

**PUBLIC TRANSPORTATION IN SOUTH AFRICA: FACTORS INFLUENCING MODAL
CHOICE FOR WORK TRIPS IN JOHANNESBURG AND CAPE TOWN**

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AUTHOR'S DECLARATION

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ABSTRACT

A very high percentage of the urban population relies on public transport for mobility services, which makes the development of public transportation absolutely crucial. The study uses the data from The National Household Travel Survey of 2013 to analyse work-travel patterns and to see how they are affected by different factors in two South African cities. The study analyses 1) the modal split of workers travelling to work, 2) the socio-demographic and socio-economic characteristics of workers who use public transport to travel to work 3), the modal choice of workers and the different modal attributes of public transport, and 4) how these factors affect workers modal choice when travelling to work. The first three questions were answered using descriptive statistics and the results revealed that the minibus taxi is the most popular used mode of public transport in the two cities, even though in Cape Town the train usage is abnormally high and a bit higher than the minibus taxis for work travel. Non-whites are more likely to use public transport than white people, with black people being the most reliant on public transport. Lower income people were also revealed to be more reliant on public transport than higher income people, while women were less likely to use trains than men. The Multinomial Logistic Regression Model revealed that social characteristics of workers had more significant influence on workers modal choice than modal characteristics.

Keywords and phrases:

Public transportation, South Africa, buses, minibus taxis, trains, work-travel patterns, modal attributes, sociodemographic characteristics, socio-economic characteristics, modal selection

OPSOMMING

'n Baie hoë persentasie van die stedelike bevolking maak staat op openbare vervoer vir mobiliteitsdienste, wat die ontwikkeling van hierdie openbare vervoersdienste absoluut noodsaaklik maak. Die studie gebruik gegewens uit die Nasionale Huishoudelike Reisopname van 2013, om ondersoek in te stel na werk-reispatrone en hoe dit beïnvloed word deur verskillende faktore in twee Suid-Afrikaanse stede. Die studie analiseer 1) die modale verdeling van werkers, 2) die sosio-demografiese en sosio-ekonomiese eienskappe van werkers wat openbare vervoer vir werksdoeleindes gebruik, 3) die modale keuse van werkers en die verskillende modale eienskappe van openbare vervoer en, 4) hoe hierdie faktore die werklike keuse van werknemers beïnvloed. Die eerste drie vrae is met hulp van beskrywende statistieke beantwoord, en die resultate het getoon dat die minibus taxi die gewildste manier van openbare vervoer in die twee stede is, selfs al is die treingebruik in Kaapstad abnormaal hoog en 'n bietjie hoër as die minibustaxi's. Nie-blankes is meer geneig om openbare vervoer te gebruik as wit mense. Swart mense is vergelykbaar die mees afhanklik van openbare vervoer te gebruik. Mense met laer inkomste is ook meer afhanklik op openbare vervoer as mense met hoër inkomste, terwyl vroue minder treine as mans gebruik. Die multinomiale logistieke regressiemodel dui aan dat die sosiale eienskappe van werkers 'n groter invloed op die modale keuse van die werkers gehad het as wat die modale eienskappe het op vervoersgedrag.

Trefwoorde en frases:

Openbare vervoer, Suid-Afrika, busse, minibustaxi's, treine, werk-reispatrone, modale eienskappe, sosio-demografiese kenmerke, sosio-ekonomiese eienskappe, modale seleksie

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ABBREVIATIONS AND ACRONYMS

	Page
NHTS (National Household Travel Survey).....	2
RSA (Republic of South Africa).....	2
Gau (Gauteng).....	3
WC (Western Cape).....	3
BRT (Bus Rapid Transit).....	4
CSIR (Council for Scientific and Industrial Research).....	7
MSA (Moving South Africa).....	9
RDP (Department of Transport).....	9
NDP (National Development Plan).....	9
DoT (Department of Transport).....	12
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1. CHAPTER 1: BACKGROUND

Public transportation in South Africa, like in so many parts of the continent and the rest of the developing world is inefficient and lacking in capacity to cater to all the needs of the population (Venter, 2019). Due to the political history of the country linked to apartheid and separate development, public and private transportation infrastructure was made to serve the minority white population, while there were no such developments in black rural homelands far away from the cities and in the townships located within urban centers (Mhlauli et al, 2015).

Policies such as The Reservation of Separation of amenities Act (1953) are responsible for the segregationist laws on public transportation use among other things (Edwards, 2007). Such pro-segregation laws and policies separated and disconnected the South African city, making the distance between the working population (black townships) and workplaces (places of economic activity) very large, increasing transport costs and travel times (Van Reyneveld, 2018; Anderson & Khan, 2014). The South African public transportation system daily offers mobility to millions of South Africans. In many instances people use public transportation to travel to work, school, do shopping and reach social facilities (Lombard et al, 2007).

RESEARCH MOTIVATION

The public transportation system in South Africa generally includes minibus taxis, buses and trains. Buses and trains are formal modes of transportation that are officially regulated. Minibus taxis are generally privately owned. By and large they are operated informally and with little regulation to provide mobility for passengers. The South African transportation system requires further improvement because it is currently not operating in a sustainable manner and is failing to address the needs of the entire population (Nwaogbe et al, 2012).

Many public transportation users in South Africa feel that buses and trains lack the capacity to provide safe, fast and time efficient services, so they often depend on the informal minibus taxi service for their transportation needs. The inability or lack of capacity of the formal public transportation modes provide transport for all public transportation users, means that the bulk of passenger travel passengers rely on the informal minibus taxis for their travelling needs (Booyesen et al, 2013). This resulted in the emergence of a minibus taxi service which operate outside the formal system. The fact

that the formal transportation services do not fully provide in the transportation needs of the population created a gap in the market. This opportunity is utilized by small business operators to provide an informal transportation services outside the public transportation sector (Schalekamp, 2015).

South Africa faces a mountain of socio-economic challenges, with the poverty rate standing at 57.10% in 2014 and the Gini coefficient at 63% for the same year (National Development Agency, 2019; STATSA, 2018). In South Africa high levels of poverty and inequality makes it increasingly difficult for many people to access public transportation. Trip purposes, trip distance, trip frequency and modal choice are significantly influenced by socio-economic factors (Bajracharya & Shrestha, 2017). It is therefore important to understand the demographics of the population and to understand their role in influencing public passenger travel.

Accessibility, reliability, average travel time and travel costs are some of the most important modal characteristics that influence public transportation modal choice in South Africa according to the National Household Travel Survey (NHTS, 2014). Research in public transportation is of the utmost importance, and this research will take a look at how each mode is able to provide for these different needs of passengers in the context of work related public transport travel.

RESEARCH QUESTIONS

Against the background of this literature, this research will try to answer three different questions:

- i. What are the sociodemographic and socio-economic characteristics of people using public transport for travelling to work in Johannesburg and Cape Town?
- ii. What are the modal attributes of different modes for work trips in Johannesburg and Cape Town
- iii. Which factors play the strongest role in influencing passengers' modal choice for work trips?
- iv. What is the degrees of significance of the factors influencing mode of public for workers in Johannesburg and Cape Town

AIMS AND OBJECTIVES OF THE STUDY

The main aim of this research is to look at public transport passenger needs, and if the different modes of public transport, that are offered in the public transport system meet these requirements. The study

will look at the most important factors and needs of passengers and analyze the data to see how public transport needs to improve to be able to meet the demands of the growing urban population.

The objectives of the study are:

- i. To look at the modal usage of workers in Johannesburg and Cape Town
- ii. To look at the sociodemographic and socio-economic factors influencing public transport for workers in Johannesburg and Cape Town
- iii. To look at the modal characteristics of work trips for different modes in Johannesburg and Cape Town
- iv. To see the degrees of significance of the factors influencing mode of public for workers in Johannesburg and Cape Town

HYPOTHESIS

Sociodemographic influences are more significant than modal characteristics for workers in South African cities when workers are choosing mode of public transportation.

2. CHAPTER 2: PUBLIC TRANSPORTATION IN SOUTH AFRICA: FACTORS INFLUENCING MODAL CHOICE FOR WORK TRIPS IN JOHANNESBURG AND CAPE TOWN

2.1 Introduction

The improvement of people's mobility through innovative public transportation advancements has become mandatory for developing economies to ensure that people have access to opportunities, facilities and services that are available to them (Jiemian & Mohanty 2012). Public transport planning plays the role of growing and developing public transport systems to ensure that it meets the demands of the population. A large number of the world's population is dependent on public transportation for their mobility needs, as such public transportation systems have to be up to standard to be able to meet the mobility needs of the people (Bickford 2014). This means that local municipalities should have a properly run and managed transportation planning department that is run by professionals and is well funded and equipped to develop the transport system in the best possible way.

Public transport is the backbone of any thriving city. Cities of the developed world are very good examples of sustainable and efficient transport systems with proper transport networks and that are easily accessible to the population. Cities found in Europe, North America and Asia rank as having some of the most efficient public passenger transit systems because of their efficient and integrated transport modes such as subways and BRT systems that operate timely and efficiently (World Bank, 2000). In the global South, the state of public transport in developing cities is often characterised by poor planning, inadequacy and inefficiency. These inadequate transportation systems and the dire socio-economic challenges that these regions face such as high levels of poverty, marginalisation and displacement results in huge percentages of the urban population being unable to access public transportation and having limited access to mobility (Cervero & Golub, 2007).

The increasing rate of urbanisation has further exacerbated the transportation challenges that urban areas currently face. With increased populations, this adds a burden to an already inadequate transportation system (Walters, 2013). Increased urbanisation means that the transport system also has to develop to cater for the extra populations moving into the cities. Many studies specifically analyse employment related travel, looking at the relationship of public transport use, work patterns and time use (Aguilera et al, 2011; Mokhtarian, 1991). Employment related travel is affected by a number of factors and it is critical that transport authorities understand these factors so that they are

able to provide the best possible transport services for workers. It is important to understand work-related travel patterns specifically in the context of the South African public transport system.

2.2. Formal Transportation in South Africa

The formal transportation system in Africa and the rest of the developing world is generally characterised by poor planning, inadequacy and inefficiency. The increasing rate of urbanisation has further exacerbated the transportation challenges currently facing urban areas, with increased populations this adds a burden to an already inadequate transportation system (Walters, 2013; Jennings, 2015). The main modes of formal transport in South Africa are municipal buses and Metrorail trains. Bus and train services are planned, managed and financed independently from each other which creates a lack of integration within the formal public transport system and leaves in a constant state of flux (Walters, 2014).

2.2.1. Buses

The South African public bus services started operating in the 1930's to reorganise the fragmented state of public transport in the country (Sey, 2008). Ever since their inception, buses have played a very important role in offering mobility services to the South African public, especially black people who travelled between the homelands and the city (McCarthy and Swilling, 1985). During the apartheid regime, segregation meant that communities of colour were often located away from employment areas, leisure areas and shopping districts, so a cheaper subsidised bus service was a much needed service for poor communities (Walters, 2014; Weakley & Bickford 2015).

Some passengers state that some of the challenges associated with commuter buses are the long travel times and high transportation costs that make taking the bus unattractive to people who rely on public transport (Mitizi, 2017; Hitge, 2015). A study looking at passenger trends in South African commuters transportation services found that passengers were mostly dissatisfied with safety related issues including safety at the bus stops and safety on the way to the bus stops, the study found that the off-peak frequency of buses was also dissatisfactory, while lack of facilities at the bus stops was found to be the most dissatisfactory issue related to buses in this study (Lombard et al, 2007).

Access to formal modes of public transportation is very low compared to access to the informal minibus taxi services. While only about 17% of households in South Africa reported that they did not

have access to taxi services, the same study reported that 50% of households in South Africa did not have access to formal bus services (NHTS, 2013). Accessibility is one of the critical issues facing public transport in South Africa, it is certainly worrying and reflects a critical state of affairs if the majority of the population has to rely on the informally run minibus taxis because formal transport services lack in capacity.

Buses are generally regarded as one of the safest options when choosing public transportation mode, even though there are some disadvantages associated with taking the bus, they are still very popular because of the safety record which is related to the professional manner in which they are run and the fact that run at low speeds, which increases safety but has the effect of increasing travel times and costs (Mtizi 2017). As much as buses have their challenges, the NHTS 2013 study revealed that buses were more popular than trains in most South African cities and were considered to be safer and much more accessible than trains, though they were shown to be lagging significantly behind minibus taxis in these regards (NHTS, 2013).

2.2.2. Trains

Train services are the least used mode of public transport, and with the current issues plaguing Metrorail and the overall rail service system it is not surprising that this is the current situation. Households in South Africa showed indicated that trains are by far the least accessible form of public transportation` with 81% of households reporting that they don't have access to train services, a large reason is that trains operate only in large metropolitan areas namely Gauteng, Cape Town, Durban, East London and Port Elizabeth (NHTS, 2013; Kerr 2017).

Metrorail trains are used by many South Africans to get to places of work. However, train services in South Africa have always been plagued by a multitude of problems that make this mode of transport unreliable (Thomas, 2016). Punctuality of service, levels of crowding, distance from the station and the security of trains are the biggest challenges related to rail commuter public transport (NHTS, 2014). Overcrowding is one of the biggest challenges that Metrorail has failed to solve with regards to train services, to the extent that some passengers are forced to sit in the spaces that connect the different carriages, endangering the lives of the passengers (Mthimkhulu, 2017).

The unreliability of the train service is another drawback to this mode of public transport. Trains are usually regarded as the least reliable mode of public transport in South Africa with a very high percentage of them usually running behind schedule, if they show up at all (NHTS, 2014). A study using NHTS 2014 data looking at commuter perceptions cited availability, overcrowding, punctuality and reliability of service as the biggest problems indicating a general dissatisfaction with the train

service (Heyns & Luke, 2018). A lack of proper infrastructure and published schedules, makes it extremely difficult of the service to keep up with its timetable, even though it does exist and is posted on their website, findings showed that 37.8% of train users claimed that it was usually not available (Walter, 2008; NHTS, 2014).

