ACCESSIBILITY OF PUBLIC TRANSPORT - WITH FOCUS ON ACCESS, EGRESS AND THE LINE HAUL TRAVEL TIME

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ABSTRACT

Equity in access to opportunities is increasingly recognised as an essential component of sustainable development and transport. In South Africa most commuters live far from their workplaces, which makes their travel expensive with most spending 15 to 30% of their disposal income on transport (NHTS, 2013). These low income transport users are subjected to ever-increasing fares and long commuting hours using public transport.

Public transport as primary line haul mode, with walking and cycling as feeder and distributor play a prominent role in sustainable urban mobility. The study seeks to measure the level of public transport accessibility for commuters and focus on access and egress within the metropolitan areas. In order to prepare for the research, a review analysis of the National House Travel Survey 2013 was undertaken through the use of SPSS statistical analysis software.

The reality remains that the working population still travel long distances to their workplaces and spend much of their disposable income on transport. On average metropolitan working population spends 55 minutes per trip commuting to work, this includes access, egress, waiting and line haul time. The results show that train users spend more time travelling than any of the other modes.

1. INTRODUCTION

Equity in access to opportunities is increasingly recognised as an essential component of sustainable development and transport. Transportation equity affects residents' economic as well as social opportunities (Saghapour et al. 2016; Cheng and Bertolini, 2013). Equity is referred as the distribution of impacts (benefits and costs) which are considered to be fair and appropriate (Litman, 2018). Transport equity refers to the shifting of institutional practices, policies and investments, and bureaucratic decision-making to benefit historically under-resourced communities who have been shut out of transportation decisions in the past. This includes: equitable access to safe, reliable, and affordable transportation options, and employment, services, etc. (Guevarra, 2016).

The White Paper on Transport Policy (1996) advocates for a safe, reliable and integrated public transport system and to make public transport competitive with the private car in order to provide a viable alternative mode. In South Africa most commuters live far from their workplaces, which makes their travel expensive with most spending 15 to 30% of their disposal income on transport (NHTS, 2013).

About 62.3% of households in South Africa fall within the poorest income bracket, below R86 000 per annum (Ismail, Mkhwanazi and Silberman, 2016). These low income transport users are subjected to ever-increasing fares and long public transport commuting hours. The Gauteng Province National House Travel Survey 2014 has also highlighted that as a result of ever-increasing fares, the proportion of household income spent on public transport increased significantly (GPDRT, 2016). Long commute times and transport costs inhibit these class of workers from fully participating in the economic, social and family maintenance activities as they spend a larger fraction of their incomes and time getting to and from work. Less time and income is therefore available to spend on child caring, home maintenance and general social activities. Most households identified travel time and cost of travel as the biggest determinants of modal choice (NHTS, 2013).

Access and egress stages (together with wait and transfer times) are the weakest part of a multimodal public transport chain and their contribution to the total travel disutility is often substantial (Krygsman, et al. 2004; Bovy and Jansen, 1979; The Central Transportation Planning Staff, 1997). Not only do people spend a lot of time on transport, but the disutility of the various time elements aggravates.

This paper presents a review of previous research in this area and seeks to measure the level of public transport accessibility with a focus on the access and egress. The study qualify and quantify access and egress time for public transport commuting as well as measure out-of-vehicle and in-vehicle-time for public transport. Section 2 introduces the methodology used to reach to the findings in the paper. A literature review from the previous studies is presented in Section 3. Section 4 discusses the results and findings, Conclusion is presented in Section 5.

2. RESEARCH METHODOLOGY

2.1. Data analysis approach

The data from the National House Travel Survey (NHTS, 2013) was used to analyse public transport accessibility. The NHTS is a sample household travel survey first conducted in 2003 and the second survey in 2013 by Statistics South Africa (Stats SA). The aim of the NHTS is to gain strategic insight into the travel patterns and transport problems in the country, and the collected information will serve as the basis for Department of Transport (DoT) research, planning and policy formulation. The data is chosen because it is a representation of South Africa's travel patterns. The total surveyed population of the NHTS was 157 253 participants. The study used the subset of the data which is on the working population both formal and informal sectors. Descriptive statistics were conducted to characterise the data as mentioned in the methodology. Only 40 820 (37%) of the surveyed participants indicated to be employed, the rest of the participants were either unemployed or in school. All missing cases were excluded from the analyses of this study.

