THE RELATIONSHIP BETWEEN URBAN NEIGHBOURHOOD TYPE AND COMMUTING DISTANCE IN GAUTENG CITY REGION, SOUTH AFRICA. A PRELIMINARY ANALYSIS

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ABSTRACT

This paper uses the 2001 and 2013 Gauteng household travel survey datasets to investigate the nature of change in commuting distances of commuters from different neighbourhood types in the Gauteng City Region, in South Africa. The investigation is done within the context of the need to evaluate the impact of the promulgated post-apartheid urban form policy reforms that were introduced since 1995. The results show that, contrary to policy intents, the overall Gauteng's average commuting distance was longer in 2013 than in 2001. Also surprisingly, the average commuting distance for inner city dwellers was also longer in 2013 than in 2001 by 40%. The average commuting distances for township dwellers remained unchanged, albeit relatively long than all other neighbourhood types. While increases in average trips distances are partly attributed to the increased poly-centrism in the city region, it appears that current spatial policy reform instruments are not as effective as intended.

1. INTRODUCTION

The widening gap between urban land use policy and transport system performance has manifested partly in increased commuting times in urban areas, warranting an improved understanding of the relationship between urban form and travel behaviour (Boarnet and Crane, 2001; Crane, 1998). The dilemma for South Africa is that most of the empirical studies informing policy reforms tend to be mostly from other parts of the world, particularly the United States of America, Asia, Europe and Australia, with little reference material for local contexts. As a result, there is still a gap in empirical knowledge regarding the relationship between urban spatial structure and transport in South Africa.

Given the post-apartheid spatial planning policy objective of reducing average commuting distances, the paper investigates the nature of changes in commuting distances in Gauteng City Region, South Africa. This is done in order to measure the rate of change and the efficacy of prevailing policy instruments. The investigation uses empirical datasets from the 2001 and 2013 Gauteng household travel surveys.

1.1 Background

Under the colonial and apartheid government, urban spatial planning in South Africa was influenced by the policy of racial segregation, pronounced mostly in the Group Areas Act (Act No.41 of 1950). Residential townships for black or coloured people were largely located on the urban fringes, away from job opportunities and economic activities, and little opportunity was granted for the establishment of employment-generating land uses in the townships. This planning paradigm has over time created spatial imbalances, for example, relatively long travel distances between labour and employment areas.

In 1995, the South African post-apartheid government endorsed an urban spatial reform policy enshrined in the Development Facilitation Act (Act 67 of 1995), which will be referred to in this paper as the DFA. The DFA was aimed largely at reducing travel distances between residential and employment areas through the promotion of mixed-use developments. Section 3(1)(c)(iii) of the DFA in particular stated one of the principles for land development as to "promote the availability of residential and employment opportunities in close proximity to or integrated with each other".

A study conducted by Mubiwa and Annegarn (2013) on historical spatial development trends in the Gauteng City region over 18 years (between 1991 and 2009) using remote-sensing, found that there was a notable ribbon development along the M1/N1 highway linking Johannesburg and Pretoria, with the development of residential areas such as Midrand and parts of Tembisa and commercial developments along the highway. Furthermore, the study deduced that low cost housing settlements have been developing on the urban periphery where land is cheaper and away from economic zones and that there has been developments of single-use office parks separated from residential areas. This has resulted in urban sprawl and most importantly an advancement of apartheid urban spatial structure. However, the study also found evidence of corridor developments, infill development, urban densification and decentralisation in some parts of the Gauteng City Region. Thus, it can be deduced from the study that Gauteng's spatial structure has changed and that the provision of residential and employment opportunities have being realised in some parts of the Gauteng City Region. The city region has over time taken the form of a polycentric city.

A research paper on mobility patterns in the Gauteng City Region by Culwick et al (2015) concluded that the origin and destination patterns of work trips reflected urban sprawling when mapped against land cover background. The average straight line distance (air distance between two points) to work by the respondents was found to be 14km in 2013. The study also concluded that the commuting distances still reflected those of the apartheid era, with black people travelling longer distance to work than white people. Some would say this implies that the DFA has not achieved its goal. However, the study did not investigate the rate of change in commuting distance over time, and the direction thereof.

A preliminary analysis of the 2013 Gauteng household survey data showed that the road based motorised transport modes were dominant for home-to-work trips, accounting for about 80% of the total home-to-work trips. Proportion of private car was found to be high in 2013 than in 2001 (Gauteng Household Travel Survey Report, 2014). The increase in private car use could be indicative of increasing commuting distances, as longer trips are likely to be made by car.

