification of municipalities into Urban and Rural Areas. (Source: Turok, & Borel-Saladin, 2014; Arndt, Davies and Thurlow, 2018).

3.2.2. Sample design of NHTS 2013

The sample design for the NHTS 2013 was based on a master sample (MS). The MS used a two-stage, a stratified design with probability–proportional-to-size (PPS) sampling of primary sampling units (PSUs) from within strata, and systematic sampling of dwelling units (DU) from the sampled PSU. A self-weighting design at the provincial level was used and MS stratification was divided into two levels, primary and secondary stratification. Primary stratification was defined by metropolitan and non-metropolitan geographic area types. During secondary stratification, the Census 2001 data were summarised at the PSU level" (Statistics South Africa, 2014).

Where possible, PSU sizes were kept between 100 and 500 dwelling units (DU); enumeration areas (EA) with fewer than 25 DUs were excluded; enumeration areas (EA) with between 26 and 99 DUs were pooled to form larger PSU and the criteria used was same settlement type: Virtual splits were applied to large PSU: 500 to 999 splits into two; 1 000 to 1 499 splits into three; and 1 500 plus split into four PSU: and Informal PSU were segmented. A Randomised Probability Proportional to Size (RPPS) systematic sample of PSU was drawn in each stratum, with the measure of size being the number of households in the PSU. Altogether, approximately 3 080 PSU were selected. In each selected PSU a systematic sample of dwelling units was drawn. The number of DU selected per PSU varies from PSU to PSU and depends on the Inverse Sampling Ratios (ISR) of each PSU. The

following variables were used for secondary stratification: household size, education, occupancy status, gender, industry, and income, (Statistics South Africa, 2014).

3.2.3. Unique Household Identifier and person number

To identify the participants, each household had a unique household identifier which can be used to link data from the file with data for the same household from other files. This is a 19-digit number that is made up of the PSU number, dwelling unit number, household number, and questionnaire number. The Unique Household Identifier valid range was between 160100091000004501 – 987106481000012501. Person (respondent) number within household valid range was: 01 – 23. The two fields above (unique number and person number) create a 19-digit unique person identifier, which can be used to link a record from this file with another record for the same individual from other files (Statistics South Africa, 2014). Therefore, the data can be identified and analysed without duplication.

3.3. **Data collection, design, and analysis approach**

William and Bayat, (2007) assert that "data collection is often carried simultaneously with data analysis and fieldwork". To prepare for the research, a review of the NHTS2013 (Statistics South Africa); a review of the South Africa Transport Policies (by-laws, and legislation governing the transport sector was applied); and a review of subsequent developments in transport planning initiatives as well as journal articles was taken. It was also through a thorough and systematic review of relevant studies around the world on the related topic. The rationale behind choosing more than one method is to gather enough information from different sources and stakeholders and integrate it into reaching the research objectives, which will help to increase the quality and reliability of the data collected.

The total surveyed population of the NHTS 2013 was 157 253 and for 2020, it was 145 385 participants. The research used the work-related travel patterns subset of the data, which is only the working population in both formal and informal sectors. The total number of households that participated in the survey (NHTS, 2013) was between 43 642 and 51 341 dwelling units (DU), and the total number of people that these households represent was 157 253. Out of a total of 157 253 participants in the NHTS 2013 survey, only 40 820 (37%) of the surveyed participants indicated to

be employed, the rest of the participants were either unemployed or in school. All missing and unknown cases were excluded from the analyses of this research.

This research used travel time and travel cost from the NHTS 2013 and 2020 data to explore social inequality, in accessing the place of work in metropolitan areas. The study confirms that geographical location, the main mode of transport, household income, travel time and cost of transport were significant predictors of travel time to the place of employment; all variables used are shown in Table 3.1. In addition, public transport accessibility indices are calculated, to measure the accessibility of transport. The coefficient of variation (CV) which was based on the sample weights as determined by the weighting methodology implemented for the NHTS 2013 was calculated. Figure 3.2 below, illustrates a model that is generally used to determine the reliability of survey estimates, based on the CV obtained for the survey estimates adopted from the NHTS 2013.

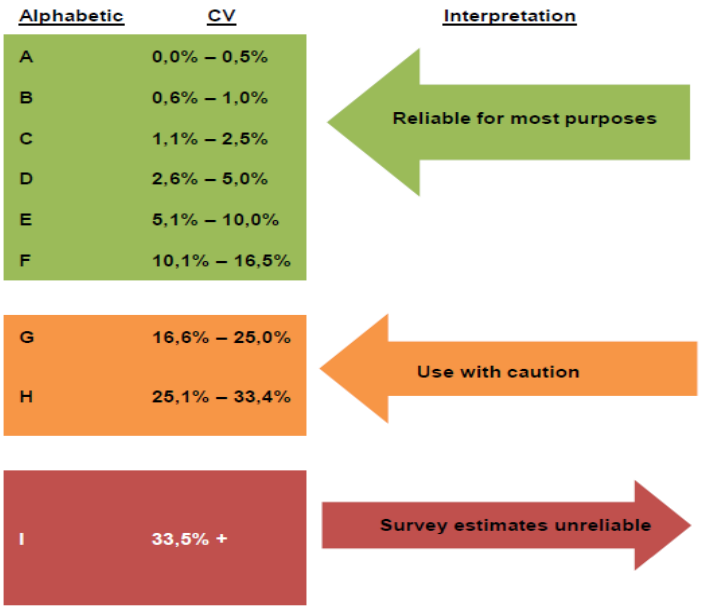


Figure 3.2: Level of coefficient of variation for survey estimates (Adopted from the Statistics South Africa, 2018)

As a result, this research conducted a comparison of public transport in-vehicle-time (IVT) and out-of-vehicle-time (OVT). The research looked at the physical access to the public transport stops or stations by considering travel time (walking time for access and egress as well as waiting time). The main modes of transport considered for this research were trains, buses, and minibus taxis, walking as well as private vehicles.

The IVT was calculated as a difference of OVT and the total travel time. Data characterisation, summary, inferential statistics, and graphical presentation were conducted in the statistical software IBM SPSS (Statistical Program for the Social Sciences) version 25. The researcher was able to make use of the Stellenbosch University Centre for Statistical Analysis. Below are the factors or variables used in the analysis about total travel time to work.

Table 3.1: Levels of the variables used in the regression model, NHTS 2013

Predictor	Level
Population group	1 = Black African 2 = Coloured 3 = Indian/Asian 4 = White
Geographical location	1 = Metro 2 = Urban 3 = Rural
Main mode of transport	1 = Trains 2 = Bus 3 = Taxi 4 = Private transport 5 = Walking all the way
Household income quantile	1 = Lowest income quintile 2 = Quintile 2 3 = Quintile 3 4 = Quintile 4 5 = Highest income quintile

Source: Statistics South Africa (2014)

3.3.1. Accessibility Indices

The Accessibility Index (AI) provides an indicator of the accessibility and density of the public transport network at a point of interest (at home, stations, or interchanges) (Schoon, McDonald and Lee, 1999; Rodrigue, 2020; Breeam, 2021). The AI is influenced by the proximity and diversity of the public transport network and the level or frequency of service at the access node. The greater the number of compliant nodes, services, and their proximity to the building, the higher the AI (Schoon,

McDonald and Lee, 1999; Breeam, 2021). Analysing the accessibility disparity of different modes between specified Origin – Destination (O-D) is recognised as an efficient way to assess the environmental and social sustainability of transport and land-use arrangements. Travel times and costs by different travel modes form an essential part of such an analysis (Schoon, McDonald and Lee, 1999; Salonen and Toivonen, 2013; Statistics South Africa, 2018).

In this research, two accessibility indices (travel time AI and travel cost AI) for different travel modes between home and work are created based on a methodology utilised by Schoon, McDonald and Lee(1999) as well as the Statistics South Africa, (2018). Travel time and cost AIs for a particular mode were calculated using the average travel time of a particular mode to the average travel time across all modes (Schoon, McDonald and Lee, 1999; Mamun, 2011). For example, the AI for a taxi is defined as:

$$Al\ taxi\ (time) = \frac{\text{average travel } time \text{ by taxi}}{\text{average travel time across all modes}}$$

$$Al\ taxi\ (cost) = \frac{\text{average travel } cost \text{ by taxi}}{\text{average travel cost across all modes}}$$

Table 3.2: Accessibility indices

A value of 1,0 (average travel cost value) signifies parity in travelling experiences for users in terms of cost	A value below 1,0 suggests that users experience low travel costs (easy access to the place of work)	A value above 1,0 suggests that users experience high travel costs (difficulty reaching their place of work)

Source: (Schoon, McDonald and Lee, 1999; Salonen and Toivonen, 2013; Statistics South Africa, 2018).

3.3.2. Interpretation of the data

Caution must be exercised when interpreting the results of the NHTS at low levels of dis-aggregation. Revisions to the NHTS data sets based on the new population estimates involved benchmarking at the national level in terms of age, sex, and population group while at the provincial level, benchmarking was by population group only (Statistics South Africa, 2014)

3.4. **Delimitations of the research**

According to Locke, Spirduso and Silverman, (2007) it is important to state the delimitations of the research to outline the weaknesses and restrictions pertaining to the research. Due to the limitations in resources and time constraints, this research mainly focuses on the employed population. The NHTS 2013 relies on population estimates and a weighting process to extrapolate sample estimates to population estimates, the absolute number of cases does not always correspond with census or administrative data sources (Statistics South Africa, 2014). In South Africa, transport data is generally very difficult to obtain because separate municipalities collect data from their areas in a form of the Integrated Transport Plans (ITPs). The National Department of Transport does not have central repository of transport data. The main source of transport data on a national level, is Statistics South Africa through NHTS. The NHTS is used since it is one of the few data sources available on a national level. While the NHTS survey data is useful to analyse general transport trends and general levels of access, it is less suitable to model accessibility. This dataset has got some limitation in terms of not detailing on distance travelled.

3.5. **Ethical implication/ considerations of the research**

Research ethics provide guidelines for the responsible conduct of the researcher. The ethical standard of the research is of utmost importance, both to the researcher and the research itself. All research is subject to ethical scrutiny and review (Field and Behrman, 2004; Best and Kahn, 2006; Trimble and Fisher, 2006; William and Bayat, 2007). Brynard, Hanekom and Brynard, (2014) state that the guiding instrument of ethics is to measure the conduct of the research. By virtue of the above statements, the researcher is obligated to do the right thing, in a manner that is objective and with integrity. The handling of data is to present findings that are valid and reliable, to achieve the objectives of the research. In this respect, the researcher has a moral obligation to conduct an inquiry by searching for the truth in a way that will neither fabricate nor falsify the information that is collected (Sarantakos, 2005). In keeping to the objectivity of the research, the research has been guided by principles such as accuracy, honesty, integrity, and a representation of an unbiased view from the researcher. The strictest consideration of ethical code to academic writing is upheld using an effective referencing system. The researcher has been cautious not to plagiarise, as such all sources will be acknowledged and cited properly.

Ethical standards are important when dealing with participants or individuals as sources of information for a study (Sarantakos, 2005). It was through a thorough and systematic review of relevant studies, the use of academic sources, journal articles, by-laws, and legislation governing the transport sector. The researcher carefully considered all the ethical issues that arose in the whole process of conducting this research. The research used the publicly available secondary data provided by both the 2013 and 2020 National House Travel Survey, and by no means revealed the identity or any sensitive information of the participants.

3.6. The demographics and work-related travel patterns in South Africa (formal or informal employment).

According to Statistics South Africa (2014) report, formal sector employment is where the employer (institution, business, or private individuals) is registered for Value Added Tax (VAT) to perform the activity, e.g., nurse, teacher, etc. who works in a formal institution, or in government. Informal sector employment is where the employer is not registered for VAT, e.g., domestic work, street trading, taxi driver, etc. Table 3.3 and 3.4 provide an overview of the descriptive statistics for the different variables identified for the purpose of this research and presents some of the analysis from the 2013 and 2020 NHTS dataset. Table 3.3.(a) present the results for NHTS 2013 while NHTS 2020 is presented in Table 3.3.(b).

Table 3.3(a): NHTS 2013 demographic information and frequency distribution for responses in each of the variables

	Unit of measure	Number	Percentage %	Min	Max	Mean
Total surveyed		157253				
Total households		43642				
Age				15	101	39.11±12.33
Geographic Location	1 Metro	16 579	40.6%			
	2 Urban	14 226	34.9%			
	3 Rural	10 015	24.5%			
Gender	Male	22 451	55%			
	Female	18 369	45%			
Race	1 African	28 966	70.9%			

	2 Coloured	5 366	13.1%
	3 Indian/ Asian	1 493	3.7%
	4 White	5 035	12.3%
Employed		40820	37%
	Formal	31024	76%
	Informal	9796	24%
Unemployed		68103	63%

(Source: Author analysis based on 2013 NHTS: Statistics South Africa, 2014)

Table 3.3(b): NHTS 2020 demographic information and frequency distribution for responses in each of the variables

	Description	**N**	**Percentage (%)**	**Min**	**Max**	**Mean**
Person number		145385				
Households		42138				
Age		145385		0	116	29.99
Gender	Male	67376	46.34			
	Female	78009	53.66			
Geographical Location	1 Metro	22568	15.52			
	2 Urban	52834	36.34			
	3 Rural	69983	48.14			
Race	1 African	125583	86.38			
	2 Coloured	13296	9.15			
	3 Asian/ Indian	1240	0.85			
	4 White	5266	3.62			
Employed		**30907**	**30.37**			
	Formal	18074	58.48			
	Informal	7623	24.67			
	Private household	5046	16.33			
	Do not know	163	0.53			
Unemployed		**70867**	**69.63**			

(Source: Author analysis based on 2020 NHTS: Statistics South Africa, 2020)

Table 3.4(a) and (b) below provides a snapshot of the travel attributes for both travel time elements and travel cost for NHTS 2013 and 2020 respectively. The results are further discussed in chapter 4 and 5. The research focuses mainly on travel time elements and transport cost or expenditure for workers in the metropolitan areas.

Table 3.4(a): NHTS 2013 travel attributes information and frequency distribution for responses in each of the variables

		Number	Percentage %	Min	Max	Mean
Do you change transport	Yes	3 197	7.8%			
	No	14 606	35.8%			
Monthly vehicle costs for drivers				0	306 282	844.24±5304.68
Total travel time to work (in minutes)				1	400	47.48±37.539
Total monthly cost to work				1	6 000	348±527.73
Walking to first transport mode				0	120	8.68±9.68
Waiting for the transport				0	120	7.24±8.85
Walking at the end of the trip				0	120	8.02±11.45

(Source: Author analysis based on 2013 NHTS: Statistics South Africa, 2014)

Table 3.4(b): NHTS 2020 travel attributes information and frequency distribution for responses in each of the variables

	N	Min	Maxi	Mean
Number of trips to the usual place of work	27944	1	10	1.23
Number of travel modes used to destination	2408	1	4	1.20
Days per week to work	33582	0	7	4.65
Total Salary/Pay from the main job	21587	0	1000000	6136.35
Minutes walking to first transport on travel day	7657	0	120	9.16
Minutes waiting for first transport on travel day	7470	0	120	6.72
Minutes walking to workplace at the end of trip	6462	0	120	7.70
Number of travel modes used on travel day	1339	2	4	2.09
Total time to travel to the workplace	26981	1	365	44.78
Total cost to a place of employment	13364	0	96000	1305.64
Cost of travel to work using a vehicle	4076	0	3000	534.88
Total expenditure on public transport for work	38553	0	150000	254.08
The minimum amount households survive on	2512	0	80000	21242.02
Total household monthly salary	145385	0	500000	3293.60
Total household income	145385	0	788888	90374.54

Source: Author analysis based on 2020 NHTS: Statistics South Africa, (2020)

3.6.1. Employment status

This question on employment status in the NHTS survey applies to members of society who are 15 years and above. It was meant to identify persons who are currently employed and unemployed or temporarily absent from their income-earning activity. The respondents were asked to identify whether they have a formal work activity or informal work activity. The main job/business would be the one where the respondent spends the most time at. It is important to note the reference period requested in this question, which is on the last seven days only (Statistics South Africa, 2014).

The dataset distribution has shown that 63% of the participants of the 2013 NHTS survey were unemployed compared to the 37% of those employed. Of those employed (37%), there were more people in the formal employment at 76%, as compared to 24% in the informal sector as shown in Figure 3.3. The 2020 NHTS also included the private household as a sector additional to the formal and informal sectors in the 2013 NHTS. For 2020 NHTS, there was 65% in the formal sector, 20% in the informal sector, and 15% in the private households. It should be noted that the further analysis in the research will be based only the working population in both the formal and informal employment sectors as stated in the NHTS 2013. All the missing cases and the unemployed population have been excluded. The section investigates the demographics of the survey population irrespective of the mode of transport used.

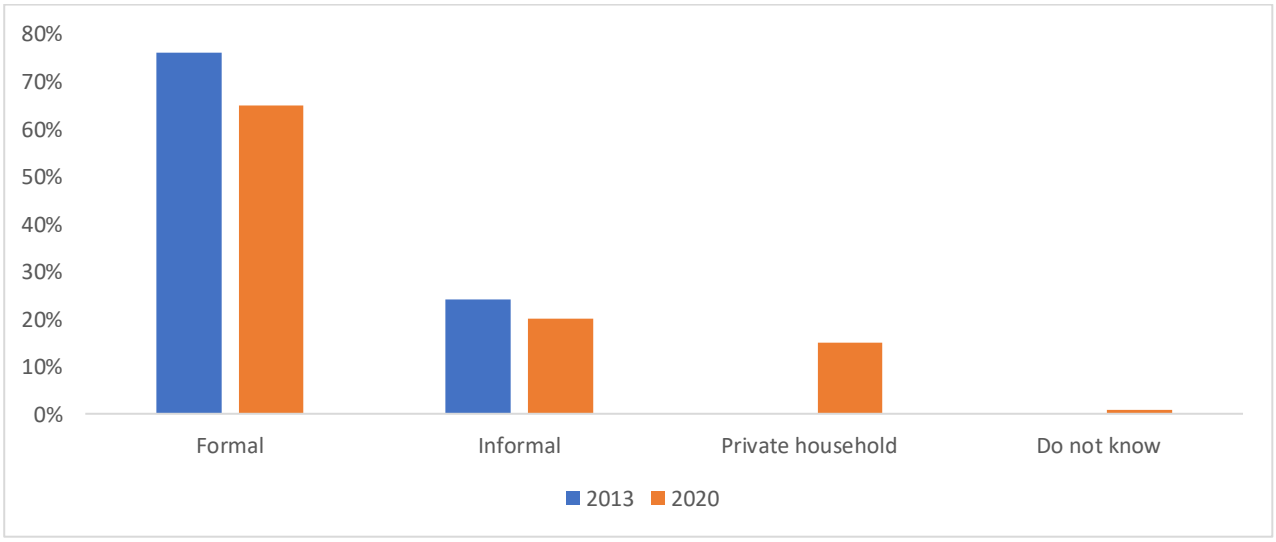


Figure 3.3: The distribution of South Africans who indicated that they are employed in either the formal, informal sector, or private household. (Source: Author analysis based on 2013 and 2020 NHTS: Statistics South Africa, 2014; 2020)

In both the surveys, the formal sector has recorded many participants, followed by those in the informal sector. The 2013 survey did not have private households and "do not know" categories as it was the case in the 2020 survey.

3.6.2. Gender, Age and Race of the participants

In 2013, out of the total national working population, there were more males (55%) than females (45%). This changed in 2020 to 49% males and 51% females (Figure 3.4a). The race distribution largely dominated by Black Africans 71% (2013), followed by Coloureds 13%, Whites 12% and lastly Indians 4%. These modifications increased to 81% in 2020 for the Black population and decreased in other races; Coloureds (9%), Asian (3%) and 8% for Whites. The average age of the respondents was 39±12.33 years (2013) and 29 years (2020), with a minimum age of 15 (both 2013 and 2020) years and maximum recorded age at 101 (2013) and 116 year (2020) respectively. The above results do not contribute significantly to the main findings of the research but gives a picture of the demographics of the dataset or the survey population.

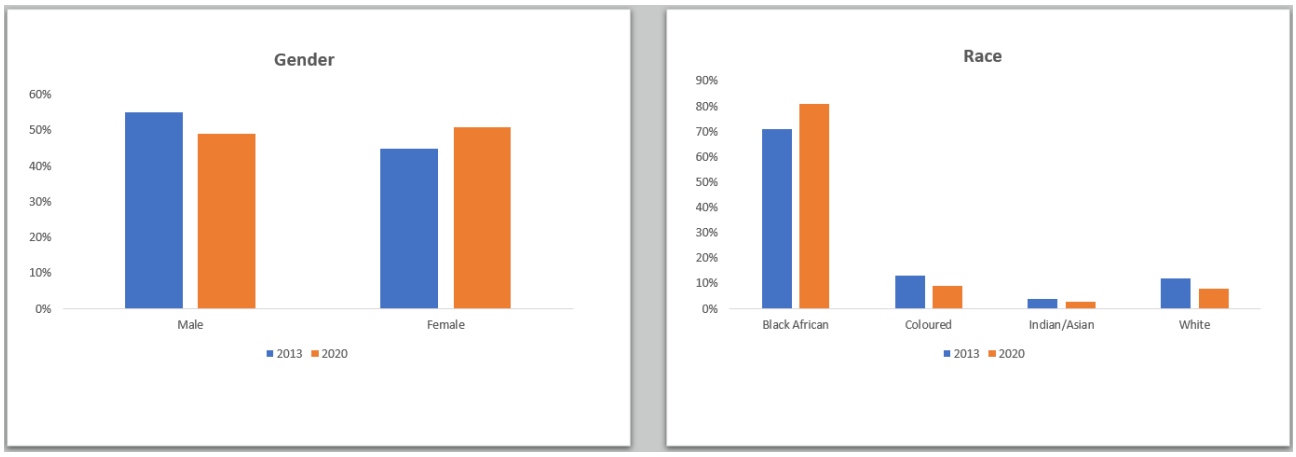


Figure 3.4a-b: Distribution of participants by (a) Gender and (b) Race. (Source: Author analysis based on 2013 and 2020 NHTS: Statistics South Africa, 2014; 2020)

3.6.3. Geographical location (type)

The NHTS under discussion covered all 9 South African provinces, which vary considerably in size. The provinces are Western Cape, Eastern Cape, Northern Cape, North-West, Free State, KwaZulu Natal, Gauteng, Limpopo, and Mpumalanga. Gauteng is regarded as the economic centre of South

Africa, responsible for over 34,8% of the country's total gross domestic product. Although it is the smallest of South Africa's nine provinces, Gauteng comprises the highest population density and the largest share of the South African population (Statistics South Africa, 2019). These metropolitan cities consist of some of the most important economic sectors and integrated industrial complexes with major areas of economic activities such as financial and business services, logistics, manufacturing, property, telecommunications, etc (Republic of South Africa Government, 1996, 2018).