A comparison of public transport "in-vehicle-time" and "out-of-vehicle-time" is quantified. The study looked at the physical access to the public transport stops or stations by considering walking time for access and egress as well as waiting time. The main modes of transport considered for this study was trains, buses and minibus taxis, walking as well as private vehicles. In order to prepare for the research, an SPSS v. 25 statistical analysis software was used for both the descriptive and inferential statistics to characterise and summarise the data and the plotting of the figures and graphs. The study calculated the line-haul (in-vehicle time) travel time as a difference of "out of vehicle" time (OVT) and the total travel time.

3. LITERATURE REVIEW

3.1 Commuting, access and egress

The NHTS defines a 'commuter' as any person who regularly travels to and from work whether on foot or by motorised transport. Commuting refers to a regular or recurring travel between locations (i.e. one's place of residence and place of work, study or even when not work-related). Commuters are subjected to ever-increasing fares and long commuting times in the public transport sector in particular those using several modes of transport (transfers). Workers using several modes of transport have their hourly wage reduced by 40% or more because of transport costs (Kerr, 2013). Those in the lowest income bracket rely heavily on public transport and non-motorised transport which is fragmented and in other areas not available.

The minibus taxi industry is dominant among the users of public transport even when compared to the state-subsidised public transport modes (train and bus). For work travel trips the use of minibus taxis remained at 67,9% for both 2003 and 2013, buses (from 19.3% in 2003 to 19.5% in 2013) and trains (from 12.8% in 2003 to 12.9% in 2013).Train users were more likely than any other kind of public transport users to make one or more modal transfer followed by bus users. About 28% of the working population drove to and from their workplaces. (NHTS, 2013)

The percentage of public transport users who made at least one transfer decreased from 26,5% to 17,1% between 2003 and 2013. This can be due to the fact that people are moving from modes such as trains to minibus taxis or private vehicles with less transfers. However total travel journey time, the cost of transport, the availability of public transport, are still challenges in most areas especially for metropolitan commuters.

Countrywide one in five workers walked all the way, with the majority of those that walked all the way to work found in the rural areas. Walking is used mostly for short distances in the lowest income quintile. Those who cycled (1.3%) all the way to work were mostly found in urban areas. (NHTS, 2013)

In a study by Saghapour, Moridpour and Thompson (2016) the maximum walk time (WT) for buses and trams is defined as 10 min or a distance of 800 m and the maximum walking time for trains was considered to be 15 min or a distance of 1200 m. The calculation done by Keijer and Rietveld (2004) using the Dutch National Travel Survey (1994) has found that 50% of people are willing to walk ±550 m or cycle 1.8 km to the station (i.e. access). This is assuming a mean access/egress speed of 4 and 12 km/h for walking and cycling, respectively. The respective distances on the egress side is 600 m and 2.4 km.

Krygsman, 2004, notes that access and egress travel time are of similar absolute magnitude (i.e. a mean of ±9 –10 min), they reveal both similar and dissimilar coefficients. Overall it seems that access and egress are a function of transport variables (mode, transfers, line-haul time, etc.), with socio-demographic variables being less important in explaining travel time. He further states that, should access and egress exceed an absolute maximum threshold, users will not use the public transport system because access and egress modes determine the catchment of public transport stops and the intensity of use within catchments.

Arguably, if the proportion of trip time spent on the access and egress stages is considerable, public transport trips will be considered a less suitable choice as these stages involve much physical effort (Bovy and Jansen, 1979).

