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of

Master of Philosophy in Transport Studies

Understanding student travel preferences in Mahikeng: A Hybrid Choice Modelling approach within the Theory of Planned Behaviour

Prepared by

Ofentse Hlulani Mokwena

Supervised by

Prof Mark Zuidgeest

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PLAIGIARISM DECLARATION

Declaration

I, Ofentse Hlulani Mokwena , hereby declare that the work on which this thesis is based is my original work (except where acknowledgements indicate otherwise) and that neither the whole work nor any part of it has been, is being, or is to be submitted for another degree in this or any other university. I authorise the University to reproduce for the purpose of research either the whole or any portion of the contents in any manner whatsoever.

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ABSTRACT

University student mobility is not reflected in the National Learner Transport Policy although some formal operators make provisions for identifiable post-school learners. South African universities do not accommodate the majority of students and they tend to have scattered campuses and residences. Only a few (6/26) public universities have contracts with scheduled bus and shuttle services specifically for students. Literature reveals that the characteristics of university student mobility are distinct from the general population. A segment specific approach to redress the potentially problematic results of aggregation could guide the treatment and inclusion of post-matric mobility needs in the National Learner Transport Policy.

Research Problem

In the broader sense of university student mobility, the level of service preferences of students is unknown in South Africa, or poorly specified in order for appropriate services to be developed. This study presents evidence of behavioural heterogeneity in the context of university student travel behaviour. It fills a policy and research gap by exploring university student travel behaviour and making a unique contribution to stated choice literature and applications in Africa.

Hypothesis Tested

Two hypotheses are tested. First, students have unique compositions of behaviour influencing their intention to use bus and minibus taxi. Secondly, there are level of service (LOS) preference differences between students who have high, medium or low intent to use any public transport mode.

Methodology

In navigating toward these hypotheses, the Theory of Planned Behaviour is used to theoretically reflect student behavioural inclinations toward bus and minibus taxi services in Mahikeng. In order to represent the choices students make between two modes the Hybrid Choice Modelling framework is adopted and applied. Therefore the hypotheses mentioned above are tested by means of grouping student responses based on a certain level of intention to use a mode, namely: high (P), neutral (N) or low (Z). To supplement the intention construct, perceived control to use bus or minibus taxi is also used to group university student level of service preferences. Behaviour specific latent class choice models (LCCM) are developed to estimate the probability of a student choosing a specific level of service related to bus and minibus taxi. Utilities are estimated in the form of multinomial logit models that are group (class) specific. An unlabelled d-optimal survey is developed based on observation and literature. Distributed at the North West University’s Mahikeng site of delivery, the survey had 121 properly completed responses of 150 printed copies, only 81 surveys were used in the study.

Results

Three findings are made. The theory of planned behaviour ratings indicate that students are much more favourable to minibus taxi use than bus use. Behavioural latent classes for intention and perceived behavioural control are distinct from the base model. The latent variable model reveals that students are willing to pay to avoid using bus and maintaining their current dispositions towards it. The relationship between intention and perceived behavioural control in the public transport context implies that control over a behaviour is a prerequisite to intention. Through this argument, three behavioural segments that are consistent with literature and theory were identified: choice users (*neutral intention and high control*), captive users (low control and low intention), and public transport

lifestyle users (high intention and neutral control). Further research is needed to validate these relationships.

Conclusions and recommendations

The study accepts both null hypotheses based on the findings that there are class specific level of service preferences, and the behavioural dispositions within these classes are unique. It is recommended that the Learner Transport Policy be expanded to include university student mobility, and that higher education institutions in SA need to manage student travel demand. The main limitations in this study is the insignificance of demographic variables, potentially due to the homogeneity of the sample.

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List of Abbreviations

AVC	Asymptotic Variance Covariance Matrix
SA	South Africa
NWU	North West University
NMMDM	Ngaka Modiri Molema District Municipality
MLM	Mahikeng Local Municipality
TPB	Theory of Planned Behaviour
DCM	Discrete Choice Modelling
SC	State Choice
SP	Stated Preference
RP	Revealed Preference
HCM	Hybrid (Discrete) Choice Modelling
LOS	Level of service
TDMP/F	Trip Decision Making Process/Framework
VOT	Value of Travel Time
VOW	Value of Waiting Time
VOQ	Value of Seating Availability
HI	High Intention
MI	Medium Intention
LI	Low Intention
CPUT	Cape Peninsula University of Technology
UCT	University of Cape Town
CUT	Central University of Technology
DUT	Durban University of Technology
FH	University of Fort Hare
FS	University of Free State
UJ	University of Johannesburg
KZN	University of KwaZulu Natal
UL	University of Limpopo
MUT	Mangosuthu University of Technology
NMMU	Nelson Mandela Metropolitan University
NWU	North West University
UP	University of Pretoria
RU	Rhodes University
UNISA	University of South Africa
SU	Stellenbosch University
TUT	Tshwane University of Technology
VUT	Vaal University of Technology
UNIVEN	University of Venda
WSU	Walter Sisulu University
UWC	University of the Western Cape
WITS	University of the Witwatersrand, Johannesburg
UZ	University of Zululand
OHCM	Ordered Hybrid Discrete Choice Model

MNL	Multinomial Logit Model
SEM	Structural Equation Model
LSS	Likert Scale Survey
AHP	Analytical Hierarchy Process
HTBR-CAID	Hierarchical Tree-Based Regression
OPM	Ordered Probit Model
HMRA	Hierarchical Multiple Regression Analysis
NL	Nested Logit Model
RA	Reasoned Action
NAM	Norm Activation Theory
I	Intention
MP	Mode Preference
CS	Consumer Surplus
MC	Mode Choice
CPI	Car Purchase Intention
TBM	Travel Behaviour Modification
TDM	Travel Demand Management