1.2 Problem statement and research questions

Public policies should be subjected to continuous review on the basis of improved knowledge. For example, the effect of the DFA on urban commuting distances is unknown. This is also important because similar pronouncements are being made in the recently promulgated Spatial Planning and Land Use Management Act (Act 16 of 2013) that has repealed the DFA. In Gauteng, since 2001, the Urban Edge Delineation Policy was in use as a policy tool until it was rescinded in 2011 (Gauteng Spatial Development Framework 2011). The Urban Edge Delineation Policy was aimed at curbing urban sprawl by promoting infill developments and not allowing developments beyond the delineated urban boundary. The effect of repealing this urban edge policy is yet to be empirically investigated.

This paper uses an empirical approach to investigate the nature of changes in commuting distances in Gauteng Province since the adoption of post-apartheid spatial reform policies. In particular, the paper seeks to answer the following research questions:

- What does the trend in Gauteng's commuting distances look like since the promulgation of the DFA?
- To what extent does urban structure influence commuting distances in Gauteng?

The investigation is important in two ways: Firstly, it contributes towards establishing a framework to empirically measure or evaluate the impact of spatial policies that are meant to effect travel behaviour. Secondly, it contributes to the growing body of research concerning the relationship between urban form and travel behaviour by providing a South African perspective.

Section 2 of this paper provides a literature review of some of the critical viewpoints on the relationship between spatial structure and travel behaviour. The study methodology and analysis are provided in section 3 and 4, respectively, followed by conclusions and recommendations in section 5.

2. LITERATURE REVIEW

2.1 Impact evaluation in travel behaviour studies

Globally, public policy making is shifting towards "evidence-based policy" (Gertler et al., 2016). Evidence-based policy requires that policy impact evaluation be undertaken in order to use empirical findings to:

- Assess changes in behaviour that can be attributed to certain policies,
- Improve, inform and guide policy decision making,
- Verify and improve the efficiency and effectiveness of policies (provides knowledge about what actually works and what doesn't),
- Improve government accountability, and
- Allocation of public funds appropriately.

The best way to evaluate impact of interventions (policies) on behaviour or any outcome of interest is to use controlled experiments in which the effects of other confounding factors could be statistically controlled for (Reis & Judd, 2014). A controlled experiment requires that two statistically identical groups be subjected to differential treatments, where one group receives a treatment (treatment group) and the other doesn't (control group). In this way a robust evidence of correlation or causal relationship can be established.

Controlled experiments in urban form and travel behaviour would be practically challenging or even impossible (Cao et al., 2006). Furthermore they would require considerable time and funding in terms of data collection and personnel. Therefore researchers in this field rely on observational studies, also known as quasi or natural experiments. These experiments involve using existing data collected over time or across jurisdictions. The treatment group and control groups are identified after the intervention has been implemented. They rely on statistical methods to control for some other factors that can influence the outcome of interest.

The main difference between quasi-experiments and controlled experiments is that quasi-experiments are not performed in a controlled environment such as a laboratory, therefore the treatment group and the control group are not statistically identical, and they may differ not only in terms of treatment received but also in terms of other known or unknown factors that could influence the outcome of interest. These other influencing factors are known as confounders.

Quasi-experiments are categorised into quasi-longitudinal and cross-sectional. Quasi-longitudinal experiments involves comparison of data collected on the same group or jurisdiction before and after the intervention. Quasi-cross-sectional involves comparison of data collected on treated group/area to a non-treated group/area. In both longitudinal and cross-sectional studies it is difficult to conclude causality due to the inability to statistically control for all factors that can influence the outcome of interest (Gertler et al., 2016).

The presence of many confounders that influence travel behaviour, such as socio-economic or demographic factors and residential self-selection provides limitations in determining causal relationships using quasi-experiments. It is also difficult to account for all these factors as the data and existing statistical methods do not allow (Ewing & Cevero, 2010; Cao et al., 2006). As a results, most of the research on the relationship between urban form and travel behaviour tend to focus more on correlation than causality. Correlation studies do not fully assess the impact as they do not control for confounders (Ewing & Cevero, 2010). However, these studies do provide insight into the association between the treatment and the outcome of interest and can therefore be used to infer causality or to understand the impact of spatial structure on travel behaviour.

2.2 Relationship between city spatial structure and commuting distance

As cities grow, they tend to transform from monocentric form, with one employment centre, into a polycentric form with sub-centres of employments that attracts passenger trips from many areas across the city. This results in both random and radial commuting trip patterns (Lin et al., 2013).