The NHTS question was applicable to those who work in both formal and informal sectors. The purpose of the question is to find out the place where the workplace (province, district, etc.) is situated and recorded. Considering the provincial distribution irrespective of the mode of transport used, Gauteng has recorded a high number of participants at about 27% followed by the Western Cape and Kwa Zulu Natal at 15% each. The lowest was Northern Cape at 5%. The numbers are not surprising given the fact that Gauteng is home to the three metropolitan cities: Johannesburg, Ekurhuleni, and Tshwane, (South African Government, 2020).

People move to cities to look for economic opportunities because metropolitan areas are regarded as drivers of economic activities. In the next discussions, the results focus on the specific geographical regions or locations, and the travel patterns. Statistics South Africa of 2014 examined three distinct categories in terms of the geographical or type of location. This included metro, urban (all non-metro urban) and rural areas. There are 278 municipalities in South Africa, comprising 8 metropolitans, 44 districts and 226 local municipalities. They are focused on growing local economies and providing infrastructure and service (South African Government, 2018). This section will provide a brief background of who this is classified in the South African context and the definitions thereof. Section 155 of The South African Constitution provides for three categories of municipalities (metropolitan, districts, and local municipalities).

As directed by the Constitution, the Local Government: Municipal Structures Act, (117 of 1998) contains criteria for determining when an area must have a category-A municipality (metropolitan municipalities) and when municipalities fall into categories B (local municipalities) or C (district municipalities). The Act also determines that category-A municipalities can only be established in metropolitan areas, (South African Government, 2018). Chapter 7 of the Constitution explains the different categories as follows:

- Category A – Metropolitan: A municipality that has exclusive municipal executive and legislative authority in its area.
- Category B – Local: A municipality that shares municipal executive and legislative authority in its area with a category C municipality within whose area it falls.
- Category C – District: A municipality that has municipal executive and legislative authority in an area that includes more than one municipality (Republic of South Africa Government, 1996; South African Government, 1996)

3.6.3.1. Metro Areas

As discussed in the earlier section, a Metropolitan refers to a formal local government area comprising the urban area as a whole and its primary commuter areas (see Figure 3.1), (UNICEF, 2012). All metropolitan municipal, legislative and executive powers are vested in the metropolitan council who have the power to decentralise powers and functions. South Africa has 8 metropolitan municipalities, as discussed in section 3.2.1 above. It is in metro areas where government has invested and developed Bus Rapid Transit (BRT) systems to improve transport systems. It was important to develop such mass transit systems since more than 80% of global GDP is generated in cities (The World Bank, 2020), therefore, there is a need provide efficient transport systems for mobility. Consequently, by increasing productivity.

Figure 3.5. shows the composition of the different geographical locations (Metros, Urban and Rural) as presented in the NHTS survey. There were more respondents in metros compared to other locations in both the surveys. Most of the respondents live in the metropolitan areas, about 41% in 2013 and 51% in 2020, followed by urban (35% in 2013 and 26% in 2020) areas and rural (25% in 2013 and 23% in 2020) respectively for the survey participants.

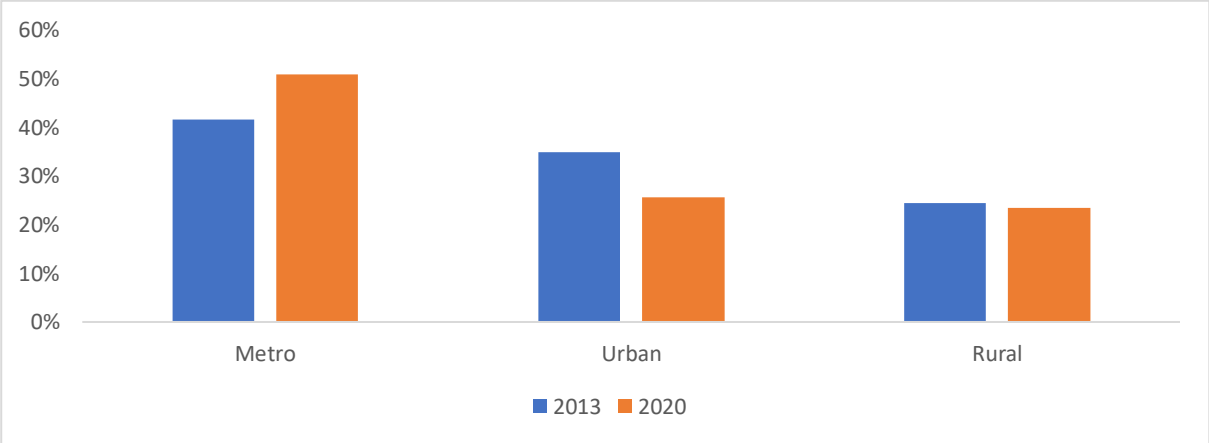


Figure 3.5. The geographic distribution of respondents who are employed per geographical location in 2013 and 2020. (Author analysis based on 2013 and 2020 NHTS: Statistics South Africa, 2014; 2020)

3.6.3.2. Urban Areas

An urban area can refer to the region and suburbs surrounding a city where most inhabitants have non-agricultural jobs (National Geographic, 2018). Towns, townships, suburbs, etc., are typical urban settlements. According to UNICEF (2012), the definition of 'urban' varies from country to country, and with periodic reclassification, can also vary within one country over time, making direct comparisons difficult. An urban area can be defined by one or more of the following:

- administrative criteria or political boundaries (e.g., area within the jurisdiction of a municipality or town committee),
- a threshold population size (where the minimum for an urban settlement is typically in the region of 2,000 people, although this varies globally between 200 and 50,000),
- population density, economic function (e.g., where a significant majority of the population is not primarily engaged in agriculture, or where there is surplus employment) or the presence of urban characteristics (e.g., paved streets, electric lighting, sewerage) (Angel, Parent, Civco, and Blei, 2010; UNICEF, 2012; United Nations Department of Economic and Social Affairs, 2012).

In 2010, 3.5 billion people lived in areas classified as urban, (UNICEF, 2012), currently that number has increased to 4.4 billion inhabitants (The World Bank, 2020). Urban areas contribute significantly to the development of societies, as metropolitan areas, though this may differ by regions. Transport is vital in connecting urban inhabitants to economic and social opportunities. In South African, urban areas are served by the rails system, busses as well as the minibus taxi industry.

3.6.3.3. Rural areas

Rural areas are the opposite of urban areas and are referred to as open and spread-out countries. They have small or low population density, small settlements, and large amounts of undeveloped land (UNICEF, 2012; National Geographic, 2018). Rural areas are typically found in areas where the population is self-sustaining of natural resources of the land, or they work in coal, copper, and oil. People in rural settings travel to the nearest large towns or cities for work, school, medical care, and any other basic living needs. In general, a rural area or countryside is a geographic area that is located outside towns and cities and can be subdivided into tribal areas and commercial farms.

The classification of the geographical location or type is discussed to provide a background on their role in meeting societal needs. Public transport is provided across in these geographical locations, however this is done in different arrangements. Because of the intensity of activities in metro and urban areas, the investment of transport systems is prioritised. In the next chapter the transport profiles of commuters are discussed and presented using public transport (minibus, bus, and train) and private car in all the three geographical locations, with main focus on metros. The research focuses mainly on metros because as mentioned above, so more than 80% of global GDP is generated in cities (The World Bank, 2020), therefore, it is important for cities to function well and provide efficient transport systems for the residents.

4. TRANSPORT PROFILE OF COMMUTERS

4.1. Main mode of transport to employment places in South Africa

Both the NHTS 2013 and 2020 have filter questions that investigate the main mode of transport for public transport users. This represents the sample of the 40 820 of the working population for NHTS 2020, and 30 907 for NHTS 2020 as discussed in the methodology section. The results below show the mode used to travel to work (the commute trip). Overall, in South Africa, three modes dominate work trips i.e., private cars, walking and minibus taxis. The research considered the main modes of transport to the place of employment as indicated in the NHTS 2013 and 2020: public transport (train, bus, and minibus taxis), private vehicle (driver and passengers) and walking. The last category recorded as "other" has shown a marginal percentage (less than 1%). This might have included modes such as cycling.

In terms of the statistics of the working population in 2013, about 28% of workers used private vehicles as their main mode of transport to their workplace, followed by those who walked all the way (26%) and minibus taxis (25%) (Figure 4.1). The minibus taxis were the main mode of public transport used at 25%, with buses (7%) and trains (4%). There was an increase of those who used taxis and cars in the 2020 survey. It is the public transport mode that have decreased in the market share as well as walking. This is worrisome because it is against what the national policy seeks to achieve. When interpreting these results, it must also be noted that not all modes are available across the country. For example, trains are mostly found in metros and urban areas, while other modes (minibus taxis and buses) are found across most of the regions. About 8% of the participants travelled as private car passengers. This is to say, there are distinct differences in the use of the modes across the different spatial areas, i.e., metros, cities, and rural areas.

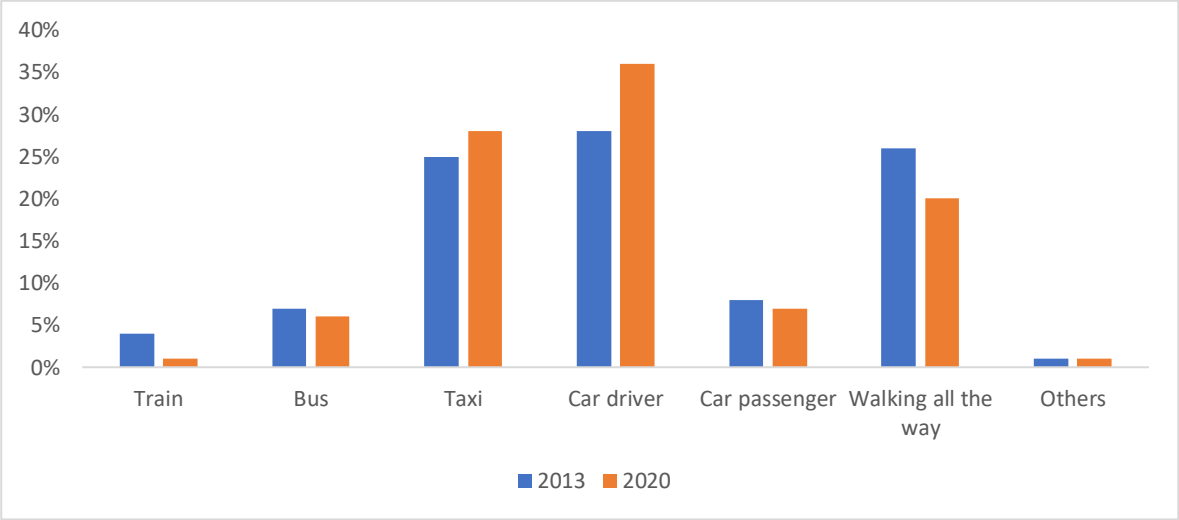


Figure 4.1: Main mode of transport to the place of employment in 2013 and 2020. (Author analysis based on 2013 and 2020 NHTS: Statistics South Africa, 2014; 2020)

Against this background, the National Development Plan (NDP) 2030, has set down plans to make investments in the transport sector (The National Planning Commission, 2011). The investment plans include strategies to "bridge geographic distances affordably, foster reliably and safely so that all South Africans can access previously inaccessible economic opportunities, social spaces and services". Social and economic exclusion is still evident as the majority of South Africans are still placed far away from work, where it is difficult to access the benefits of society and participate in the economy. For this reason, the National Planning Commission proposed a strategy to address the apartheid geography that will achieve a creative balance between spatial equity, economic competitiveness, and environmental sustainability. These include inclusiveness or equity in ownership of assets, income distribution and access to management, professions, and skilled jobs, (Department of Transport, 1996; The National Planning Commission, 2011). Furthermore, the White Paper on Transport Policy (1996) advocates for a "safe, reliable and integrated public transport system and to make public transport competitive with the private car to provide a viable alternative mode".

Transportation equity affects residents' access to economic as well as social opportunities, (Saghapour, Moridpour and Thompson, 2016). Most commuters live far from their workplaces, and this increases their travel expenses. Many poor households spend 15 to 30% of their disposal income on transport, this is more than double the national benchmark and inconsistent with the White Paper on Transport Policy of limiting and reducing transport expenditure to less than 10% of disposable

household income to measure the affordability of public transport, (Department of Transport, 1996). Furthermore, the Gauteng Province National House Travel Survey of 2014 highlighted that, because of ever-increasing fares, the proportion of household income spent on public transport increased significantly.

4.1.1. The main mode of travel to work: rural, urban, and metro travel differences

Figures 4.2a-c present an overview of the main mode of transport used by South Africans to place of employment per geographical location. Private car drivers (38%) and minibus taxis (30%) were prevalent across metros and urban areas (Figure 4.2a) as the main mode of transport while "walking all the way" (44%) was mostly found in rural areas (32%) followed by who urban also used walking as their main mode of transport. About 30% of public transport users in metros depend on minibus taxis to travel to work, followed by trains and buses, respectively. Trains were mostly used in metro areas, compared to other regions. This is simply because the train is mostly a metro mode and less in urban areas as compared to buses which are found across the country. Buses are used more in rural areas at 12%.

The minibus taxis were predominant across all the regions or geographical locations, which highlights the importance of accessibility of public transport which enables them to reach most corners of the country. In terms of the survey, there was a huge population relying much on "walking" as their main mode of transport in rural areas as well as in urban areas. Metros recorded about the least for "walking" as the main mode of transport. Those who relied on private cars were more predominant in metros followed by those in urban areas. There were more train users in metros than in urban areas and this could be attributed to the fact that train services which are under Metrorail (PRASA) are mostly prevalent in metros. The train is thus mainly a metro mode but taxi, and private cars are available everywhere. Rural areas did not have train services. Buses are used heavily in rural areas (12%), with metro and rural areas recording 6% and 5% respectively.

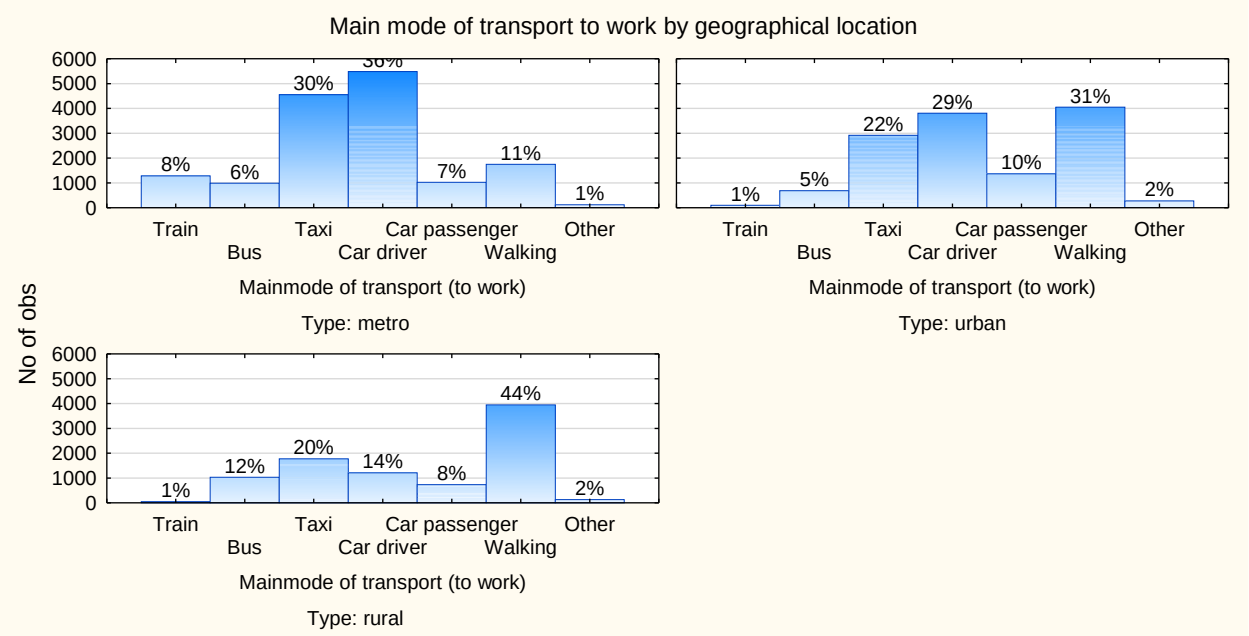


Figure 4.2a-c: Distribution of respondents' main mode of transport by geographical location (Source: Author analysis based on 2013 NHTS: Statistics South Africa, 2014)

The assumption is that in metros, many people would walk to work as this is where people live close to work or should live close to work. But this is not the case as shown in figure 4.2a. There are a lot of people in private cars in metros and far less of the walking population on work trips. This is different from most countries in Western Europe where for example in the Netherlands more than half of all daily trips are by walking or cycling (Buehler and Pucher, 2012). Moreover, walking and cycling are economical—they cost far less than the private car or public transport, in terms of direct outlays by users and of investments in infrastructure. For South Africa, the challenge is that low-income people do not live close to work, so walking is not an option. This is worrying because these groups at most cannot afford the cost of transport. South Africa is very far behind compared to other countries mostly in West Europe. Most European countries have levels in between, with NMT accounting for 25% to 35% of daily trips. At the low end, approximately one-tenth of daily trips are by foot or bike in car-oriented countries. At the high end, more than half of all daily trips in the Netherlands are by walking or cycling (Buehler and Pucher, 2012). However overall, the differences in national travel surveys limit the comparability of walking and cycling statistics. For South Africa, this indicates a very poor structured metro and points out the problem between trip origins and destinations. It is mainly poor people that walk; however, these masses are located at the periphery

of the centres of economic activities. They are forced to use expensive modes of transport such as minibus taxis to commute.

4.1.2. The main mode of transport in the formal versus the informal sector.

Figures 4.3a-b give an analysis of the formal and informal employment and the mode of transport used. It must be noted that from the analysis of the 2013 survey there was 63% of the participants which was the unemployed population which was not part of the analysis. The research focused on 37% of the employed (formal and informal) population. Of the 37% of the working population, 76% was employed in the formal sector and 24% in the informal sector.

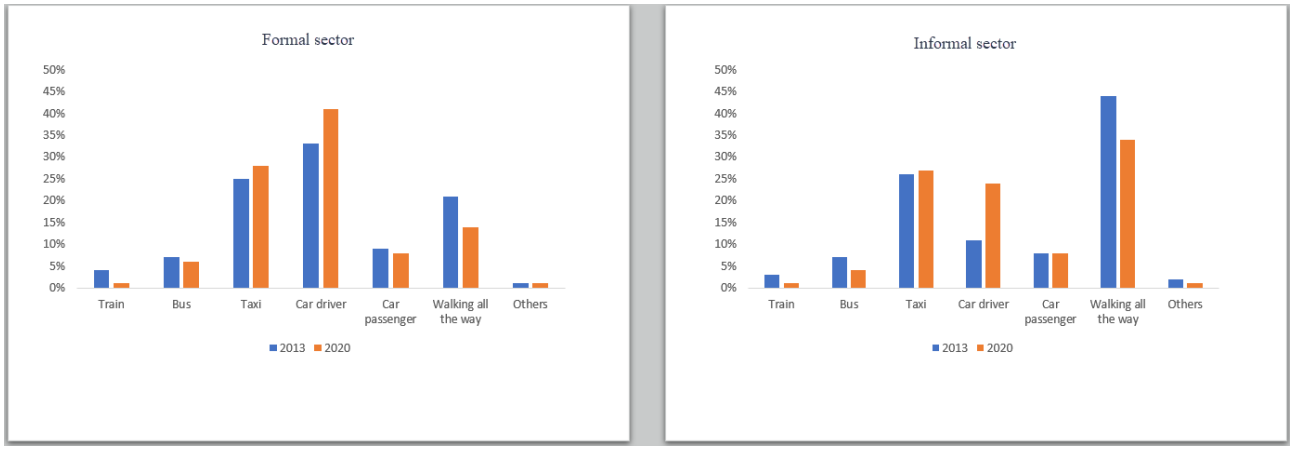


Figure 4.3a-b: Main mode of transport in the formal vs informal sector in 2013 and 2020. (Author analysis based on 2013 and 2020 NHTS: Statistics South Africa, 2014; 2020)

Figure 4.3a shows that those in the formal sector rely heavily on private cars 33%, followed by minibus taxis (25%) and walking (22%) for 2013. This was more for private car drivers and taxis in 2020 at 41% and 28% respectively. In the informal sector, walking (44%) was the main mode used by workers in 2013 and less at 34% in 2020, with the minibus taxis at 26% in 2013 and 27% in 2020 as the second most used. About 12% of the workers were private car drivers. This number increased in 2020 to 24%. Trains were the least used main mode of transport in both the informal and formal sectors and reduced significantly in the latest survey (2020). Most commuters who use public transport are heavily reliant on minibus taxis in both the formal and informal sectors and this has also increased slightly (Figure 4.3a-b). The usage of minibus taxis has been consistently high throughout

the industry's existence & shows no sign of slowing down (Fobosi, 2019). According to the taxi industry representative, South African National Taxi Council (SANTACO), about 15 million South Africans make use of taxis daily. This is higher than over the 2 million daily commuters transported by Metrorail services in Cape Town, Gauteng, eThekwini, Gqeberha and East London, on the 471 railway stations and representing a national public transport market share of 15%, (PRASA, 2019). These commuters usually travel from city outskirts and townships into business districts and suburban South Africa. Minibus taxis are an integral part of the South African public transport infrastructure. The industry carries the heaviest weight without any state assistance and funding while government transport infrastructure initiatives such as the Gautrain, BRT, etc. are still not able to address the transport challenges of the metropolitan areas. The results indicate the importance of the minibus taxi industry in the public transport space even when compared to the state-subsidised public transport modes (train and bus). These three main modes of public transport were used heavily in the formal sector. However, this may be attributed to the fact that there were a huge number of people in the formal sector from the survey.