Major Notation for Latent Class Choice Models

U	Utility
V	Observable utility
r	Decision maker
$j = f(b, t)$	Alternatives
$X_{r,j,g}$	Attributes describing the transport modes
G	is a specific LOS attribute such that $X_{r,j} = (X_{r,j,1}, \dots X_{r,j,G})$
β	Attribute LOS attribute parameter estimate
α	Behavioural indicator parameter estimate
π_{ri}	Probability that decision maker r selects alternative i is articulated as
ε_{in}	Error of independent and identically distributed Gumbel random variables
μ	A scale factor which is used to impose parameter equality
W_j	Waiting time
Q_j	Seating availability
F_j	Price/fare
H_j	Travel time
C	Is the choice set individual r is facing with k scenarios
k	Is the hypothetical scenario within the choice set (i.e. $k = 1, \dots K$), which are the observations.
m	Is the threshold used to specify latent classes
P	High intention class
Z	Neutral intention class
N	Low intention class
I	Intention indicator
A	Attitude indicator
SN	Subject norm indicator
PBC	Perceived behavioural control indicator
s	Latent class as a function of $s = f(P, Z, N)$
u	Salient beliefs for each behavioural construct in the Theory of Planned Behaviour (which is a specific psychometric indicator for each respondent)
ϱ	Belief statement(s) that inform attitudes in the TPB
σ_i	Evaluation statements that assess an alternative in order to inform attitudes in the TPB
$\aleph_i$	Statements related to social and or subjective norms in the TPB
$\mathcal{M}_i$	Behavioural indicator for the motivation to comply in the TPB which informs Subjective Norms
C_i	Behavioural indicator for perceived control over behaviour
P_i	Behavioural indicator for power over a certain behaviour
B_{jk}	The sum-product of parameter priors and choice observations
Θ_{jkc}	Variance covariance
Γ	Fischer information matrix
Ω	Asymptotic Variance Covariance

CHAPTER 1

THE CASE FOR UNIVERSITY STUDENT TRAVEL BEHAVIOUR RESEARCH IN SOUTH AFRICA

1.1 University Student Travel Behaviour

As cities grow and countries develop, skillset needs become increasingly advanced. This places upward pressure on universities to absorb greater enrolments, while managing their impact on the area they are located in. Considering that China has nearly 2000 universities with 25 million full-time undergraduate students (Zhan, Yan, Zhu, & Wang, 2016), or that each day 21 000 trips are attracted to the University of Trieste, a medium sized town in Italy (Rotaris & Danielis, 2015), university mobility will be of increasing importance for transport planning and service design wherever they are located.

One challenge is that student populations are not as heterogeneous as the general population in terms of occupation, and they are distinct enough to require mobility management approaches that are specific to the segment and the dynamics of university life (Gurrutxaga, Iturrate, Oses, & Garcia, 2017; Rotaris & Danielis, 2015; Molina-Garcia, Castillo, & Sallis, 2010). A number of studies reveal that university student travel preferences tend to be different from the general population (Danaf, Abou-Zeid, & Kaysi, 2014; Limanond, Butsingkorn, & Chermkhunthod, 2011; Daisy, Hafezi, Lui, & Millward, 2018), and there are different commuting behaviours between staff and students at universities (Rotaris & Danielis, 2014; Shannon, et al., 2006; Daisy, Hafezi, Lui, & Millward, 2018). Unlike residents in an area, the university student community is a mix of locals-- tend to live further from the university; and students from other areas—who tend to live much closer to the university (Davison, Ahern, & Hine, 2015). To the extent that living with students living with related persons is positively related to driving alone, and being an undergraduate can induce cycling (Zhou, 2016). In addition to this, part-time, and full-time schedules contribute to the students' commuting patterns, unlike the usually fixed nature of daily commuting by the working population.

An area of interest for university student mobility is reducing car use intention. Students may have a deep inclination to purchase cars due to their previous contact with public and non-motorised transport use during their schooling years preceding higher education (Muromachi, 2017). While in school, student's recall that their mobility patterns were based on parents' and their behaviour—whether escorting or enabling public and non-motorised transport use (*ibid*). Malone (2007) argues that young learners who have been taken to school by private car tend to be *bubble-wrapped* and notably limits children's (a) environmental competence; (b) sense of purpose; (c) self-worth and efficacy; (d) social competence and (e) resilience –mainly resulting from 'protectionist parenting'. Parents tend to use private cars to take children to school mainly because of the safety, security and reliability of alternatives although private car use may induce weaker spatial knowledge on the part of the child (Ahmadi & Taniguchi, 2007). This is influenced by the size of the spatial environment, parent relationships with the community and the type of settlement (i.e. urban or rural) (Alparone & Pacilli, 2014). As adolescents, young people in a Dutch city[1] are largely influenced by individual experience and parents' use of bicycles, and changes with respect to their long-term expectations for when they become adults (Sigurdardottir, Kaplan, Møller, & Teasdale, 2013). Viewed more broadly, it can also be argued that influencing ethics, cooperation and inducing behaviour change through long-term education may be a suitable approach to improve the attractiveness of public transport for students (starting at an early age) (Van & Fujii, 2011; Van, Choocharkul, & Fujii, 2014). At university level social pressure from parents is a key factor in the car purchasing intentions of students (Belgiawan, Schmöcker, Abou-Zeid, Walker, & Fujii, 2017). University student travel behaviour is layered based on where they are located, how and with who they live, their experiences as youth, and parents in addition to the sheer demand of higher education. These underlying factors are important points of entry for modifying travel behaviour in the long term.

Internationally, universities tend to have Mobility Management programmes, and Travel Demand Management (TDM) schemes partially funded by the university in some cases. *Unlimited Access* in American universities is programme that facilitates partnerships between transport agencies and universities through university subsidised public transport routes, it dates back to the 1980's. Within the first year of implementation it increased public transport use, reduced car use in addition to reducing subsidy requirements for bus, and increasing ridership and therefore reducing costs per seat kilometres (Brown, Hess, & Shoup, 2001). More specifically, University of California, Los Angeles (UCLA), the university offers a carpooling programme called *Zimride* (Zhou, 2016) and bus service that is free for students, staff and faculty for free called BruinGo (Boyd, Chow, Johnson, & Smith, 2003). At the University of Trieste, Italy, the institution has taken a position on the managing travel through a research programme also supported by a management position referred to as a "Mobility Manager" (Rotaris & Danielis, 2014; Longo, Medeossi, & Padoano, 2015). While at the University of the Basque Country, Spain, a Mobility Management Team was formed in order to identify, formulate and implement TDM strategies at the university (Gurrutxaga, Iturrate, Oses, & Garcia, 2017). These are among the few of many examples of institutions approaching the travel demand around universities, with specific measures that reflect the unique characteristics of university mobility. Such approaches make it difficult to aggregate travel demand, service preferences and use national surveys to inform service design at university level. Merely providing transport services without considering the behavioural layers underlying university student mobility may limit the full potential of the services' impacts. From a behaviour modification perspective improving public transport is much more

[1] Note that the modal split for cycling is 38% in this study.

influential than *promoting it* because service improvements reduce the physical and attitudinal barriers in a self-reinforcing manner (Shannon, et al., 2006). At the same time, a number of universities in SA, do not have any such interventions in place and may need evidence to guide approaches to manage university related mobility.