There are somewhat conflicting views on the relationship between polycentric developments and commuting distances. Some empirical studies that used cross-sectional comparison of cities found that average commuting distance in polycentric cities is shorter than that of monocentric cities (Gordon et al., 1989, Guth et al., 2009, Veneri, 2010). While

some studies that used longitudinal analysis of average commuting distance in the same city found that as cities develops from a monocentric to polycentric form the commuting distances increased (Cervero & Landis, 1991; Levinson & Kumar, 1994; Naess & Sandberg, 1996; Cervero & Wu 1998, Aguilera, 2005). Aguilera (2005) argues that the reason of increased commuting distance is that job opportunities in sub centres are likely to be taken by people or commuters living outside of the sub centres.

The conflicting findings may have resulted from the presence of confounding factors that are more prevalent in cross-sectional studies than in a longitudinal studies. In cross-sectional studies, the areas compared may differ not only in terms of the treatment but also in terms of many other factors that cannot be accounted for. Longitudinal studies provides better results as they measure changes experienced by the same area over time. Yang (2005) addressed this issue by using both cross-sectional and longitudinal analysis: Yang (2005) evaluated the impact of spatial decentralisation on commuting by comparing commuting trends in two American cities of Atlanta and Boston which offered to types of spatial decentralisation. Boston presented a relatively restrained decentralisation (has an urban boundary and highly dense) while Atlanta offered a relatively sprawling decentralisation without any urban boundary and less dense. The study used census travel data to investigate the change in commuting trip lengths over 10 years as a result of decentralisation of employment and residences. The results showed that the average commuting lengths increased over time in both cities. However, the average commuting distance in Atlanta (22.1 km) was higher than in Boston (16.3 km). The results supported the view that city size growth and polycentric developments result in increased commuting distance.

Yang (2005) argues that as cities grow, spatial decentralisation occurs naturally but restrained decentralisation outperforms sprawling decentralisation with respect to commuting distances. This means that the increase in commuting distances in the developing cities could be minimised by urban growth management tools such as Urban Edge Delineation Policy. The urban development boundary is aimed at promoting infill developments instead of “leap-frog” developments. “Leap-frog” developments are new development that are established on the urban periphery and are associated with longer commuting distance and increased cost of travel (Jun & Hur, 2001).

2.3 Relationship between land use and commuting distance

Many studies have found that higher diversity of land use and job-housing balance are associated with shorter commuting distance (Etminani – Ghasrodashti & Ardeshiri, 2016; Manoj & Verna, 2016; Litman, 1995; Zhou et al., 2011). Inner city or urban core dwellers in most cities were also found to be making shorter commuting trips than suburbs and villages/rural dwellers (Nielson, 2004). The reason for this could be that urban core has higher diversity of land use and a good job-housing balance when compared to suburban and villages/rural areas, which tend have a higher component of residential than other land uses.

Notwithstanding literature findings, many researchers acknowledge non-transferability of findings relating to urban form and travel behaviour. It is therefore important that area specific studies are undertaken.

3. METHODOLOGY

The investigation uses both cross-sectional and longitudinal analysis of the average commuting distance of commuters from different urban neighbourhood types in Gauteng City Region, South Africa. This practice is similar to the one used by Nielson (2004) and Yang (2005)**.**

The longitudinal data was obtained from the Gauteng Province's household travel surveys carried out in 2001 and 2013. Urban neighbourhood type was used as a surrogate variable for urban form. The road based travel distance from home to work was used as a surrogate variable for travel behaviour, irrespective of the mode of transport used.

The distance from home to work was estimated as the minimum road based distance between the origin Transport Analysis Zones (TAZs) and destination TAZs using the Gauteng Integrated Transport Model (GITM) built on the EMME/4 modelling platform. The GITM is a provincial-wide transport model that was, in its current form, initially built in 2002 based on the 2001 road network with approximately 900 TAZs. The road network includes only higher order roads (freeway and arterial roads, and generally no streets providing access to individual dwellings), appropriately connected to the centroids of the TAZs. The model was updated in 2011 and 2013. The model can therefore be used to estimate home to work travel distances for both 2001 and 2011.

The TAZs in the household travel survey were clustered as follows based on the spatial categorisation information contained in the published Gauteng Spatial Development Framework depicted in Figure 1:

- Historical central business district (Urban Core)
- Suburban
- Township (including informal settlements)