Much of the problems associated with train and rail services stem from infrastructure and maintenance problems. A study looking at train infrastructure challenges in the city of Cape Town identified that one of the key issues was the delayed response time for cases that need fixing or maintenance, the results showed that, time of occurrence, the location, the nature of incidents and the location of maintenance workers, influence the time it takes to respond to these instances, the paper suggested that a decision support model that was developed for the purposes of the paper should be adopted because it has the potential not to only just reduce response time, but to help managers locate the places where the incidents take place at a faster time and help to see the root cause of the problem (Conradie et al, 2019).

In certain areas of the city of Cape Town the train has a criminal elements associated with it since they are not adequately policed (Holtman & van Vuuren, 2007). It is important that passengers feel safe in and around the train and its station, more attention has to be directed towards the safety of passengers in the trains and in and around the train stations. The travel survey indicated that out of all the modes of transport available, the train was the least used by women, this speaks to the lack of safety in train stations and the long walking distances hindering accessibility (NHTS, 2013).

2.3. Informal transportation in South Africa

In South Africa minibus taxis are the most commonly used mode of public transport, throughout all Southern African cities millions of people rely on informal modes of transport to travel to work and school (Schalekamp, 2015). Minibus are the most dominant forms of public transportation and a large part of the population depends on them (Woolf & Joubert, 2013; Van Zyl, 2009). Paratransit modes on average account for between 50-98% of all public transport trips in sub-Saharan Africa (Behrens et al, 2016). In the Gauteng region, minibus taxis account for as much as 70% of all public transit trips, so the industry is by no means a small paratransit illegal operation anymore, In fact it the mode has grown so much that it even exceeds the number of trips of private cars when considering all trip purposes (DoT, 2007; Golub, 2003).

Informal services such as the minibus taxis are usually not the result of deliberate planning. This is because transportation systems are often not properly planned and underfunded, rising urban

populations and urban sprawl creates more challenges on an already struggling transportation system. It arises as a localised response to serve unserved passengers who are not catered for by the formal transit sector (Nkambule & Govender, 2014; Coetzee et al, 2018).

Minibus taxis fulfil a type of demand that generally can only be met by the paratransit sector. 'Paratransit adapts in a pragmatic way to the local context in Global South cities where the institutional framework is inadequate or inefficient and where topography and geography become genuine obstacles to the development of large bus services' (Forray & Figueroa, 2011). In African many cities, minibus taxis are the only mode of public transport available. In South Africa the minibus taxi industry in South Africa is currently carrying 65% of the country's public transport passengers and can be described as the perfect public transportation solution for the country (Van Zyl, 2009).

A study looking at passenger satisfaction levels of minibus taxi users with regards to different factors including costs, driver behaviour, availability at convenient times, ease of access, availability in area, comfort and safety. The study used its own data and compared that data with the NHTS 2013 data, both datasets showed consistency in that the highest dissatisfaction levels were driver behaviour and safety, and the lowest dissatisfaction levels were ease of access and availability in the area, the only factor which was different in the data results was regarding costs with NHTS 2013 data showed that costs showed low dissatisfaction levels and the research data showed high dissatisfaction levels. The study showed that accessibility is high, but driver attitude and safety remain a major concern in the minibus taxi industry (NHTS 2013; Qwabe, 2018).

Minibus taxis transportation has a long history of providing transportation for people of colour who lived in the margins of urban areas of South Africa. The history of minibus taxis in South Africa is closely linked the political history of South Africa and is largely affected and shaped by legislation and policies. The combination of apartheid, poverty and the displacement of people to the outskirts of urban societies promoted the singularly unique, organic spirit of transport operations in the country (Woolf & Joubert, 2013; Sey, 2008).

Minibus taxis played an important role in transporting African workers from the peripheral townships to city centres during apartheid, and filled a gap which was created by the failure of the formal modes of transportation to fulfil all the transportation needs and demands. The minibus taxis industry is such an integral part of the South African transportation system that it is impossible to imagine the transportation system without minibus taxis, and a distinct feature South African roads (Sebola, 2014).

2.4. Significant post-1994 public transportation improvement initiatives

Urban governments are continuously struggling with transportation developments within their constituencies. This is achieved through policy, revitalisation programmes, and the implementation of new infrastructure with the aim of modernising the transportation systems (Albalade & Bel, 2010). The growth and development of the transportation system has been affected by guiding policy documents such as the RDP, MSA, and the NDP.

2.4.1. The Taxi Recapitalisation Program

Through different types of programs and policies, South Africa is continuously engaged with the task of improving the service quality of minibus taxis. A major challenge with public transport in South African cities and those of other developing regions, is the fact that there is a lack of integration between the different modes offered in the public transport system (Wilkinson, 2008).

The informal manner in which the paratransit business is conducted and outdated methods of conducting daily operations would make it very difficult to integrate paratransit modes into the integrated public transportation system. It is for these reasons that in some of Africa's major cities have been pondering on whether efforts should be directed towards formalizing or at least regulating the service as part of a broader integrated public transit system (Wilkinson, 2008). One of the greatest challenges that has plagued the taxi industry has been the safety factor. Minibus taxis are involved in many road accidents and transgressions in part because of reckless driving, but another reason for this is the fact that a large number of the vehicles do not even meet the standards to be operating on the roads, much less carrying fleets of passengers (Salazar et al, 2013).

The Taxi Recapitalisation programme was introduced in 2000 with the aims to improve the taxi industry by legalise paratransit operations, introducing more updated and formal methods of conducting business and to replace old and un-roadworthy vehicles with new minibus taxis (Schlalekamp et al, 2009). This programme was envisaged to be the first step in the process of formalising and regulating the taxi industry. The challenges that were encountered with getting the taxi industry to restructure the sector, this resulted focusing the programme on fleet renewal, this did not go well because there was a lack of enthusiasm from the industry. Over 75% of the fleet remained, meaning that this initiatives was a failure in this regard (Schlalekamp, et al, 2009).

A study looking at taxi owners and their perceptions of the TRP in Temba a township located 55km north of Pretoria. The study found that the main concern for owners related to the economic effects on aging taxi owners, financial position of taxi owners, lack of subsidies, taxi co-operatives and their level of education as well as their limited knowledge about the program strategy, while there was a general opinion that the TRP had done with regards to legalising and registering taxi businesses and reducing conflict, institutionalising and registering, provincial regional and local taxi associations and regulating the industry to make it safer for passengers. (Mashishi, 2010).

There have been numerous studies on perceptions of the TRP that have indicated that those involved in the taxi industry were unhappy about the results of the program. A study of two different district areas in the Limpopo province name Greater Mankweng district and Capricorn district showed that those involved in the taxi industry felt that TRP was not bringing significant advantages to those that it was intended to help (taxi operators, drivers etc.) and therefore was a big failure (Martha & Baloyi, 2012). An article said that SANTACO stated that they felt marginalised from the program and that every time formalisation initiatives were almost complete, they always encountered new challenges or hiccups that delayed progress (IN ON AFRICA IOA, 2013).

The TRP has been instrumental in the fact that it achieved the objective of reducing the number of minibus taxis that are not roadworthy and that might be a potential danger or threat to the safety of passengers, while this is true, there were however, some other objectives that the program failed to meet. In a case study of the taxi industry in the urban areas of Durban and Pietermaritzburg results showed that the removal of old vehicles was mostly successful as most old and dangerous vehicles were removed from the roads and improved passenger comfort, but strategic objectives which were projected to bring about total transformation to the industry such as such as the skills development of drivers and taxi operators were an epic failure. These reasons, implementation issues and problems related to feasibility and financial constraints of taxi owners were some of the biggest reasons why perceptions of the TRP were often negative (Wosiyana, 2013).

2.4.2. Bus Rapid Transit (BRT)

BRT systems were introduced to the developing world via Latin America, where the implementation of BRT systems in cities such as Bogota have been extremely successful and serve as a case study for successful implementation in developing nations (Scortia & Munoz-Raskim, 2017). BRT's have been promoted as efficient way improving current transport systems by improving mobility while simultaneously reducing congestion, solving the biggest challenges pertaining to urban transport. African cities such as Dar es Salaam (Tanzania), Nairobi (Kenya), Lagos (Nigeria) , in South Africa it was Johannesburg and Cape Town that first got BRT and after this other urban areas have followed

and got their own BRT's in hopes of emulating its success in South America (Ferranti, 2020).

Many arguments have been made and debated in favour of BRT and its effectiveness, many of these points and arguments are solid and make BRT a very good solution for public transportation in the developing world and particularly some of the main challenges that were revealed by the data of the NHTS 2013. The main advantages of BRT include improved reliability, affordability, accessibility, dedicated bus lanes that reduce travel times, increased capacity, safety, comfortability and an overall improved service (Dibakwene 2011, Todes 2013, Deng & Nelson, 2013; Khumalo & Ogra, 2018). These attributes of the BRT could do a lot to address South Africa's public transportation challenges and if integrated with other modes in a single public transport system could do even more and yield more results (Strydom, 2010).

The implementation of BRT systems in South African cities has been difficult but metropolitan areas such as Johannesburg (Rea vaya) and Cape Town (My Citi) have established these bus systems and they have been operating for a number of years. The BRT system was a vision initiated in 2007 with an aim of improving public transport in South African cities (Thomas, 2016). The adoption of BRT was applauded throughout the global south, for being a southern innovation better suited for cities with fewer financial and institutional resources' (Wood, 2015; Allen, 2013). BRT has seen growth in South African urban areas, with cities such as Pretoria, Durban, the East Rand, Port Elizabeth, George and Rustenburg and has steadily been gaining many more users in Cape Town and Johannesburg (Boya, 2016).

With the history of high levels of violence linked to the minibus taxi industry it was no surprise that the biggest challenge for this project was to get the taxi industry on board, and this proved to be very difficult because there was already a significant level of distrust between the two parties, the deal had to be attractive and had to have the right mix of incentives to allow them to be integrated fully in the formal transport system. Naturally it was difficult to come to an agreement on terms and conditions, and the whole process has been very difficult to negotiate and there have been a few cases of violence, where the taxi industry has often destroyed and burned BRT infrastructure and buses (Woolf & Joubert, 2013; Boya, 2016).

The Rea Vaya BRT in Johannesburg was South Africa's first ever bus rapid transit system. Rea Vaya can be directly translated to 'we are going' became operational in August 2009 after the completion of its first phase linking Soweto to the Johannesburg CBD. The buses have a maximum capacity of 90 and as of 2013 transports 16000 people each day (Adewumi & Allopi, 2013). These type of affordable but also high quality buses are just what the city of Johannesburg needed and successful implementation of the system has forever changed the face of Johannesburg public transport, phases

1 a and b have been completed, and now phase 1c is being constructed which will Sandton to the Johannesburg CBD (Ubisi, 2016).

In the Western Cape city of Cape Town the BRT system is called the Myciti and part of its significance is that it is leading a larger initiative of to transform public transport in Cape Town in the fifteen years, this project includes a massive railway renewal within the city and also includes integrating these modes with taxis and traditional buses (Boulle et al, 2015). The Myciti BRT service became operational in time for the FIFA world cup in 2010 while the first phase 1A was still under construction, by 2015 the first phase was nearly complete, with operational capacity at 54000, which is expected to increase to 850000 upon completion of the first phase (Boulle et al, 2015; Bulman et al, 2014).

2.4.3. Gautrain

The Gauteng province in South Africa got Africa's very first high speed rail transport mode in 2010 just in time for the FIFA world cup. This initiative was a component of a broader integrated transport development project, the Gautrain was intended to provide a safe, efficient and reliable service to commuters the commuters of Pretoria and Johannesburg, with great emphasis placed on strengthen the integrated transport system of the province (Akoojee, 2015).

Gauteng is the fastest growing province and also the economic hub of South Africa with Johannesburg, Pretoria and the East Rand all having metropolitan status in this region. There is a clear need for proper transportation routes and networks to service these areas. The Gautrain network connects all the major economic nodes in and between Johannesburg and Pretoria, this includes areas such as Sandton, Rosebank, Midrand, Marlboro, Downtown Johannesburg and Eastgate in the city of Johannesburg, and Centurion, Hatfield, and downtown Pretoria in the Pretoria (Negota, et al, 2017).

The Gautrain received a lot of backlash because of exorbitant prices and was accused of entrenching further inequality in the transportation sector because the average South African cannot afford to use the Gautrain rail service (Creighton, 2016). With the political history of the country having shaped the current economic climate, South Africa remains one of the most unequal and segregated countries in the planet, and this project further exacerbated this reality because the majority of commuters cannot afford to use this mode of transport because it is too expensive. One of the central tenets of the post-apartheid era has been about the social inclusion and many considered a project of this kind to be in bad taste in a country like South Africa (Thomas, 2016; Pieterse, 2013).

Many advantages have been cited for why it is a good mode of transport, it is a high-speed traffic free train service, and Gautrain stations are easily accessible by buses (Rea Vaya) and trains (Metrorail) that act as feeders and integrate the modes. There is also accessible parking available for as little as R15 a day (Wray & Gotz, 2014). The fact that it is expensive was the main drawback of the Gautrain was the fact that it is expensive with a trip to Sandton from Ortia costing R125, other drawbacks include that it's not available at night, and that feeder buses to the stations are not frequent enough (Chakwizira & Mashiri, 2009).

2.5. Social factors affecting public transport

During apartheid, transport infrastructure was mainly organised according to the needs of the white minority in the cities, while the homelands were left underdeveloped, public transport being no exception. The Reservation of Separate Amenities Act (1953) imposed segregation laws on the use of public transport (Edwards, 2007). These are some of the reasons why transport development has been very difficult and fragmented in South Africa.

2.5.1 Socio-economic factors

South Africa has one of the highest number of wealthy people on the African continent, while it also very high levels of poverty, making it one of the most unequal societies in the world (Keeton, 2014). A study found that in the cities Johannesburg and Pretoria found that people with higher levels of income, higher levels of education were and employed in the formal sector were more likely to have drivers licences and travel to work using their own privately owned vehicles. Conversely people with lower levels of income, education and employed in the informal sector were more likely to not have drivers licence and take public transportation to work (Creighton, 2016).