1.1.1 Universities in South Africa

In the South African context the low on-site accommodation and increasing student populations place upward pressure on travel demand and the generalised cost of travel. In Figure 1, full time student year on year increased by 3% on average between 2010 and 2014. The total population of university students in SA was 0.96 million head counts and 0.66 million full time students in 2014 (DHET, 2016). Although many universities have invested in expanding in infrastructure, student enrolment continues to grow and travel demand is sure to follow. The *Statistics on Post-School Education and Training in South Africa 2016,* estimated that in 2015 the total number of university students was 1.13 million, increasing to 1.43 million students across 26 universities and 123 private higher education institutions (DHET(b), 2018). The yearly growth from 2014 to 2015 was 17%, rising to 27% toward 2016. The *Report on the Ministerial Committee for the Review of the Provision of Student Housing at South African Universities* reveals that on average, universities could only accommodate 23% of students in 2010 (DHET, 2011, p. 32). With the massive growth in enrolments between 2010 and 2016, the off-campus and on-campus housing demand must have placed even more pressure on travel demand.

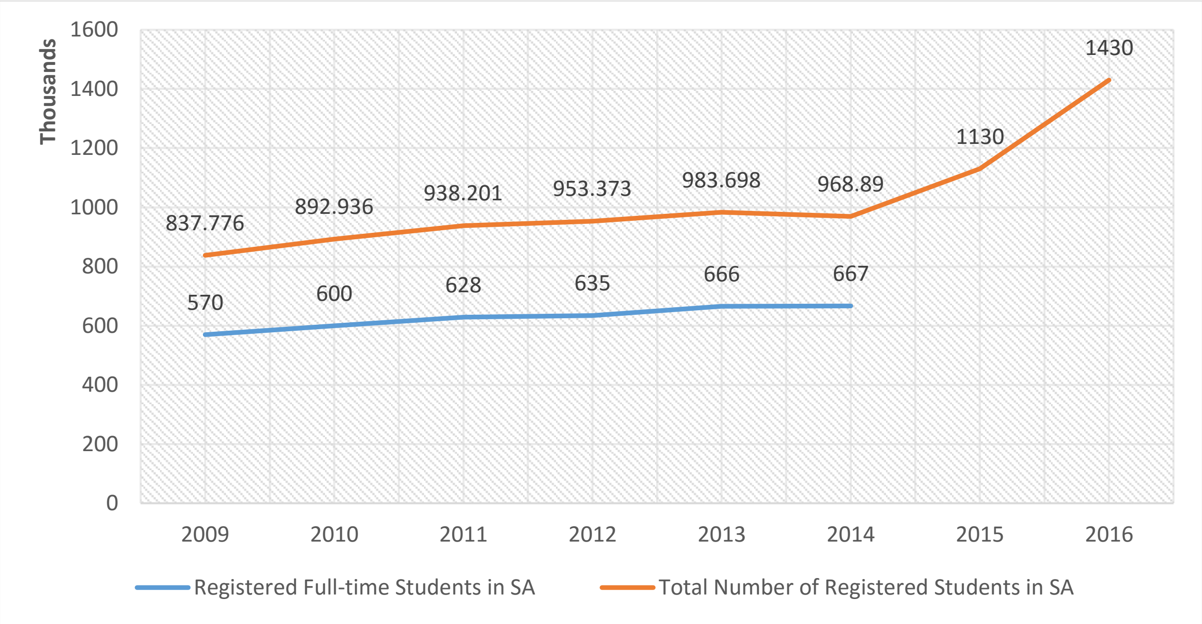

Figure 1: Number of Students Enrolled in Higher Education Institutions

In Figure 2, 23 of the 26 public higher education institutions are presented with the percentage share of students living in university residence for based on 2010 data (DHET, 2011, p. 32), and their full time equivalents for 2010 and 2014.

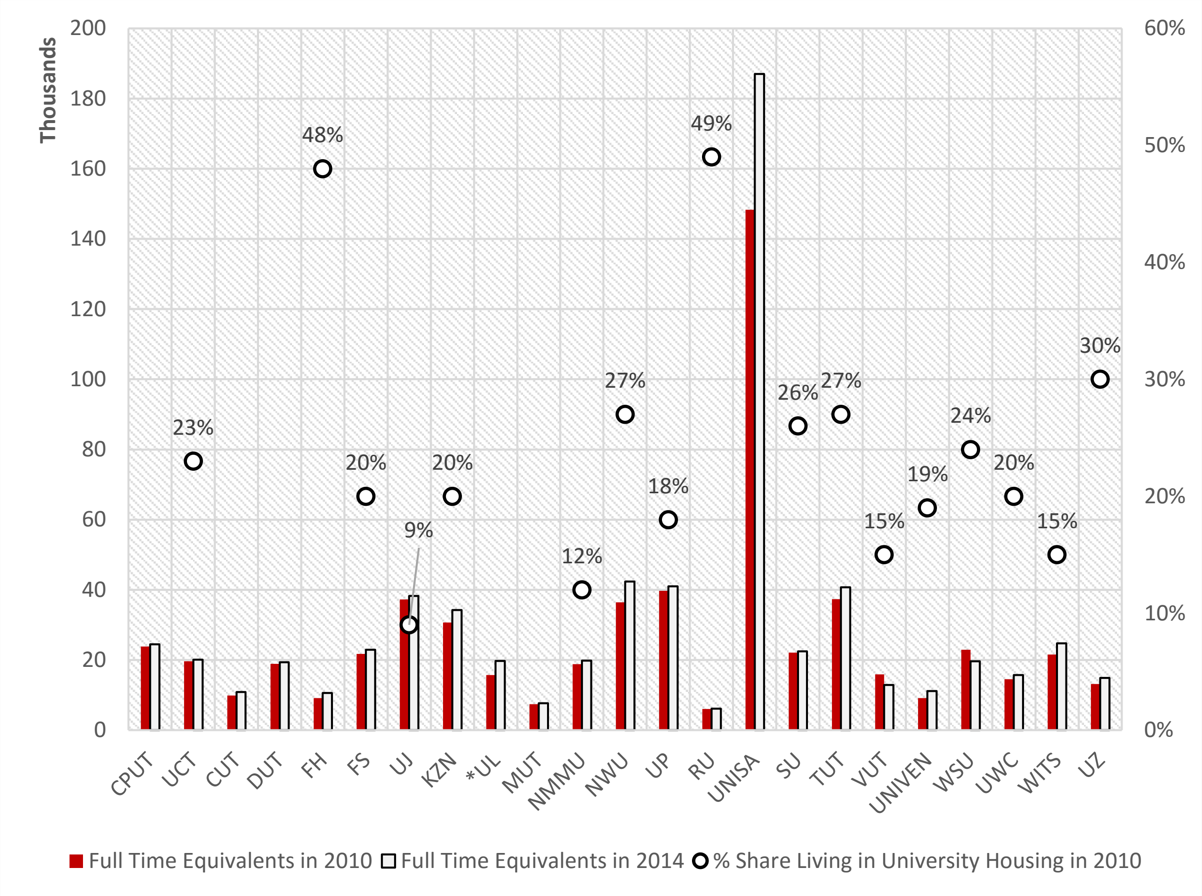

Figure 2: University Student Population and Accommodation by Higher Education Institution