3.2 Public transport travel time

Travel time is described as the single most significant factor explaining the demand for a transport mode and is arguably the biggest existing contributor to the public's aversion to public transport (Krygsman, 2004; Bovy et al., 1991; Ortúzar and Willumsen, 2002). According to Litman (2009), other than sleep and work, a major share of people's personal time is devoted to transport. People around the world tend to devote 60-90 daily minutes to personal travel (Litman, 2016). Travel time is one of the largest categories of transport costs, and travel time savings are often the primary justification for transportation infrastructure improvements. According to the NHTS (2013) travel time was confirmed to be important to the transport users in South African in determining transport modal choice (32.5%). For example, the average travel time in Cape Town for all modes was, at about 90 minutes in 2013, Hitge and Vanderschuren (2015) found. This is above the global range, which averages around 70 minutes per person per day (Metz 2010; Schafer & Victor 1998). While travel time can have both the discomforts and a positive utility, this depends on a number of factors, such as origin-destination distance, the transport system used etc.

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

The out-of-vehicle-time (OVT) are *weighed* more onerously than the line-haul time (the in-vehicle-time or IVT). The value of out-of-vehicle time may be set at a rate higher than the value of in-vehicle time since this include some time spent standing around and being exposed to warm, cold, or rainy weather (Krygsman, 2004; Litman, 2016; Small 1992); i.e. a high disutility as the individual derives no benefit (or space benefit).

4. RESULTS

The findings in this study was derived from an analysis conducted using the National House Travel Survey (NHTS) 2013, as discussed in section 2 of the methodology. The distribution has shown that 63% of the participants in the survey were unemployed. Of the 37% employed population, 76% mentioned that they are employed in the formal sector and 24% in the informal sector. According to the (NHTS, 2013) report, formal sector employment is where the employer is registered for VAT to perform the activity, e.g. nurse, teacher, etc. who works in a formal institution, or in government. Informal sector employment is where the employer is not registered for VAT, e.g. domestic work, street trading, taxi driver, etc. Table 1 provides an overview of the general descriptive statistics.

Table 1: Demographic information and frequency distribution for responses in each of the variables

		Number	Percentage %	Min	Max	Mean	Standard Deviation
Geographic Location	1 Metro	16 579	40.6%				
	2 Urban	14 226	34.9%				
	3 Rural	10 015	24.5%				
Gender	Male	22 451	55%				
	Female	18 369	45%				
Race	1 African	28 966	70.9%				
	2 Coloured	5 366	13.1%				
	3 Indian/ Asian	1 493	3.7%				
	4 White	5 035	12.3%				
Employed %			27%				
Unemployed			63%				
Do you change transport	Yes	3 197	7.8%				
	No	14 606	35.8%				
Monthly vehicle costs for drivers				0	306 282	844.24	±5 304.68
Total travel time to work (in minutes)				1	400	47.48	±37.539
Total monthly cost to work				1	6 000	348	±527.73
Walking to first transport mode				0	120	8.68	±9.68
Waiting for the transport				0	120	7.24	±8.85
Walking at the end of the trip				0	120	8.02	±11.45

4.1 Main mode of travel to place of employment by geographic location

Minibus taxis were used much across all regions (Figure 1) as the main mode of transport. About 30% of public transport users in metros depend on minibus taxis to travel to work, followed by trains and buses respectively. About 20% of the metro commuters (Figure 2) made transfers on the way to work. The transfers between modes not only contribute to commuters' long travel time but also to high travel costs.

People (36%) in metro areas rely heavily on cars as their main mode of transport (as shown in Figure 1) than any other mode. Those who walk all the way (44%) to work were mostly found in rural areas (Figure 1) and least in the metros. Buses were used more in rural areas. About 32% of urban commuters also used walking as their main mode of transport.