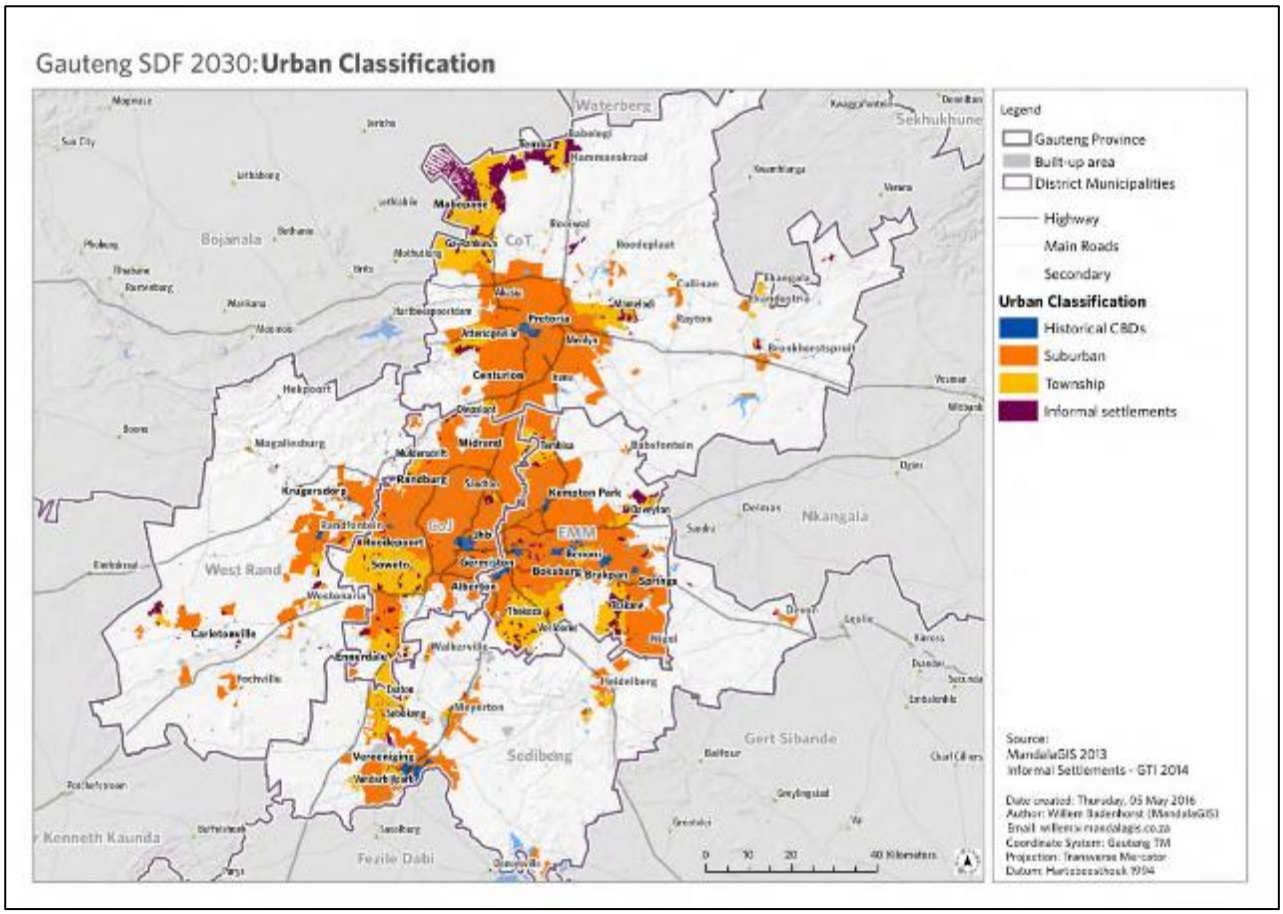

Figure 1: Urban neighbourhood classification (Gauteng Spatial Development Framework 2030)

The average home to work road-based distance for an origin TAZ was calculated as the weighted average of all home to work trips made from that TAZ. It is represented mathematically as follows:

$$Average\ D_{TAZ} = \frac{\sum T_d \times D_d}{\sum T_d},$$

where D_{TAZ} is the home to work distance of trips made from the origin TAZ to all destinations. T_d is the total number of trips (by all modes) made from the origin TAZ to destination *d*. D_d is the EMME4 based distance between the origin TAZ and destination *d*.

The limitation is that the road based average distance was measured from the centroid to centroid of TAZs, whereas in reality trip distances are measured from door to door, including distance travelled on low order roads such as access roads and drive-ways. However, it was ensured that the centroids of TAZ and the road network in the GITM remained the same in the 2001 and 2013 models. Only road closures and additional roads were added in the 2013 road network. Intra-zonal trips were included in the analysis. Given the aggregate nature of the GITM, commuting distance for intra-zonal trips would be equal to zero, as D_d would be zero.

4. RESULTS AND DISCUSSION

4.1 Gauteng's overall average commuting distance commuting since the promulgation of the DFA (1995)

Figure 2 shows that the overall average commuting distance has increased marginally by 1.7 km from 29.7 km in 2001 to 31.40 km in 2013. Figure 3 shows the trip length distribution, from where it can be seen that the proportion of home-to-work trips that were less than 30km in length was 60% in 2001 and 50% in 2013.