CPUT=Cape Peninsula University of Technology; UCT=University of Cape Town; CUT=Central University of Technology; DUT= Durban University of Technology; FH= University of Fort Hare; FS=University of Free State; UJ= University of Johannesburg; KZN = University of KwaZulu Natal; UL= University of Limpopo (*incl. Sefako Makgatho Health Sciences University); MUT= Mangosuthu University of Technology; NMMU= Nelson Mandela Metropolitan University; NWU= North West University; UP= University of Pretoria; RU= Rhodes University; UNISA= University of South Africa; SU= Stellenbosch University; TUT= Tshwane University of Technology; VUT= Vaal University of Technology; UNIVEN= University of Venda; WSU= Walter Sisulu University; UWC= University of the Western Cape; WITS= University of the Witwatersrand, Johannesburg; UZ= University of Zululand.

In 2010, there was no record of student accommodation in Cape Peninsula University of Technology (CPUT), Central University of Technology (CUT), University of Limpopo (UL), University of South Africa (UNISA)[2] and Mangosuthu University of Technology (MUT). The percentage of students accommodated by universities range from 9% to 49% which in some sense relate to the number of students enrolled at the university. At the University of Johannesburg (UJ), Witwatersrand (WITS), Vaal University of Technology (VUT), Nelson Mande Metropolitan (NMMU), Pretoria (UP), and Venda (UNIVEN) student housing accommodated less than 20% of the full-time students enrolled. Enrolments range from 11000 to 24000 in these universities. Assuming that full-time students are not in distance learning programmes, in six universities, 80% of the students needed to use some form of transport to commute to campus from accommodation other than that provided by the university. The University of Zululand (UZ), Fort-Hare (FH) and Rhodes University (RU) with 14

[2] UNISA is an open distance learning university and thus may not necessarily need student housing for all qualifications.

000, 10 000 and 6 000 enrolments have student accommodation rates between 30% and 49%. In which chase travel demand for these university towns is considerably lower than the rest of the universities. The remaining universities accommodate between 20% and 29% of students on the campus residences and have enrolments that range between 20 000 and 40 000 students. The most recent universities—excluded from the chart—are in towns such as Kimberly in the Northern Cape, and Nelspruit in Mpumalanga.

University enrolments in South Africa are most probably going to increase at a higher rate. Davison et al. (2015) argue that the manner in which higher education cost changes may have an effect on travel demand. The more affordable, the greater the likelihood of higher enrolments, more students and much greater travel demand. After the #FeesMustFall protests to lower university fees in South Africa, the *Commission of Inquiry into the Feasibility of Making Higher Education and Training Fee-free* made significant recommendations related to access to university (DHET, 2017):

(a) Government expenditure in higher education and training should be at least 1% of Gross Domestic Product;
(b) The severe shortage of student accommodation can be addressed through affordable housing and Public-Private-Partnerships; and
(c) Pecuniary access to higher education needs to be eased by means of Income Contingency Loan System, supported by a fee capping mechanism, and the removal of application and registration fees.

Changes in such regulations may attract investment toward higher education centres and induce more trips between university campuses, residences and the local area. Higher education in SA is now highly subsidised and this will continue to be the case as the cost of operation increases while the price is capped. With respect to public transport provision, recommendations presented do not account for university student mobility needs and how they will be impacted by the rapid growth in higher education enrolments and the concomitant accommodation, and other land-use needs. More so, there are very few studies in the South African context that attempt to investigate the provision of public transport for university students, staff and local residents in university towns and precincts.

1.1.2 Public Transport Provisions for University Students in South Africa

South African universities are predominantly constituted by multiple campuses and residences varying in proximity. Access to the institution, whether living in university residence or not, is done through various ways. One of the few reports on university student mobility in SA emphasises that students at the University of Johannesburg (UJ) use different transport modes for different campuses: in one campus walking dominates (60%); car dominates in another (20%<); Minibus (40%), bus (30%<) and rail (10%<) on other campuses (Mbara & Celliers, 2013). They also find that most of them use one mode of transport, whilst being exposed to a number of factors: congestion, safety-security limitations, high likelihood of late arrival and so on—particularly in those who live off campus (ibid). Some universities have however found ways to integrate with transport operators in order to offer safe, secure and consistent transport services exclusively to students on their respective campuses. In order to connect students, university facilities and relevant activity centres, 6 of the 26 universities have official *shuttle* services exclusive for students.

The University of Witwatersrand offers an intercampus Bus Service with 65 seater buses integrated to a mobile app with schedules and other details (Wits, 2016). The service links students with other campuses and activity centres. Similar to Wits University, the University of Pretoria offers Residence Bus Services between residences and Inter-campus bus services through two operators Stabus and Grundling Buses (UP, 2016). The University of KwaZulu-Natal also operates an inter-campus shuttle service linking Howard College with Westville between 07:15 and 20:30 (UKZN, 2016). For Johannesburg and Tshwane (Gauteng Province) the university transit service supplemented by the availability of other public transport modes (i.e. Metro Bus, Reya Vaya Bus Rapid Transit).

The University of Cape Town Jammie Shuttle is one of the earliest examples of university student public transport services (UCT, 2016). It has a neighbourhood network, time tables and is aimed at improving connectivity between student residences and university property—week day and weekend. A recent addition to the mobility programme at the UCT is a carpooling programme for registered students, which is administered on a university platform.

At the University of Stellenbosch a campus shuttle service is available (SUN, 2016). Private car restrictions on campus enable this shuttle service which is primarily designed to transport students from the periphery (largely parking areas) to the campus from 07:00 to 17:30. An evening shuttle from town is also available for late night study; whilst a shuttle between residences and the periphery is available from 07:30-02:00. To the author's knowledge, emerging universities such as University of Mpumalanga, Sol Plaaitjie University and North West University are yet to introduce dedicated and exclusive transport services for daily commutes in the respective areas.