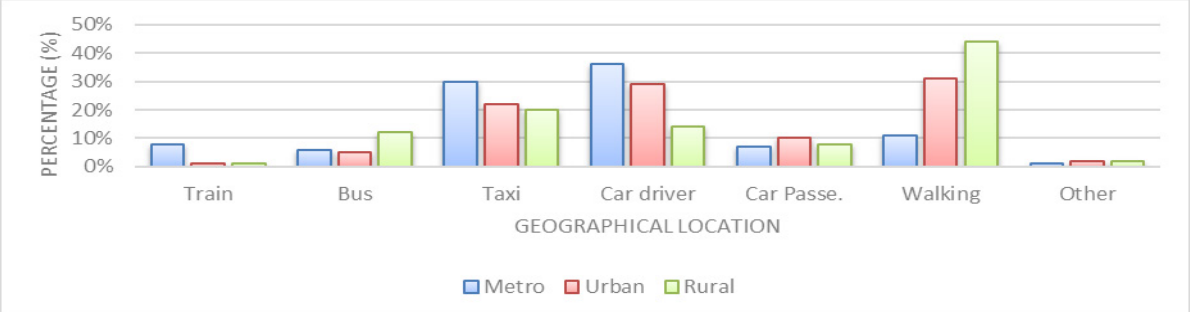

Figure 1: Main mode of travel to place of employment by geographic location

4.1.1 Geographical location (type)

The NHTS (2013) looked at three distinct categories in terms of the geographical or type of location. This included metro, urban and rural areas. The study discussed only on the metro areas. South Africa has eight metropolitan municipalities, which include Buffalo City (East London), City of Cape Town, Ekurhuleni Metropolitan Municipality (East Rand), City of eThekwini (Durban), City of Johannesburg, Mangaung Municipality (Bloemfontein), Nelson Mandela Metropolitan Municipality (Port Elizabeth) and City of Tshwane (Pretoria). South African Government, 2018)

4.1.2 Metro areas

Metropolitan refers to a formal local government area comprising the urban area as a whole and its primary commuter areas. This may comprise a large concentration of people or population of at least 100 000 (UNICEF, 2012). Metropolitan councils may decentralise powers and functions. However, all original municipal, legislative and executive powers are vested in the metropolitan council. The South African eight Metropolitan areas has a population of about 22,196,701 (39% of South Africa's population), with the City of Johannesburg having the highest population (4,949,347) followed by the City of Cape Town (4,005,016). Mangaung has the smallest population of 787 803 of all the metro areas. (Municipality of South Africa, 2019)

The December 2018 Quarterly Financial Statistics of Municipalities (*QFSM)* (Stats SA, 2018) indicates that municipalities in South Africa generate, in total, 72% of their own income. Metropolitan councils are relatively self-sustainable, on average they generate 83% of income themselves. A report from the Brookings Metropolitan Policy Program, the 2018 Global Metro Monitor has found that 300 of the biggest metropolitan areas grew faster than the overall global economy, making up two-thirds of global GDP growth and more than a third of global employment growth between 2014 and 2016. The report has shown that Metro areas that have emerging economies continue to excessively drive growth, they account for 80% of the 60 best performing metro economies on the index (Business Tech, 2018; Business Report, 2018). This highlights the significance of Metropolitan areas in the economy of a country. Without proper infrastructure development and lack of accessible transport systems, they will not be able to function effectively for economic growth and development.

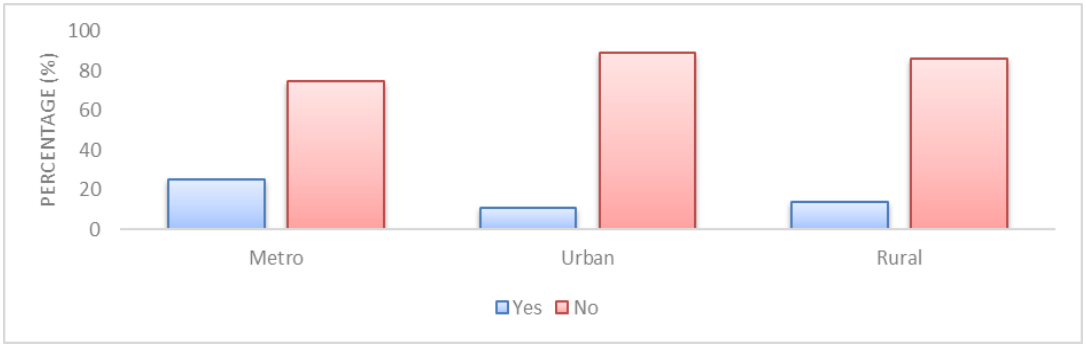

Figure 2: Employed individuals changing modes of transport by geographic location