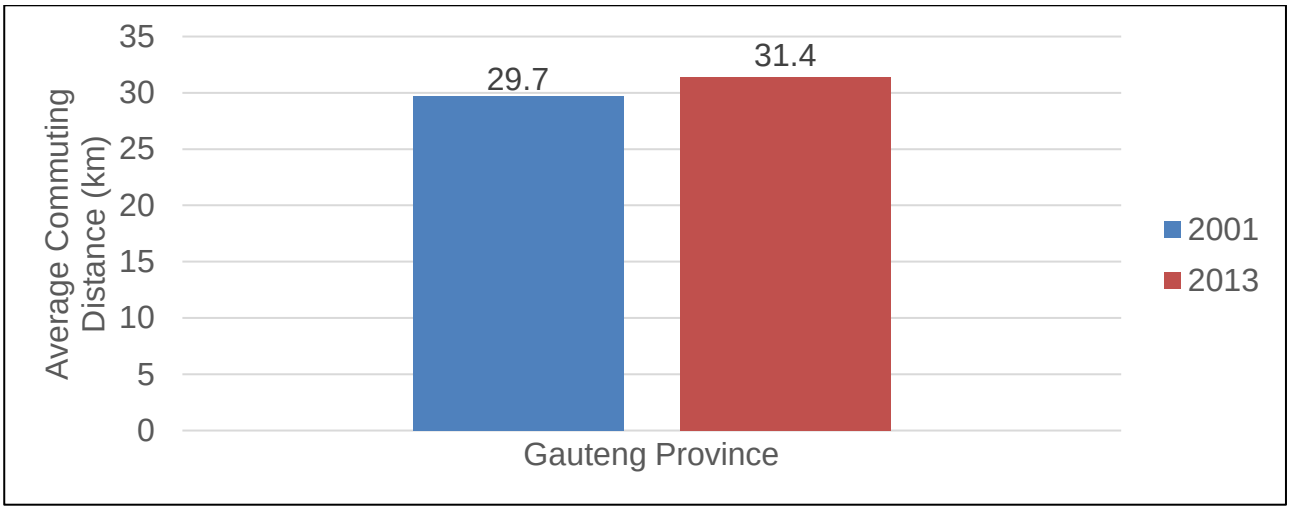

Figure 2: Gauteng's 2001 and 2013 overall average commuting distance

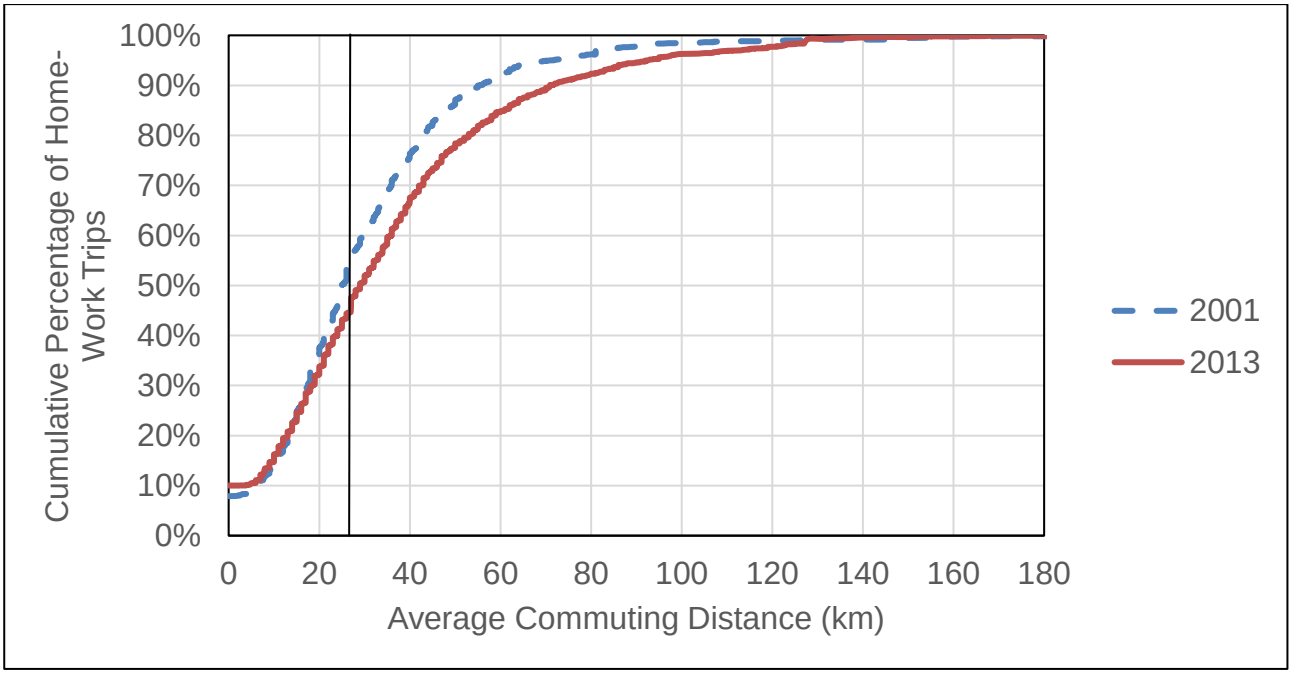

Figure 3: Cumulative percentage of home-to-work trips by average trip length

4.2 Average commuting distance by urban neighbourhood type

Figure 4 shows that the commuting distance for all neighbourhood types were considerably higher in 2013 than in 2001, except for township areas which had no increase. Urban core had a relatively higher increase, by 40%.