1.1.3 National Household Travel Surveys Underrepresent Student Travel Behaviour

Household travel surveys tend to be expensive, and overly aggregate target groups with very particular needs. This is fundamentally because they are aimed at contributing to national transport policy and strategic objectives. The broad limitation of national travel surveys is that they may provide a large sample of responses (and cost); but constrain the degree to which new modes; willingness to pay and other service design factors are estimated (Ortuzar & Willumsen, Modelling Transport, 2011). They also tend to underrepresent the particular dynamics and attributes related to university student travel behaviour (Zhan, Yan, Zhu, & Wang, 2016)-- and their distinction from the broader population (Khattak, Wang, Son, & Agnello, 2011). In order for *trip* distribution considerations to be made at a strategic level the modal split across different education centre types and between universities by province need to be accounted for.

Figure 3 presents modal distributions for school, colleges, higher education and other forms of post-school education based on the *National Household Travel Survey (n = 12880 for this cleaned data)*. There is a response issue in the NHTS worth mentioning: many of the responses in post-school education lean toward *metered taxi* and not *minibus taxis*—the dominant mode in public transport in SA. It is assumed that this may be a response error, hence *taxi services* as a collective term is used for description.

In the Figure, most of the trips were reported motorised trips for education trips other than the learner segment (‘school, all grades). Higher Education mobility is predominantly motorised through private cars (31%), paratransit (29%) and *metered taxi* (26%). Walking is not a prominent mode in the NHTS, but public transport, metered taxis and car use are. Non-motorised transport on a national level appears to be small—although it is a key mode in connecting individuals to public transport modes and moving around within the campus[3]. School mobility takes place through *taxi services* (41%), while private cars (37%) and bus transport follow (18%).

ABET centres attract trips that are dominated by *taxi services* and as much bus transport as in the Other education centres with modals splits of 22% and 25% respectively. *Taxi services* dominate FETs and other Colleges by 61% and 57% respectively. Home based education students seem to use cars (44%) and public transport (50%). Between 1% and 7% of the trips take place through non-motorised transport, suggesting that only a small share of students live in such proximity with the campus that they can walk to the institution. Each education cluster presented is distinct from the next, but when looking at one specific cluster the effect of aggregation begin to set in, limiting the scope and usefulness of available data.

[3] In the *National Household Travel Survey Stakeholder Engagement Session* hosted by the North West Provincial Department of Transport and Community Safety in early 2016, it was noted that the survey does not capture the mode trip chain. The statistical approach is hierarchical where the mode choice data is ranked by ‘capacity’ and not respondent indication. In other words, ‘train’ is ranked number one and ‘bus’ number two. Even if a person travels most of their trip by bus, and only a small portion by train, train will be the ‘main mode’ according to Statistics South Africa.

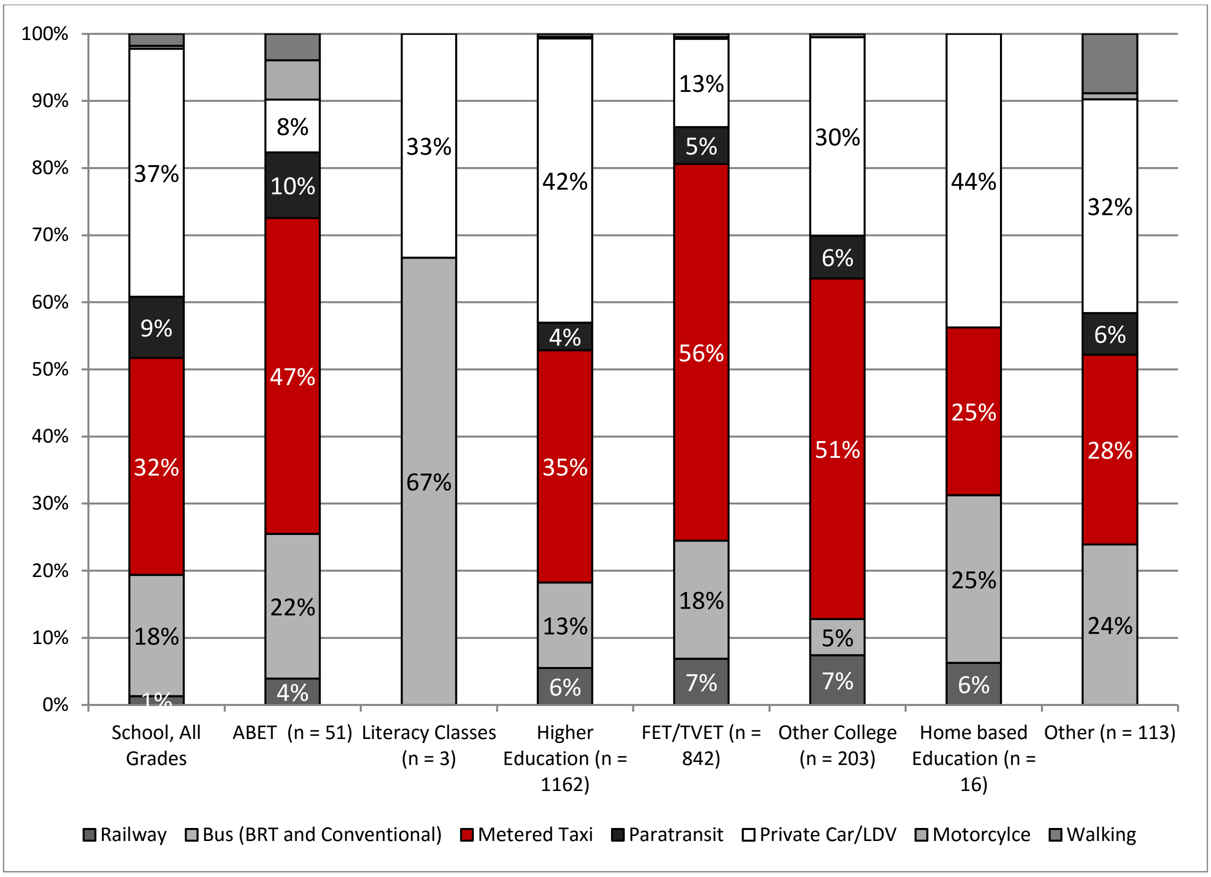

Figure 3: Modal Split for Education Trips on a National Level (n = 12880) (StatsSA, 2014)

ABET= Adult Basic Education and Training; FET= Further Education and Training.