The new government inherited a transportation system which was fragmented through policy and bureaucratic processes. Poor people in South Africa find themselves as group that is most dependent on public transportation, this is a result of displacement, former economic policies, and the fact that they are the group of people with the least access to cars and drivers' licences, this reality can be traced to the former policy of the previous apartheid government. In contrast to this, those in the middle or upper class prefer to travel by their private cars, and rarely make use of public transport (Creighton, 2016).

A study in the Gauteng province looking at spatial trends associated with socio-economic and households using the 2014 NHTS. The data revealed a correlation between income, employment and ownership of a drivers licence and car ownership; income, employment, and trip generation; income, employment and mode choice; income, employment and type of trip. What these results indicate is that travelling by your own private car is the preferred mode of travel in Gauteng, but this is only available households that earn from a salary threshold and those that fall below are forced to use public transport which is limited and not preferred (Luke & Pisa, 2018).

Apartheid legislation dictated the city planning and urban design of South African cities, which is a legacy that negatively affects many aspects of South African life even until this day (Charman et al, 2017). Low income areas known as townships in South African cities are located on the periphery or the urban edge, this places them far away from the central business and other areas of economic activity, this results in longer travel times and higher travel costs, while the location of some of these areas is far away from certain modes of public transport resulting in decreased public transport accessibility (Cloete et al, 2016; Gotz & Simone, 2014).

2.5.2 Sociodemographic factors

Different demographics show different levels of significance in the importance of travel time. Households headed by black African males had a higher concern for travel time (35.3%) and lesser need for flexibility (7.5%) than those headed by males belonging to other population groups (NHTS 2013). This is one of the reasons the South African government has embarked on an integrated transport planning approach, where different transport modes work in unison instead of competing and clashing with each other, to ensure that average travel time remains low, and to ensure that the entire transport system is functioning efficiently and people can make the best use of the public transport system (Jennings, 2015).

Research looking into the relationship between transport behaviour and gender, notes that there is a difference between the travel behaviour of women in comparison to men. Women generally travel shorter distances as opposed to men and interpretations generally point to spatial and economic factors, these include lower salaries, spatial location of female dominated industries and their greater dependency on public transportation (Hanson & Pratt, 1990). Other factors that could be affecting gender variance in the use of public transportation includes crime, distance travelled to bus stop or train station, and a lack of drivers licences amongst women.

In a more recent study it was revealed that the most important factor for South African women when

choosing a mode of public transport is harassment and safety concerns. A Cape Town study showed that travel times and distances didn't show that much of a significance between genders except that women make fewer trips but more care trips, the more significant finding was related to the perception of potential harassment of women on different modes, and trains were perceived to have a higher potential of harassment than other modes, which is why trains were recorded as having the lowest usage for women (Gweynne-Evans, 2019). South Africa has one of the highest rates of rape and murder in the world and these are important factors to consider for policy makers (Abrahams et al, 2017).

Immigration status plays a big role in influencing and shaping travel behaviour and patterns. The effects of place of birth and year of arriving to the US were found to be significant in the full models that control for commute mode and yearly miles driven but not for weekly walk trips or number of daily trips (Gil and Handy, 2005). Migrants usually set up their own communities within the cities in which they have settled. Most of these times these communities are displaced and located on the periphery of cities, and this makes mobility difficult for them because the areas in which they live often do not have public transportation routes resulting in difficulty in mobility (Lamanna et al, 2018).

Elderly people usually have different travel needs than the younger population, as such the different growth rates of older people and an aging population will have a significant impact on the transportation system. This impact will have to be considered as the transportation system evolves (Koffman et al, 2010). The evolution of the transportation system has to consider population growth, geriatric needs and other factors, to ensure that mobility impaired people always have access to public transportation.

2.6. Modal attributes

The mode of transport is influenced by the passenger's transport needs. According to the Stats SA's National Household Travel Survey of 2014, the most important factors that passengers take into account when choosing a mode of public transport to travel with are 1) travel costs, 2) average travel time, 3) accessibility and 4) safety.

2.6.1. Accessibility

Accessibility is one of the most important factors that transport planners have to take into account when creating public transportation systems. Lack of access and the fact that South African cities are

car-oriented can be a significant challenge in South Africa where poor communities are predominantly located on the outskirts of the city and far away from places with job opportunities (Rodrigue et al, 2006; DoT, 2007). There seems to be no immediate solution to the issue of displaced communities, with most new low-cost residential developments happening along the urban edges due to cheap land prices (Bond 1994).

Accessibility is a pressing issue because it is absolutely imperative that people are able to travel to and from their places of employment, to look for job opportunities and to access social facilities such as schools, clinics and parks. Transport injustices mean that the poor and displaced people suffer proportionally more because they do not have sufficient mobility and therefore are denied access to a host of facilities that are made available to them by the government. In the South African context the importance of accessibility is critical because of the very high levels of crime in the country, especially in the townships. South Africa has one of the world's high rates of crime, and the reality is that bus stops and train stations can sometimes be far to walk to especially early in the morning and late at night because this exposes public transport users to these types of crimes (Kruger & Landman, 2007).

2.6.2. Travel times

Travel time is defined as the period of time that is needed to travel from one location to another (Wanjek et al 2017). Numerous studies have demonstrated that public commuting can be a major cause of stress (Bhat & Sardesai 2006). This kind of stress can and usually does affect other aspects of people's lives such as work and personal lives, this makes average travel time a very important influence in choosing public transportation mode. Average travel time is affected by traffic congestion, transport routes, state of the vehicle, reliability of arrival and departure times and it changes between peak and off-peak hours, days of the week. Prolonged journeys can be particularly stressful if the mode of public transportation is crowded and does not have sufficient capacity to make the journey pleasurable and comfortable (Cantwell et al, 2009).

In South Africa public transport is usually unreliable and can get very uncomfortable especially during peak hours where everybody is scrambling to get to and from work. Mini-bus taxi operators are widely known to overload passengers and squeezing them into one vehicle just so that they can make more profit from the extra passengers, making the commute very uncomfortable and unsafe (Martha & Baloyi, 2012). Although they are the most convenient mode of public transport most of the complaints from commuters taxi wars, violence, driver attitude, speeding and overloading placing their lives at risk (Sauti, 2006). Metrorail trains are known to get to extremely overcrowded in peak

hours where hundreds of people are on one train, and people are hanging out of open doors and standing in between the coaches. Average Travel Time is very important because Workers spend long hours at work and it is therefore obvious that they would not want to spend a lot of unnecessary time travel to and from their places of work (Cantwell et al, 2009). A healthy economic system relies on an efficient transportation system, where journey durations are minimal.

2.6.3. Travel costs

Public transport travelling costs are an important influence when choosing certain a mode of travel. Public transport travel costs are influenced by the distance travelled, socio-economic position, employment position, education level and other significant socio-demographic factors that influence affordability (Carruthers et al, 2005). Given South Africa's status as a developing nation, the country has one of the world's highest rates of inequality and poverty, it is therefore imperative that there is always low cost transport services available for the poor, and that lack of mobility does not hinder poor people's access to opportunities and facilitate social exclusion. Previous research has shown that when people cannot afford public transport have limited access to social facilities (Venter, 2011). The situation in South Africa is very difficult in this regard because on average South Africans spend 20% of their earnings on public transport costs and research shows that for transport to be affordable commuters should be spending 10% or less of their earnings (NHTS, 2014).

A study suggested that since space and spatiality play a big role when it comes to the pricing of travel costs, spatially targeted interventions in transport supply and land use policy are utilised to address issues of transport affordability in the country (Venter, 2011). Travel costs are tied in with issues related to cost of living and thus it is essential to ensure that energy prices are always kept at a minimum and that people are able to become mobile around on a constrained budget (Sanchez et al., 2007). In South Africa Metrorail trains and municipal buses are usually subsidised, and travel costs can drop significantly during off-peak hours, but prices rise significantly during the rush hour. Paratransit is relatively cheap in South Africa, but in a lot of instances trains or busses are far cheaper than minibus taxis. Since the majority of public transportation commuters are poor, affordability is a important factor, and continuous engagements are needed to make sure that public transportation fares are kept low (Venter, 2011).

2.6.4. Safety

The safety of commuters is a very important topic of public transportation planning, and it is very

high in the list of factors that help commuters determine which mode of travel to select. But the reality is that many of the public transport forms are old and this poses a significant threat to the safety of commuters (Mtizi, 2017). Railway transport can be relatively unsafe because of overcrowding which creates a potential threat for some of the passengers. Trains are generally insufficiently funded and under policed (Ngubane, 2017). However, trains can also be the cheapest options for public transport and so for some people the cheaper prices may outweigh the disadvantage of lack of safety.

Due to their informal and unregulated nature of minibus taxis, the operation of these businesses are often unsafe. Many minibus taxis on South African roads are below the authorised safety standard, but they continue to offer their services at significant commuter risk (Mtizi, 2017). Other issues include reckless driving, the disregard of road rules, and the overloading of passengers over the legal capacity of the vehicle by taxi operators (Thomas, 2016). Buses are considered to be the safer public transport option because they are less risky and more regulated (Mtizi, 2017). However, bus services do not cover certain routes leaving travelers with the option to walk or use another form of transport to get to their destination.

2.7. Work-related public transport travel

Since the end of the apartheid, South Africa has undergone some significant changes and this has affected the passenger trends in public transport. From 1997 to 2003 the growth of the population, an increase of 14.4% (40.6 million to 46.4 million), was exceeded by the growth of people who joined the working population at an increase of 22.1% (9 million to 10.9 million) and as of 2019 the population of South Africa was at 58.78 million people (Development Bank of Southern Africa, 2007; StatsSA, 2019). Looking at the data for this time period, it is clear that the growth in employment exceeded the growth of the population.

Most public modes of transport and private car related trips to work have been steadily increasing since the dawn of the democratic era. Between 1997 and 2003, the number of work trips increased especially in provinces of Gauteng, Kwa-Zulu Natal and the Western Cape because of high levels of economic development in the cities. Conversely, the provinces of the Free State and the Northern Cape experienced a decrease in the number of work trips (Development Bank of Southern Africa, 2007). The public transport system has to be able to cope with growth of the population and there must be enough vehicles on the road on peak times when people are going to, or coming back from work.

Work trips in sub-Saharan African cities are usually done by public transport because there are high levels of poverty and a low access to private cars. In South Africa's big cities, minibus taxis are the most popular mode of public transport and account for about two thirds of daily work trips, particularly in all low-income localities in the year 2004. Taxis are a popular mode of public transport for working women because its modal flexibility is better suited for the dispersed female travel patterns. In Durban the private car was only used by 7% of men for work trips and only 4% of women's work trips (Pirie, 2013). These trends indicates the failure of formal public transport modes to meet the needs of workers and the general population at large. Developments happening in urban areas need to be planed so that the urban poor can gain from these types of initiatives.

2.7.1. Differences between work and non-work related public transport travel

There are a number of differences between work-related and non-work travel. Factors include space-time constraints related to employment, the number of hours spent at work and work location in relation to where your home is (Aguilera, et al, 2011). These factors have a significant impact on differences in travel patterns between working days (weekdays) and non-working days (weekends), peak and off-peak periods and congestion in the roads. It is important to understand the nature and patterns of work-related patterns because the literature has shown that this kind of mobility is a major and time consuming aspect of people's professional lives (Westman & Etzion, 2002).

Numerous studies have shown that there is a significant difference between the distances travelled by workers and non-workers, with the National Household Travel Survey of the US (2001) showing that workers travel about 12 more miles than people who do not work (Aguilera, et al, 2011; McGuckin & Srinivasan 2005, NHTS, 2001). These longer distances are a result of work patterns and the fact that for most people work places are mostly not at the home and these distances sometimes even cross municipal boundaries (Bhat, 1997).

Non-work related public transportation trips are not long, usually do not cross municipal boundaries and are largely influenced by trips to work, work schedules and the local geography of the area (McGuckin & Srinivasan 2005). On week workdays the geography and duration of activities which are not related to work activities are affected by space-time constraints related to work-related activities. For this reason a number of non-worker trips cover a shorter distance from the workplace (De Coninck & Massot, 2007).

Studies have also shown that compared to the rest of the adult population, workers have more private cars and as a result more workers travel by car as opposed to using public transport, whether as drivers

or passengers (Aguilera et al, 2011). Since the public transport system in South Africa is not fully developed, it struggles to meet the requirements of the whole population and middle class persons usually opt to travel using their own cars (Chee & Fernandez 2013; Creighton, 2015). With countries trying to decrease the number of private vehicles on the roads in an attempt to try and lower the emissions of fossil fuels, it is imperative that public transportation systems are improved and made accessible to all communities and people.

2.7.2. Social factors influence on work-related public transportation travel

Sociodemographic and socio-economic characteristics play a big role in influencing public transport work related trips. Certain population groups often find themselves suffering from lack of access to certain modes of public transportation modes at certain times of the day (Martinez et al, 2018). Differences in gender influences variations in work-related travel patterns and distances due to differences in household responsibilities, with women making more trips related to taking care of the household needs such as grocery shopping and taking children to different places (Levinson, 1999; Mauch & Taylor 1997).

A study showed that on working days men and women make the same number of trips but the average distance travelled by women was 8 km lower than that of men, while on non-working days this difference was reduced to only 2 km (Aguilera et al, 2011). The socio-economic position of the person plays a role, with higher earning individuals having more access to private cars and having more options to choose where to live in the city. Professional level and education level status influence time-use and the schedule of in-home and out of home work activities, on working days a study showed that craftsmen, tradesmen and firms managers makes significantly more trips than other categories because of more work trips to regular workplace and also more business trips (Aguilera et al, 2011).

In the global south where there is a high prevalence of poverty and an unequal distribution of wealth leads to difficulties with regards to transport accessibility for a large percentage of the urban population (Starkey & Hine, 2014). The provision of safe, accessible, and affordable public transport infrastructure is a fundamental prerequisite for the socio-economic advancement of the South African population (Thomas, 2016). A study looking at public transport patterns in Johannesburg and Pretoria showed that black people are the race group that is most dependant on public transportation for travelling to work purposes, this limits their mobility and this results in them having a higher percentage of people working within their municipalities, while white people usually rely more on private car use and can travel between Johannesburg and Pretoria daily for work purposes, they travel

from Pretoria to places like Sandton, Randburg, Honeydew and Johannesburg central (Simpson et al, 2011).