4.1.2.1. Employment status in metropolitan areas

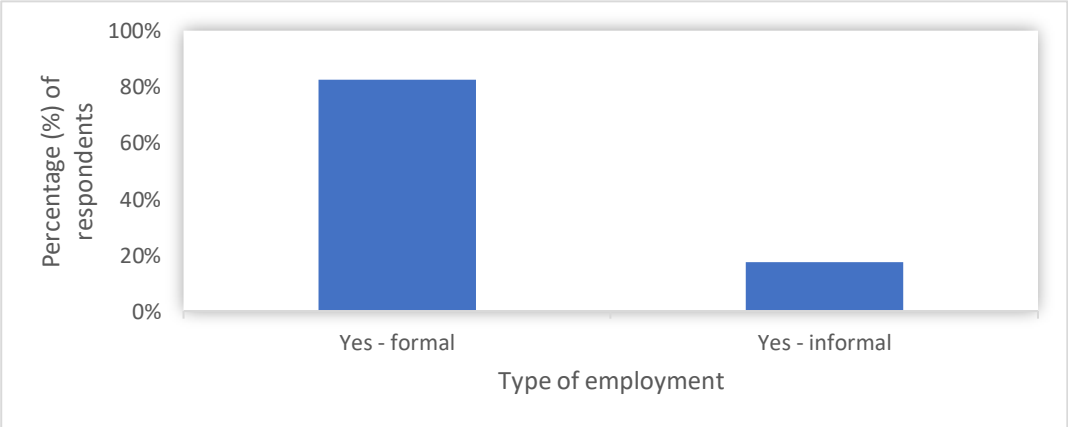


Figure 4.4: Employment for metropolitan areas (Source: Author analysis based on 2013 NHTS: Statistics South Africa, 2014)

This section presents the distribution of type of employment in metro areas in 2013. The results shows that about 52% of the metropolitan population indicated that they are not employed while 48% are employed. Of the 48% employed, about 83% are working in the formal sector while 17% are in the

informal sector, which highlights a significant number of those in the formal sector as compared to the informal sector (Figure 4.4). The employment split in metros follows a similar trend to that of the country, where a huge number of participants indicated that they are not working.

4.1.3. Metro areas and travel challenges

As discussed above in section 3.2.1, South Africa has got eight metropolitan municipalities. The South African 8 Metropolitan areas occupy only 2% of South Africa's land area with a population of about 22,196,701 (39% of South Africa's population). They are accounted for nearly two-thirds (60%) of South Africa's total population and employment increase between 2001 and 2011 (Turok and Borel-Saladin, 2014). The City of Johannesburg has got the highest population (4,949,347) followed by the City of Cape Town (4,005,016). Mangaung has the smallest population of 787 803 of all the metro areas, (Municipalities of South Africa, 2019).

Turok and Borel-Saladin, (2014) assert that the metros average growth rate over the decade was nearly three times higher than the rest of the country and the fastest increase occurred in two of the Gauteng metros (Johannesburg and Tshwane), followed by Cape Town and the third Gauteng metro (Ekurhuleni). This supports the fact that metros are facilitators of economic growth and generate more resources to raise living standards and investment as well as the demand for jobs. However, this also brings about strain on public services and infrastructure in these large metros. This is simply because the relationship between the location of economic growth and where people settle is particularly important since employment provides the main source of income for household consumption and the key mechanism for social inclusion.

The December 2018 Quarterly Financial Statistics of Municipalities (*QFSM)* (Statistics South Africa, 2018) indicates that municipalities in South Africa generate a total of 72% of their own income. Metropolitan councils are relatively self-sustainable, on average they generate 83% of income themselves. Reports from the Brookings Metropolitan Policy Program and the 2018 Global Metro Monitor has found that 300 of the biggest metropolitan areas grew faster than the overall global economy, making up two-thirds of global GDP growth and more than a third of global employment growth between 2014 and 2016. The reports have shown that metro areas that have emerging economies continue to excessively drive growth, they account for 80% of the 60 best performing

metro economies on the index (Business Tech, 2018; Business Report, 2018). This highlights the significance of metropolitan areas in the economy of a country. Without proper infrastructure development and lack of accessible transport systems, they will not be able to function effectively for economic growth and development.

Transport has a negative utility which should be minimised. The metros, for example, are characterised by the expensive transport modes with rail being the least used though it's the cheapest mode of transport. The bus also does not carry much in metros but is mostly used in rural areas. Private car drivers and minibus taxis are the important modes for metropolitan areas; however, they are the most expensive modes. People value time and cost in modal choice. NHTS 2013 found that most households identified travel time and cost of travel as the biggest determinants of modal choice (Statistics South Africa, 2014). The subsequent NHTS 2020 study also found that these two factors are still the biggest determinants of modal choice amongst transport users, (Statistics South Africa, 2020). Long commute times and transport costs inhibit workers from fully participating in the economic, social, and family maintenance activities as they spend a larger fraction of their incomes and daily time getting to and from work. Less time and income are therefore available to spend on childcaring, home maintenance and general social activities.

Though walking is an essential mode and a travel mode used by many as a primary way of getting around. it is about, 3 million workers (21, 1%) who walked to work (Statistics South Africa, 2014). About 1 in 5 workers walked, and only 1,3% cycled to work with the majority of those that walked to work found in the rural areas. The built environment in South African cities does not provide access for NMT users which are most the low-income group. The above argument illustrates the reasons why metros and urban areas have few people walking which can be different for rural areas, where workers walk because they are not able to afford other modes of transport or lack of other transport services thereof.

The role played by walking in meeting the daily mobility and accessibility needs, among middle to low-income households cannot be overemphasized. It is evident that even though there are no proper facilities for walking, there is a significant amount of the working population who walk to and from home and work. Commuters must contend with potholed tarmac, open manhole covers, running sewage and dirt roads turning to mud baths when it rains which leave them exposed to danger because

the access and egress infrastructure is not provided for. Those who walk, do so because they have no other choice. This demands that facilities for non-motorised transport should receive priority to improve walking times to access modes of public transport. Most workers in rural areas walked to work, while private car drivers and taxi users were mostly found in metropolitan areas. Train users were mostly in metro areas. Though trains are the cheapest mode of transport, they are still the least used mode in both urban and metro areas. This can be attributed to the fact that the train is mostly in metro mode. The minibus-taxi industry has proved to offer more frequent service compared to other public transport modes. The challenges in cities contribute to other social and economic issues and affect users of public transport and those who walk to places of employment. Furthermore, public transport users experience long commuting times. The following section looks at travel time to work for different modes of transport in metropolitan areas. The travel time elements are quantified and discussed.

4.2. **Travel time elements for the journey to work for the various transport modes in metropolitan areas.**

4.2.1. Total travel time to work by main mode of transport (walking, driving, and cycling)

This section explores travel time for the journey to work of workers for the various transport modes in metropolitan areas. It seeks to determine and quantify the travel time elements for public transport users in terms of out-of-vehicle (access, egress, wait and transfer) and relate this time to the journey to work. The question is on workers who travel to work on the travel day of the survey, focusing on the time they usually leave and get to the workplace. The question in the survey asked the total travel time to place of employment by walking, driving, and cycling, however it was not specific on the location of the place of work. As shown in Figure 4.5, many respondents did not indicate what mode of the 3 mentioned they used, so they were classified as missing cases. The results show that those who cycle to work spend more time travelling than those who drive (excluding public transport) and walk. However, this should be interpreted with caution given that the distance was not prescribed on the questionnaire. The distance is not prescribed on the survey because NHTS does not measure distances but travel time.

However, to determine the distance, the research assumed the following: average walk speed of +/- 4 – 6 km per hour; average driving speed of +/- 80 km per hour; average cycling speed of +/- 25 km per hour, based on calculation done by Keijer and Rietveld (2000). If they travel for 33 minutes on average (as shown in 4.5) it means that workers can find work within an average distance of +/- 2–- 3 km if walking: 19km cycling and 53 km for those driving.

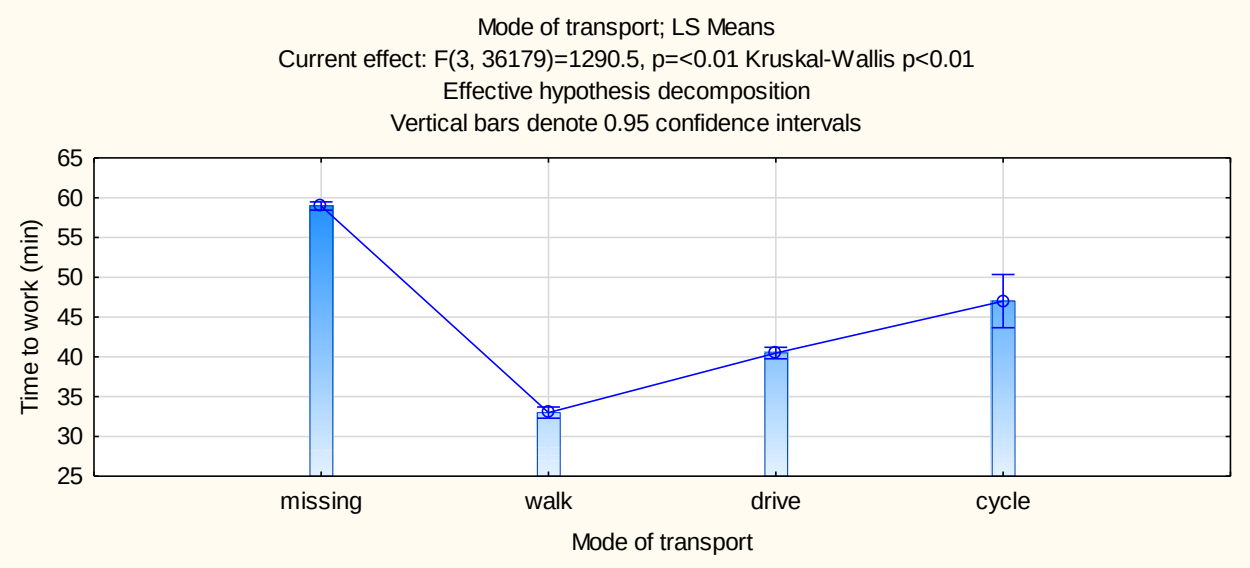


Figure 4.5: Total travel time to work by main mode (excluding public transport) (Source: Author analysis based on 2013 NHTS: Statistics South Africa, 2014)

Table 4.1: Travel distances for main modes (excluding public transport)

a) Walking	b) Driving	c) Cycling
Distance = Speed x Time = 4km/h * 33m = 2.2 km	Distance = S * T = 80km/h * 40m = 53 km	Distance = S * T = 25km/h * 47m = 19 km

NB: The calculation is based on the travel time to work by main mode as shown in Figure 4.5

The results shown above highlight the advantages of people who have access to private cars to job opportunities. Despite the evidence that walkability has always been an important part in cities transport mode, there is still not enough investment in non-motorised infrastructure to support access and egress trips. People still reside far from where they work. In most cities, the quality of sidewalks

has eroded noticeably (if they are present at all) (Sturgis, 2015). The literature indicates sidewalk quality, availability, and street network connectedness are crucial access factors in walking to public transport stations and in other instances as a main mode from origin to destination.

4.2.2. Total travel time to work – for urban, metro, and rural by main mode of transport.

Table 4.2: Descriptive statistics – total travel time to place of employment by geographical location for all survey participants.

Descriptive Statistics (NHTS, 2013 and 2020)							
		N	Mean (min)	Std.Dev.	Std.Err	-95.00% CI	+95.00%CI
SA	***2013***	***36 459***	***47.5***	***37.5***	***0.2***	***47***	***47.9***
	2020	***145385***	***47***	***34***	***0***		
Metro	2013	14 798	54.6	37.9	0.3	54	55.2
	2020	22568	57	36	0		
Urban	2013	12 980	38.8	31.9	0.3	38.3	39.3
	2020	52834	38	29	0		
Rural	2013	8 681	48.2	41.8	0.4	47.4	49
	2020	69983	46	37	0		

(Source: Author analysis based on 2013 and 2020 NHTS: Statistics South Africa, 2014; 2020).

Table 4.2 above gives an analysis of average travel time for each geographical location and main mode of travel. This covers total travel time for all main mode of transport in the country as analysed in the 2013 NHTS (Statistics South Africa, 2014). Travelling by train in all regions proved to be longest, followed by buses and minibus taxis respectively. Those who walked to place of employment recorded the lowest travel time because of the lower distance they can travel.

The research shows that urban areas perform better than rural and importantly, metro areas in terms of access time to employment (see Chapter 3, Section 3.6.3 for definition of geographical locations). In metropolitan areas such as City of Tshwane, City of Johannesburg, Ekurhuleni, Cape Town, eThekwini, a significant number of workers needed more time (55 minutes in 2013 and 57 in 2020 one way) to get to their workplace. In general, total commute time, one direction appeared to be

higher in the centres with significant employment, where workers may encounter traffic delays, mode inefficiency when they travel to work.

A study by Waller (2005), showed that transit travel generally takes longer than travel by private cars, even in cities with extensive transit service. It found that on average commuting to work takes over twice as long on public transit as commuting by private vehicle. Relying on transit makes it quite difficult to take care of everyday family responsibilities that go well beyond the usual to-work-and-back travel. For example, most parents perform other no-work activities between work, school, and other errands. This research also found that travelling by car takes less time than by public transport which means public transport users lose more time than car users.

The 2013 NHTS survey revealed that workers in the metro areas (Table 4.2) spend more time travelling (55 minutes), followed by those in rural areas (48 minutes), while urban areas recorded the least travel time (39 minutes). In 2020, there was a slight increase in metros but slight below in rural areas. The travel time in the metros is also higher than the national average which is 47 minutes (this is one direction travel). The national average remained the same in the 2020 survey. This is even though most of these metro areas have been prioritised in terms of the investments for roads and rail (public transport) infrastructure (Department of Transport, 2016). So, despite government's objective to follow an urban led growth policy, where people live closer to work, and have access to various efficient modes, it is clear there are significant impediments with transport system in metropolitan areas. The following section discuss the travel time per mode in the various spatial settings.

4.3. Travel time elements for public transport users: OVT (access, egress, wait and transfer) and IVT.

This section explores travel time elements which include the time (minutes) it takes to walk to the first transport mode or station, waiting time, transfers, line haul and time walking at the end of the trip to reach the workplace in metropolitan areas. The public transport travel time includes all these travel times as well, which is not the case with private car trips. Public transport stages (i.e., access, egress, wait and transfer) are unproductive, they require energy, commuters are exposed to the weather elements, and they are simply unpleasant times because of this disutility involved. From the literature, walking time to public transport is a function of walking speed (influenced by personal characteristics, gradient, surface quality, etc.) and distance (influenced by the proximity of the nearest

public transport, trip purpose, etc.). The proximity of public transport is defined as the time it takes (in minutes) for the person to travel from the dwelling unit to get to their first transport.

4.3.1. Walking to the first transport (access)

The literature has shown that walking is an essential and a travel mode used by many as a primary way of getting around, as (PRASA, 2008; Statistics South Africa, 2014; Lah, 2015). The latest 2020 NHTS survey (Statistics South Africa, 2020) has also found that about 17,4 million South Africans walked to their destination. For this research, on those surveyed (employed) in the metros, irrespective of the mode used, the results show that public transport (train, bus, and taxi) users in metropolitan areas spend about 9 minutes on average walking from their dwelling units to the first mode of public transport. Train users spend more time (16 minutes) walking from their dwelling units to the first mode of public transport than other modes (bus and taxi). This has also increased in 2020 to around 19 minutes in metros, implying that people are now located a bit far from train station. This could be because some train stations are no longer operational.

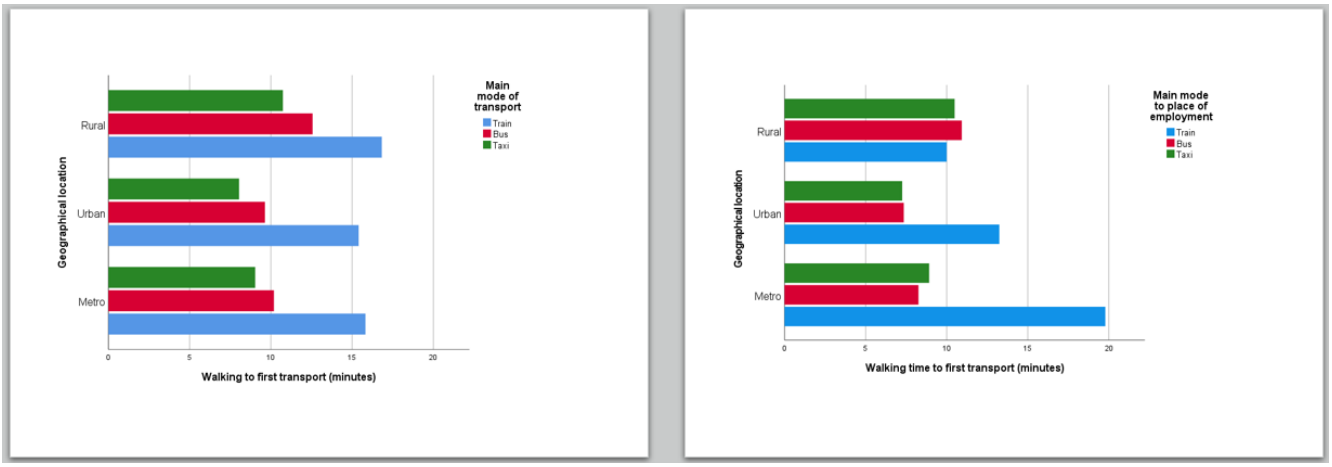


Figure 4.6: Walking time to first transport by geographical location in 2013 and 2020 (Author analysis based on 2013 and 2020 NHTS: Statistics South Africa, 2014; 2020)

4.3.2. Waiting time

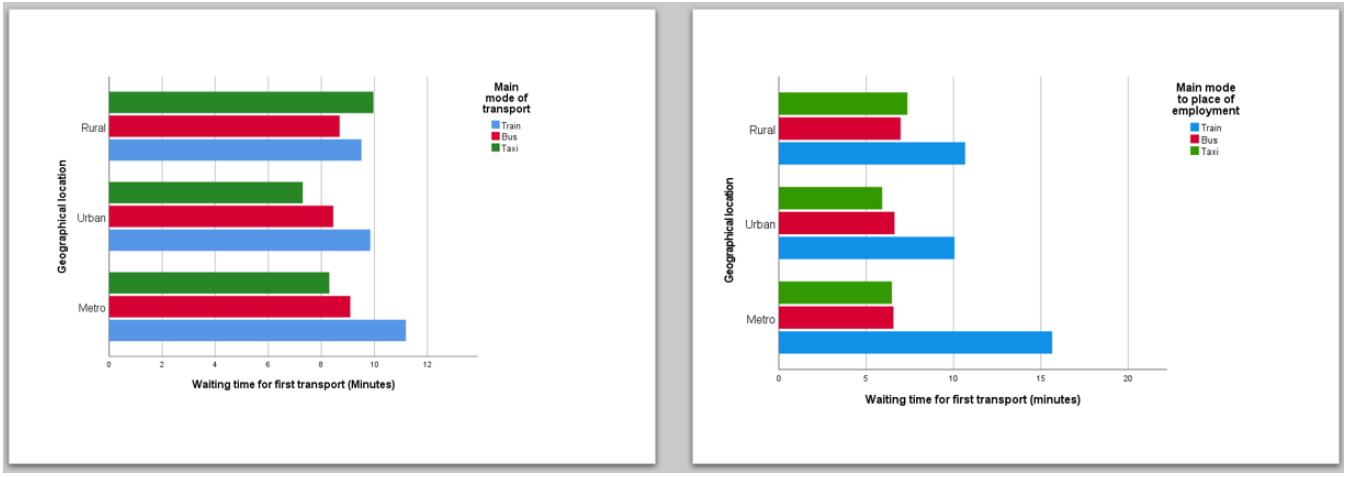


Figure 4.7: Waiting time for first transport by geographical location in 2013 and 2020. (Author analysis based on 2013 and 2020 NHTS: Statistics South Africa, 2014; 2020)

On average, commuters in the metros spend almost 8 minutes waiting for their first transport to work in 2013. The time is not associated with a specific mode however, in 2013 train users were likely to spend more time waiting or making transfers in both metros and urban areas. In the 2020 survey, waiting time for trains has since increased across all regions. In 2013, taxi users in rural areas spend more time waiting than other modes. However, in 2020 trains users are now experiencing more waiting time in all regions. This goes to show that travel time has increased for public transport users. This is against what government policies are advocating of the provision of public transport that is accessible to all users.