Consider the modal split estimates for universities across provinces presented in Figure 4. The sample size is low compared to the total population of university students highlighted above, because the survey is designed to provide an aggregate view. This problem is accentuated by the fact that universities in SA seldom perform mobility assessments of students in order to understand their travel needs. Responses from provinces range from one to 462 in Gauteng. Western Cape passenger rail use accounts for 24% of the modal split followed by 5% in KZN and 4% in Gauteng. Bus use to higher education is at its highest in Mpumalanga, accounting for 40% all trips, followed by Limpopo with 30%.

Metered taxis, which are assumed to have been confounded with paratransit in some cases, account for 45% and 44% of the trips in the KZN and EC. Private car use by university students is highest in the Western Cape, accounting for 54% of the university student modal split, while being on average 49% of the modal split of all university mobility. In NW, 18% of the students use bus (34%) and *taxi* services (34%) are used less than private cars (46%). From a strategic policy making point of view, the insights derived from these results are useful for descriptive purposes. Each cluster of education travel seems to be unique in terms of modal split; for university travel the dominance of car use persists in most provinces; or the use of *taxi* services (both paratransit and meter taxi) feature prominently; and bus and rail use vary most significantly across the provinces due to unique endowments. While 6 universities in the country have some type of transport service intervention to support university student mobility, no policy framework to support or guide these interventions—other than the ones related to transport provision in general.

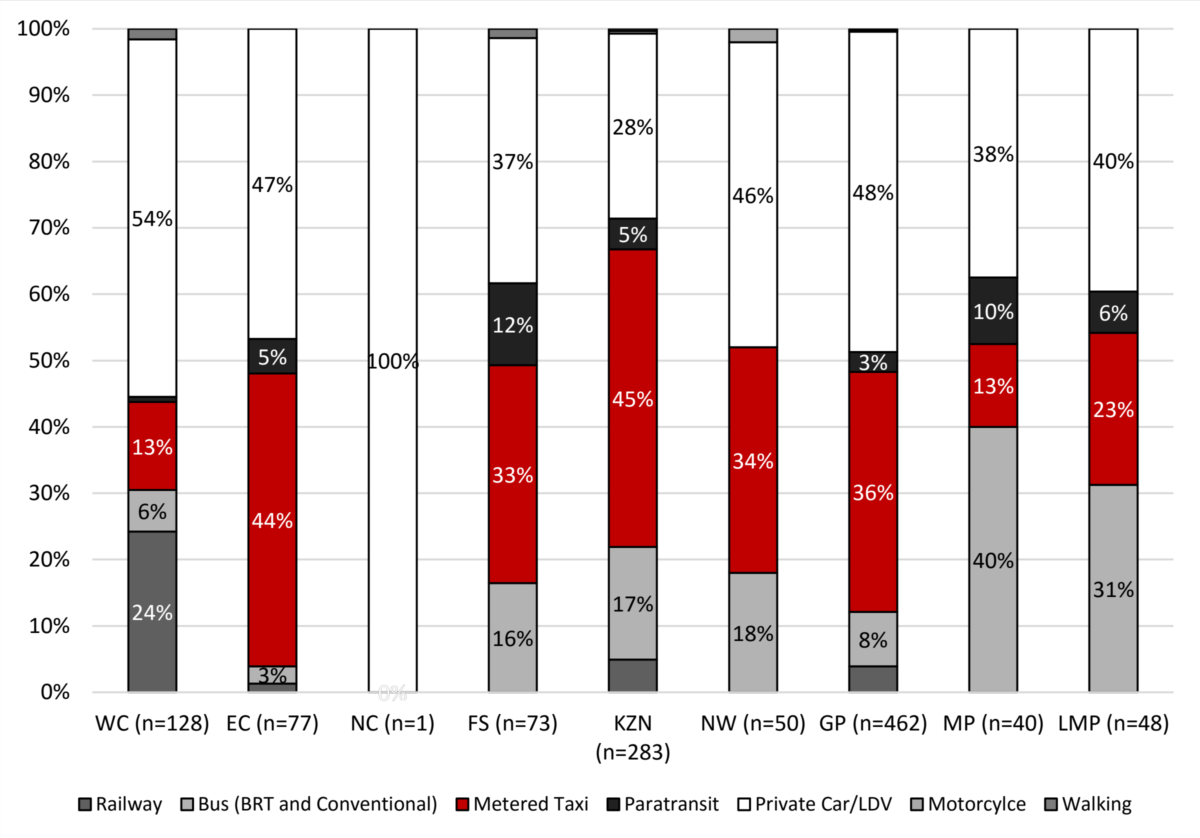

Figure 4: Main Mode to University by Province (StatsSA, 2014)

WC= Western Cape; EC=Eastern Cape; NC= Northern Cape; FS= Free State; KZN= KwaZulu Natal; NW= North West; GP= Gauteng Province; MP= Mpumalanga; LMP= Limpopo.

1.2 The Importance of Reflecting University Students in the Learner Transport Policy

Empirical research in transport needs to be aligned and located within the policy context associated with its application. Research in transport tends to be dislocated from the policy making process, with very few studies specifying the role of empirical evidence in the policy environment in which the results need to be translated (Marsden & Reardon, 2017). The policy making environment in SA is more effective for roads policies over public transport policies mainly due to the non-linearity of a myriad of factors influencing commuter bus policies (Mitchell & Walters, 2011). Integrated Transport Planning (ITP) is the implementation arm of different policies and specific features in an area, they are expected to be responsive to customer demand; principles of national policy and strategies; and are financially viable relative to the equity needs they serve (see guidelines (DoT, 2016)). However, they need to be deeply aligned with specific performance targets and associated incentives in order for local authorities to take tangible action on ITP programmes and their relationship with policies (Marsden, Kelly, & Nellthorp, 2009). While Walters (2008) argues that in SA, policy making takes place in silos between different modes; it is also important to note the different capacity, values, and administrative boundaries between public sector service sectors—which can be disconnected (Hull, 2008). At a policy level, the underlying interest in this study is to explore the manner in which university student mobility needs can be accounted for in general. However, there is no transport policy that grapples with university mobility specifically.

Considering the distinct nature of university student behaviour, demand, and mode choice it is feasible to argue that specific provisions could be made for this education cluster as much as any other. However, the Learner Transport Policy (LTP) was developed in order to (DoT, 2015):

> *"...meet the mobility needs of learners through the provision of a safe, secure, reliable and affordable learner transport service to support social development and enhance future economic growth".*[4]

The long term ambition of the policy is:

> *"To ensure that learner transport is integrated with mainstream public transport services according to the IPTN in both rural and urban areas" (DoT, 2015, p. 19).*

Which implies that the policy was specifically developed for learners from grades R to 12 (ages 5 to 18) to enable the effective, multi-modal, coordinated, safe, viable, uniform and well monitored learner transport services. It is a suitable interface between the National Department of Transport and the Department of Basic Education, but Higher Education travel demand requires institutional support to reflect the broad mobility needs. In line with Hull (2008) the layers of systematic differences between Basic and Higher Education, in addition to the Department of Transport may accentuate the challenges of including university transport services into the policy.