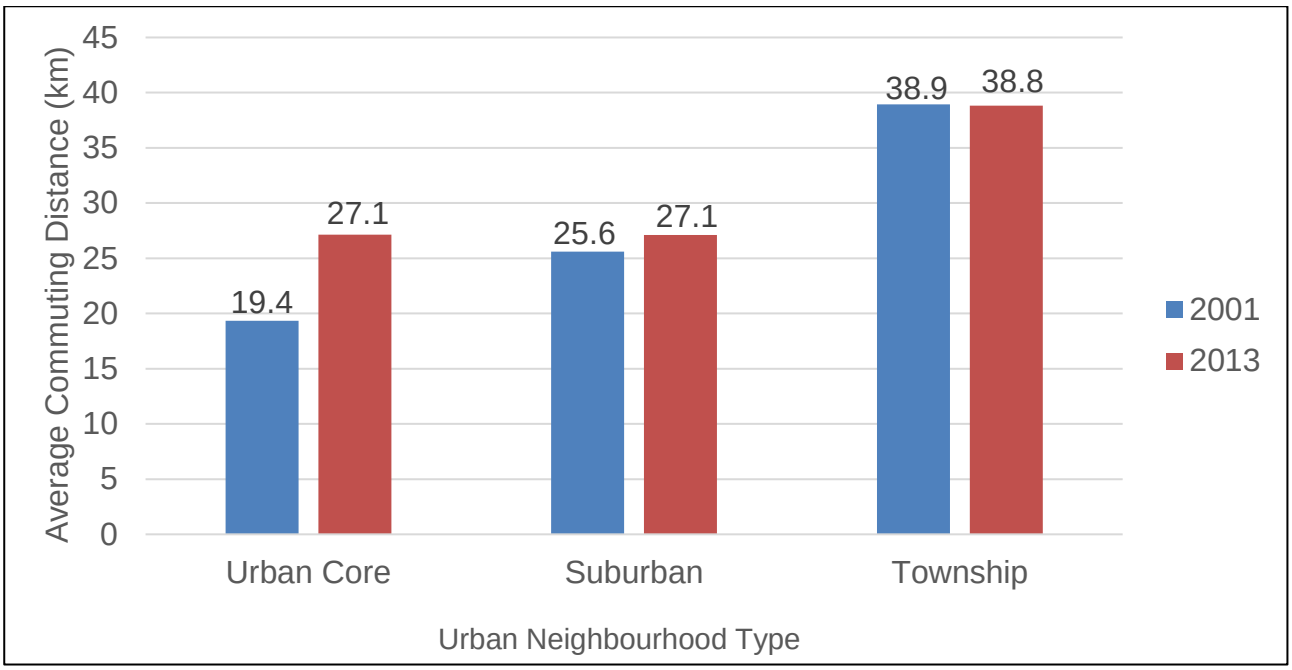

Figure 4: Average 2001 and 2013 commuting distance by urban neighbourhood type

Figure 5 shows the proportion of home-to-work intra-zonal trips as a percentage of total home-to-work trips, from which it can be seen that the proportion of intra-zonal trips for both urban core and suburban decreased, while for township it remained the unchanged.