4.3.3. Walking at the end (egress)

Workers spend almost 9 minutes on average on egress (end trips) which is mostly walk trips. Train users experience long walking time at the end to place of employment across all regions in 2013 and only increase in metros during the 2020 survey. PRASA (2008) has argued that many commuters walked to reach the origin station and back home. These users spend more time on the access and egress than any other mode. Across all regions, taxis seem to record the lowest time in the above elements. Therefore, one can argue that minibus taxis are more accessible that other modes of public transport. This is also because taxis can cater different types of settlement due to their sizes and flexibility.

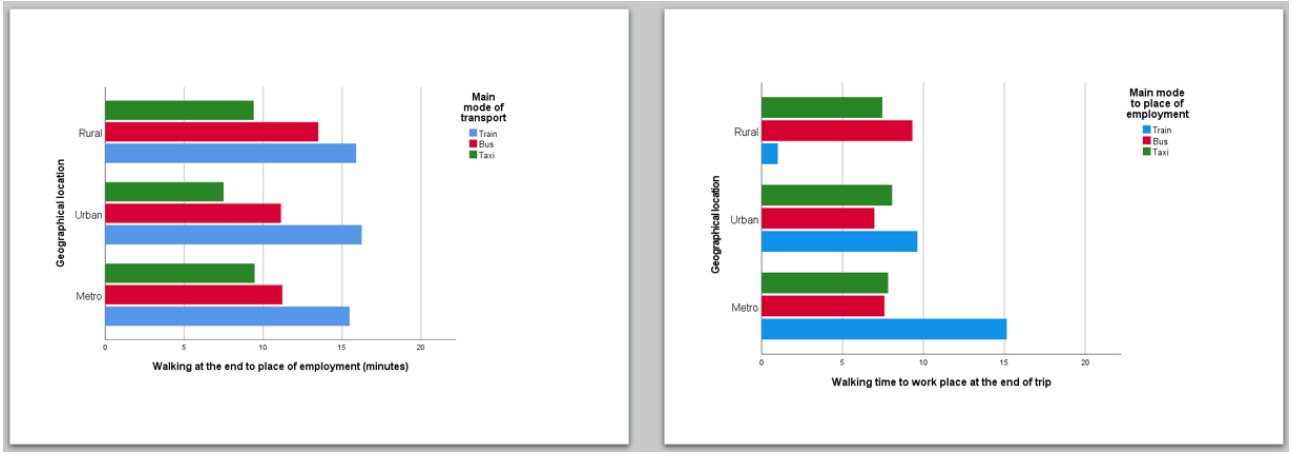


Figure 4.8 Walking time at the end to a place of employment by geographical location in 2013 and 2020. (Author analysis based on 2013 and 2020 NHTS: Statistics South Africa, 2014; 2020)

The results in Figures 4.6 and 4.8 highlight the importance of walking as a preferred mode of transport for short distances and as part of the urban transport system. Approximately 1 in 5 workers (21,1%) South Africans reported walking to their workplaces, which highlights the importance of walking in meeting the daily mobility and accessibility needs, among the middle to low-income households. However, NMT is still not considered to be part of the urban transport system even though it presents a high potential to address urban mobility challenges for short distances.

4.3.4. Total travel time to work (time leaving and arriving at work)

In terms of the NHTS (Statistics South Africa, 2014) the total travel time can be defined as the time duration between when workers usually leave and get to the workplace on the travel day. On average metropolitan commuters spend 55 minutes travelling (one way) from when they leave their house to the workplace across all modes. Train users spend more time (90 minutes) travelling but recorded IVT close to that of the bus (Figure 4.10). Mini-bus taxis recorded the lowest travel time for the line-haul but still high when compared to private cars on the total travel time. This makes the mini-bus taxis the fastest public transport mode with about 56 minutes average travel time.

Looking across all the three geographical regions in Figure 4.9, all modes form the “U” shape, i.e., start very high and then drop and then go up, except for rail that increases throughout. This is also the

case for bus which recorded the second highest across all regions. Considering both the metro and urban areas, the results point to the fact that there is an optimal area size in urban areas than in metros. When cities get too big like in the metros, travel time is likely to increase unlike in small towns. This can be because of congestion or distance from centres of attraction to new developments, as well as the urban land use.

The total travel time to places of employment varies significantly based on the main mode of transport and the geographic location (F (12,36326) = 26.90 P <0.001, Table 4.3). The effect of the main mode of transport alone on the variation in the total time to place of employment is significantly high, explaining nearly 12% of the variation in total time (Partial eta squared = 0.113).

Table 4.3. Results of a Two-way ANOVA assessing the differences in the mean total travel time based on the main mode of transport and the geographic location

Source	**F**	**df**	**Sig.**	**Partial Eta Squared**
Main mode of transport	768,573	6	0,000	0,113
Geographic location	58,001	2	0,000	0,003
Main mode of transport x Geographic location	26,901	12	0,000	0,009

NB: Only data from NHTS (2013) was used.

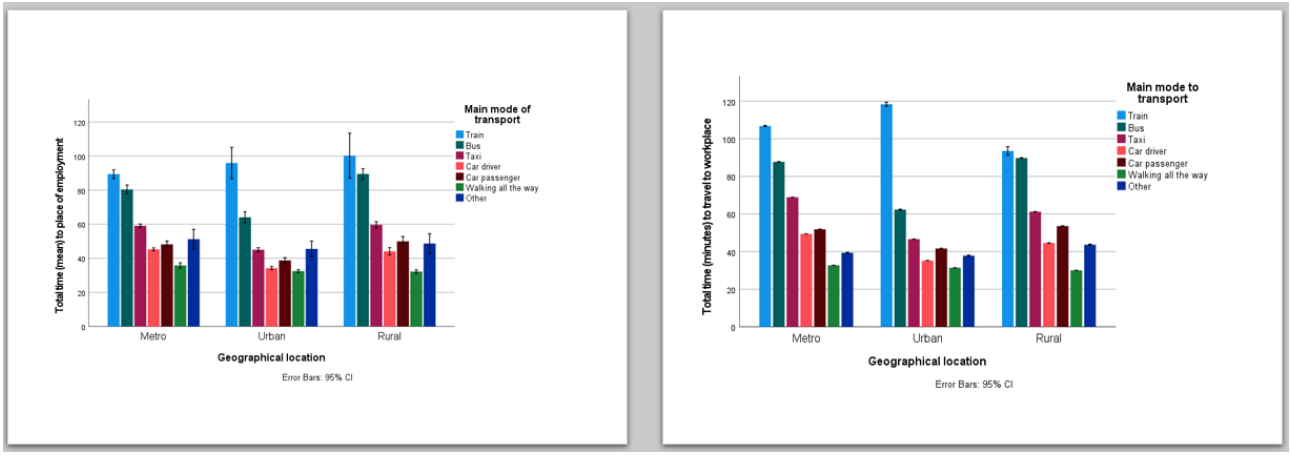


Figure 4.9: Total travel time to place of employment (2013 and 2020) for the main mode by geographical location. (Author analysis based on 2013 and 2020 NHTS: Statistics South Africa, 2014; 2020)

Train users (Figure 4.9) across all regions or geographical locations travel longer than any other mode. Trains are mostly metro and urban modes of transport. The 2013 results show higher travel time for trains in rural and urban than in metros and higher in urban and metros than in rural areas in 2020. For 2013, this can be attributed by the fact that there was more or frequent train service in metros than in urban areas. Interestingly, for 2020 train users in rural areas experienced less travel time compared to urban and metros. Surprisingly buses spend much time on the road in metros than in urban areas, which is a different case with trains. However, with buses and minibus taxis, the long travel time could be attributed to traffic congestion. Furthermore, this can be attributed to the fact that trains and bus services are limited and run infrequent services. Minibus taxis recorded the lowest travel time for public transport modes across the regions. Taxis are flexible and able to offer door to door services unlike buses and trains. It also means that the South African metros are not as effective as they should be, because of the level of resources in those regions.

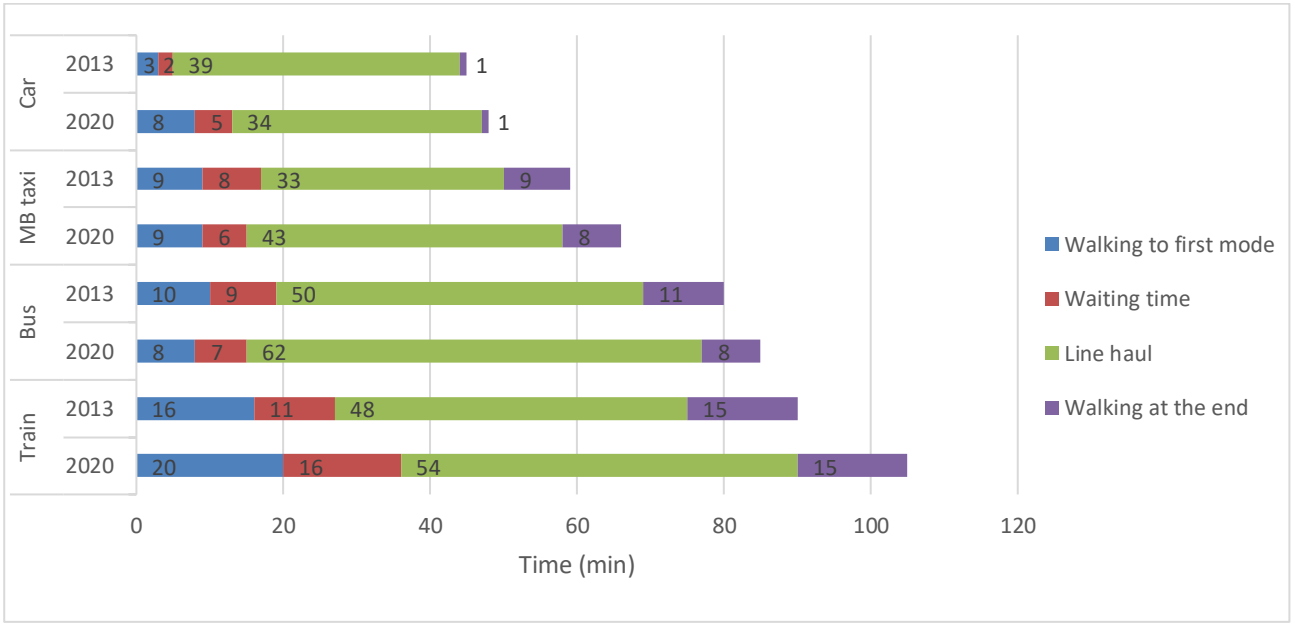


Figure 4.10: Cumulative travel time for main mode of transport to place of work in metropolitan areas for 2013 and 2020. (Author analysis based on 2013 and 2020 NHTS: Statistics South Africa, 2014; 2020)

The result in Figure 4.10 shows that train users spend more time on OVT (about 42 minutes in 2013 and 56 minutes in 2020) than any of the other modes. Buses recorded the second longest total travel time of 80 minutes but somewhat unexpected, the longest IVT (50 minutes) in 2013 and 62 minutes

in 2020. In terms of waiting times all the public transport modes had fairly the same wait time between 8 and 11 minutes in 2013 and 6 and 16 minutes in 2020. The significant share of OVT time compared to IVT highlights the onerous public transport travel time. Overall, travel time has increased across all modes as shown above.

At most, public transport is regarded as one mode where commuters hop in and get to their destination, however, that is not the case. Public transport means users must access the system which is not at their home. Even if they can reach the system, public transport may not be there because users do not control the frequency/ operations of the systems. The proximity of public transport is also a problem. Once on the system, it is seldom that users can use one mode to travel from origin to destination. The interconnectivity or transfers between modes becomes an issue as well as the travel time and cost. Comparing the travel time shows that trips involving transfers, commuters spend more time travelling than those without transfers. Transfers also contribute to high costs of travel. Similarly, public transport modes often drop users far from their destination which then requires them to use other modes to reach their destinations. For many, this means walking to the destination. All of these entail a public transport trip. It is often that these factors are not considered when planning for public transport trips. While there is a consideration for the main mode, there is less or no attention to other modes (access and egress) including the collection of data on the full trip but only for the line haul (main mode). This is often not the case with private car trips. Private transport trips do not involve long access, egress time or transfers at most. Figures 4.10 and 4.11 show that in 2013 it took around 45 minutes to travel by private car from origin to destination, which is 45 minutes less to the rail system. For 2020, travel time for private car users in metro areas increased from 45 to 48 minutes. The planning around the main mode has neglected other modes on the access and egress, at most there is not even data collected on the full trip.

The overall aim of the research is to evaluate the multimodal and multistage character of public transport on daily travel time and household expenditure and illustrate the access and overall cost penalty imposed on users of public transport. The research explores the complete journey from origin to destination and to understand the time and distance penalty that people pay for using public transport, i.e., what do commuters give up, in terms of other activities, if they use public transport.

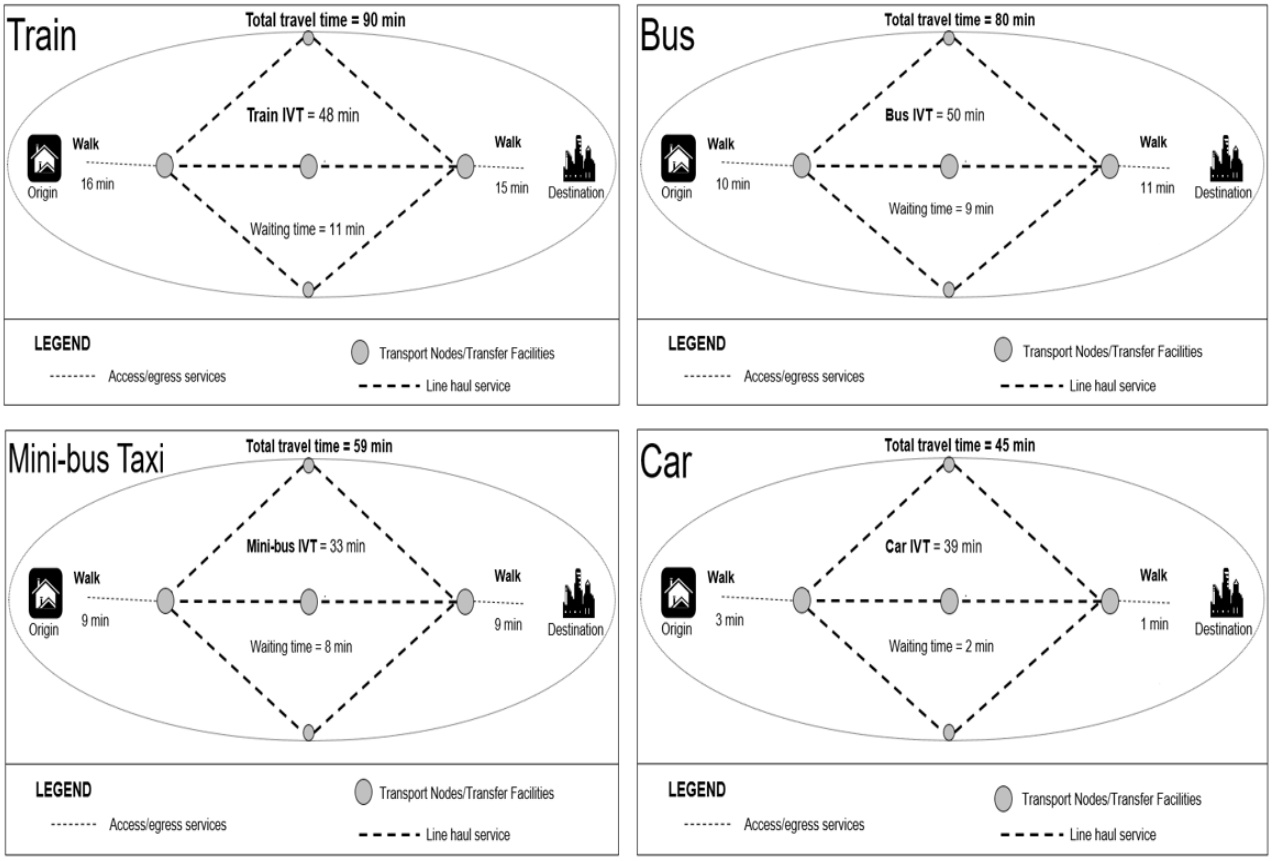


Figure 4.11: Out of vehicle time and in-vehicle-time for public transport modes and private car (only metro areas) (Source: Adopted from Krygsman, (2004); based on 2013 NHTS: Statistics South Africa, 2014)

4.3.5. In-vehicle time or linehaul and out-of-vehicle time

The research used the difference between the total travel time and the OVT which include access, waiting time, and egress to derive the in-vehicle time (IVT). The IVT depends both on the average speed of the mode and the distance travelled. Speed is influenced by the speed limit and the prevailing level of service (LOS) of the road or network. In total commuters, irrespective of the model used, spend 55 minutes travelling. The split between IVT and OVT is 29 minutes / 26 minutes respectively. Though the OVT is less than IVT, users still experience some form of disutility which also highlights unproductivity. The OVT are weighed more onerously than the IVT because transfer and wait are often spent in less desirable locations where there are no proper facilities such as shelter or proper waiting areas with seating facilities. If this time can be used for more productive activities such as remote working and shopping, the negative disutility associated with these travel elements may be mitigated. It is therefore important to consider that users benefit in public transport system when they

spend less time OVT because of its disutility. On the other hand, there are benefit associated with IVT, because users of the public transport system can do other activities such as working, reading, etc.

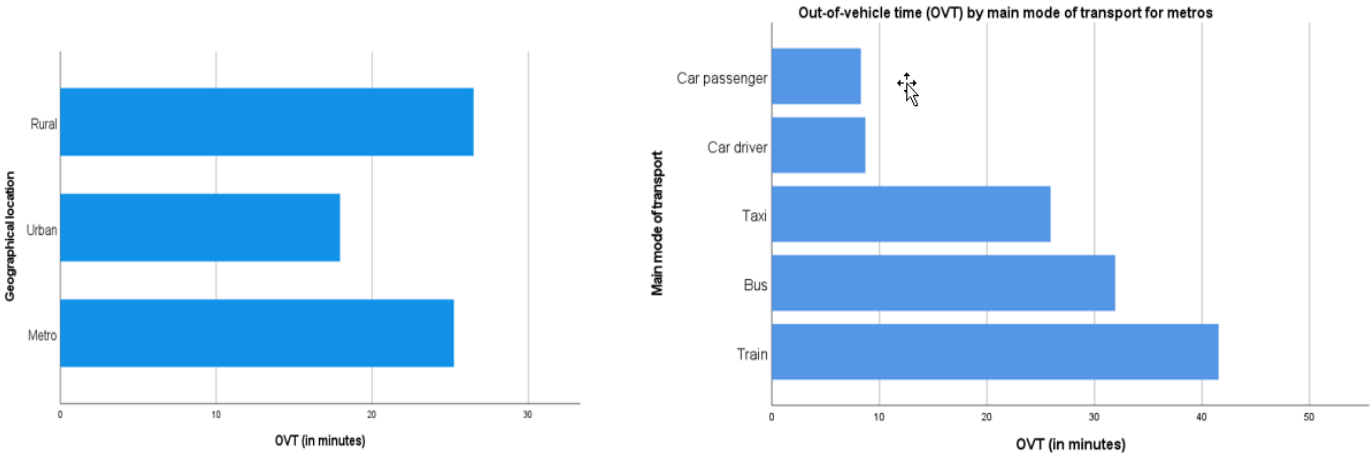


Figure 4.12a-b: Out of Vehicle Time (OVT) to place of employment by geographical location and by main mode of transport for Metropolitan areas (Source: Author analysis based on NHTS: Statistics South Africa, 2014)

As mentioned, above, public transport travel time includes OVT which includes waiting, transfer, access, and egress time elements. The OVT is high (at 27 minutes) in rural areas, followed by metros (25 minutes) with urban areas recording the lowest OVT (18 minutes). According to Litman (2016); Small (1998) travel time costs are a large component of transport economic impacts, so how they are evaluated significantly affects planning decisions. Travel time unit costs vary depending on the type of trip, travel conditions, and traveller preferences. For example, time spent relaxing on a comfortable seat tends to impose less cost than the same amount of time spent driving in congestion or standing on a crowded bus. Walking, cycling, waiting, and travelling as a passenger or driver may each have different unit costs which vary depending on travel conditions, needs and user preferences. Travel time unreliability (uncertainty of how long a trip will take, and unexpected delays) imposes additional costs (SSHRP, 2014).

The travel time elements show that the public transport system is not reliable. Almost all workers walk before they can make use of any other modes of transport. The average walking time (both access and egress) to the first mode is significantly longer for rail, which is mainly preferred by the low-income group because of its affordability compared to order modes. Workers who use trains walk longer than in any other modes to reach to their first station (train) in all types of geographical

locations (metro, urban and rural). As compared to all other modes, trains seem not to be accessible given its long access and egress time (Figure 4.10). For public transport modes, the minibus taxi has recorded the lowest OVT making it more accessible than others. Commuters in rural areas are the ones experiencing the longest walking time to their first mode of transport (this applies to all main modes of transport). In terms of the waiting time, the results highlight the weaknesses in the public transport system planning. It is an indication of lack of real-time information, availability of updated schedules. In most case people arrive early to public transport station or terminus to secure a seat.