3. CHAPTER 3: METHODOLOGY

This section provides the methodology, which was used in order to ensure that an accurate collection of data took place and to guide an appropriate analysis of the data. The aim of this study was to firstly analyse the modal usage for public transport for work travel in Johannesburg and Cape Town, secondly the demographic profile of people who use public transport to travel to work in Johannesburg and Cape Town, thirdly the modal attributes of the public transport modes used in this study in Johannesburg and in Cape Town, and fourthly the way in that these different influence decisions to the mode of public transport compared to using private cars.

3.1. Description of the study

The specific aims of the study are to establish the relationship between the socio-demographic and socio-economic characteristics of workers using public transport and the modal characteristics of the different modes of public transport used in this study, with public transport patterns and behaviour of workers. The second objective is to discover the impact of each of the individual factors on workers' public transport travel behaviours and patterns. The study will also attempt to determine which factors have a greater degree of influence than the other.

The first section of the analysis will use descriptive statistics to look at the differences in modal usages for work trips and compare the differences between the modes, and also analyse the similarities and differences between the two cities used in the study. Secondly, the analysis looked at the relationship between socio-economic and socio-demographic characteristics of workers using public transport. This section of the analysis specifically looks at the characteristics of gender, population group (race), total salary (monthly salary) and disabilities. Descriptive statistics were used to analyse the socio-demographic profile of each mode according to the variables used in this section of the analysis. This shines a light on which demographics gravitate towards which mode, and which mode is inaccessible to which demographic.

The third part of the analysis looked at the influence of modal characteristics on work travel patterns and behaviour. This was achieved by specifically analysing the modal characteristics such as travel time, travel costs, time spent walking to stop\station and time spent waiting for transport. This will analyse the characteristics of each mode using the variables used for this study, descriptive statistics will show the characteristics of each mode and this will shed light on where each mode has to improve on which regard. The last section of the analysis will use a Multinomial Logit Regression Model to look at the varying degrees in which each of the factors used on this study influence workers travel patterns modal usage, and to see which factors between modal and social characteristics have a larger influence in modal choice.

3.2. Data Sources

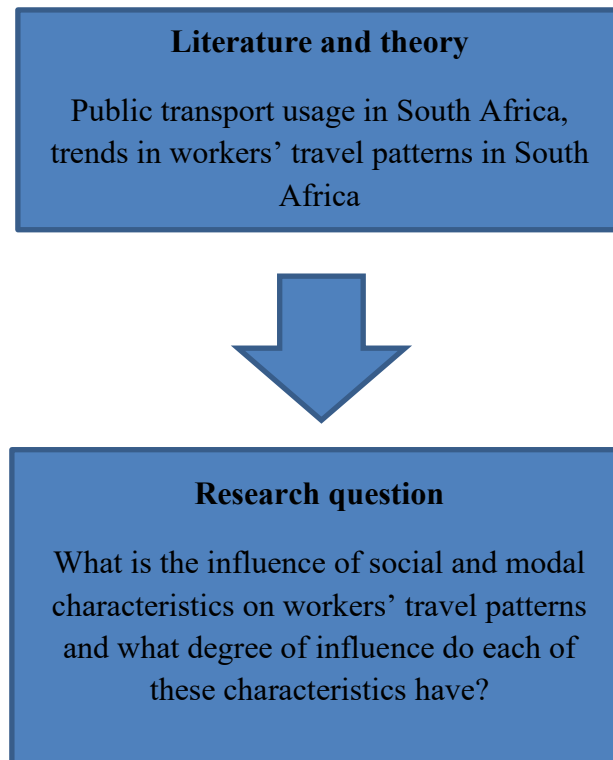
The data was acquired through a secondary source, the 2013 National Household Travel Survey (NHTS). For the purposes of this study, data from the metropolitan municipalities of Cape Town and Johannesburg (analysed at the municipal level) were used for analysis and comparison. The study sample in Johannesburg included 7103 participants and in Cape Town it included 6424 participants. The most common advantage, which is associated with the use of secondary data, is the fact that it is highly cost-effective. This is a major advantage, which is linked to the use of secondary data (Creswell, 2013). This is because another party has collected the data and as a result, the researcher generally does not have to invest time, effort or money when it comes to the collection of any kind of data.

3.3. Research design

The research design can be defined as the framework of techniques and methods that a researcher selects to combine different elements of a study in a reasonably logical manner with the aim of making sure that the research problem is handled in a manner that is efficient (Mendlinger & Cwikel, 2008; Schoonenboom, 2016). The objective of this research is to analyse the influence social and modal characteristics on workers modal choice of public transport.

This paper achieves this objective through a series of stages, the first process involves studying previous literature and identifies the gap in theory about studies looking specifically on social and modal characteristics and their individual and combined influence on workers modal choice. Secondly, the secondary data is obtained on the 2013 StasSA NHTS database to specifically look at

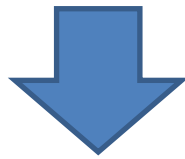
Johannesburg and Cape Town. The third stage is the first part of the analysis which uses descriptive statistics to look at differences in modal choices of workers and also descriptive stats that analyse social characteristics of the modal choice of workers. The fourth stage is the MLM analysis used to determine the degree of influence each of the factors have on workers modal choice. The fifth stage discusses the results and their practical implications. The final stage is the conclusion which gives closing remarks on the study.





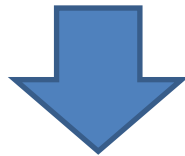
Secondary data

Obtain NHTS 2013 survey from StatsSA website



Descriptive statistics

Descriptive stats will be used to analyse the effects that social and modal characteristics have on workers public transport modal choice



Multinomial Logistic Regression Model

This will be run to determine the varying degrees of influence each of the characteristics has on workers' public transport modal choice



Results

Discussion of the findings and their practical implications

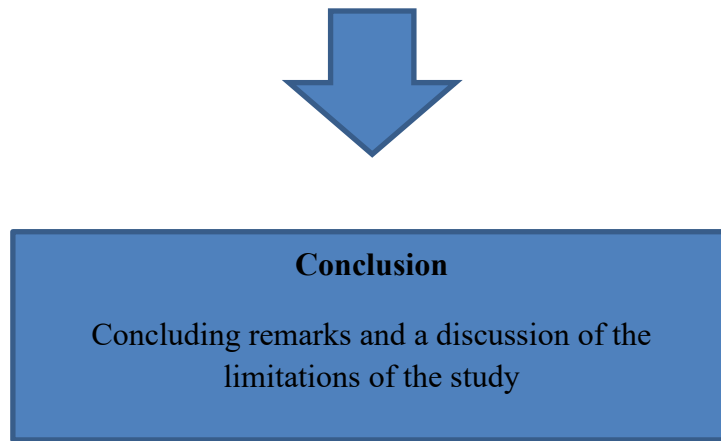


Figure 1: Stages in the research design

3.4. Previous studies related to this topic

A research paper looking at public transportation in Kathmandu Metropolitan City, located in Nepal which is a bussing city with increased levels of economic activities reveals that socio-demographic characteristics are important influences workers modal choice. The study looked at travel behaviour of employees in that region and its relationship with four variables of socio-demographic background such as gender, age, and income group and vehicle ownership. Descriptive analysis and inferential statistical analysis were conducted and revealed that the role of socio-demographic variables on travel behaviour is quite significant in many aspects on choice of travel mode and trip length of the employees (Bajracharya & Shrestha, 2017).

In South Africa, a study looking at socio-demographic and socio-economic factors affecting modal choice in the Gauteng cities of Johannesburg and Pretoria revealed that minibus taxis were the most popular mode of public transport, while private cars remained the most popular mode for higher income groups and white people. The study revealed socio-demographic factors such as gender play a role because the study revealed that women generally take taxis as opposed to buses and trains, and that black people had least percentage of driving licences and were the population group most dependable on public transport (Creighton 2015).

A study looking at the transportation needs of the informal settlements located in Cape Town found that modal characteristics such as walking safety, personal safety, unsafe driving, overcrowding and walking distance were the 5 main concerns of the participants involved in their study. There was also not much variances between different socio-demographic groups such as men and women, but rather differences were noted between different locations and across different mode uses. Thus, the study

concluded that modal characteristics have a higher degree of influence rather than the socio-demographic characteristics of the passengers (Teffo et al, 2019).

These papers are related to this study because like this study they are all analysing factors that influence modal choice, while the first two look at social characteristics, the latter study concentrated on modal characteristics. This study will consider both sets of variables and use them both in this single study.

3.5. Motivations for doing this study

Much of the literature that looks at influences on modal choice usually looks at social characteristics exclusively or modal characteristics exclusively. There is a gap in the literature on how these two different sets of influences may influence each other and how they influence public transport relative to each other. This kind of research could be instrumental in understanding public transportation patterns and behaviours and lead to better planning and development of the public transportation system in South Africa.

This study takes into account socio-demographic and socio-economic influences, this is especially relevant in the context of South Africa where inequality levels are one of the highest in the world, and transport needs vary across different classes, genders and races. It is important to understand this so that public transport can be made more accessible to marginalised groups and so that transport planners should know the specific transportation needs of different social groups.

Modal characteristics are also very important to understand, because of the poor provision of public transport in South Africa. All of the modes that are used in this study have positive and negative modal characteristics that act as push and pull factors when passengers are deciding on modal choice.

3.6. Study areas

The study areas used for this study are the biggest metropolitan cities found in South Africa, namely Johannesburg and Cape Town. These two cities have very large populations living in them and the large majority of those rely on public transport, public transport improvements in these two cities would have positive effects for the whole of South Africa.

3.6.1. Cape Town

The city of Cape Town is a metropolitan municipality with the size of approximately 2461km² and a total population of 4.52 million people, making it the second biggest city in South Africa. The city has a population density of 1,530 people per square km (World Population Review, 2019).

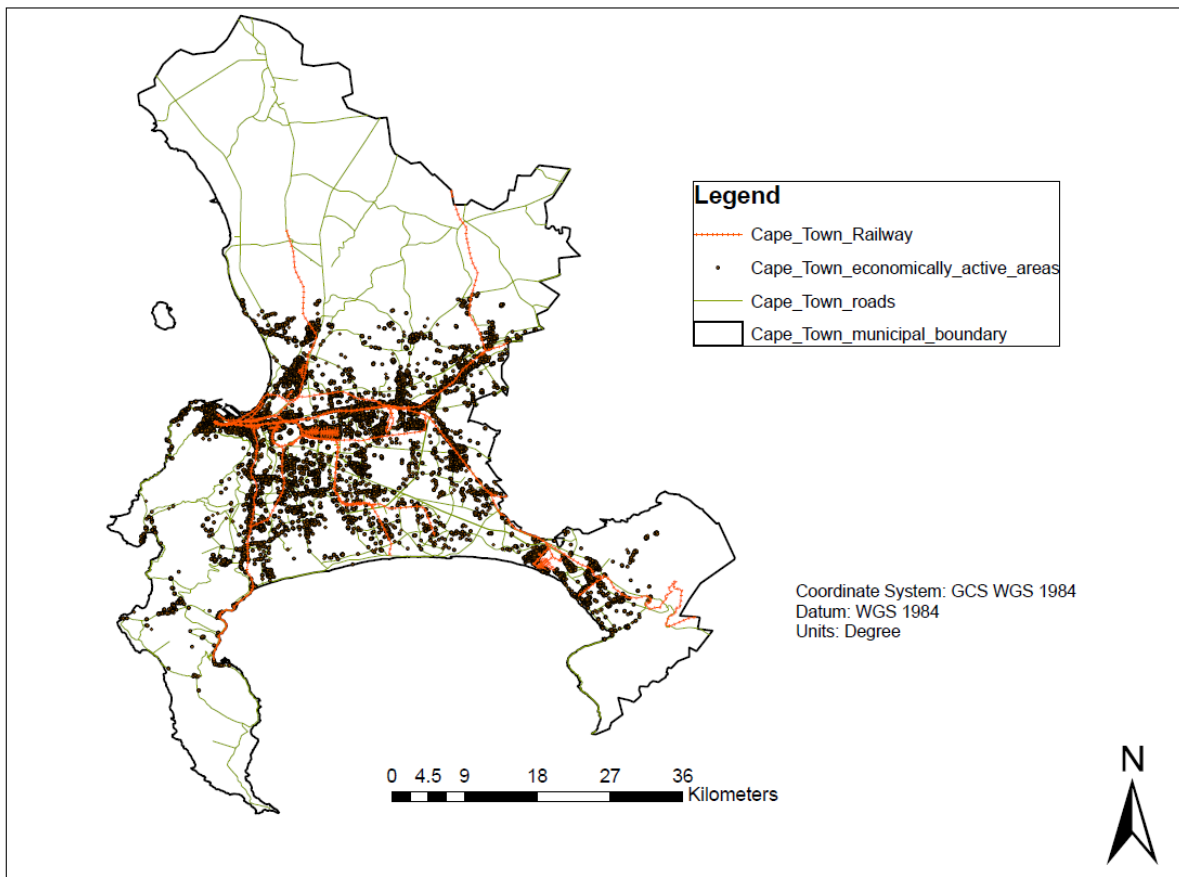


Figure 2: Map showing transport routes and economic nodes in the city of Cape Town

3.6.2. Johannesburg

The city of Johannesburg is the biggest in terms of population and the most economically vibrant city in South Africa contributing more than 20% of the country's GDP. It is located in the Gauteng province and has a total surface area of 2 300km² with a population of 5.64 million people. The population density of the city is 2,900 people per square km (World Population Review, 2019).