4.2. Travel time by geographical location

Workers in the Metro areas (Figure 3) spend more time travelling (55 minutes), followed by those in rural areas (48 minutes). Urban areas recorded the least travel time (39 minutes). The travel time in the metros is also higher than the national average which is 47 minutes. There seems to be less transport options but higher travel times. This is despite the fact that most of these metropolitan have been prioritised in terms of the investments for roads

and rail (public transport) infrastructure. So despite government's objective to follow an urban led growth policy, people are spending their time in metro areas on unproductive travel activities. However at this level the travel time is not specific to modes. Travel time in relation to main modes of transport is discussed in the next section.

Table 2: Descriptive statistics – total travel time to place of employment

Effect	Descriptive Statistics (NHTS2013)						
	Level of Factor	N	Total time Mean	Total time Std.Dev.	Total time Std.Err	Total time -95.00%	Total time +95.00%
Total	SA	36 459	47.5	37.5	0.2	47	47.9
Type	Metro	14 798	54.6	37.9	0.3	54	55.2
Type	Urban	12 980	38.8	31.9	0.3	38.3	39.3
Type	Rural	8 681	48.2	41.8	0.4	47.4	49

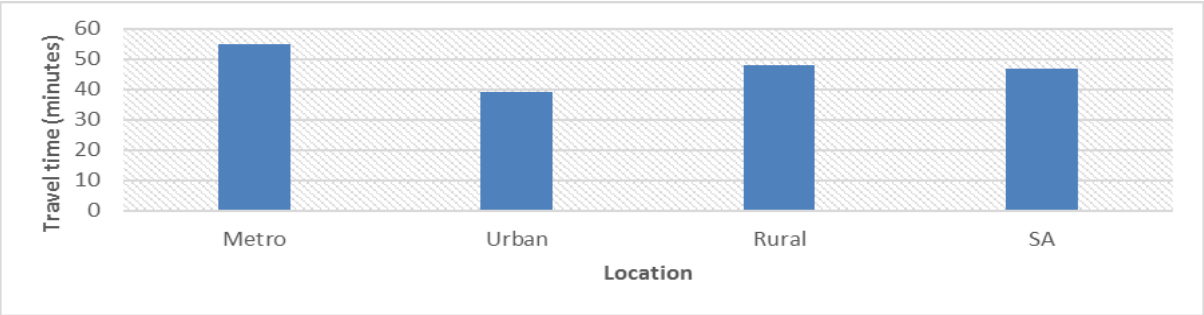

Figure 3: Total travel time to place of employment by geographical location and the country

4.3. Travel time elements

This section explores travel time elements which include time (minutes) walking to first transport mode or station, waiting time, line haul and time walking at the end of the trip to reach the workplace.

4.3.1 Minutes walking to, waiting for first transport and walking at the end

Walking time to public transport is a function of walking speed (influenced by personal characteristics, gradient, surface quality, etc.) and distance (influenced by the proximity of the nearest public transport, trip purpose, etc.) (Hitge and Vanderschuren, 2015; Hermant, 2012). The proximity of public transport is defined as the time it takes (in minutes) for the person to travel from the dwelling unit to get to their first transport. Of those surveyed (employed) in the metros, irrespective of the mode used, the results show that public transport (train, bus and taxi) users in metropolitan areas spend about 9 minutes on average *walking from their dwelling units to the first mode of public transport*.

On average commuters in the metros spend almost 8 minutes *waiting for their first transport* to work. The time is not associated to a specific mode, however train users were likely to spend more time waiting or making transfers. Workers spend almost 9 minutes on average *on egress (end trips)* which is mostly walk trips.