The scope of transport provision seems to transcend transport services, and include various other interventions in the context of mobility management. Some studies argue that transport planning for education institutions should be reinforced by travel demand measures (Gurrutxaga, Iturrate, Oses, & Garcia, 2017), and transit oriented development (Muromachi, 2017), in addition to good quality infrastructure and good quality public transport services. A combination of TDM and TOD measures are necessary, however improvements in public transport tend to have significant impacts on its attractiveness (Shannon, et al., 2006; Rotaris & Danielis, 2015). In a study of students at the University of Western Australia, introducing a public transport pass could increase PT use by 127% for staff and students within a 1km < 8km

[4] The policy position resonates with 'trickle-down' economics wherein economic growth supersedes the underlying economic development that is necessary to activate good quality equitable growth. This is a counterintuitive narrative because meeting access and mobility needs requires interventions that develop local economies, not necessarily translating to growth.

range of the university (Shannon, et al., 2006, p. 246). At the University of Trieste, Italy, a free one-way bus ticket reduce car use by 58%, with students' car use lowered by 71%, faculty down by 55% and staff by 41% (Rotaris & Danielis, 2015, p. 162). At the University of California Los Angeles, the introduction of *BruinGo* a bus route service subsidised by the university (small subsidy really) resulted in a 42% and 40% increase in public transport use of direct *Blue Bus* routes to campus, and any route to campus (Boyd, Chow, Johnson, & Smith, 2003). In a study of 35 universities in the USA, which offer *free* public transport passes for university students some universities not only had the programme running since the 1980s, but the impact on ridership within the first year of some ranges from an increase in 71% to 200% in public transport ridership (Brown, Hess, & Shoup, 2001). In terms of access to higher education, the ridership implications for *free* and *paid* PT services have far reaching impacts. Most universities, however interface with basic education schools, colleges and other education centres. In the SA context, the current framework of the *Learner Transport Policy* (LTP) artificially constrained to one segment. For travel demand management to work, behavioural attributes that influence mode preferences supplement the land-use, and public transport service design elements.

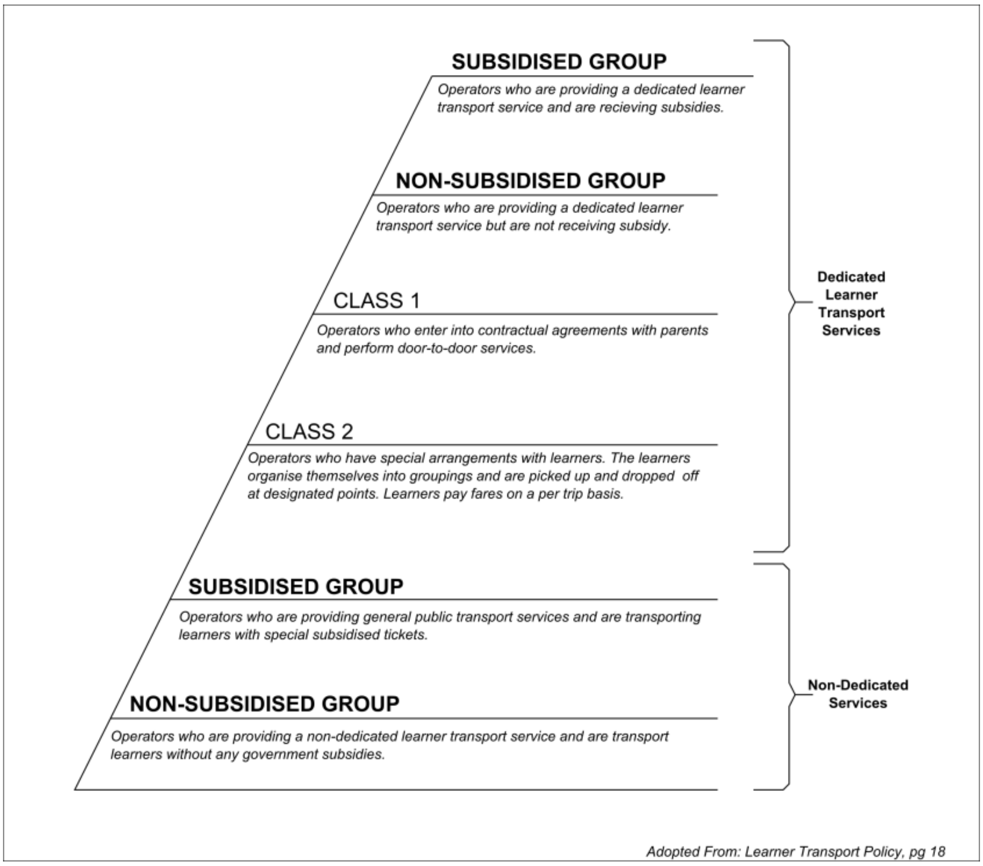

Figure 5: Types of Learner Transport in the Policy (DoT, 2015)

The LTP does make some provisions for operational arrangements with PT operators. In Figure 5, various types of learner transport operations are presented in the LTP. Some offer services solely dedicated to moving learners and others are not—both may be subsidised. Many short and long distance scheduled bus services offer lower prices for post school students and children under a certain age.

Paratransit services however, tend to only offer discounts for non-seat occupying age groups (i.e. toddlers that may be carried by parents or sit in non-seating areas)[5]. Bus services in most metros have dedicated learner-trip and student-trip ticket prices charged with the driver's discretion or the tickets that students may have bought before hand—if not the production of a student card. Returning to Figure 5 most metro bus services are in the subsidised group wherein general transport operators receive a subsidy for learner trips. The non-subsidised group has two classes. The first is where the trip arrangements are between parents and operators, offering door-to-door services. And secondly, learners make the arrangements with an operator on a per-trip basis—particularly high-school learners. Many of the paratransit services offer non-subsidised mobility dedicated to learners, although most may perform other trips after transporting learners.