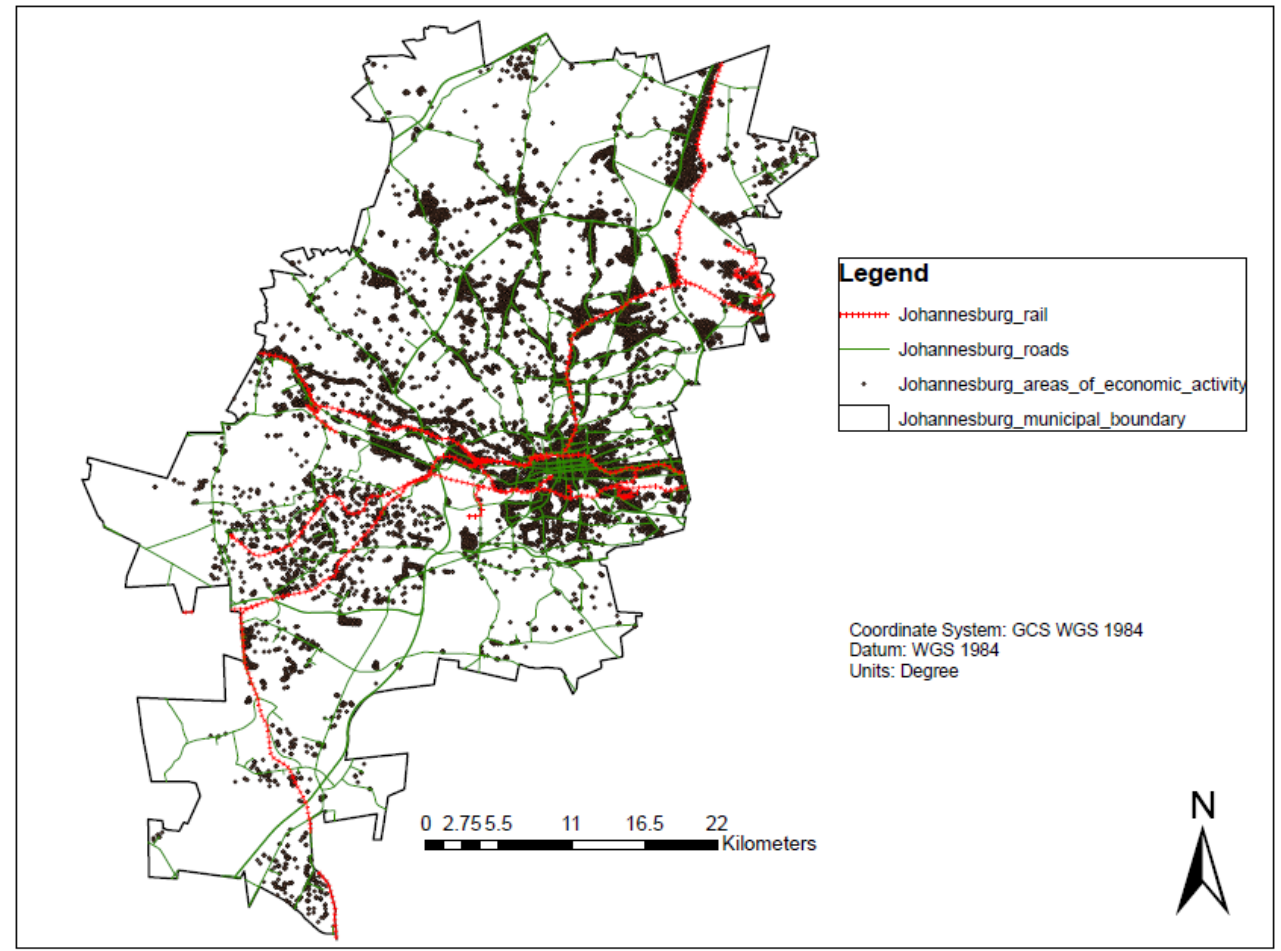


Figure 3: Map showing transport routes and economic nodes in the city of Johannesburg.

3.7. Variables used in the study

The dependent variables that will be used in this study are the public transport modes such as buses, minibus taxis and trains. The reason for using these modes for this study is that these are the three most popularly used modes of public transport in South Africa (NHTS, 2013).

Table 1: Main mode to place of employment

<u>Main mode to place of employment</u> <u>(dependent variables)</u>
Train
Bus
Taxi

The independent variables that were used for this study came in two different sets of variables. The first includes the social characteristics of the population and the second set of variables are modal characteristics of public transportation users. These two sets are analysed independently for the first part of the analysis:

Table 2: Independent variable indicating the social characteristics of the population.

Social Factors	Categories	Reasons for inclusion in the study
Gender	Male Female	To determine the relationship between gender and modal choice by analysing which genders use which mode (Buehler 2011).
Population status	African Coloured Indian White	To determine if there has been any changes in racial spatial and transport patterns in the post-apartheid era (Simpson et al 2014)
Total income	R0-R5000 R5001-R10 000 R10 001-R15 000 R15 001-R20 000 R20 001-R25 000 R25 001+	To look at the differences in modes of transport used by the different income groups and to see which groups are more reliant on public transport

Table 3: Independent variable indicating the modal characteristics of public transportation users.

Modal characteristics (independent variables)	Categories	Reasons for inclusion in the study
Travel time	0-20 minutes 21-40 minutes 61-80 minutes 81-100 minutes 101-120 minutes 120 minutes and higher	To determine the differences in travel times between the modes used in this study (Russell, 2012), this was also included as one of the factors most important in influencing modal choice (NHTS,2013)
Walking time to stop/station	0-5 minutes 6-10 minutes 11-15 minutes 16-20 minutes 21-25 minutes 26-30 minutes 31-35 minutes	To determine which is the furthest mode to access by walking. This category can also form part of accessibility which was named as one of the four important factors influencing modal choice (NHTS,2013)

	36-40 minutes 41 minutes and higher	
Waiting time for mode	0-3 minutes 4-6 minutes 7-9 minutes 10-12 minutes 13-15 minutes 16-18 minutes 19-21 minutes 22-24 minutes 25 minutes and higher	To determine which mode has the shortest waiting time.

3.8. Analysis process

The first part of the analysis uses descriptive statistics to look at the social characteristics of the people using public transport in Johannesburg and Cape Town, using bar graphs to firstly look at the modal usage difference in the study areas for workers. Secondly, this section analyses the socio-demographic and socio-economic profile of workers using public transport and thirdly to look at differences in modal attributes and characteristics. The advantage of using descriptive statistics is that they visualise the data and make it easy for most people to see patterns and interpret the findings. With graphically represented data it is very easy for humans to distinguish patterns and relationships between variables. This makes it perfectly suited for the first section of the analysis which strictly deals with looking for patterns and relationships.

The second part uses a multinomial logistic regression model (MLM) to analyse the relationship between the main mode of transport to employment (dependent variable) with social factors and modal characteristics (independent variables) to look at which mode of transport might be picked for work transport and which factors affect this choice more than others. The motivation for using a MLM is that it is used for the specific purpose of predicting categorical placement in or the probability of category membership on a dependent variable based on multiple independent variables (Starkweather & Moske, 2011). This makes it ideal for this kind of study where we are trying to determine the degree of influence of each independent variable on mode of transport (buses, taxis and trains). Another advantage of using MLM is that it is able to model the relationship of multinomial responses with their explanatory variables, analyse association and estimate log-odds (Gikoyo, 2013).

The MLM has a dependent variable (Main mode to place of employment) which consists of 3 categories (trains, buses and taxis) in this formula will be Y and there are eight independent variables which consist of social characteristics and modal characteristics variables.

The general MLM thus uses the following formula (1):

$$Y = \beta_0 + \beta_1x_1 + \beta_2x_2 + \dots + \beta_n x_n + \varepsilon$$

With $\beta_0 = \text{constant}$ and, $\beta_i =$ coefficient for x_i while the response Y in formula (1) is as follows:

$Y =$

- 1 if the transportation mode is a train
- 2 if the transportation mode is a bus
- 3 if the transportation mode is a taxi

The final MLMs for the cities of Johannesburg and Cape Town will use the following formula (2)

$$Y = \beta_0 + \beta_1x_{\text{gender}} + \beta_2x_{\text{population group}} + \beta_3x_{\text{total salary}} + \beta_4x_{\text{disability}} + \beta_5x_{\text{travel time}} \\ + \beta_6x_{\text{travel costs}} + \beta_7x_{\text{walking time to the station}} + \beta_8x_{\text{waiting time for mode}} + \varepsilon$$

4. CHAPTER 4: DATA ANALYSIS

The first objective of the analysis is to look and analyse the differences in modal usages of public transport for workers, this will be done by using histograms to show the modal split of workers in percentages. Secondly is to look at the socio-demographic and socio-economic characteristics of public transport users by using bar graphs. The third objective is to look and compare the modal

characteristics of the different modes by graphically displaying the data. The last section of the analysis will use the MLM to determine the degree of influence of each variable used in the study.

4.1. Modal usage for work trips

The results for modal usage reflected that the train was the most popular public mode of transport for work trips in Cape Town, and closely followed by the minibus taxi. Bus transport was the least used mode. In Johannesburg almost 80% of work trips are undertaken by minibus taxis, with the train taking second place just over 15% and the bus following closely but being the least used mode of transport for work trips. The low percentages for buses and trains in Johannesburg could be a result of limited accessibility to bus stops and train stations (Simpson et al. 2014). The main difference between Johannesburg and Cape Town is the high percentage of people travelling by train to work in Cape Town. This confirms a study that found that in all major metropolitan areas of South Africa, the modal share of minibus taxis has increased compared to other modes of public transport, with Cape Town being the exception and transport by train being the most popular mode of public transport in the city (Lombard, 2007). This study is also consistent with findings of a study that found a 5% increase in taxi usage between the NHTS of 2003 and 2013 in Pretoria (Creighton, 2015).

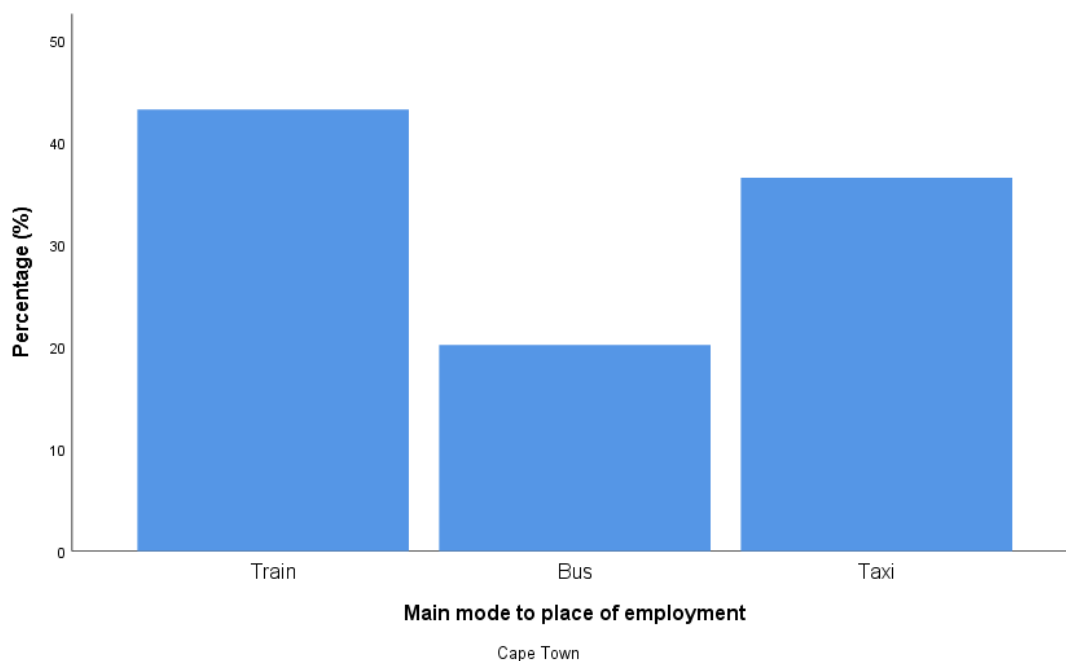


Figure 4: Modal share for work trips in Cape Town (NHTS, 2013)

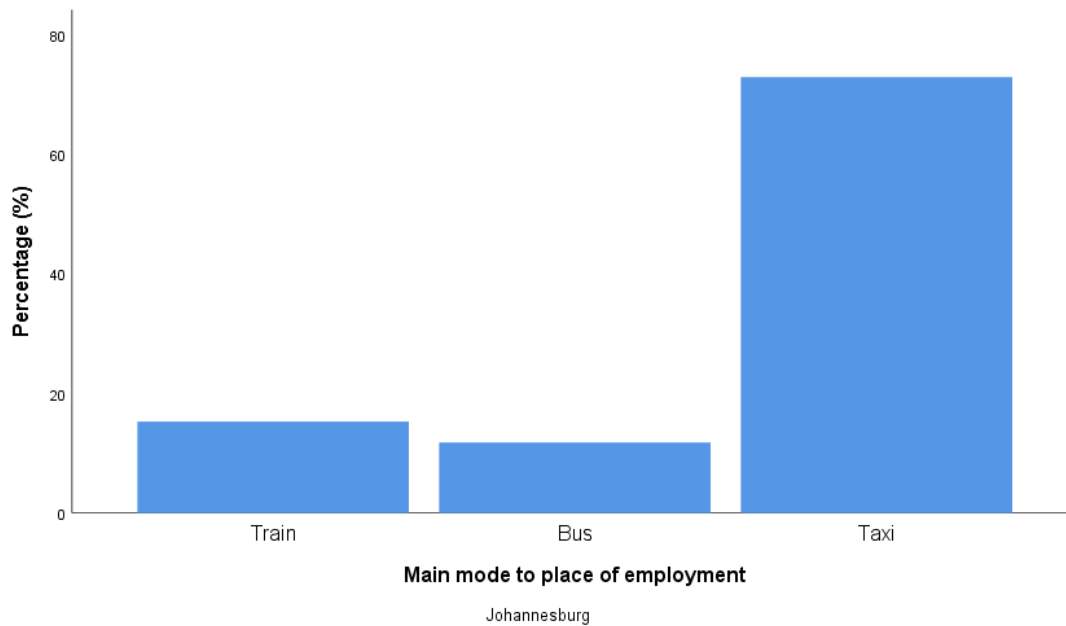


Figure 5: Modal share for work trips in Johannesburg (NHTS, 2013)

4.2. Social Characteristics of workers

4.2.1. Gender

The gender profiles in public modal usage are quite different between the two cities. The data shows that males and females have almost equal shares in train commuting in Cape Town but female usage of buses and taxis is far higher than that of males. In Johannesburg the gender differences in train usage are big with the composition of users being 70% male and 30% female. This is in contrast to bus usage where women make up almost 70% of users and men making up 30%. This reason why women generally prefer buses is because of the safety factor. Buses are regarded as one of the safer options of public transport in South Africa (CSIR, 2007). The data clear shows that women are more inclined to using taxis and buses for travelling to work than men in both cities, even though in Cape Town train usage is almost equal between the genders for work travel.