4.3.2 In-vehicle travel time (IVT)

This study used the difference between the total travel time and the out of vehicle time (OVT) which include access, waiting time, and egress to derive the IVT. The in-vehicle travel time depends both on the average speed and the distance travelled. Speed is

influenced by the speed limit and the prevailing level of service (LOS) of the road or network. Figure 4 shows a graphical representation of travel time in metro areas. In total commuters, irrespective of the mode used, spend 55 minutes travelling. The split between IVT and OVT is ***29 minutes / 26 minutes*** respectively. Though the OVT is less than IVT, users still experience some form of disutility which also highlights unproductivity. Transfer and wait are often spent in less desirable locations where there are no proper facilities such as shelter or proper waiting areas with seating facilities. If this time can be used for more productive activities such as remote working and shopping, the negative disutility associated with these travel elements may be mitigated.

4.3.3 Total travel time to work (Time leaving and arriving at work)

In terms of the NHTS (2013) the total travel time can be defined as the time duration between when workers usually leave and get to the workplace on the travel day. On average metropolitan commuters spend 55 minutes travelling (one way) from when they leave their house to the workplace across all modes. The total travel time as shown in Figure 4 is regardless of the mode of travel usually used nor the working area. Figure 5 shows travel time in metro areas for the main modes of transport. Train users spend more time (80 minutes) travelling but around the same time with bus in terms of IVT. Mini-bus taxis recorded the lowest travel time for the line-haul but still high when compared to cars on the total travel time. This makes the mini-bus taxis as the fastest public transport mode with about 56 minutes average travel time.

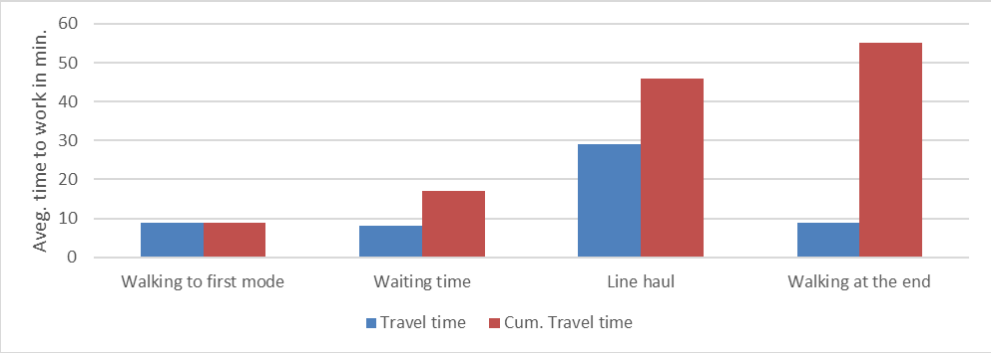

Figure 4: Line graph showing travel time in metropolitan areas to place of employment with cumulative time

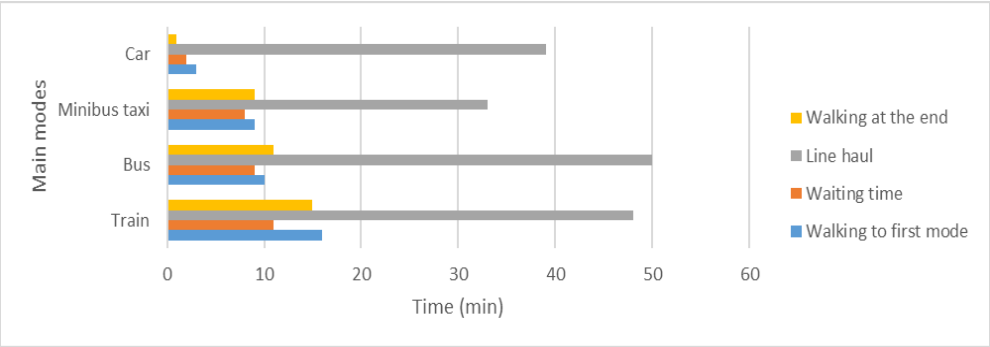

Figure 5: Line graph showing travel time in metropolitan areas to place of employment by main mode of transport

Figure 5 and 6 indicates various travel time elements for the various modes used in metros and compares this to the total travel time. The result shows that train users spend more time on OVT than any of the other modes. Buses recorded the second longest travel time of 80 minutes but somewhat unexpected, the longest IVT. In terms of waiting times all the

public transport modes had fairly the same wait time between 8 and 11 minutes. The significant share of OVT travel time compare to IVT highlights the onerous public transport travel time.