The results in Figure 4.12(b) show that for train, commuters would prefer to arrive early which adds to their waiting time since trains have proven not to be punctual or not to provide frequent service. For minibus taxis, the waiting time in urban and metro areas could be because of supply and congestion in peak hours similar with buses, while in rural areas could be a result of lack of economic activities. However overall, the minibus taxis recorded the lowest of the travel elements, which makes it the preferred mode of public transport.

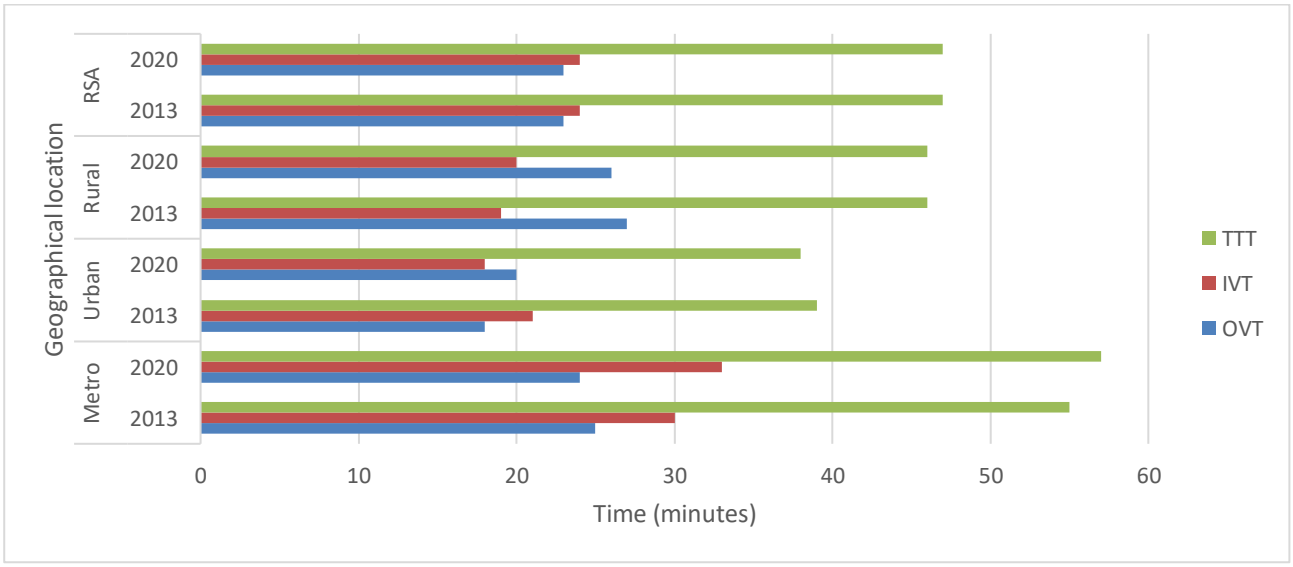


Figure 4.13: Out-of-vehicle travel time (OVT), in-vehicle travel time (IVT) and total travel time (TTT) for geographical location (one direction). (Author analysis based on 2013 and 2020 NHTS: Statistics South Africa, 2014; 2020)

Figure 4.13 above presents a comparison of travel time elements for both 2013 (55 minutes) and 2020 (57 minutes), in the 3 geographical locations. In both surveys (2013 and 2020), metros recorded the highest travel time which is IVT and OVT. This is even higher than the national average of 47 minutes. Urban areas have recorded the lowest total travel time in both years, which is below 39 minutes. The results imply that urban areas are more efficient than metro and rural areas. Many metros across the country have been experiencing high traffic volumes, which could be contributing to the

long travel times. For rural areas, it could be attributed to the fact that they are located at the periphery of places of economic activities.

4.4. **Accessibility Indices for travel time to place of work in metros**

This section explores travel time accessibility indices (AI) for different main modes of transport and compares these indices for these modes of transport. The travel time AI reflect travel time related to the average travel time value. As discussed earlier in section 3.3 these indices were calculated based on a methodology utilised by (Schoon, McDonald and Lee, 1999; Statistics South Africa, 2018). The results presented in Table 4.4 below show average travel times to the workplace, standard errors, and coefficients of variation.

Note: The research used only 2013 NHTS average travel time in metros to calculate the Coefficient of Variations (CV) and Accessibility Indices (AI). The 2020 NHTS was omitted because there were no significant differences in travel time for the modes of transport to 2013 data. CV was calculated using the following formula:

$$CV = \frac{\text{Standard Error}}{\text{average travel time (mean)}}\ x\ 100$$

Table 4.4: Distribution of workers by the main mode of transport and average travel time to work, in metros (NHTS 2013)

Main mode of transport		**No. of respondents**	**Per cent (%)**	**Average travel time**	**CV (%)**	**Std error of mean**
Public transport	Train	1286	8,5	89	1	1
	Bus	987	6,5	80	1	1
	Taxi	4551	29,9	59	2	1
Private transport	Car/ truck driver	5484	36,1	45	0	0
	Car/ truck passenger	1027	6,8	48	2	1
Walking all the way		1748	11,5	36	3	1
Other		121	0,8	51	6	3
All modes		**15204**	**100,1**	**58**	**2**	**1,1**

NB: Based on NHTS 2013 data. (Author analysis based on 2013 NHTS: Statistics South Africa, 2014)

Overall, in metropolitan areas, workers needed 58 minutes on average to get to their place of work. Public transport users experience longer travel times to get to their workplace with trains (89 to 90 minutes), buses (80 minutes) and taxis (59 minutes). For private car driver, an of average 45 minutes, and private car passengers travelled on average 48 minutes. Both are below the national average travel time. Those who walked to their place of work travelled an average 36 minutes. All estimates are accurate, as the coefficients of variation are small below 16,5% as shown in Figure 3.2.

AI was calculated using the following formula:

$$Al\ mode\ (mode\ (e.g.,taxi)) = \frac{\text{average travel time by } mode\ (\text{e.g., taxi})}{\text{average travel time across all modes}}$$

Figure 4.14 reveals that travel time AI scores for public transport modes are high compared to private transport modes. The highest travel time AI scores were estimated for trains (1,5), buses (1,4) and taxis (1,0), whereas the lowest travel time AI scores was for walking at 0,6. Both private car passengers and car drivers were at 0,8. These results show that public transport users were most likely to have trouble in accessing their workplace, especially train users who needed more time compared to other users.

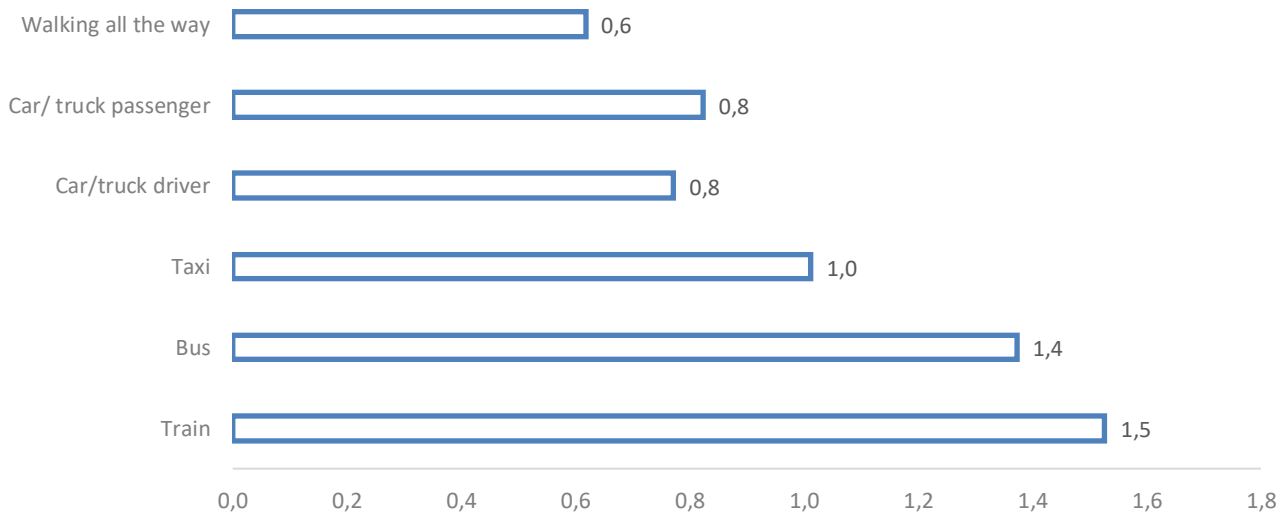


Figure 4.14: Travel time accessibility indices for workers by public transport mode in metros. (Author analysis based on 2013 NHTS: Statistics South Africa, 2014)

4.5. **Transport travel time ratio**

Travel time ratio is defined as the travel time by public transport divided by travel by car between the same origin and destination (Krygsman, 2004; Ortúzar and Willumsen, 1996; Rietveld et al., 1996). According to Krygsman (2004) the ratio can fluctuate from 1 to 5 for most trips, the larger the ratio, the less competitive public transport is. Travel time ratio for South Africa is the time is taken to travel to work by main modes of transport (2013 NHTS): i.e., train and car. It must be noted that this was not measured on the same origin and destination.

Example:

Travel time by Train/ travel time by car

= 90 minutes/ 41 minutes

= 2.2

Source: (Adopted from Krygsman, 2004; Ortúzar and Willumsen, 1996; Rietveld et al., 1996)

Given the above explanation and calculation, it will be evident that public transport modes will arguably not be competitive with private cars. As discussed in section 2.10.2, public transport loses most of its competitiveness when the travel time ratio exceeds about 1.5 (Krygsman (2004; Hitge and Vanderschuren, 2015). In Cape Town, Hitge and Vanderschuren (2015) have found that there is a travel time ratio of 1.81; and even though this records below the national average, it is still above the 1.5 travel time ratio.

Table 4.5: The ratio i.e., travel cost by multimodal divided by travel cost by unimodal trip for the three main modes of public transport:

Train ratio	Multimodal travel cost/ Unimodal travel cost 567/247 = 1: 2.3
Bus ratio	Multimodal travel cost/ Unimodal travel cost 747/440 = 1: 1.7
Minibus taxi ratio	Multimodal travel cost/ Unimodal travel cost 806/493 = 1:1.6

NB: Based on NHTS 2013 data. (Source: Author analysis based on 2013 NHTS: Statistics South Africa, 2014)

Table 4.6: The ratio i.e., travel time by multimodal divided by travel time by unimodal trip for the three main modes of public transport is shown below:

Train ratio	Multimodal travel time/ Unimodal trips 99/81 = 1: 1.2
Bus ratio	Multimodal travel time/ Unimodal trips 98/75 = 1: 1.3
Minibus taxi ratio	Multimodal travel time/ Unimodal trips 73/51 = 1:1.4

NB: Based on NHTS 2013 data. (Source: Author analysis based on 2013 NHTS: Statistics South Africa, 2014)

4.5.1. Interconnectivity ratio (metros)

As defined by Krygsman, Dijst and Arentze, (2004) interconnectivity ratio refers to the proportion of access and egress time to total trip travel time. They state that the ratio always falls between 0 and 1 (Krygsman, Dijst and Arentze, 2004). For calculating interconnectivity ratio the study did not include wait and transfer times because they are not considered to be part of access/egress because there is no physical exertion (Krygsman, Dijst and Arentze, 2004; Goel and Tiwari, 2016) but used reported access, egress, and line haul time.

$$Interconnectivity\ Ratio = \frac{Access\ time + Egress\ time}{Total\ travel\ time}$$

Table 4.7: Interconnectivity Ratio for main modes of transport

Interconnectivity Ratio for car	$\boldsymbol{Interconnectivity\ Ratio\ for\ car = \frac{3+1}{39} = 0.10}$
Interconnectivity Ratio for MB Taxi	$Interconnectivity\ Ratio\ for\ MB\ Taxi = \frac{9+9}{33} = 0.55$
Interconnectivity Ratio for Bus	$Interconnectivity\ Ratio\ for\ Bus = \frac{10+11}{50} = 0.42$
Interconnectivity Ratio for Train	$Interconnectivity\ Ratio\ for\ Train = \frac{16+15}{48} = 0.65$

NB: Based on NHTS 2013 data.

Table 4.8. Access, egress and line haul time and interconnectivity ratio for main mode of transport (multimodal trips) in metropolitan areas based on NHTS 2013

Mode of transport	**Access travel time (minutes)**	**Egress travel time (minutes)**	**Line haul travel time (minutes)**	**Interconnectivity ratio**
Walk-Car-Walk	3 (car)	1	39	0.10
Walk-MB Taxi-Walk	9 (MB taxi)	9	33	0.55
Walk-Bus-Walk	10 (bus)	11	50	0.42
Walk-Train-Walk	16 (train)	15	48	0.65

NB: Based on NHTS 2013 data.

In the calculation (Table 4.8) the research used walking as the access – egress mode because the NHTS records walking trips and less if none of other access and egress modes (e.g., bicycle). Considering the two chains for all modes or multimodal trips, walk–train–walk; walk–bus–walk; walk–taxi–walk; and walk–car–walk the study found the average interconnectivity ratio across the four modes to be 0.43 with train being the one with the highest interconnectivity ratio of 0.65 more than the total average, followed by the minibus taxis at 0.55.

Among the public transport modes, bus recorded the lowest ratio since it has the long line haul travel time. The lowest interconnectivity ratio was recorded for cars at 0.10. This goes to show that public transport is not competitive with private cars. It also implies the significance of access and egress time in the total travel time of different modes of transport. This part of the public transport journey has been neglected and allows a room for improvement in the access and egress elements or journeys. Transport policy decisions should talk to these issues.

5. EXPENDITURE PROFILE OF COMMUTERS

5.1. Expenditure profile of transport users on transport activities

5.1.1. Introduction

This chapter evaluates the cost of transport in relation to how much commuters spend monthly on public transport in metropolitan areas. The research considered the main modes of public transport (trains, buses, and minibus taxis) and private vehicle users, and determines how these users spend on transport per month. In this section, the research seeks to assess how accessible and affordable public transport is to commuters in South Africa's metropolitan areas. Ismail, Mkhwanazi and Silberman, (2016) found that about 62.3% of households in South Africa fall within the poorest income bracket (below R86,000 per annum). Most of the households (64%) are predominantly dependent on salaries and wages as their main source of income and 24% rely on the government for income. Of the total household expenditure 60% of household spending is on essential items and 40% on non-essential items. Both the low-income group (R0 – R86,000 per annum) and middle-income group (R86,001-R1,481,000 per annum) have transport expenditure as the second dominant item in their basket. It comprises between 11%-12% and 15%-19% of this groups budget respectively (Ismail, Mkhwanazi and Silberman, 2016).

On the other hand, the upper income group (R1,481,001 – R2,360,001+ per annum) spends much of their income (30.1%) on transport. However, this includes the purchases of new vehicles since this group is heavily dependent on private cars. This could also highlight access to more expensive modes of transport such as airlines, because of affordability. Ismail, Mkhwanazi and Silberman (2016) also found that transport expenditure increases depending on how one climbs up the income brackets. The NHTS (Statistics South Africa, 2013) found that most black Africans are at the receiving end of this costly transport service since they are located far away from central business district (CBD) or economic activities. Long commute times and costs of travel inhibit this class of workers from fully participating in the economic, social, and family maintenance activities as they spend a larger fraction of their incomes on time getting to and from work.

According to the Gauteng Province Department of Roads and Transport (DRT) (2016), the proportion of household income spent on public transport increased significantly. This is inconsistent with both the national and provincial policies of reducing household public transport cost to less than 10% of disposable household income. The research found out that on average, workers in South Africa spend close to R550 on transport. Travel costs were the highest for those who drove cars/bakkies/trucks (R1158 for 2013) and (R2116 for 2020) as their mode of travel, and for car/bakkie/truck as a passenger about R638. In the public transport modes those using minibus taxi were paying more (R552 in 2013 and R1115 in 2020) than those using buses (R508 in 2013 and R857 in 2020). Using trains was the least expensive mode of travel compared to all the other modes, with a mean value of R411 in 2013 and R731 in 2020. This section investigates how much South African households/ workers spend on transport getting to work and whether the provision of subsidy has got an effect on the disposable income of the workers using public transport. Table 5.1 below provides some of the descriptive statistics of the cost of main mode of transport in South Africa.

Table 5.1: Descriptive Statistics: Cost for the main mode of transport

		Total cost to place of employment			
		Year	Mean	Standard Deviation	Percentile 95
Main mode to place of employment	**Train**	**2013**	411	524	439
		2020	731	2672	1200
	Bus	**2013**	508	416	525
		2020	857	1664	1680
	Taxi	**2013**	552	476	562
		2020	1115	4027	2016
	Car driver	**2013**	1157	1225	1313
		2020	2116	3327	5600

(Source: Author analysis based on 2013 and 2020 NHTS: Statistics South Africa, 2014; 2020)

The cost of transport (Table 5.2) was significantly different between the three geographical areas of transport ($F(2, 13373) = 12.241$, $p < 0.001$), with the metro (R611) and rural (R677) areas showing significantly higher mean cost of travel (Table 5.2).

Table 5.2: Total cost of transport by geographical location

Geographical location/ type; LS Means.

Current effect: F (2, 13373) =12.241, p=.00000 Effective hypothesis decomposition

Type	Mean	Std.Err.	-95.00%	+95.00%	N
Metro	610.9269	6.97242	597.2600	624.5938	6836
Urban	596.8625	12.48724	572.3857	621.3392	3708
Rural	676.6400	12.87396	651.4052	701.8748	2835

NB: Based on NHTS 2013 data. (Source: Author analysis based on 2013 NHTS: Statistics South Africa, 2014)

The cost in the metros is also related to the use of private vehicles versus public transport. This makes it clear that time and monetary costs of commuting are extremely high. Kerr (2015), argues that the government's public transport subsidies are mostly benefiting those in the middle of the income distribution rather than low-income workers (Kerr, 2015); this is also evident from this research where rural commuters spend significantly more on transport. Commuters that drive, use taxis or multiple modes of transport (usually a combination of bus, train, and taxi) to get to work spend an average of more than 15% of their gross income getting to work (Kerr, 2015; Statistics South Africa, 2013). Furthermore, Kerr (2015) also argues that time and monetary costs of transport can be thought of as a kind of 'tax' that commuters pay on the incomes that they earn from work. This 'tax' varies between modes of transport (and levels of income). High costs of commuting (in terms of time and money) can thus lower the returns to work and may decrease the number of people that are willing to work or look for work.

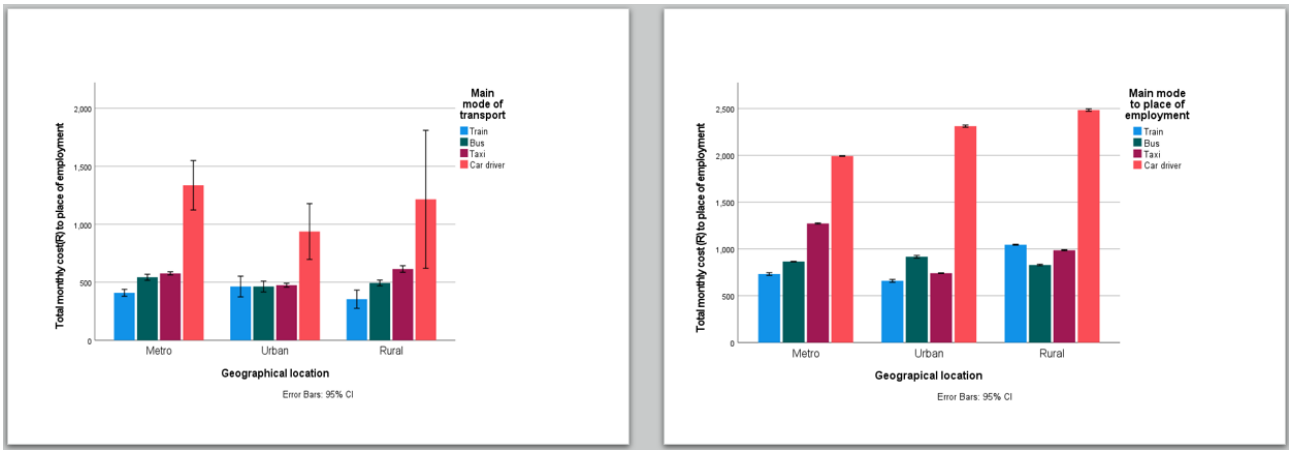


Figure 5.1: Total monthly cost to place of employment by main mode for geographical locations in 2013 and 2020. (Source: Author analysis based on 2013 NHTS: Statistics South Africa, 2014)

Figure 5.2 below shows transport cost by race for main mode of transport. The results show that transport cost differ by race. This may be an indication of differences in household incomes. South Africa consists of a combination of those with higher income and the low income residing at the far outskirts and travel further longer. While the cost of travel for those in the higher income may be higher, the share of costs to salary may not be high as compared to the low-income group.