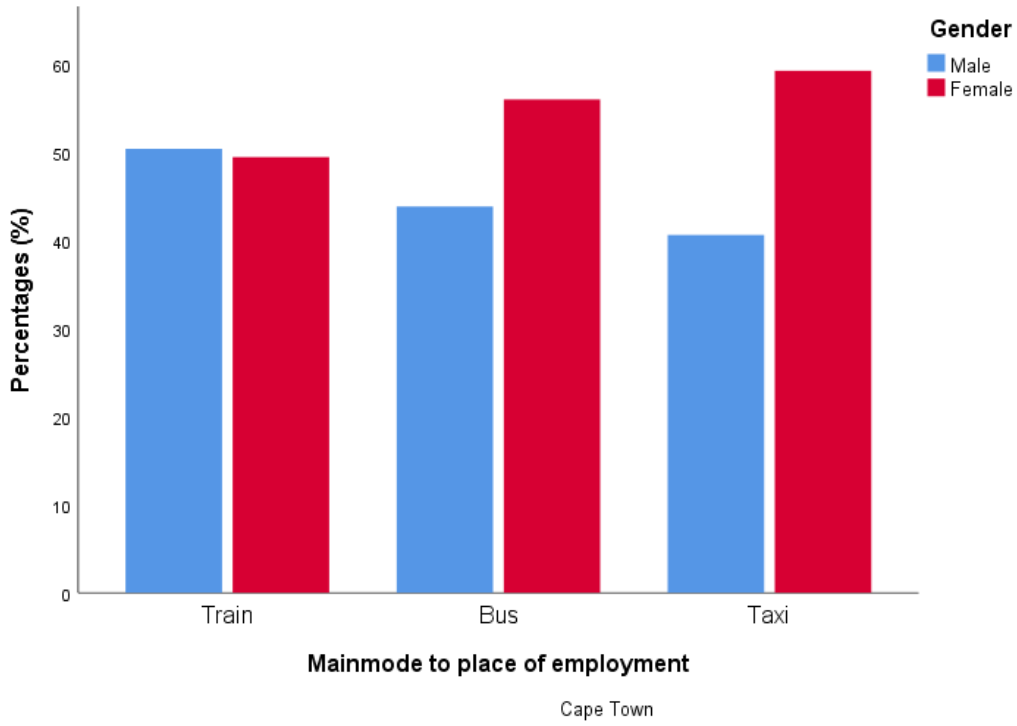


Figure 6: Modal Share of different modes for the different genders travelling to work in Cape Town (NHTS, 2013)

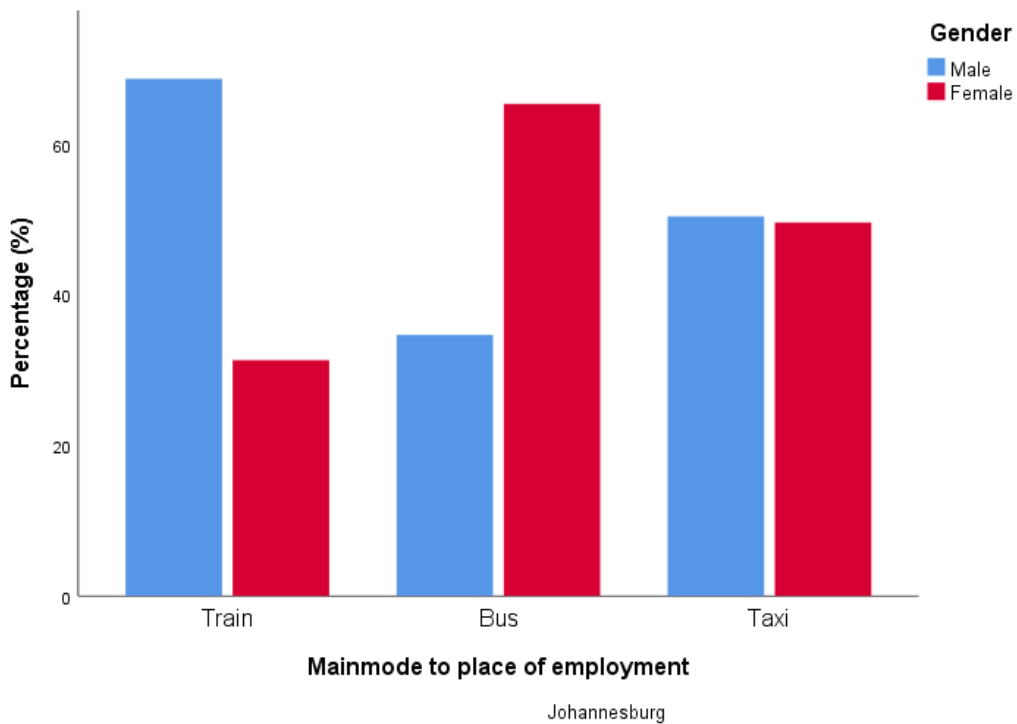


Figure 7: Modal Share of different modes for the different genders travelling to work in Cape Town (NHTS, 2013)

4.2.2. Population group

The differences between population groups reflect the racially segregated history of South African cities. In Cape Town, all the public transportation modes are almost exclusively used by black and coloured populations only. While the data shows that trains and taxis are used almost equally by coloured and black people, coloured use buses more than black people, and while their usage of trains is really low, this is the mode of public transportation that white populations prefer in the city of Cape Town. In Johannesburg public transportation is mostly used by just black people, black people as a race constitute no less than 94% of the usage population for all the three modes of transport. This is consistent with the study that found that people of colour (especially coloureds and blacks) are more dependent on public transport for work and non-work trips, while white people mostly use private cars (Creighton, 2016; Simpson et al, 2011; Nurdden, Rahmat & Ismail 2007).

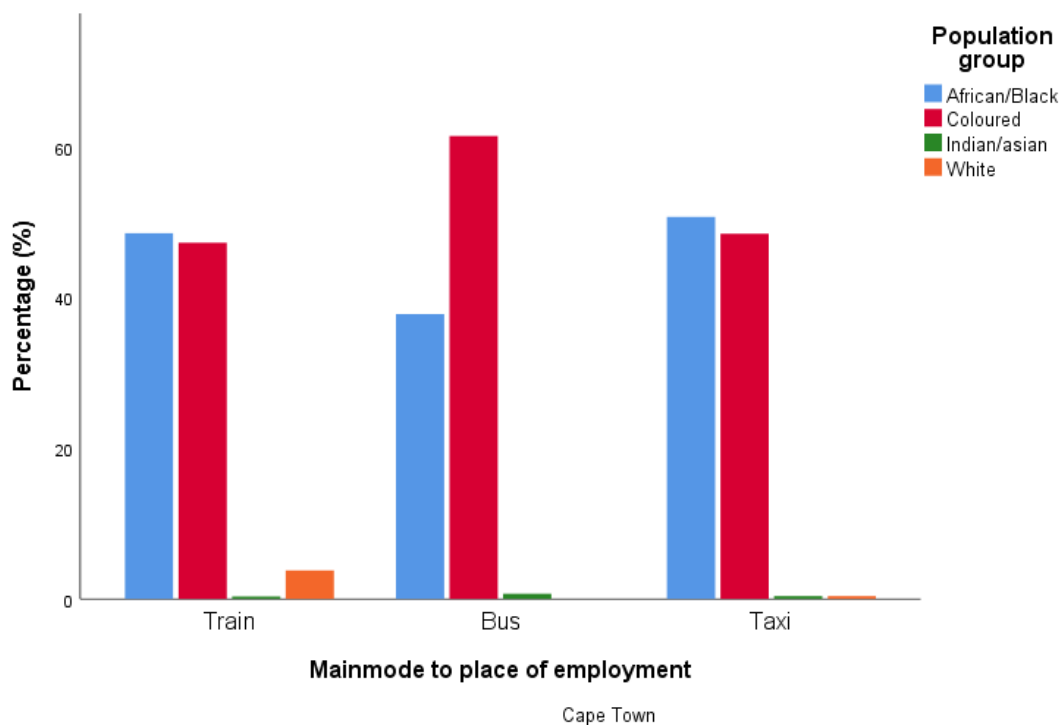


Figure 8: Modal share between the different races travelling to work using public transport in Cape Town (NHTS, 2013)

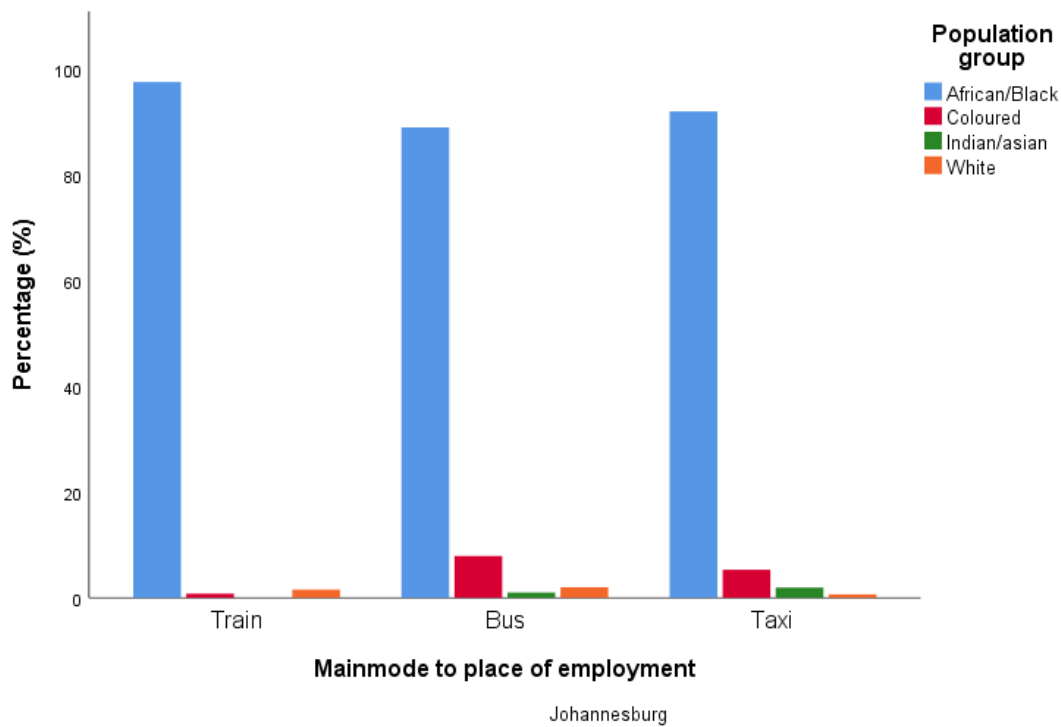


Figure 9: Modal share between the different races travelling to work using public transport in Johannesburg (NHTS, 2013)

4.3.3. Monthly income

Monthly income showed the reality of public transport in South Africa, in that it is the urban poor who are more dependent on public transport while those who can afford to buy their own cars usually travel by this mode when they are going to work. That revealed that for both cities most users of public transport are people earning below R5000 a month, whilst persons earning between R5000 and R10 000 were the second highest salary group using public transport, and the general trend was that it gets less and less as you move up the salary category.

The statistics were consistent for both cities, and prove that the poorer you are, the higher the chances of depending on public transport. The trend was that from the income bracket of R10 000 to R15 000 there was a drastic reduction in the people using public transport. This confirms that showed that poor people are the most dependent on public transport (Simpson et al, 2011; BickFord 2014; Buehler 2011; Hensher 2000). There is also consistency of patterns across all modes in Cape Town.