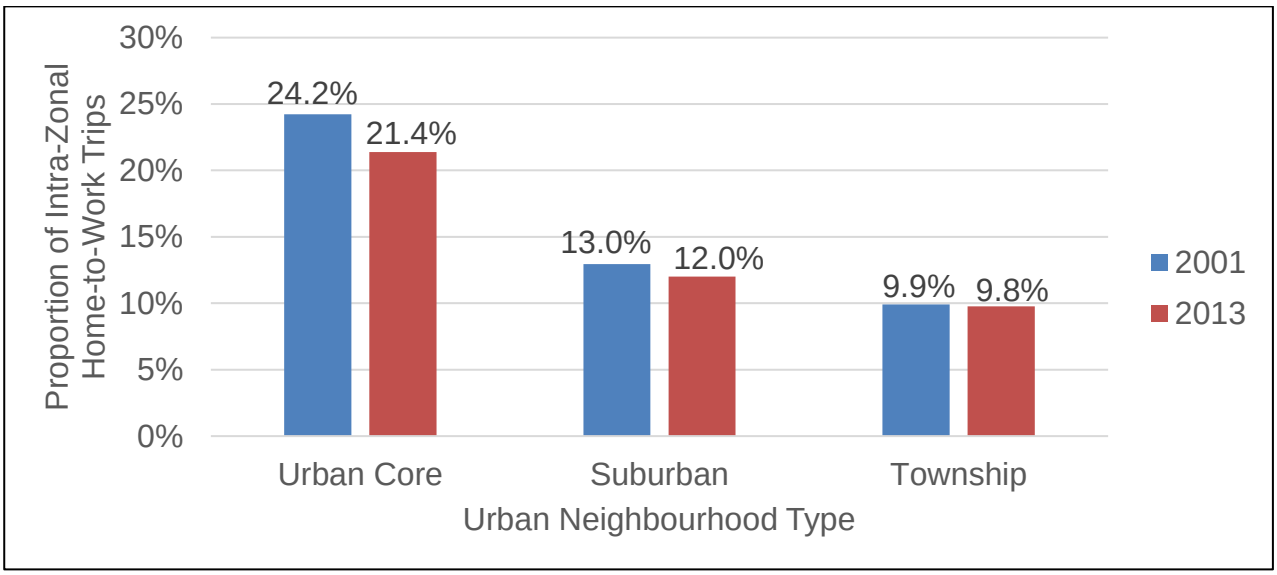

Figure 5: Proportion of home-to-work intra-zonal trips

Figure 6 shows a comparison of commuting distance between different neighbourhood types. A substantial difference was found between township areas and both urban core and suburban areas in both 2001 and 2013. For 2001, township dwellers we found to be commuting approximately 20km and 13km longer than urban core and suburban dwellers, respectively. For 2013 township residents were found to be commuting approximately 12 km more than both urban core and township residences. There was no difference in average commuting distance between urban core and suburban areas in 2013 while in 2001 the difference was notable. Notably, township commuting average distance in both 2001 and 2013 was above the average for the whole province.