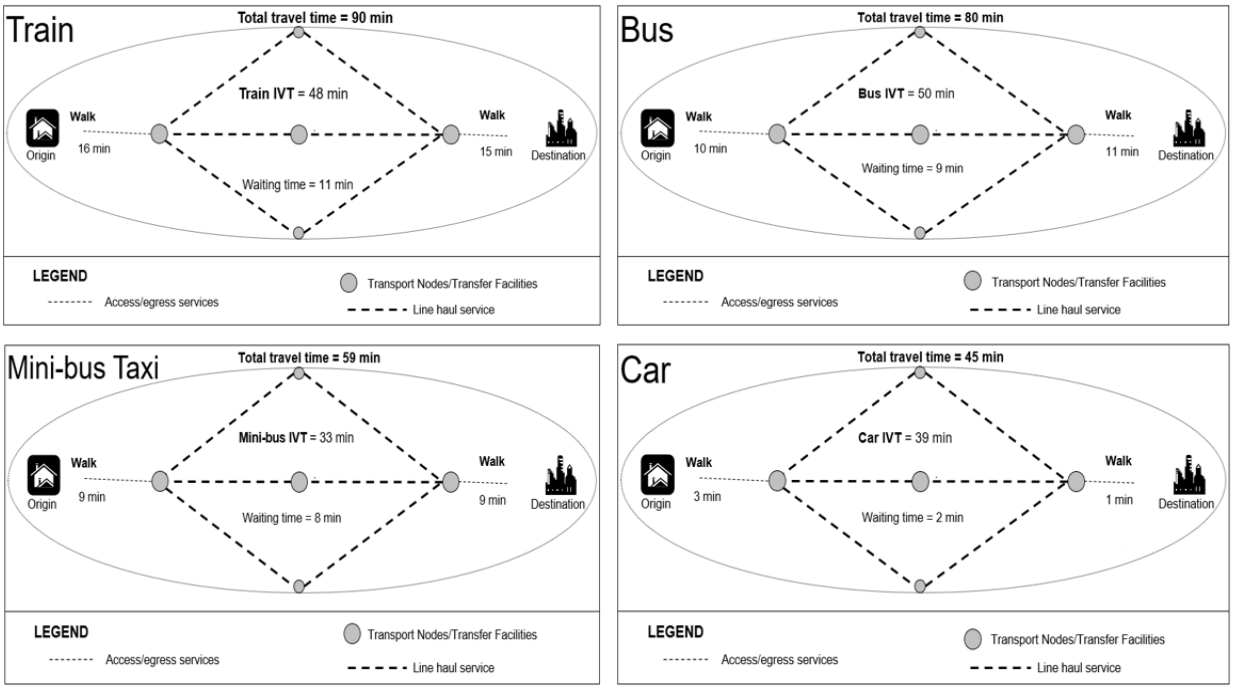

Figure 6: Out of vehicle time and "in-vehicle-time" for public transport alternatives and private car (only metro areas) (Adopted from Krygsman, 2004)

4.3.4 Transfers: Travel time and cost

As stated in earlier section there is a substantial fraction of South African workers who reside far from their workplaces. The cost of travel varies and depends on whether users make transfers or not. On average the cost (Figure 7a) of those making transfers in the metro regions is about R716 on a monthly basis as compare to R506 for those who do not make transfers, a difference of R210. Comparing the travel time (Figure 7b), shows that trips involving transfers, commuters spend 26 minutes more than those without transfers. Therefore it can be shown here that transfers contribute to long travel times and high costs of travel.