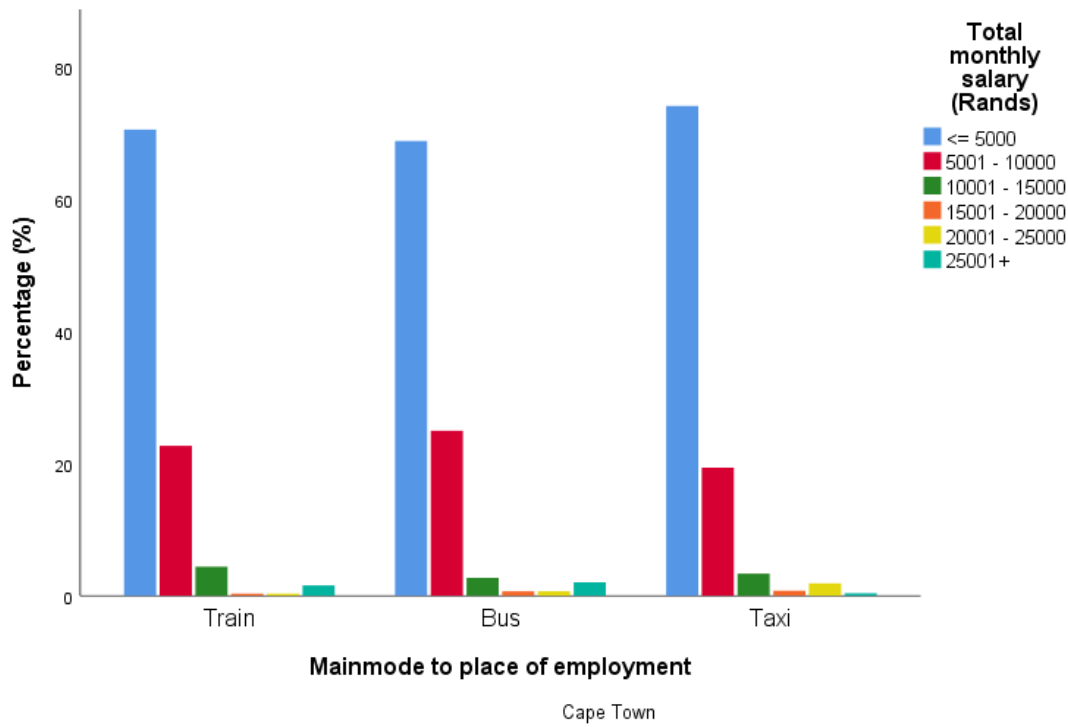


Figure 10: Modal share of different salary groups using public transport for work trips in Cape Town (NHTS, 2013)

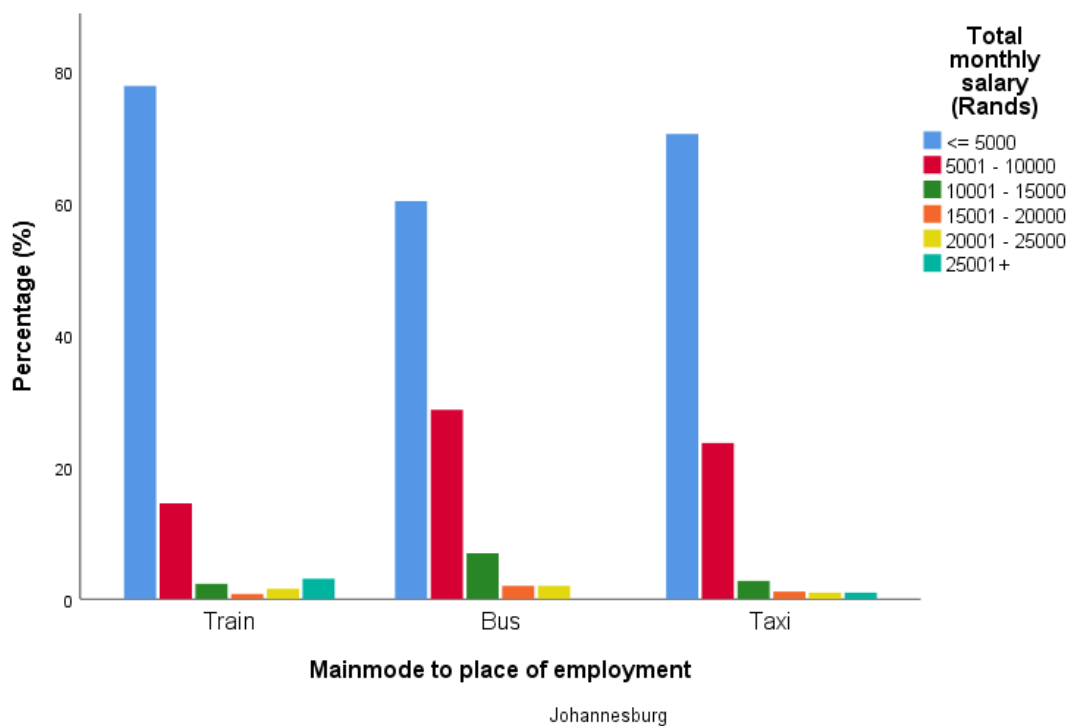


Figure 11: Modal share of different salary groups using public transport for work trips in Johannesburg (NHTS, 2013)

4.3. Modal Characteristics

1.3.1 Travel times

The analysis of travel times reveals that minibus taxis are the most convenient mode of public transport, with more than 40% of workers who travel by minibus taxi taking between 40-60 minutes to get to work in both cities (Van Zyl, 2009). About 80% of the workers who travel by taxi take under 60 minutes to travel to work in both cities, this makes the mode the fastest in the travel time regard, and is one of the reasons why minibus taxis are extremely popular for South African workers (Behrens, 2016; Schalekamp, 2015). The difference in travel time between buses and trains were minimal, indicating that taxis are by far the fastest mode. The main difference between the two cities was that buses and trains were generally slower in Johannesburg than in Cape Town, with workers who take 2 hours or more hours to travel to work making up under 10% for both modes, and in Johannesburg people who take two hours or more using buses and trains make up more than 20%.

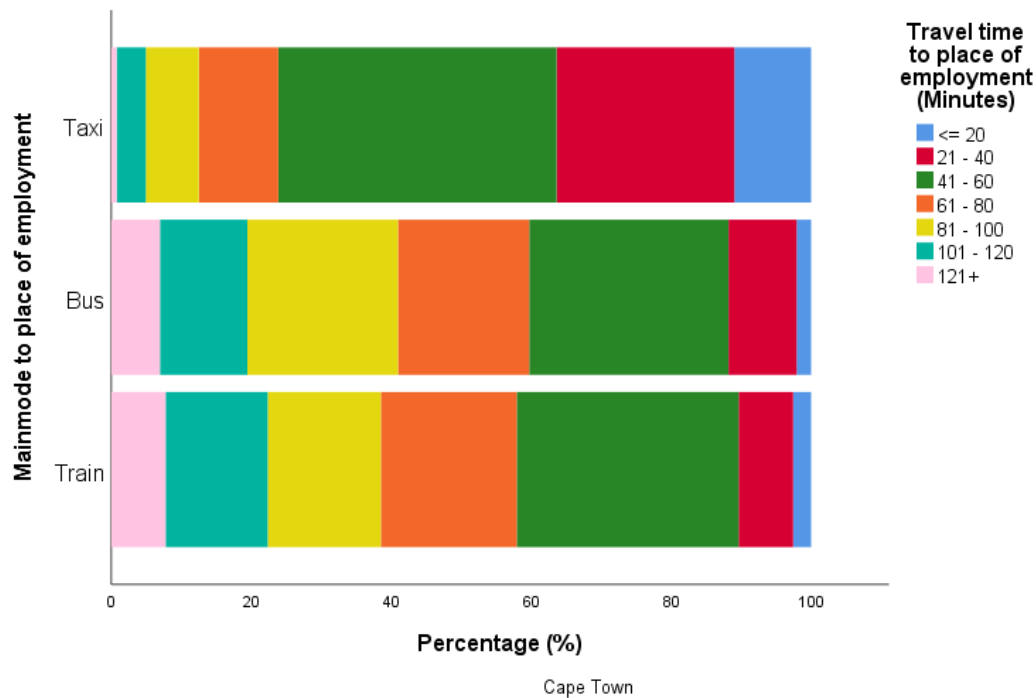


Figure 12: Travelling times for work travel in Cape Town (NHTS, 2013)

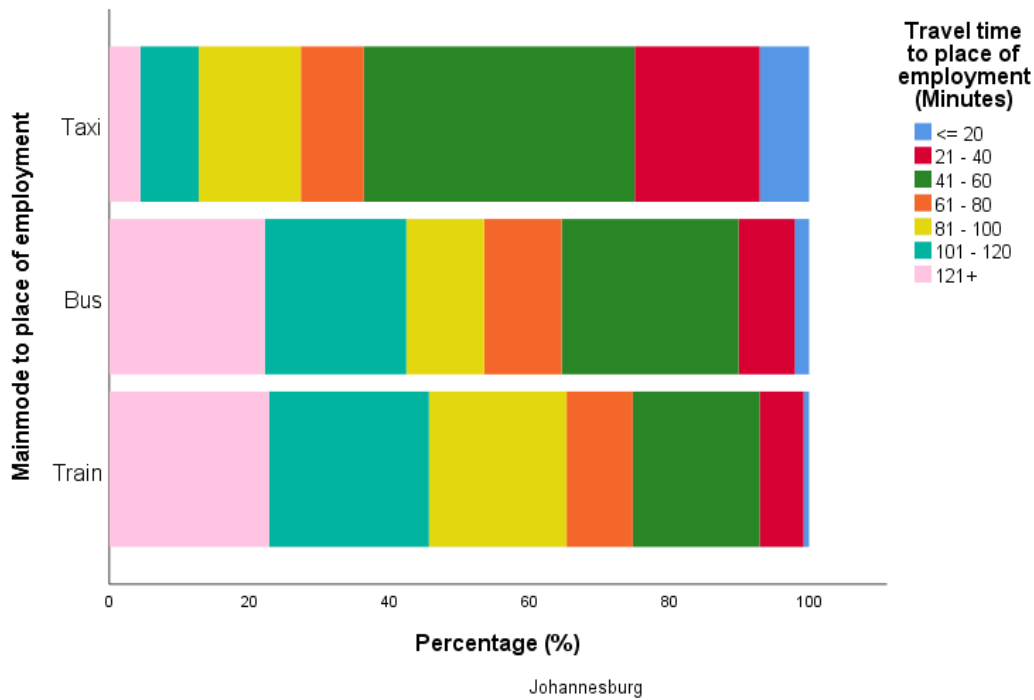


Figure 13: Travelling times for work travel in Johannesburg (NHTS, 2013)

1.3.2 Time taken to walk to nearest station

The data for accessibility by time taken to walk to nearest station and bus/taxi stops revealed that buses were the most accessible mode of public transport in this regard in one of the cities. In Cape Town all participants of the study indicated that they spend less than 5 minutes walking to the bus stop, more than 60% taxis and bus user take 5 minutes or less to get transport, the second highest bracket was people walking for between 6 and 10 minutes. This finding is not consistent with the findings from a study that showed that taxis were the most accessible mode in South Africa (Rodrigue et al, 2006). In Johannesburg the data showed that the most accessible mode in regards to walking to place of access were minibus taxis. Buses came second and the train was the least accessible in Johannesburg, The data for the different modes is in line with findings which suggests that minibus taxis are the most accessible and trains are the least accessible (Woolfe and Joubert, 2013). There is an overall broad similarity in patterns between different modes in JHB compared to completely varying patterns between modes in CPT, the reason for this could be the differences in transport costs and travel times between the two cities.

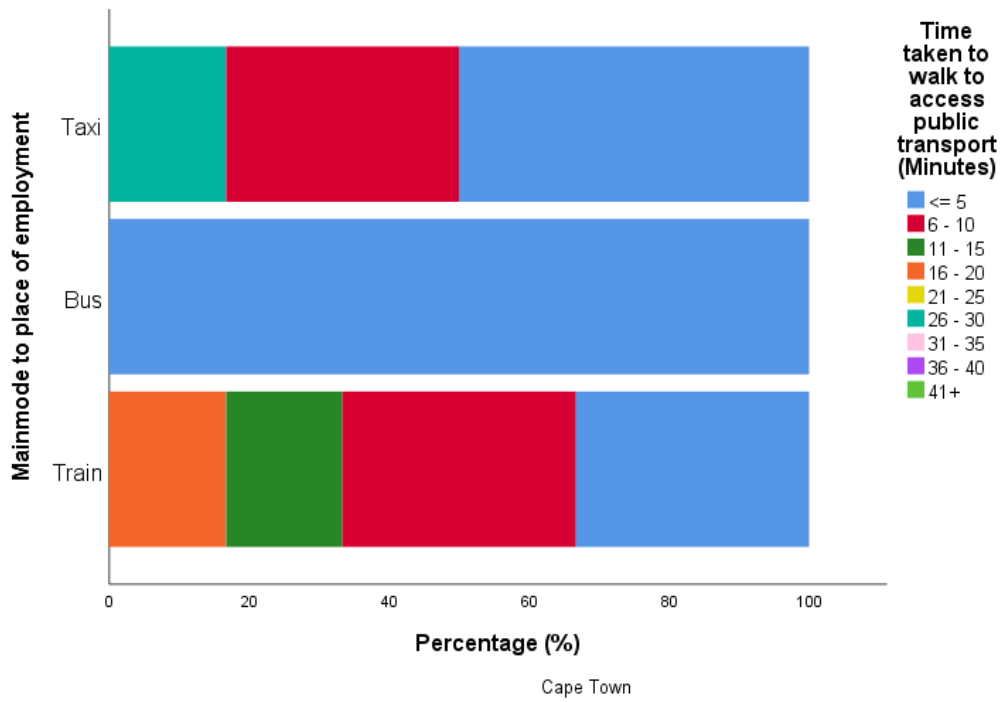


Figure 14: Time taken to walk to access public transport for work trip in Cape Town (NHTS, 2013)

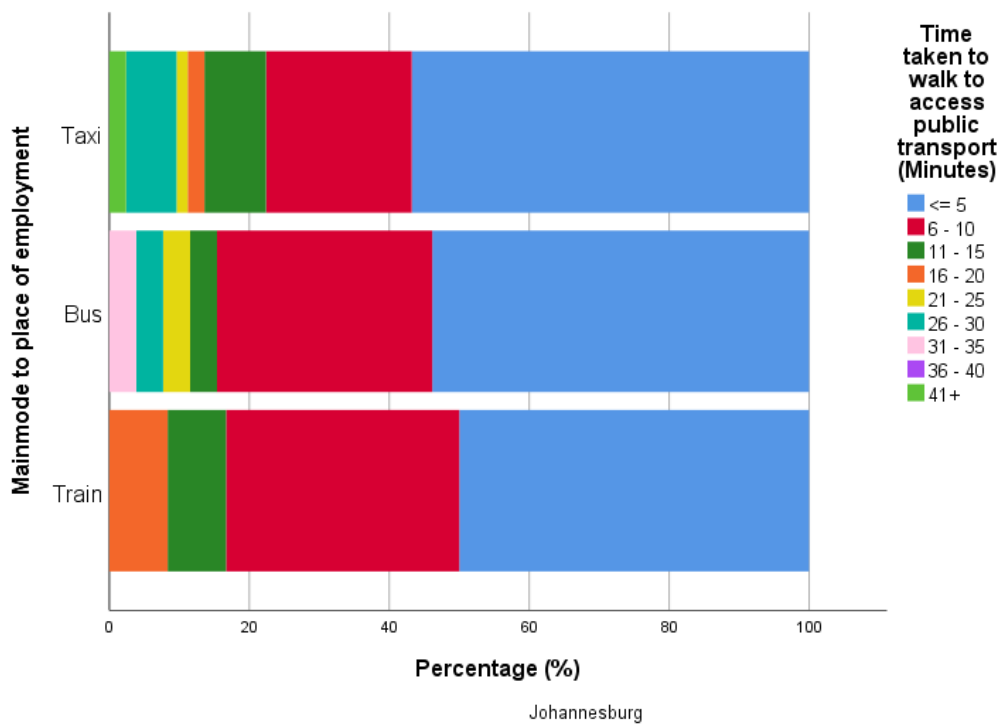


Figure 15: Time taken to walk to access public transport for work trip in Johannesburg (NHTS, 2013)

4.3.3 Time spent waiting for transport

Time spent waiting for transport is a huge factor. Waiting time in Johannesburg looks minimal with all train commuters saying that they all usually have a waiting time of under 3 minutes, with 70% of taxi users indicating the same thing, the bus had the longest waiting time with over 35% of workers indicating that they wait from 19-21 minutes, and the workers of the other modes did not indicate such long waiting times. In Cape Town train commuters had the longest waiting times for passengers travelling to work, with almost 20% of workers indicating that they wait 25 minutes or more. Minibus taxis have the second highest waiting times with almost 30% of passengers travelling to work say their waiting time is between 7 and 10 minutes. The data findings for the two different cities are not consistent with each other, and while bus commuters have the longest waiting time in Johannesburg, it has the shortest waiting time in Cape Town.