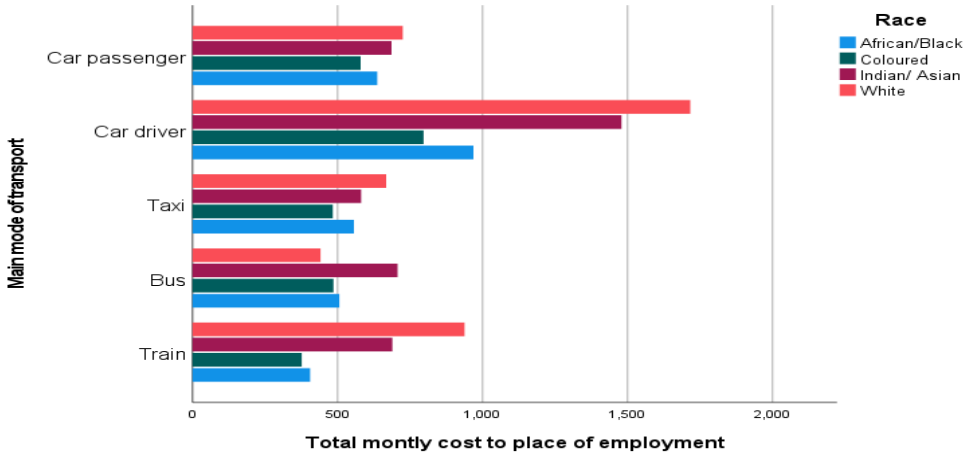


Figure 5.2: Total monthly cost to place of employment for main mode by race (Source: Author analysis based on 2013 NHTS: Statistics South Africa, 2014)

5.1.2. Comparison between total cost and total time to place of employment by geographical location

The analysis that follows below compares travel time with cost of travel for the working population in the geographical locations irrespective of the mode of transport used. The results show that those in metropolitan and rural areas spend more time and money traveling to place of work, than those in urban areas. Metropolitan commuters spend 18 minutes and about R65 more than their counterparts in urban areas. As stated in the discussion under section 4.3.4 and Figure 4.13, the long travel times in the metropolitan is because of aspects such as congestion and transfers. There are some factors that influence travel time and cost. This includes the size of an area, density, and availability of transport systems. Urban areas at most have got an optimal area size than metros. However, when cities get too big like in the metros, travel time is likely to increase unlike in small towns. Rural areas are mostly underdeveloped and have got few options in terms of mobility. Therefore, it cannot be disputed that commuting has got both the cost element of money and time.

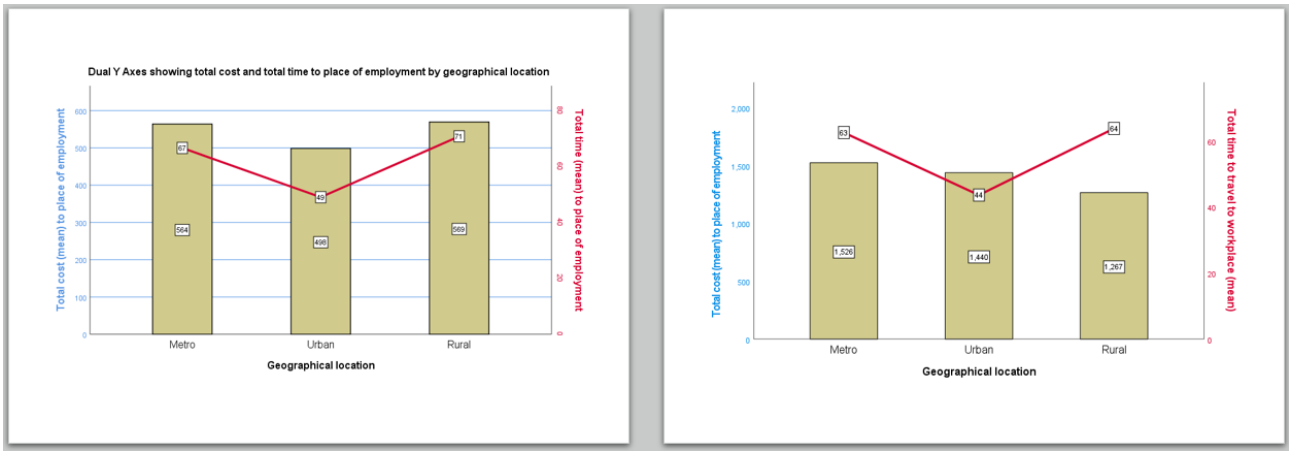


Figure 5.3: Dual axes showing comparison between travel time and cost of travel for the working population in the geographical locations in 2013 and 2020. (Source: Author analysis based on 2013 and 2020 NHTS: Statistics South Africa, 2014; 2020)

Table 5.3 below presents the percentage of transport on each mode by geographical location. Public transport users spend between 11% to 26% of their salary on transport as presented at Table 5.3. Train users in the metro spend about 17% of salary on transport, 15% for bus and the highest was taxi at 26%. The results show that the cost of public transport in metros is double the national benchmark and inconsistent with the South African White Paper on Transport Policy (1996) of limiting and

reducing transport expenditure to less than 10% of disposable household income to measure the affordability of public transport, (Department of Transport, 1996). Private car drivers, in the metro who earn more than the rest of the groups spend about 12% of their salary on transport.

Table 5.3: Percentage of transport cost for main mode in geographical location.

Main mode to a place of employment	**Geographical location**	**Total cost to the workplace (mean)**	**Total time to travel to the workplace (mean)**	**Total Salary/Pay from the main job (mean)**	**Percentage of transport cost on salary (%)**
Train	Metro	733	107	4328	0,17
	Urban	660	118	5767	0,11
	Rural	1046	94	4171	0,25
Bus	Metro	866	88	5600	0,15
	Urban	917	62	7876	0,12
	Rural	830	90	4825	0,17
Taxi	Metro	1273	69	4951	0,26
	Urban	742	47	4960	0,15
	Rural	987	61	4805	0,21
Car driver	Metro	1994	49	16313	0,12
	Urban	2313	35	14599	0,16
	Rural	2485	45	10239	0,24
Car passenger	Metro	1119	52	15045	0,07
	Urban	961	42	6673	0,14
	Rural	761	54	4858	0,16
Walking all the way	Metro	.	33	3463	.
	Urban	.	31	3511	.

	Rural	.	30	2638	.
Other	Metro	612	39	5029	0,12
	Urban	667	38	6109	0,11
	Rural	1331	44	3007	0,44

NB: Based on NHTS 2020 data.

The results table 5.3 suggest that commuters who use the three main modes of public transport (bus, train, and minibus taxi) spend a significantly higher percentage of their income on transport than private vehicle users especially in metros followed by rural areas. This is mostly the lower-income quintile households who rely on public transport. What is more concerning is that that lower-income workers find it difficult to 'transfer' the cost of commuting to their employer and to allocate a significant percentage of their salaries to transport compared with higher-earning individuals as argued by Van der Merwe and Krygsman (2020) and Kerr (2015). Though metropolitan areas are seen to have infrastructure within their proximity and stand to benefit more of developmental as compared to rural areas, they have recorded the highest transport expenditure.

5.1.3. Comparison between total cost and total time to place of employment by main mode of transport

The following analysis compares travel time with cost of travel for the working population for main mode of transport irrespective of the geographical location. The results show that those using trains spend more time travelling than any other system. Taxi users spend less time among the users of public transport but more compared to private car drivers. However, it is cheaper to travel by trains as compared to other public transport modes. According to Statistics South Africa (2014; 2020), travel time is the main factor that influences commuters' choice for a particular mode of transport, followed by cost (of travel). This means commuters make trade-offs between travel time and cost. But for the poor, this could mean relying on trains even when the travel time is long for trains. Most of these train commuters are captive users, they do not have options other than to rely on the cheapest mode of transport. Though train users spend less money travelling, they still experience long travel time to reach to their place of work. Those using minibus taxis spend slightly more money than bus and train users, but their huge savings is travel time. They spend on average 55 minutes, which is 35 minutes less than those using trains and 28 minutes less than those using buses. The minibus taxis are

reasonably cheap compared to buses considering that they are not receiving any operating subsidy from government as it is the case with buses and trains.

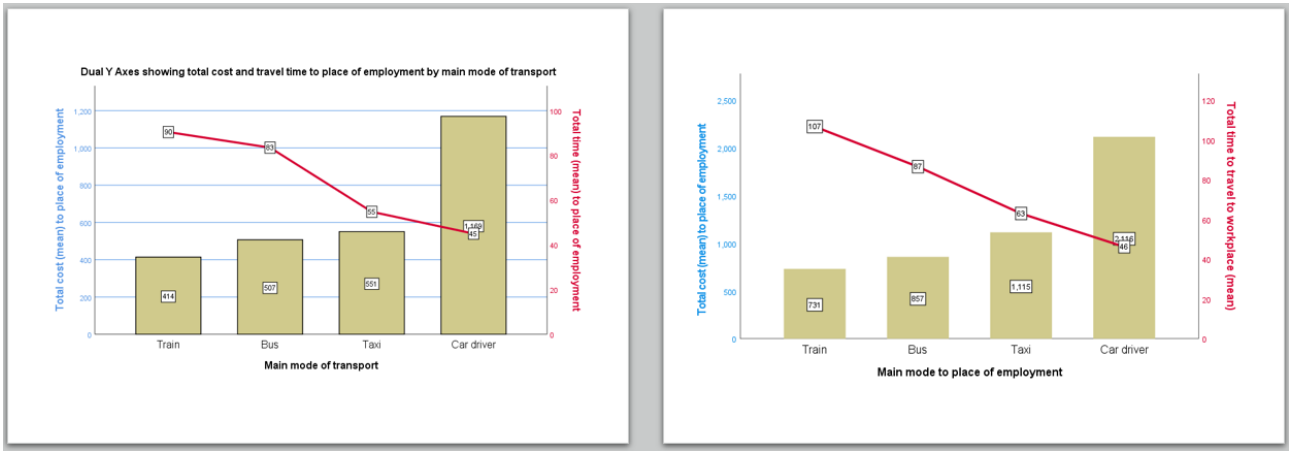


Figure 5.4: Dual axes showing comparison between travel time and cost of travel by main mode of transport for the working population in 2013 and 2020. (Source: Author analysis based on 2013 and 2020 NHTS: Statistics South Africa, 2014; 2020)

Figure 5.5 gives an indication of the relationship between transport costs and total salary (monthly income). This gives an idea of how much people spend per month on transport (commute) in relation to their monthly income.

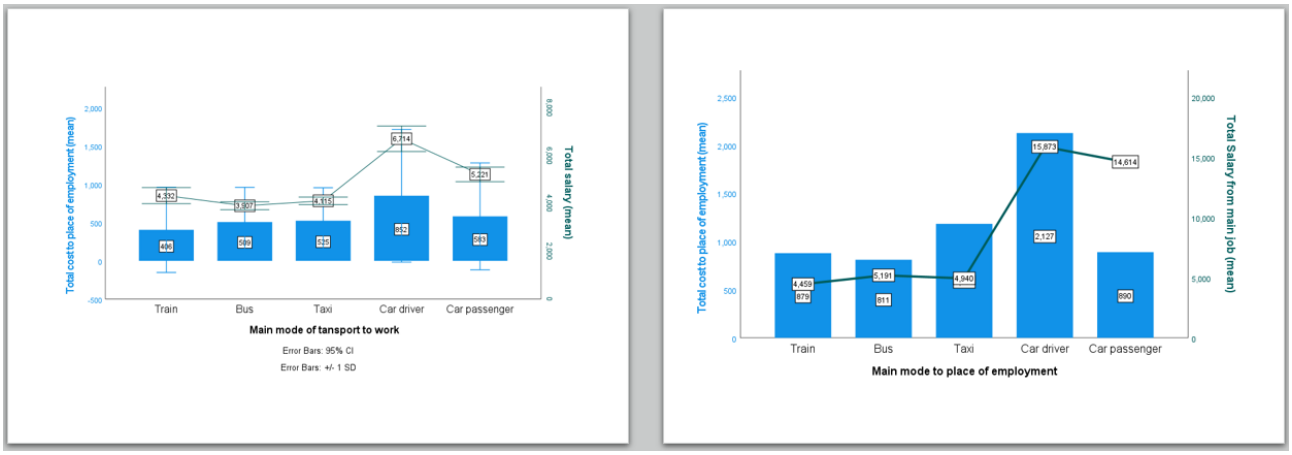


Figure 5.5: Dual Y Axes with Categorical X Axis of total cost to place of employment, and total monthly salary by main mode of transport (mean) for 2013 and 2020

The results in Figure 5.5 show that most of the low-income group with an average of R4332 income use mostly public transport for commuting. The longer travel time (for the commute trip) have got a negative impact on the daily travel time / number of activities of workers and cuts into other activity time. The longer commuters travel (the longer the daily commute), the less time they have for other out of home activities (non-work) and in-home activities. It is also evidence that not all people have the same 24 hours in terms of the daily activities they can engage in.

5.2. **Multimodal and multistage trips in metro areas (travel time and cost)**

Statistics South Africa (2014) found that people who make transfers are mainly those using public transport. In South Africa, about 18% of the workers make transfers on their way to work. Multimodal and multistage trips are typically longer and more expensive. Workers across all modes spend more time and money on transport if they make transfers, which accounts for R250 more than those who do not make changes (Figure 5.6b).

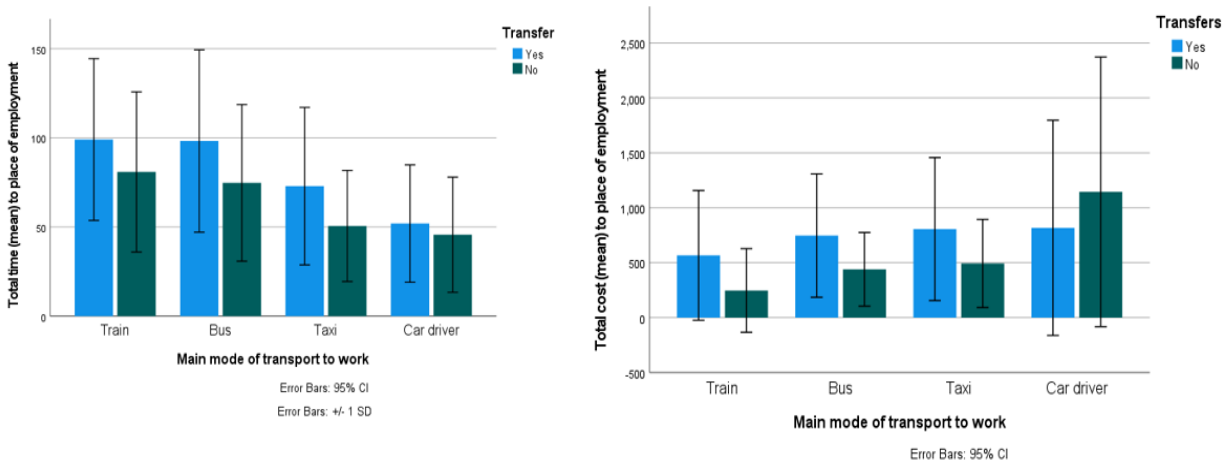


Figure 5.6a-b: Travel time and cost of travel for workers making transfers on their way to work by main mode (Source: Author analysis based on 2013 NHTS: Statistics South Africa, 2014)

Although there was a small number of those making transfers, there is an opportunity to bring about significant improvement or savings in total travel time and cost. One of the key focus areas of the public transport investment strategy should be on the reduction of travel time in public transport, both

relative to that of the private car and in real terms moving closer to the global average for metropolitan areas. The results hint to this, as there is strong evidence of increased cost associated with travel time (Figure 5.7). A moderate, positive association between total time and cost to place of employment (Pearson r =0.195 p <0.001), which indicates that as travel time increases, so does cost.

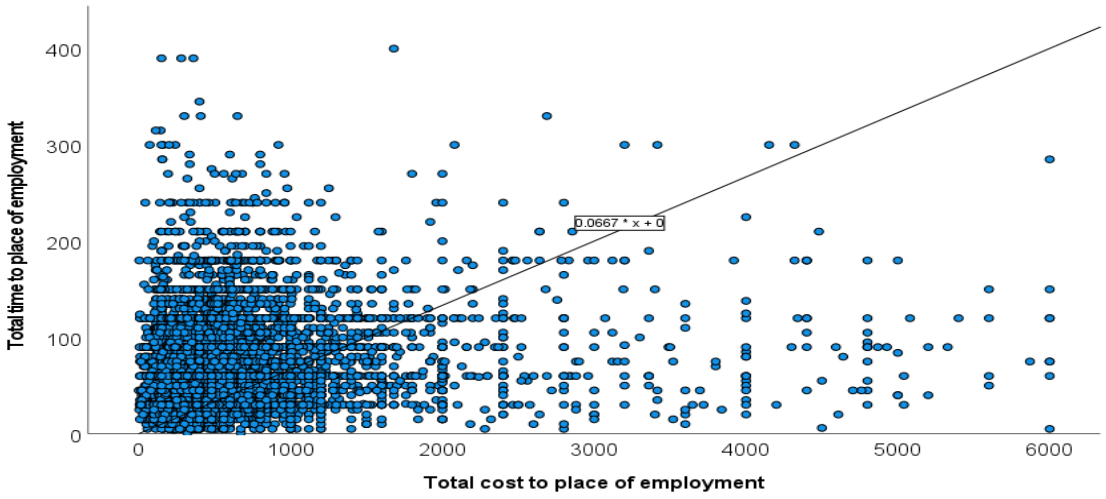


Figure 5.7: Scatterplot showing the relationship between total travel time and costs to place of employment.

Hitge and Vanderschuren (2015) has argued that the in-vehicle travel time compares very poorly with international benchmarks and is certainly also an area that holds significant potential for improvement. Travel time and cost could be reduced if improvements are made where transfers occur.

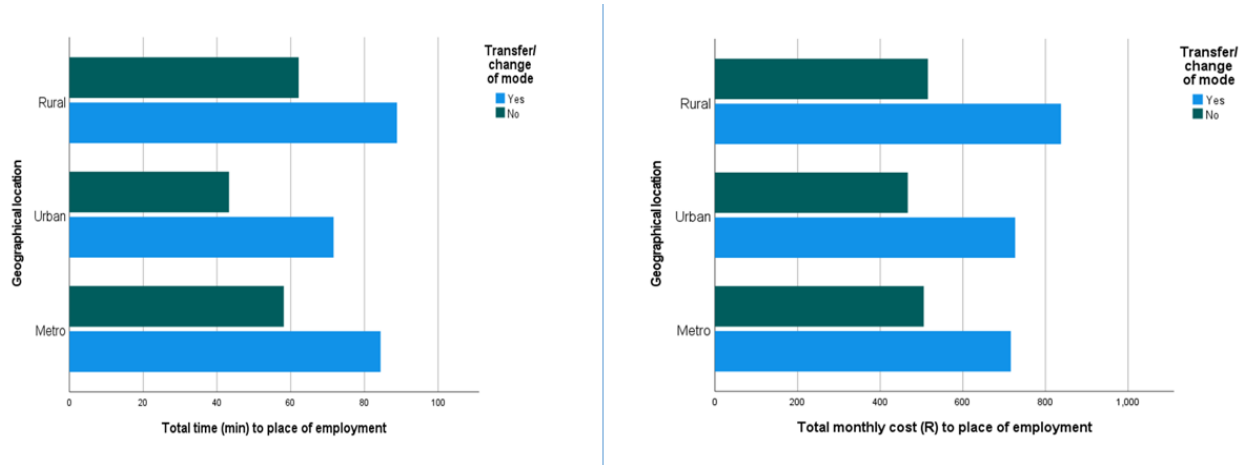


Figure 5.8a-b: The cost of travel and travel time for workers making transfers on their way to work by geographical location. (Source: Author analysis based on 2013 NHTS: Statistics South Africa, 2014)

As stated in section 1.1 of the introduction, there is a substantial fraction of South African workers who reside far from their workplaces. The cost of travel varies and depends on whether users make transfers or not. On average, the cost of those making transfers in the metro regions is about R716 monthly as compared to R506 for those who do not make transfers, a difference of R210 (Figure 5.8b). Comparing the travel time (Figure 5.8a), shows that trips involving transfers, commuters spend 26 minutes more than those without transfers. Therefore, it can be shown here that transfers contribute to long travel times and high costs of travel.

5.3. **Accessibility indices for travel cost to place of work in metros**

As has been seen in discussions about travel time accessibility indices under section 4.4, this section further explores travel cost accessibility indices for different main modes of transport and compares these indices across key sociodemographic variables. The travel cost AI reflect travel cost related to average travel cost value. These indices were calculated based on a methodology utilised by (Schoon, McDonald and Lee, 1999; Statistics South Africa, 2018) as discussed in section 3.3 above .

[Note: The research used only average travel time in metros to calculate Coefficient of Variations (CV) and AI]. As mentioned in section 4.4. above, the 2020 NHTS was omitted because there were no significant differences in travel cost for the modes of transport to 2013 data.

CV was calculated using the following formula:

$$CV = \frac{\text{Standard Error}}{\text{average travel cost (mean)}}\ x\ 100$$

Table 5.4: Distribution of workers by main mode of transport and average travel cost to work, in metros

Main mode of transport		No. of respondents	Per cent (%)	Average travel cost	CV (%)	Std error of mean
Public transport	Train	1286	9,6	409	4	15
	Bus	987	7,4	543	2	13
	Taxi	4551	34,1	577	1	7
Private transport	Car/ truck driver	5484	41,1	1336	8	108
	Car/ truck passenger	1027	7,7	723	5	33
All modes		13335	100	718	5	35,2

NB: Based on NHTS 2013 data.

Table 5.4 above presents the average travel costs between home and place of work with their standard errors and coefficients of variation. The estimates are highly accurate, as the coefficient of variations are small. There is a visible difference between private and public transport in terms of average travel costs. Of all the modes of travel, trains were the least expensive for workers to use with a mean of R409 a month, followed by buses (R543) and taxis (R577). On the other side of the scale, travel costs were the highest for car/truck drivers (R1 336) and car/truck passengers (R723).

$$Al\ mode\ (taxi) = \frac{\text{average travel cost by } mode \text{ (taxi)}}{\text{average travel cost across all modes}}$$

Figure 5.9 below shows travel cost AI scores for different modes of transport. Parity (equality) is reached at 1,0 and any value below 1 suggests that workers experience low travel cost when commuting to work and a value above 1 suggests that workers experience high travel cost (difficult access).