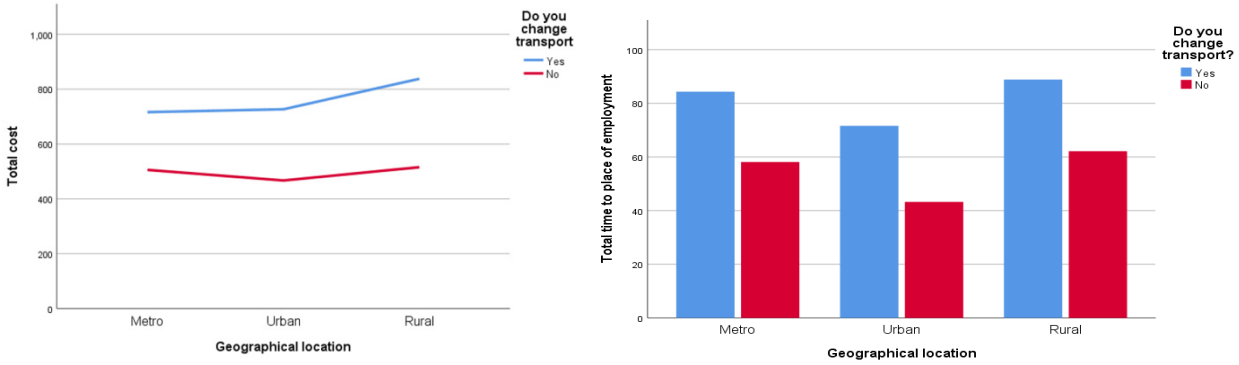

Figure 7a and b: The cost of travel and travel time for workers making transfers on their way to work

5. CONCLUSION

The long commuting and transfer times impact excessively on the time of the poor households. It leads to high commuting costs which impact negatively to family income. These factors can contribute to raising unemployment rates, lower productivity, hindrance to access to opportunities and the long travel time places enormous pressure on family life.

Public transport accessibility is key to providing economic opportunities to society, together with walking and play a prominent role in sustainable urban mobility. Currently road infrastructure does not provide for a multimodal public transport system. Train users spend more time on both the IVT and OVT with 80 minutes for buses which is longer than both the minibus taxis (59) and cars (45 minutes).

Previous studies have established that residents of (Boarneta et al, 2017). There is a high reliance on cars for most of the metro commuters which means low-income neighbourhoods in major metropolitan areas have access to many more jobs by car than by transit as Boarneta et al. (2017) argued. This is against what the White Paper on Transport Policy (1996) advocates for public transport competitiveness. The reality remains that the working population (27%) still travel long distances to their workplaces and spend much of their disposable income on transport.

Government transport infrastructure initiatives such as the Gautrain, BRT, etc. are still not able to address a whole of these challenges. The financial impact of transport for the already poor South Africans (63% of the unemployed population) is huge. They remain challenged in terms of their travel choices and the cost of travel. They are excluded and discouraged from participating in the economic activities because they stay far from economic centres. It is likely that this group will remain in the poverty bracket should the conditions remain the same.

From the previous literature it is noted that public transport travel time is measured differently across studies. One of the key focus areas of the public transport investment strategy and policy is on the reduction of travel time for public transport, both relative to that of the private car. In this study, access, egress, waiting and in-vehicle time was captured and discussed as part of the public transport travel time. Pre-journey waiting times, journey durations, and transfers, shown to cause discomfort to public transport users and led to travel impendence. The in-vehicle travel time compares very poorly with international benchmarks, and is certainly also an area that holds significant potential for improvement. Travel time also becomes a benefit when transportation improvements improve mobility (i.e., ability of more residents to use transportation to access more destinations) or expand accessibility (i.e. ability to reach more job opportunities. Though there was a small number of those making transfers, there is a need to for intervention which can bring about significant improvement in total travel time.

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