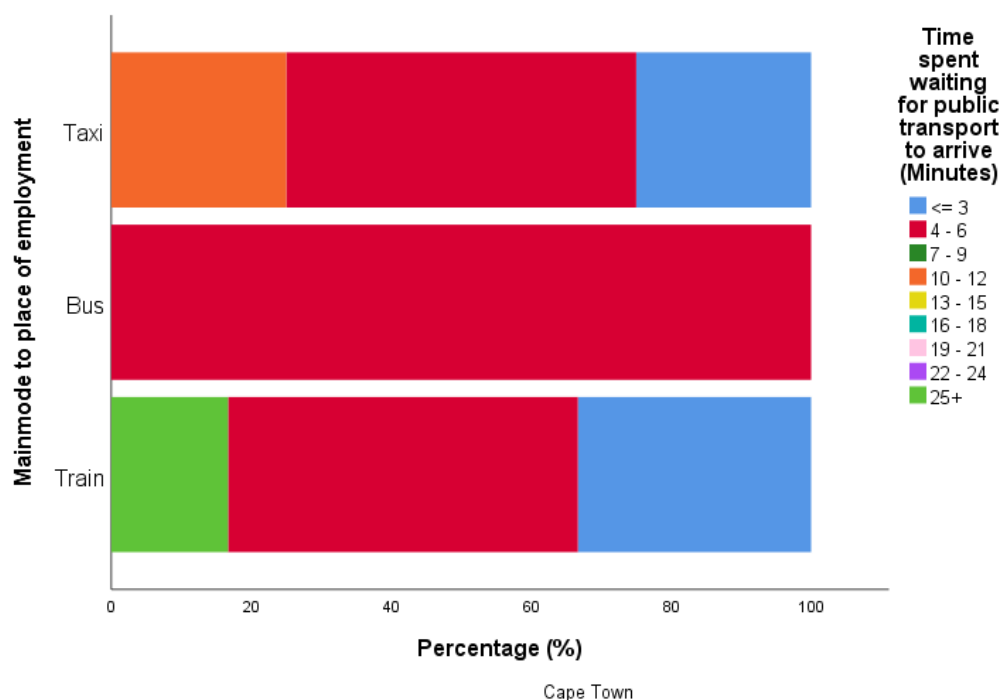


Figure 16: Time spent waiting for public transport for work trip in Cape Town (NHTS, 2013)

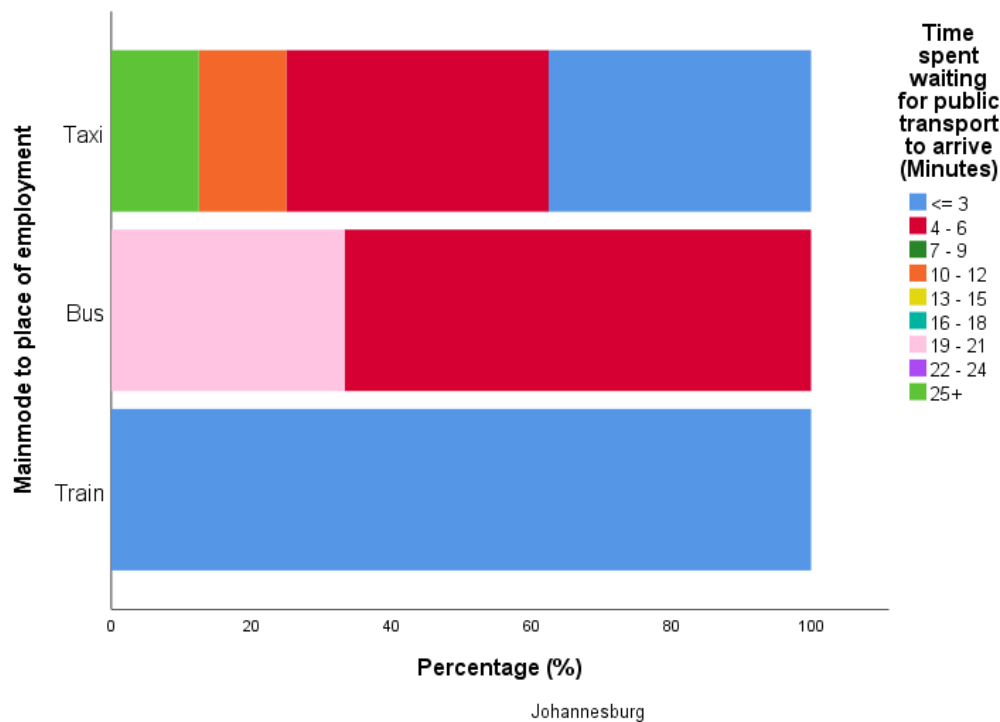


Figure 17: Time spent waiting for public transport for work trip in Johannesburg (NHTS, 2013)

4.5 Social factors and modal characteristics associated with modal choice for work trips

A single Multinomial Logistic Regression model (MLM) was run to see how different factors influence public transport choice for work using data from the metropolitan cities of Cape Town and Johannesburg. The reference category for the model was Car/Bakkie/Truck driver meaning that the modes are compared relative to Car/Bakkie/Truck driver so there will be a train model relative to Car/Bakkie/Truck driver, bus model relative to Car/Bakkie/Truck driver and a taxi model relative to Car/Bakkie/Truck driver. Therefore, since the parameter estimates are relative to the referent group, the standard interpretation of the multinomial logit is that for a unit change in the predictor variable, the logit of outcome m relative to the referent group is expected to change by its respective parameter estimate (which is in log-odds units) given the variables in the model are held constant.

The first part of the MLM looked at the relationship of the dependent variable train and how it is affected by the social characteristics of the passenger and the modal characteristics of the mode. The train is the first dependent variable we will take a look at, and upon first glance it is clearly visible that social characteristics generally play a bigger role when it comes to influencing modal choice, the coefficient of all the social characteristics had a positive coefficient indicating a positive relation between train usage and social characteristics. Population group data showed that blacks and coloureds are way more reliant on public transport with high positive relationships, while Indians showed significantly lower dependence on trains, this is the factor with the most influence with

regards to deciding on the train, race is the biggest factor. Males also showed that they are more likely than females to take the train.

The negative relationship between train usage and total monthly salary indicates that an increase in the workers total monthly salary increases the chances if the worker using a private car (Simpson et al, 2011). Total salary is also important and a coefficient value of indicates that the money you have, the less likely you are to take a train. Minutes spent walking and minutes spent waiting for the train are the least import factors with very small negative values.

The second part of the MLM looked at the relationship of the bus with the independent variables. The results clearly show are consistent with the findings on the train section, because it also revealed that social factors are more influencing choice for and against bus modal choice. The most important factor is race and blacks and coloured showed high positive values showing that they depend more on bus services than Indians and white people. There is also modal consistency with the modal characteristics showing little significance. Minutes spent waiting for transport is the least significant factor when it comes to buses.

The third and final section looked at the relationship between the independent variables and the taxi for work purposes. The taxi data showed that social characteristics are the more import factors with race being the most important factor influencing modal choice. Blacks and coloured showed higher dependence on taxis than Indians and whites. Males had a negative relationship indicating that females are more likely to take a taxi rather than males. Modal characteristics showed little significance and travel time showed the least significance with regards to affecting taxis in modal choice.

Table 4: Factors influencing public transport choice for workers

Main mode to place of employment	B	Std. Error	Wald	Df	Sig.	Exp(B)	95% Confidence Interval for Exp(B)	
							Lower Bound	Upper Bound
Train	Intercept	-.707	.262	7.268	1	.007		
	Total monthly salary	-.041	.000	.001	1	.975	1.000	1.000
	Total time to place of employment	.002	.000	57.897	1	.000	1.002	1.001
	Total cost to place of employment	.000	.000	1602.232	1	.000	1.000	1.000
	[Gender=Male]	.058	.085	.457	1	.499	.944	.799
	[Gender=Female]	0 ^b	.	.	0	.	.	.
	[Population group=Black]	3.247	.249	170.114	1	.000	25.717	15.787

	[Population group=Coloured]	3.692	.266	192.358	1	.000	40.109	23.806	67.579
	[Population group=Indian]	.981	.446	4.838	1	.028	2.668	1.113	6.398
	[Population group=White]	0 ^b	.	.	0	.	.	.	.
Bus	Intercept	-1.012	.305	11.032	1	.001			
	Total monthly salary	-.004	.000	.307	1	.580	1.000	1.000	1.000
	Total time to place of employment	.001	.000	32.724	1	.000	1.001	1.001	1.001
	Total cost to place of employment	.000	.000	2304.425	1	.000	1.000	1.000	1.000
	[Gender=Male]	-.517	.072	52.140	1	.000	.596	.518	.686
	[Gender=Female]	0 ^b	.	.	0	.	.	.	.
	[Population group=Black]	4.646	.298	242.641	1	.000	104.208	58.076	186.982
	[Population group=Coloured]	4.145	.312	177.024	1	.000	63.135	34.282	116.269
	[Population group=Indian]	3.200	.359	79.366	1	.000	24.525	12.131	49.583
	[Population group=White]	0 ^b	.	.	0	.	.	.	.
Taxi	Intercept	-.131	.257	.261	1	.609			
	Total monthly salary	-.006	.000	28.967	1	.000	1.000	1.000	1.000
	Total time to place of employment	.000	.000	1.238	1	.266	1.000	1.000	1.001
	Total cost to place of employment	.007	.000	3557.625	1	.000	1.000	1.000	1.000
	[Gender=Male]	-.640	.068	89.835	1	.000	.527	.462	.602
	[Gender=Female]	0 ^b	.	.	0	.	.	.	.
	[Population group=Black]	5.237	.252	432.190	1	.000	188.050	114.778	308.098
	[Population group=Coloured]	4.491	.266	286.011	1	.000	89.249	53.033	150.198
	[Population group=Indian]	3.883	.307	160.128	1	.000	48.576	26.621	88.640
	[Population group=White]	0 ^b	.	.	0	.	.	.	.

a. The reference category is: Car/Bakkie/Truck/Lorry driver.

The MLM revealed that when it comes to modal choice in South Africa, race is the most significant factor influencing the modal choice of people travelling to work in South Africa.

5. CHAPTER 5: CONCLUSION AND RECOMMENDATIONS

5.1. Conclusion

Previous studies and literature indicated that in South Africa and in other developing and underdeveloped nations, minibus taxis and other forms of paratransit are the most popular form of public transport. This is due to the failure of governments of developing regions to create and maintain adequate and properly functioning formal transportation modes and this has created a gap for local entrepreneurs to provide mobility services for the underserved population especially in metropolitan areas (Schalekamp, 2015; DoT, 2007; Golub 2003; Behrens et al, 2016).

The literature also indicated that, in terms of the sociodemographic and socio-economic profile of persons using public transport in South Africa, most commuters are generally Black and Coloured while White and Indians persons use public transport the least (Simpson et al, 2011). Poor people, with lower education levels are generally more inclined to use public transport to travel to work because middle income people and people who can generally afford to use a car usually just buy a car rather than use public transport (Creighton, 2015; Hensher 2000).

The findings in the descriptive statistics analysing modal usage was consistent with the literature that the minibus taxi is the most popular mode of public transport used by workers in South Africa. This is not the case in Cape Town where trains are more popular than the minibus taxis. Cape Town is an exceptional case compared to the rest of the big cities in South Africa, with an unusually high number of persons who use the trains compared to the rest of the country. In Johannesburg it was the least popular mode, which was a contrast to Cape Town, but the usage levels were almost the same between the two modes.

The descriptive statistics looking at the social characteristics of people using public transport revealed that black persons and other people of color, and low income persons working low paying jobs were

more likely to use public transport. White persons and the middle to upper class prefer using their private cars over using public transport, this is consistent with the literature which was looked at in this study. The study also revealed that women generally prefer taxis and buses over taking the train to work, and that the percentage of disabled persons using public transport is very low. The modal attributes which were analysed using descriptive statistics revealed that minibus taxis have the fastest travel times, followed by buses and then trains, although the difference was minimal.

In conclusion the study revealed that social demographic and socio-economic factors of workers showed more influence on public transport choice for going to work compared to modal attributes of the different modes, they showed higher degrees of influence on modal choice. Races was shown to be the most important factor, with South Africa's racial history this comes as no surprise that even the transport sector is still affected by this after 25 years of democracy.

5.2 Limitations of the study

The section on travel costs did not have enough data to explore how distance and other factors might affect the cost of the different public transport modes. This makes the information on this topic incomplete and that this research only managed to get a shallow grasp of this topic.

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