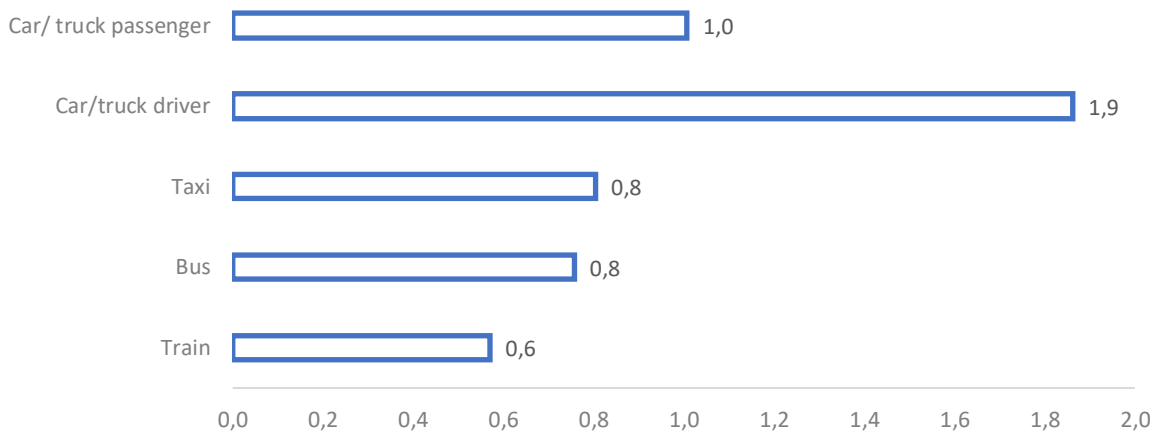


Figure 5.9: Travel cost accessibility indices for workers by public transport mode in metros. NB: Based on NHTS 2013 data.

A breakdown of the results shows that the highest travel cost AI score was estimated for car/truck drivers (1,9), followed by car/truck passengers (1,0), while the lowest travel cost AI scores were found for trains (0,6) and buses (0,8). These travel cost AI values suggest that private car drivers were more likely to experience high travel cost when commuting to work. However, the indices do not present the income scale of these users and thus must be interpreted with caution.

6. CONCLUSION AND RECOMMENDATIONS

6.1. Introduction

Chapter 2 of this study introduced the different modes of public transport in South Africa, namely minibus-taxi, bus and train and highlighted that South Africa has a mass public transport crisis resulting from a combination of legacy spatial planning, large geographical distances between residential and commercial nodes, and slow policy execution. Households require access to reliable, sustainable, and affordable public transport that provides them with an opportunity to access essential social and other public services i.e., health, education, and employment. Public transport investment is crucial to provide better and improved transport accessibility to the working population, mainly the marginalised lower-income workers. The investments on public transport should seek to reduce the cost of travel and long commuting time spatial layout of cities. Both the absolute and relative travel time of public transport (trains, buses, and minibus taxis), when compared to the private car, is high, and must be reduced drastically. These challenges call for an integrated public transport and land-use planning to achieve change in the spatial distribution and accessibility of public transport.

The emphasis, on cities, needs to be on integrated land use and transport planning, forcing more compact cities to drive down transport cost. Coordination between residential development and transport planning must be emphasised and implemented. The overall aim of the research as indicated in chapter 1, was to evaluate the multimodal and multistage character of public transport on daily travel time and household expenditure. This has illustrated the access and overall cost penalty imposed on users of public transport, for South Africa's metropolitan areas. The research looked at time and cost penalty that people pay for using public transport and the impact of the poor accessibility offered by the multimodal, multistage stage character of public transport.

The research used the work-related travel patterns, a subset of both the 2013 and NHTS data conducted by the National Department of Transport and Statistics South Africa. The 2013 and 2020 NHTS provide a snapshot of the perceptions and travel experiences of South Africa. For these reasons, this research focused only on the working population in both formal and informal sectors on the South African metropolitan areas. A variety of other sources and literature in the said field were also analysed to build on the content of the research. Household travel surveys by their very nature provide planners and policy makers with a sense of the immediate and future travel needs of residents across the spectrum of issues surveyed.

6.2. **Summary of literature**

It is vital to note that, the spatial mismatch between place of residence and centres of employment, and social and economic opportunities prevents the poor from breaking the cycle of poverty and restricts access to job and networking potential opportunities. Both the 2013 and 2020 NHTS (Statistics South Africa) have shown that the spatial planning of the past remains cemented into the planning of South African cities. More commuters or households still spend more time and money travelling, this impacts on their livelihood and disposable income. There is evidence that reducing the absolute travel time would add social benefits, such as more time for other priorities like family, leisure, and further education. High transportation costs, fragmentation, and slow commuting speeds are preventing cities from acting as matchmakers and fostering economic growth.

Cities need to look at a few strategies; first is the need to provide inexpensive and integrated public transport system solutions; Second, to recognise and include the need to encourage NMT as first and last mile mode. Third, to bring cost-effective transport within the reach of all citizens at acceptable levels of subsidy. For cities to act as integrated labour market and match job seekers and employers, they need to make employment accessible and create high density settings. Transport accessibility, travel cost and commuting time are very important to commuters. Public transport must be competitive with private cars in terms of travel time and to improve the competitiveness of the public transport system. Competitiveness of public transport can be brought about by the provision of dedicated or semi-dedicated right-of-way services for public transport vehicles, as well as reducing access and egress walking distance by increasing coverage of the feeder system.

Public transport policy and governance is important to address the persistence of fragmentation between national, provincial and city government. Where there is fragmentation of responsibility, challenges emerge because it becomes difficult to align and integrate services and create synergies between different responsibilities. For example, because of the way bus contracts are configured often, the vehicles used in provincially subsidised contracts cannot be used on municipal bus routes even when it would be most efficient to do so, and vice versa. The delays in the devolution of transport functions to the lower sphere of government as pointed out by the National Land Transport Act (NLTA) are impeding the alignment and integration of public transport systems. Municipalities seem not to have capacity for this role. For example, transport and land use planning are not well coordinated and so far, little progress has been made with such devolution. This goes to show that

there is an undoubted need for institutional arrangements that both allow metropolitan level control and integration with land use planning.

Given that commuters use more than one mode of transport in making their work journey, alignment and integration are important for complimentary of modes. In the absence of public transport policy changes, and a single clear locus of responsibility for ensuring modally integrated city-wide access, investment in each of the different modes becomes driven, to a large degree, by the financial power and status of the institution responsible for each mode rather than by more rational considerations aimed at optimising the public transport system for users, (Treasury, 2014). As a result, the poor, who at most rely on public transport, are likely to be restricted in terms of participation in the economic activities because of the location of job opportunities. This is different in a case for those who have access to private vehicles which offer a high level of flexibility and access to better employment alternatives. Given the goal of the South African government to subsidise public transport for marginalised users, it should be an overarching public transport subsidy policy that incorporates all modes of public transport (including minibus taxis) to subsidise users and not the operators.

However, subsidising the minibus taxis may not lead to increase in productivity or lower fares for passengers, but may simply increase operator profits if these models are more than just being mere scheme that do not benefiting commuters. Most transport policies made suggestions that an effective publicly owned passenger transport system be developed, integrating road and rail transport including regulating all privately controlled passenger transport. This is because it is difficult to manage, align or integrate a public transport system that is fragmented. The challenges remain with the legacies of land use patterns. Inefficient land use planning that perpetuates low densities and urban sprawl must be eradicated. There is a need to develop a coordinated, safe, affordable, and efficient passenger transport service as a social service. The institutional reform is of the utmost importance in ensuring the effective provision of public transport with necessary legislation in place to enable, empower and strengthen the proposed structure. Public transport planning guidelines must be developed, including the provision and integration of non-motorised transport facilities around BRT stations, to allow universal access of all classes of passengers, people with disabilities, and the elderly.

6.3. **Summary of the findings**

The study flagged the major metropolitan areas (City of Tshwane, Johannesburg, Ekurhuleni, Cape Town, eThekwini, etc.) as having a significant number of workers who needed more time (more than 55 minutes in 2013 and 57 minutes in 2020) to get to their workplace. Not much has changed to address the issues around travel time and cost from the 2013 survey, but instead travel time has increased in terms of the 2020 NHTS. This could be attributed to factors such as fragmented public transport, travel distances, transfers, and traffic delays when workers travel to work. These areas are centres of employment. It is important to note that workers who used private transport were from households with the highest average per capita monthly income across all travel time intervals as discussed in Statistics South Africa report (Statistics South Africa, 2018; 2020). In contrast, those who walked to work were from households with the lowest average per capita monthly household income.

Based on a quantitative and qualitative analysis of the NHTS data, it can be concluded that multimodal or multistage trips lead to long travel times and high cost of commuting. This can be attributed to the fact that this is not well integrated in the entire public transport trip as shown in the out-of-vehicle time (OVT). The results also show that metropolitan residents spend more time travelling than urban residents, despite the investment made to improve mobility of people in cities. Among urban transport modes, public transport has three distinguishing features that make the assessment of travel impedance difficult. First, as discussed in the literature, public transport journeys require access and egress legs with another mode, typically walking. The results have shown that there is a significant amount of time people spend outside the line-haul. Secondly, section 4.3 (Figure 4.11) revealed that public transport is a scheduled service that offers connections between stops only at specific intervals. This adds up to the waiting time. Lastly, section 4.3 further shows that public transport provides services through a network on a spatial coverage. These three structuring elements increase OVT for public transport trips which is weighed more onerously than the line-haul time (or the in-vehicle-time or IVT).

In 2013, the OVT was high (at 27 minutes) in rural areas more than the national average (23 minutes), followed by metros (25 minutes) with urban areas recording the lowest OVT (18 minutes). There were no major changes in 2020 survey; the OVT was 26 minutes for rural, 20 minutes in urban and

24 for metros. However, the study focused on the metro areas. Train users spend more time on OVT (about 42 minutes in 2013 and 51 minutes in 2020) than any of the other modes; while buses recorded the second longest total travel time of 80 minutes but somewhat unexpected, the longest IVT (50 minutes in 2013 and 62 minutes in 2020), which could be attributed to factors as congestion. Commuters that use train, travel much longer to work, nearly twice as long as private car drivers. This means that they (train users) must take time from other activities such as their sleep time, in-home activities (family time) for their travel needs. This implies that most of the poor working-class population must trade-off some of their time for travel, which can vary based on mode of transport and can increase significantly based on the number of transfers. In the long run, it is likely to contribute negatively to the effectiveness or productivity of these people at work, as well as on their family responsibilities. Longer travel time (for the commute trip) has got a negative impact on the daily activity time of workers, recreation, among others. The longer one travels, the longer the daily commute, and the less time one has for other out-of-home activities.

It is apparent that the time and monetary costs of commuting in South Africa are high. This means that commuters face large effective taxes on their income for commuting, i.e., reductions in their effective hourly wages. This is likely to contribute to lower productivity, hindrance to access to opportunities and the long travel time places enormous pressure on family life. The key emphasis of capital spending by government should be on the kind of urban forms, such as the corridor formations which is not part of this research, and transport technologies.

From the discussions and findings, it has been shown in section 5.1.2, Table 5.3 that households from the lowest income quintile spent more on public transport. These are people who reside mostly at the periphery of economic centres, in rural areas or living in poor households. The findings prove that low-income households spend more time and money on travelling than high-income households, which likely contributes further to the income inequality in South Africa. This may also likely contribute to the high unemployment rates of lower-income groups in the country, by limiting their access to opportunities. The results indicate that driving to work is done mostly by the higher income groups, while a minibus taxi is the most common way in which those in the second and third quintiles commute to work. A majority of those in the lowest income quintile either walk to work or work from home (informal employment). However, the high transport cost will become significantly more challenging for individuals who live much further from their place of work. Few of the commuters in

the lowest quintile use buses or trains which are likely to be subsidised by the state. This means that government's transport subsidies seem to benefit those in the lower middle of the income distribution. This study has pointed out that different modes receive differing amounts of subsidy, disproportionate to their contribution to the number of people making use of them.

As shown in section 4.1, taxis transport a large fraction of commuters across all income groups, rather than just the poor, although they certainly do transport a substantial fraction of low-income workers. The results show clearly that public transport is not competitive with private cars on a variety of fronts. Firstly, the distance of public transport trips is currently longer than that of private cars because of the spatial configuration. Secondly, the in-vehicle speed of the car is higher than the speed of public transport, and the private car trip is not subjected to transfer time. However, the minibus taxi industry has shown to have competitive line haul travel time with private cars (33 and 39 respectively). The long travel distances to public transport users add to the total trip length and reduces users transport accessibility. This implies that there is a need to move people closer to where opportunities are and increase investment on access and egress trips to reduce their travel time and cost.

Furthermore, it is important to note that, the length of transfers and OVT pose an area for significant improvement in total travel time. The White Paper on Transport Policy (1996) advocates for public transport competitiveness. However, the reality remains that the working population still travel long distances to their workplaces and spend much of their disposable income on transport. One of the key focus areas of the public transport investment strategy and policy is on the reduction of travel time for public transport, both relative to that of private cars. In this research, access, egress, waiting and IVT was captured and discussed as part of the public transport travel time. Issues such as pre-journey waiting times, journey durations, and transfers, have been shown to cause discomfort to public transport users and lead to travel impendence. Travel time also becomes a benefit when transportation improvements improve mobility or expand accessibility.

In terms of the relationship between transport costs and total salary (monthly income) the results show that most of the low-income earners use mostly public transport for commuting, earning an average of R4332. This implies that transport is the least expensive in urban areas, meaning that the metros

are not as efficient as what they should be. This is indicative of the fact that there is a limit to the efficiency of metros as negative externalities of urbanisations are starting to kick in.

The integrated urban public transport networks and provision of well-located dedicated roadways and other prioritisation measures for public transport can offer a highly effective mechanism for reducing operational costs and enhancing travel times and passenger convenience. The fact that minibus taxis transport such a high number of passengers means that this sector needs to be given intense and focussed attention since it is the dominant feature of the public transport sector. While the formalisation and more intensive regulation of the taxi industry in certain contexts may be appropriate, such initiatives must avoid adding significant costs without concomitant increases in productivity.

Transfer time also contributes to the total travel time; meaning that it is another important element that needs to be reduced in a multi-modal system by appropriate design of transfer facilities. At facilities where large volumes of passengers' transfer, the vertical separation of modes should always be considered. This goes to show that public transport accessibility is key to providing economic opportunities to society. Currently, road infrastructure does not provide for a multimodal public transport system. Government transport infrastructure initiatives such as the Gautrain, BRT, etc. are still not able to address many of these challenges, and in some instances appear to be failing to reduce the weight and demand on other modes of transport. The financial impact of transport for the already poor South Africans is huge, and they remain challenged in terms of their travel choices and the cost of travel. In this way, they are excluded and discouraged from participating in the economic activities because they stay far from economic centres. It is likely that this group will remain in the poverty bracket should the conditions remain the same, and the inability to take corrective action on this will certainly be to the detriment of government which will not be able to meet its own strategies of improving the lives of the poor. The improvements in public transport system in travel time are likely to attract choice passengers to public transport.

Travel time AI scores for public transport modes are high compared to private transport modes and this means that public transport users are most likely to have trouble in accessing their workplace, especially train users who need more time compared to other users. The highest AI for travel cost

scores was for car/truck drivers (1,9), followed by car/truck passengers (1,0), while the lowest travel cost AI scores were found for trains (0,6). Buses and minibus taxi scored the same AI of 0.8 which put them higher than trains. The scores suggest that private car drivers are more likely to experience high travel cost when commuting to work. However, the indices do not present the income scale of these users and thus must be interpreted with caution.

It is evident that not much has changed from the 2013 to 2020 NHTS. This implies that the government has failed to meet its target of reducing travel time and cost of commuting especially for workers. For these reasons, this research proposes the following recommendations.

6.4. **Recommendations**

Based on the issues raised above, policymakers should support investment and policy that is equitable for low-income transit riders. Public transport modes require subsidies for them to be sustainable. The implicit penalties of transport costs and times could be reduced by transport subsidies. Subsidisation would bring not only more regulation, limitation, but also control. In this way. it would probably find favour among commuters but maybe less so among a cohort of operators/drivers, who have built the industry (minibus) through rapid responsiveness. The debate on public transport subsidy, especially on the minibus taxis should be about the model or approach such as the proposals that have been put across, i.e., including token or coupon system which should be benefiting commuters more than just being a mere scheme.

Government should focus on reorganising existing modes more effectively into a single, integrated transport system for each area, whether metro, urban or rural so that resources are allocated fairly. Until this is corrected, the majority of South Africans, whether residents of metros, urban areas or rural areas will continue to experience substandard public transport conditions. Since, metropolitan governments are also responsible for land use planning, it will make sense to consolidate transport at the metropolitan level and be beneficial to develop transport system at their levels to cater for their environment. Public transport services must be coordinated and financed by one organisation for it to function and to encourage complementarity not competition. Metropolitan planning authorities should be responsible for planning, coordination, and provision of all 'metropolitan' transport facilities within metro areas. Importantly, funding for public transport should come both from central government and from local rates and taxes.

To better understand the implications of these results, future studies could address the possibility of reviewing or amending policies to encourage land use planning that discourage urban sprawl and fragmented transport planning. Policies should encourage and incentivise cities or programs that involves allocating housing for lower-income households closer to work opportunities, and in areas that are more accessible by public transport and NMT. There is need to start with unresolved inclusivity plans and the vested interests that prevent the transformation of public transport. Therefore, living closer to work, encourage the densification of cities and towns, target subsidies for public transport better are policies that can improve public transport and reduce the cost and times of commuting. This is to say, on its own, public transport won't transform the spatial planning but can provide better mobility for accessibility. This comes at a price, those in the high echelons need to be engaged on the role of public transport. Policy makers and practitioners should have more direct experience on the issues they make policy on and regulate for the better.

This research focused on the impact of access and egress on the accessibility of public transport and to understand the impact of public transport is on (1) daily mode of transport used, (2) travel time elements and (3) household expenditure. Progress has been made in public transport and accessibility research, but many important research opportunities remain, to also look at better assessment of overall transport mobility needs. To cope with these issues, future research may collect more detailed information of travel patterns using other technology-based systems such as such as mobile phone data and global positioning system (GPS) patterns which will arguably provide more contemporary and potentially accurate information on travel patterns, and activities. In conclusion, further research is encouraged to combine measures of public transport and employment access with other measures of access to amenities.

REFERENCE LIST

Angel, S., Parent, J., Civco, D., and Blei, A. M. (2010) *Making Room for a Planet of Cities*, *The Heart of Teaching Economics*. doi:10.4337/9781849808057.00023.

Arndt, C., Davies, R. and Thurlow, J. (2018) "Urbanization, structural transformation and rural-urban linkages in South Africa," *International Food Policy Research Institute*, (April), pp. 1–43.

Automobile Association (AA) (2021) *Submission on Proposed Route for Gautrain Extensions Phase 1 and Related Issues*, *Submission on Proposed Route for Gautrain Extensions Phase 1, and Related Issues*. Johannesburg. Available at: https://aa.co.za/gautrain-expansion. (Accessed: 15 September 2021)

Best, J.W. and Kahn, J. V. (2006) *Research in Education.* 10th Editi. Boston, MA: Pearson Education Inc.

Bovy, P.H.L., Jansen, G.R.M., 1979. Travel times for disaggregate travel demand modelling: a discussion and a new travel time model. In: Jansen, G.R.M., et al. (Eds.), New Developments in Modelling Travel Demand and Urban Systems, Saxon House, England, pp. 129–158.

Bovy, P.H.L., Van der Waard, J., Baanders, A., 1991. Substitution of travel demand between car and public transport: a discussion of possibilities, PTRC ed, Proceedings of PTRC seminar, pp. 43–54.

Breeam (2021) *Tra01 Public transport accessibility*. Available at: https://www.breeam.com/BREEAMUK.htm. (Accessed: 08 May 2021)

Brooks, S. (1986) *Public Policy in Canada: An Introduction*. Toronto, McClelland & Stewart, 1989.

Brynard, D. J., Hanekom, S. and Brynard, P. A. (2014) *INTRODUCTION TO RESEARCH*. Third Edition. Van Schaik Publishers. South Africa

Buehler, R. and Pucher, J. (2012) "Walking and Cycling in Western Europe and the United States," *TR News*, pp. 34–42.

Buliung, R. N. and Kanaroglou, P. S. (2006) 'Urban form and household activity-travel behaviour', Growth and Change, 37(2), pp. 172–199. doi: 10.1111/j.1468-2257.2006.00314.x.

Capitec Bank, (2017) "A car to match your salary". Available from: https://www.capitecbank.co.za/bank-better-live-better. Accessed [25 March 2022]

Carruthers, R., Dick, M. and Saurkar, A. (2005) *Affordability of Public Transport in Developing Countries*, *Transport Papers*. Washington DC. doi:10.2307/2069794.

Cervero, Sandoval, O. and Landis, J. (2002) 'Transportation as a Stimulus to Welfare-to-Work: Private Versus Public Mobility', p. 28.

Cervero, R. (2013) *Bus Rapid Transit (BRT): An Efficient and Competitive Mode of Public Transport*, *IURD Working Paper 2013-01*. Available at: http://escholarship.org/uc/item/4sn2f5wc.pdf.

Cheng, J. and Bertolini, L. (2013) "Measuring urban job accessibility with distance decay, competition and diversity," *Journal of Transport Geography*, 30(May 2018), pp. 100–109. doi:10.1016/j.jtrangeo.2013.03.005.