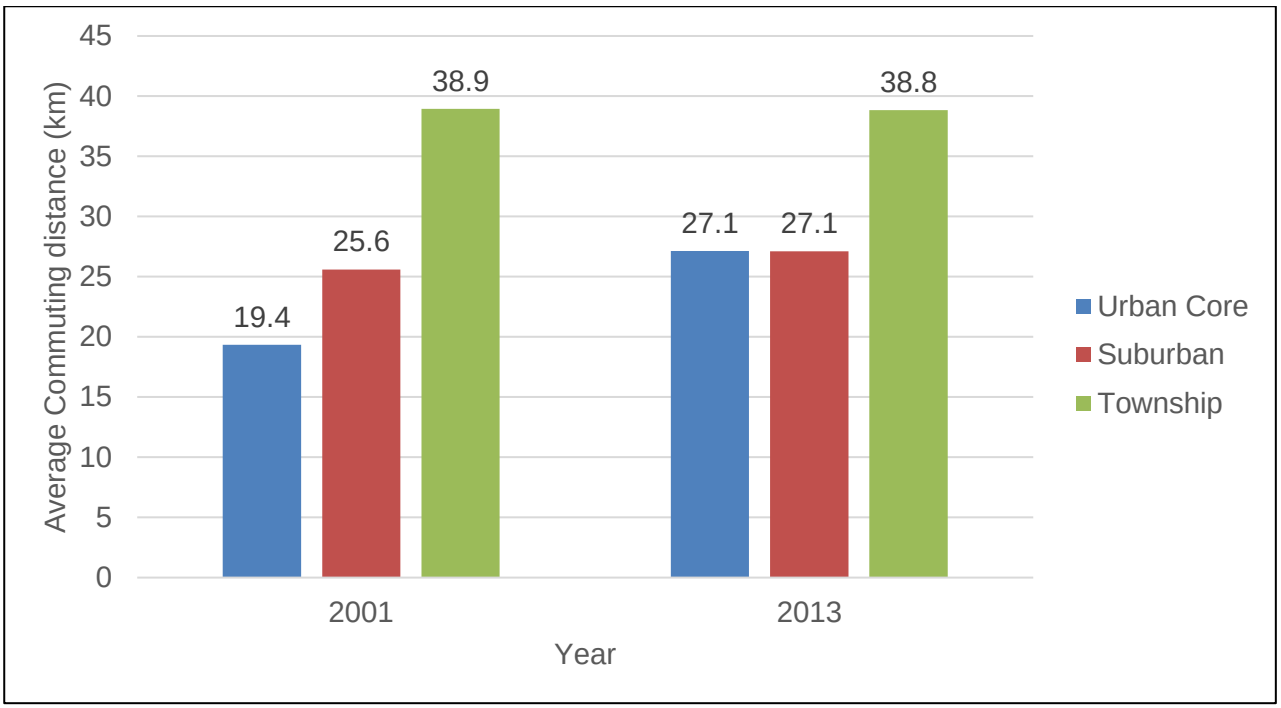

Figure 6: Comparison of commuting distance between neighbourhood types

5. SUMMARY AND CONCLUSIONS

The overall mean average commuting distance for Gauteng province seems to have increased marginally by 1.7 km between 2001 and 2013. Commuters made relatively longer trips in 2013 than in 2001.

There was a significant difference in average commuting distances between townships and urban core or suburban areas in both 2001 and 2013. In both instances township residents were found to be commuting longer distances, followed by the suburban residences. The average commuting distance in both 2001 and 2013 was above the average for the whole province. Notably, the commuting distances for all neighbourhood types increased between 2001 and 2013, except for township areas which showed no change. The proportion of intra-zonal trips for both urban core and suburban decreased, while for township it remained the unchanged. This could imply that most townships are still predominantly residential areas with fewer jobs, resulting in residents travelling closer to the urban core and suburban areas for jobs. Surprisingly, urban core had a relatively higher increase of about 40% from 19km in 2001 to 27km in 2013 compared to other neighbourhood types. The proportion of intra-zonal home-to-work trips as a percentage of total home-to-work trips also decreased by about 3%. This could be due to some employers relocating from the historical central business districts during the analysis period.

The increasing urban commuting distance should be of concern from an urban form and transportation policy perspective as longer commuting distances are associated with high cost of public transport (Jun & Hur, 2001; Venter, 2011). At this stage, however, the increase in Gauteng's commuting distance cannot be conclusively attributed exclusively to urban form policies. It could also be argued based on literature that the slight increase in commuting distance is due to Gauteng's growing polycentric structure. Some could

attribute the increase to job-housing imbalance especially in township areas and some suburban areas. Furthermore, the significant increase in average commuting distance of people living in historical central business districts supports an argument by Aguilera (2005) that in a polycentric structure job opportunities in one sub-centre are taken by commuters living in other sub-centres even if there are job opportunities in origin sub-centres, resulting in increased city's average distance. The argument is that the phenomenon may be exacerbated by improved transport systems connecting the sub-centres. Therefore, it cannot be concluded that the DFA has failed in terms of achieving one of its main objectives of reducing the distance between home and work place for all South Africans. The question then from a policy point of view is how can we improve spatial or land use policies to take into account the challenges that are posed by a polycentric spatial structure.

It would be difficult to reduce the commuting distance in a developing city such as Gauteng but its rate of increase can be minimised through urban growth management tools that restrains the city's built environment footprint (Yang, 2005), such as the Urban Edge Delineation Policy, 2009. Furthermore, land use policies (implemented for example through town planning schemes) that are aimed at promoting mixed use infill development at a neighbourhood level should be closely monitored. For example, since townships cannot be relocated to be closer to areas of economic activities, it is imperative therefore to develop labour-absorbing land uses closer to townships. New mega-housing projects that are proposed in Gauteng such as the Syferfontein mega-housing project that was mentioned by the Premier of Gauteng in his 2017 State of the Nation Address should also be accompanied or supported by labour absorbing land uses. Historical central business districts should continue to be invigorated so as to attract employment.

6. RECOMMENDATIONS FOR FURTHER STUDIES

This investigation explored changes in commuting distance by commuters from different urban neighbourhood types in Gauteng City Region. A more comprehensive impact evaluation framework for measuring the impact of land use or spatial structuring policies that are aimed at effecting change in travel behaviour, in the South African context, should be developed. This would allow for improved evidence-based policy generation. Unlike the current approach that used more aggregated trip analysis approaches, more disaggregate trip analysis tools should also be explored, especially with regard to overcoming the limitation of intra-zonal trips.

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