Chidambara, M. (2014) "Greening the 'last' mile to transits: Place making for healthier and sustainable mobility." New Delhi: Department of Urban Planning, School of Planning and Architecture.

Chikagwa, E. W. (2014) 'A policy analysis of the Gautrain public private partnership in South Africa'. Available at: https://researchspace.ukzn.ac.za/2014.pdf (Accessed: 16 May 2021)

Clark, B., Chatterjee, K., Martin, A., and Davis, A (2019) "How commuting affects subjective wellbeing," *Transportation*, 47(6), pp. 2777–2805. doi:10.1007/s11116-019-09983-9.

Competition Commission South Africa (2021) 'Land based public passenger transport sector main report', (March), pp. 1–305.

Cox, W. (2012) "Developing Africa: Toward Customer Oriented Urban Transport Policy," (October 2012). Available at: http://www.demographia.com/pdf. (Accessed: 20 November 2019)

Delbosc, A. and Currie, G. (2011) 'Exploring the relative influences of transport disadvantage and social exclusion on well-being', Transport Policy, pp. 555–562. doi: 10.1016/j.tranpol.2011.01.011.

Department of Transport (1996) "White Paper on National Transport Policy," pp. 1–32.

Department of Transport (2008) "Draft National Non-Motorised Transport," pp. 1–53.

Department of Transport (2017) *Revised White Paper on National Transport Policy: Draft*. Pretoria.

Dziekan, K. and Kottenhoff, K. (2007) "Dynamic at-stop real-time information displays for public transport: effects on customers," *Transportation Research Part A: Policy and Practice*, 41(6), pp. 489–501. doi:10.1016/j.tra.2006.11.006.

Field, M.J. and Behrman, R.E. (2004) *Ethical Conduct of Clinical Research Involving Children*. Edited by M.J.F. and R.E. Behrman. Washington (DC): National Academies Press (US).

Fobosi, S.C. (2013) "Formalisation, In-formalisation and the Labour Process within the Minibus Taxi Industry in East London, South Africa." Rhodes University.

Fobosi, S.C. (2019) "Regulated Set against Unregulated Minibus Taxi Industry in Johannesburg, South Africa—A Contested Terrain: Precariousness in the Making," *World Journal of Social Science Research*, 6(3), p.p303. doi:10.22158/wjssr.v6n3p303.

Frieslaar, A. Jones, J., Van der Merwe, L., and Dlamini, B., (2015) 'Intersection and Signal Design for BRT: Challenges, Lessons Learned & the Road Ahead', (SATC), pp. 754–763.

Gauteng Province Department of Roads and Transport (2013) "25-Year Integrated Transport Master Plan (ITMP25)."

Gauteng Province Department of Roads and Transport (2016) "Gauteng Province Household Travel Survey," *Gauteng Province: Roads and Transport* [Preprint], (March 2016). Available at: https://cmbinary.gauteng.gov.za. (Accessed: 23 September 2020)

Gauteng Province Department of Roads and Transport (2020) *Gauteng Province Household Travel Survey Report 2019/20*. Johannesburg. Available at: https://www.csir.co.za/sites/default/GHTS.pdf

Gautrain Management Agency (2015) *Management Of A PPP Contract*. Available at: https://gma.gautrain.co.za/PPP%20Contract%20Management_S.pdf. (Accessed: 17 May 2020).

Gautrain Development Agency (2013) *Socio-economic Development Progress*. Available at: https://gma.gautrain.co.za/Style%20Library.pdf. (Accessed: 11 February 2019)

Givoni, M. and Rietveld, P. (2007) 'The access journey to the railway station and its role in passengers' satisfaction with rail travel', Transport Policy, 14(5), pp. 357–365. doi: 10.1016/j.tranpol.2007.04.004.

Glaeser, E. and Joshi-Ghani, A. (2013) "Rethinking Cities: Toward Shared Prosperity," *Poverty Reduction and Economic Management (PREM) Network*, (126), pp. 1–14.

Goel, R. and Tiwari, G. (2016) 'Access-egress and other travel characteristics of metro users in Delhi and its satellite cities', *IATSS Research*, 39(2), pp. 164–172. doi: 10.1016/j.iatssr.2015.10.001.

Gordon, P. and Lee, B. (2015) "Spatial structure and travel: Trends in commuting and non-commuting travels in US metropolitan areas," in *Handbook on Transport and Development*. Cheltenham, UK: Edward Elgar, pp. 87–103. doi:10.4337/9780857937261.00012.

Guevarra, J. (2016) *Defining transportation equity in Los Angeles County*, *Investing in place*. Available at: https://investinginplace.org/2016/08/04/defining-transportation-equity-in-los-angeles-county/ (Accessed: March 29, 2018).

Hassan, M.N., Hawas, Y.E. and Ahmed, K. (2013) "A multi-dimensional framework for evaluating the transit service performance," *Transportation Research Part A: Policy and Practice*, 50, pp. 47–61. doi:10.1016/j.tra.2013.01.041.

Hess, D. B. (2005) 'Access to employment for adults in poverty in the Bufallo-Niagara region', *Urban Studies*, 42(7), pp. 1177–1200. doi: 10.1080/00420980500121384.

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.

Horner, M.W. (2004) "Exploring metropolitan accessibility and urban structure," *Urban Geography*, 25(3), pp. 264–284. doi:10.2747/0272-3638.25.3.264.

Huang, R. (2020) "Transit-based job accessibility and urban spatial structure," *Journal of Transport Geography*, 86(May), p. 102748. doi:10.1016/j.jtrangeo.2020.102748.

Ismail, Z., Mkhwanazi, S. and Silberman, K. (2016) "Consumer Expenditure Trends." PDF document

Jennings, G. (2011) "A challenge shared: is South African ready for a public bicycle system?" *SATC 2011*, (July), pp. 419–429.

Jennings, G. (2015) "Public Transport Interventions and Transport Justice in South Africa: A Literature and Policy Review," *SATC 2015*, (SATC 2015), pp. 764–775.

Kawabata, M. and Shen, Q. (2006) "Job accessibility as an indicator of auto-oriented urban structure: A comparison of Boston and Los Angeles with Tokyo," *Environment and Planning B: Planning and Design*, 33(1), pp. 115–130. doi:10.1068/b31144.

Keijer, M.J.N. and Rietveld, P. (2000) "How do people get to the railway station; a spatial analysis of the first and the last part of multimodal trips," *Journal of Transport Planning and Technology*, To Appear, pp. 1–20.

Kerr, A. (2015) "Tax(i)ing the poor? Implications of our high commuting costs," (2013). pp. 1–7. Available at: https://www.opensaldru.uct.ac.za/Journal_of_Economics.pdf. (Accessed: 14 October 2019)

Khosa, M.M. (1998) "'the travail of travelling': Urban transport in South Africa, 1930–1996," *Transport Reviews*, 18(1), pp. 17–33. doi:10.1080/01441649808716998.

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.C. (2004) "Activity and Travel Choice(s) in Multimodal Public Transport Systems." Available at: https://www.researchgate.net/Activity_and_travel_choices. (Accessed: 17 July 2022)

Lah, O. (2015) "Sustainable development benefits of low-carbon transport measures," p. 27.

Lall, S., Henderson, J. and Venables, A. (2017) *Africa's Cities: 2017). Africa's cities: Opening doors to the world., Washington, DC: World Bank.* Available at: https://openknowledge.worldbank.org/handle/10986/25896.

Ligege, A. and Nyarirangwe, M. (2015) "Framework for Sustainable Walking and Cycling Within the City of Polokwane, South Africa: A Comparative Assessment," (SATC 2015), pp. 41–53.

Litman, T. (2005) "Evaluating Transportation Equity: Guidance for Incorporating Distributional Impacts in Transportation Planning," *Victoria Transport Policy Institute, Victoria, British …*, 8(2), pp. 50–65.

Litman, T. (2016) "Evaluating Active Transport Benefits and Costs," *Victoria Transport Policy Institute*, pp. 134–140.

Locke, L.F., Spirduso, W.W., and Silverman, S.J. (2007) *Proposals That Work: A Guide for Planning Dissertations and Grant Proposals*. 6th Edition

Mackie, P.J. *et al.* (2003) "Universities of Leeds, Sheffield and York Conference paper," *Institute for Transport Studies, University of Leeds in association with John Bates Services*, 22 (2003), pp. 1–24.

Maggie, T. and Niclesse, M. (2016) *BRT Impacts at a Neighbourhood Level*. Available at: https://www.sacities.net/SACN_BRT-Impact2016.pdf. (Accessed: 30 September 2018)

McCaul, C. (1992) "Trends in commuting," *South African Review- SARS*, (6), pp. 294–308.

Metrorail (2007) *Welcome to Metrorail*. Available at: http://www.metrorail.co.za/ (Accessed: May 22, 2018).

Morency, C., Oaez, A., Roorda, M., and Mercado, R.. (2011) 'Distance travelled in three Canadian cities: Spatial analysis from the perspective of vulnerable population segments', Journal of Transport Geography, 19(1), pp. 39–50. doi: 10.1016/j.jtrangeo.2009.09.013.

Mullan, E. (2013) "Exercise, weather, safety, and public attitudes: A qualitative exploration of leisure cyclists' views on cycling for transport," *SAGE Open*, 3(3), pp. 1–9. doi:10.1177/2158244013497030.

Municipalities of South Africa (2019) *Municipalities of South Africa*. Available at: https://municipalities.co.za/.

Muñoz, J.C., Ortuzar, J. de D. and Gschwender, A. (2008) "Transantiago: The fall and rise of a radical public transport intervention," *Travel Demand Management and Road User Pricing: Success, Failure and Feasibility*, (January 2009), pp. 151–171.

Murray, A.T. *et al.* (1998) "Public transportation access," *Transportation Research Part D: Transport and Environment*, 3(5), pp. 319–328. doi:10.1016/S1361-9209(98)00010-8.

Murray, A.T. (2001) "Strategic analysis of public transport coverage," *Socio-Economic Planning Sciences*, 35(3), pp. 175–188. doi:10.1016/S0038-0121(01)00004-0.

National Geographic (2018) *Urban area, National Geographic*. Available at: https://www.nationalgeographic.org/encyclopedia/urban-area/ (Accessed: July 18, 2019).

National Planning Commission (2011) *National Development Plan*. Available at: https://www.gov.za/summary-NDP.pdf. (Accessed: 28 January 2019)

Niedzielski, M.A. and Boschmann, E.E. (2014) *Travel Time and Distance as Relative Accessibility in the Journey to Work, Source: Annals of the Association of American Geographers*. Pages 1156-1182 Otsuka, N., Delmastro, T., Wittowsky, D., Pensa, S., and Damerau, M., (2019) 'Assessing the accessibility of urban nodes: the case of TEN-T railway stations in Europe', *Applied Mobilities*, 4(2), pp. 219–243. doi: 10.1080/23800127.2019.1573778.

Parkin, J., Ryley, T. and Jones, T. (2007) "Barriers to Cycling: An Exploration of Quantitative Analyses," *Cycling and Society*, pp. 67–82.

Perlnah, J. (1984) "Bus Boycotts, Monopolies and the State." Available at: https://www.sahistory.org.za/.May1984.10.pdf. (Accessed: 03 May 2021)

Pirie, G.H. (1987) "African township railways and the South African state, 1902-1963," *Journal of Historical Geography*, 13(3), pp. 283–295. doi:10.1016/S0305-7488(87)80117-2.

PRASA (2019) *PRASA Annual report 2018/19*. Cape Town. Available at: https://www.prasa.com/Annual/Reports.pdf (Accessed: 28 March 2021)

Pucher, J. and Buehler, R. (2008) "Making cycling irresistible: Lessons from the Netherlands, Denmark and Germany," *Transport Reviews*, 28(4), pp. 495–528. doi:10.1080/01441640701806612.

Republic of South Africa (1994) *The Reconstruction & Development Programme, The Black Scholar*. doi:10.1080/00064246.1994.11413149.

Republic of South Africa Government (1996) *The Constitution of the Republic of South Africa*, *Claiming Turtle Mountain's Constitution*. doi:10.5149/North Carolina/9781469634517.003.0008.

Republic of South Africa Government (2009) "National Land Transport Act," *Government*, 52(3), pp. 63–63.

Republic of South Africa Government (2018) *Constitution of the Republic of South Africa, 1996 - Schedule 4: Functional areas of concurrent national and provincial legislative competence*. South African Government. Available at: https://www.gov.za/documents/constitution-1996-schedule-4. (Accessed: 06 March 2021)

Rietveld, P. (2000a) "Non-motorised modes in transport systems: a multimodal chain perspective for The Netherlands," *Transportation Research Part D: Transport and Environment*, 5(1), pp. 31–36. doi:10.1016/S1361-9209(99)00022-X.

Rodrigue, J.-P. (2020) The Geography of Transport Systems. Fifth Edit. New York: Routledge. Available at: https://transportgeography.org/.

Saghapour, T., Moridpour, S. and Thompson, R.G. (2016) "Public transport accessibility in metropolitan areas: A new approach incorporating population density," *Journal of Transport Geography*, 54, pp. 273–285. doi:10.1016/j.jtrangeo.2016.06.019.

Salon, D. and Gulyani, S. (2010) "Mobility, Poverty, and Gender: Travel 'Choices' of Slum Residents in Nairobi, Kenya," 1647. doi:10.1080/01441640903298998. Available at: https://www.tandfonline.com/doi/full. (Accessed: 30 April 2021)

Salonen, M. and Toivonen, T. (2013) 'Modelling travel time in urban networks: Comparable measures for private car and public transport', *Journal of Transport Geography*, 31, pp. 143–153. doi: 10.1016/j.jtrangeo.2013.06.011.

Sanchez, T. W. (1999) 'A Transit Access Analysis of TANF Recipients in Portland, Oregon', 2(4), pp. 61–73.

Sanchez, T. W., Shen, Q. and Peng, Z. R. (2004) 'Transit mobility, jobs access and low-income labour participation in US metropolitan areas', *Urban Studies*, 41(7), pp. 1313–1331. doi: 10.1080/0042098042000214815.

Sandra Hanzl, Meschik, M. and Sammer, G. (2003) *Policy Formulation and Implementation*. *PORTAL Written Material 2003*. Available at: https://www.eltis.org/sites/.pdf. (Accessed: 11 October 2020)

Sarantakos, S. (2005) *Social Research*. Third edition. New York: Palgrave Macmillan.

Schafer, A., and Victor, D.G. (2000) "The future mobility of the world population," *Transportation Research Part A: Policy and Practice*, 34(3), pp. 171–205. doi:10.1016/S0965-8564(98)00071-8.

Schoon, J., McDonald, M. and Lee, A. (1999) 'Accessibility Indices: Pilot Study and Potential Use in Strategic Planning', *TRANSPORTATION RESEARCH RECORD 1685, Paper No. 99-0606*, Paper No. (99), p. 9.

Shearlaw, M. (2015) "Potholes, sewage and traffic hostility: can Kampala ever be a bike-friendly city?" Guardian Africa Network, Uganda.

Silm, S. and Ahas, R. (2014) 'Ethnic Differences in Activity Spaces: A Study of Out-of-Home Nonemployment Activities with Mobile Phone Data', *Annals of the Association of American Geographers*, 104(3), pp. 542–559. doi: 10.1080/00045608.2014.892362.

Small, K.A. (1998) "Project evaluation," in *Evaluating IT Projects*. UCTC No. 3. UCTC No. 379 The University of California Transportation Centre, pp. 4–15. doi:10.4324/9781315102320-2.

South African Government (1996) *Constitution of the Republic of South Africa, 1996 - Schedule 4: Functional areas of concurrent national and provincial legislative competence*. Pretoria: Constitution of the Republic of South Africa.

Statistics South Africa (2013) 'A Survey of Time Use: 2010', pp. 1–67. Available at: http://www.statssa.gov.za/publications/Report-02-02-00/Report-02-02-002010.pdf.

Statistics South Africa, (2014) "National Household Travel Survey February to March 2013," pp. 1–179.

Statistics South Africa (2015a) *Living Conditions of Households in South Africa: An analysis of household expenditure and income data using the LCS 2014/2015, Statistics South Africa*.

Statistics South Africa (2015b) *Measuring household expenditure on public transport: in-depth analysis of the National Household Travel Survey 2013 data*.

Statistics South Africa (2018) 'Exploring social disparities in accessing workplace and educational institutions: Using travel time and travel cost. In-depth analysis of the National Household Travel Survey data 2013'. Available at: http://www.statssa.gov.za/publications/Report.pdf. (Accessed: 11 April 2021)

Statistics South Africa (2019) *Four facts about our provincial economies*. Available at: https://www.statssa.gov.za/. (Accessed: 24 October 2021)

Statistics South Africa (2020) 'National Households Travel Survey 2020 Statistical release P0320'. Available at: http://www.statssa.gov.za/publications/P0320/P03202020.pdf.

Sturgeon Consulting (2015) "Stellenbosch Municipality 2015 NMT Network Plan."

Sturgis, S. (2015) "Expanding Walkability in Two African Cities: What's at Stake?" Available at: https://www.bloomberg.com/what-s-at-stake. (Accessed: 16 February 2021)

Tao, S. He, S. Y., Kwan, M., and Luo, S., (2020) 'Does low income translate into lower mobility? An investigation of activity space in Hong Kong between 2002 and 2011', *Journal of Transport Geography*, 82(August 2019). Doi: 10.1016/j.jtrangeo.2019.102583.

Tonkin, A. (2008) *Sustainable medium-density housing*. Cape Town: Development Action Group (DAG). Available at: https://www.dag.org.za/wp-content.pdf. (Accessed: 09 May 2020)

Transport Education Training Authority (TETA) (2018) *Taxi Chamber, Transport Education and Training Authority 2018*. Available at: https://www.teta.org.za/inner.aspx?section=2&page=23 (Accessed: April 16, 2019).

Treasury (2014) "Expenditure and Performance Review of South Africa's Public Transport And Infrastructure System Conducted for the Presidency and National Treasury by Hunter van Ryneveld (Pty) Ltd," (October 2014). Draft - Version 6. Public Transport Infrastructure & Systems Expenditure & Performance Review

Tribby, C.P. and Zandbergen, P.A. (2012) "High-resolution spatio-temporal modelling of public transit accessibility," *Applied Geography*, 34, pp. 345–355. doi:10.1016/j.apgeog.2011.12.008.

Trimble, J.E. and Fisher, C.B. (2006) *The Handbook of Ethical Research with Ethnocultural Populations and Communities*. Edited by C.B.F. Joseph E. Trimble. SAGE.

Turok, I. (2015) *The Evolution of National Urban Policies a Global Overview*.

Turok, I. and Borel-Saladin, J. (2014) "Is urbanisation in South Africa on a sustainable trajectory?" *Development Southern Africa*, 31(5), pp. 675–691. doi:10.1080/0376835X.2014.937524.

UNICEF (2012) "The State Of The World's Children 2012," p. 2. doi:10.1016/b978-1-84569-595-8.50037-4.

United Nations Department of Economic and Social Affairs (2012) *World Urbanization Prospects, the 2011 Revision*. Available at: https://www.un.org/en/development/desa/publications/world-urbanization-prospects-the-2011-revision.html#:~:text=Africa's urban population will increase, and Social Affairs (DESA) (Accessed: December 12, 2019).

United Nations Department of Economic and Social Affairs (2018) *68% of the world population projected to live in urban areas by 2050, United Nations*. Available at: https://www.un.org/development/desa/en/news/population/2018-revision-of-world-urbanization-prospects.html (Accessed: December 8, 2019).

Van der Merwe, J. and Krygsman, S. (2020) "Transit-based job accessibility and urban spatial structure," *Journal of Transport Geography*, 18(1), pp. 17–33. doi:10.1016/j.jtrangeo.2020.102748.

Victoria Transportation Policy Institute (2020) "Transportation Cost and Benefit Analysis II – Travel Time Costs," in *Transportation Cost and Benefit Analysis II - Travel Time Costs*, pp. 1–26.

Von der Heyden, C., Laing, K., Hastings, E., Koch, P., and Reddy, T. (2015) Financing IRPTN operations: Considerations for cities implementing I(R)PTNS in South Africa. Available at: https://repository.up.ac.za/VonderHeyden_Financing_2015.pdf. (Accessed: 25 August 2020)

Waller, M. (2005) 'High cost or high opportunity cost? Transportation and family economic Success.', The Brookings Institution: Policy Brief, p. 8.

Walters, J. (2014) "Public transport policy implementation in South Africa: *Quo vadis*?" *Journal of Transport and Supply Chain Management*, 8(1), pp. 1–9. doi:10.4102/jtscm. v8i1.134.

Wardman, M. and Tyler, J. (2000) "Rail network accessibility and the demand for inter-urban rail travel," *Transport Reviews*, 20(1), pp. 3–24. doi:10.1080/014416400295310.

William, F. and Bayat, M. (2007) *A Guide to Managing Research*. 1st Edition. Cape Town

Woldeamanuel, M. and Kent, A. (2016) "Measuring walk access to transit in terms of sidewalk availability, quality, and connectivity," *Journal of Urban Planning and Development*, 142(2), pp. 1–13. doi:10.1061/(ASCE)UP.1943-5444.0000296.

World Bank, The. (2020) Urban Development. Available at: https://www.worldbank.org/en/topic/urbandevelopment/overview. Accessed: 16 June 2022)

Zhang, X., Wang, J., Kwan, M., and Chai, Y. (2019) 'Reside nearby, behave apart? Activity-space-based segregation among residents of various types of housing in Beijing, China', *Cities*, 88(October 2018), pp. 166–180. doi: 10.1016/j.cities.2018.10.009.