In the learner transport policy three *'policy focus areas'* that need contribution and development are (1) criteria for benefit, (2) level of service design and (3) modal integration (DoT, 2015, pp. 22-25). The level of service design (LOS) issues resonate directly with the interests of this study further justifying a deeper investigation that is transferable to other learner mobility policy and planning challenges. Universities in SA tend to be located in close proximity to many activity centres and existing operators already offer mobility services—within a local ITP framework. This makes the design of university student mobility services a unique opportunity to identify ways in which they may be attracted and retained to public transport use if targeted specifically.

1.2.1 The Institutional Importance of Service Preference

The provision of public transport services, their unique operational requirements and historical setting is disrupted by emerging interventions in many South African cities. Synthesised in Figure 6, the operational, contractual and land-use basis of interventions is informed by the policy, budget and infrastructure implemented to realise the initial objectives of these actions. Supporting interventions is the presence of, *inter alia*: information technology infrastructure; marketing and communication strategies; institutional reform; zoning and other land-use bi-laws; environment related taxes and incentives; public participation systems and so on. Locating the importance of segment specific interventions is crucial in the design of public transport services as it enables the reader to assemble the (a) funding, (b) contracting, and (c) network related proponents of designing services suited for a specific user group. **Developing preference models for certain levels of service for a specific segment's behaviour enables greater specificity in directing interventions—linked to other**

[5] These are the author's observations as there is no empirical study on the subject.

broader ones—to promote and perhaps induce sustainable mode choice in the motorised transport context.

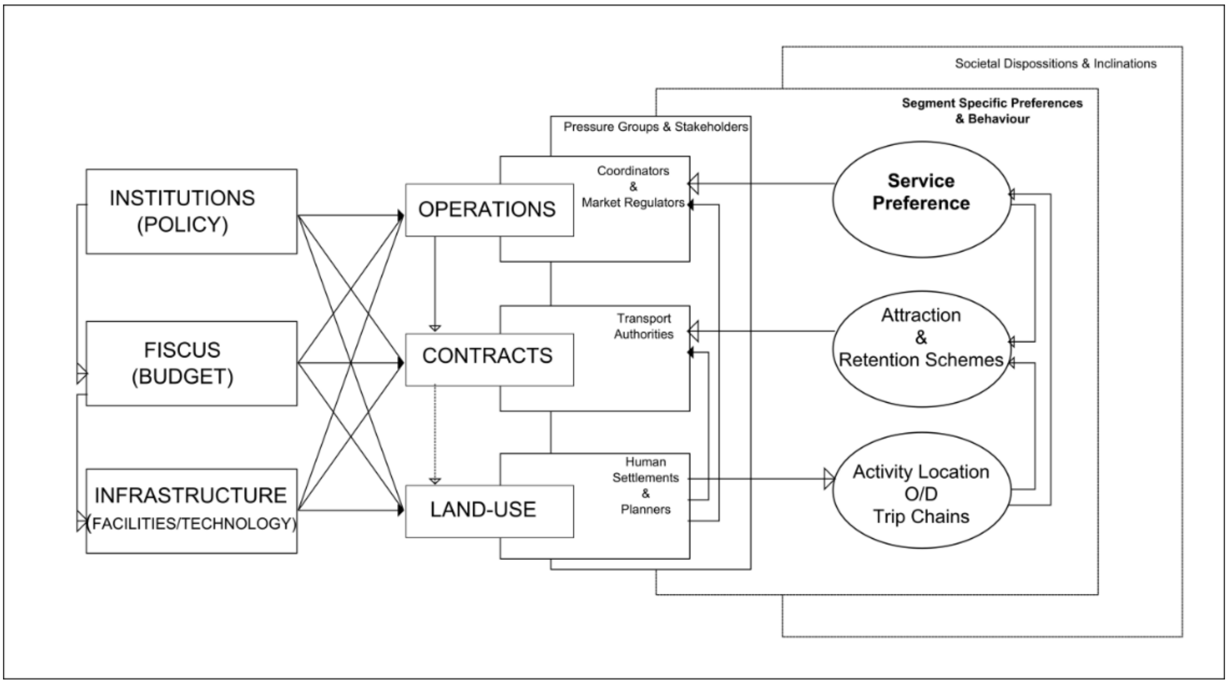

Figure 6: Broader Outline of Interventions in Public Transport Service Design (developed by Author)

1.2.2 Practical Policy Considerations for University Student Mobility

Understanding segment specific preferences and targeting them could be a key determinant of next-generation public transport service design, passenger attraction and retention. The dynamics are simplified in Figure 6, wherein interventions take place within and across various factors and decision groups. In particular, policies, budgets and infrastructure interact with societal and segment specific preferences through some of the common interventions. The societal dispositions are manifested through parenting, schooling and other factors discussed earlier may be continued by university students and influence their current and future mobility preferences within a total transport system. The interaction between the *National White Paper on Land Transport Policy* (DoT, 1996), on the base of the *Constitution*, with the *Learner Transport Policy* (Government Gazette, 2014) is animated through interactions between the Department of Basic Education, the Department of Transport and the gap identified is that the Department of Higher Education and Training (DHET) also needs to be involved.

On one hand, contracts are issued through bidding processes wherein learner transport services are expected to be outlined within some terms of reference. The level of service is specified for schools, in terms of frequency and capacity necessary. Funding for this activity emanates from the *Division of Revenue Act* under the *Public Transport Operations Grant* (The Presidency, 2016) facilitated by the *Rural and Scholar Transport* Programme in the National

Treasury increasing from R 4 million in 2012/2013 to R 41m in the 2015/16 financial year (National Treasury(a), 2016, p. 21). Projections for the transport services are in the R 58 million in the 2017/18, specifically to enable the development of "*a costing and financial framework on learner transport by 2017*" (ibid.). Although there are various operator categories, learner mobility within the existing framework is relatively appropriate for the target age groups. For university mobility schemes, the problems may be more complex. Each university will have unique and dynamic needs in an environment that has limited funding but open to partnership(s). At an institutional budgeting level, this study largely contends for an integrated extension of the LTP such that post-school education and training trips form part of the learner mobility umbrella. In doing so, the need for LOS models and service designs approaches could enable universities to respond to the growing mobility challenges with a policy backbone implemented through the ITPs.

1.3 Research Problem & Objectives

The preceding discussions outlined an international and local perspective on university student travel in at a strategic level, with broad challenges that are impossible to address in one study. The lack of literature and practical knowledge about university student travel preferences in South Africa exposes a gap in access to education research. Whether for commercially or university run transport services, such a gap in literature raises concerns over the adequacy of existing services offered in the university precinct. Level of service (LOS) in this research refers to how public transport services are offered in terms of access (i.e. price, coverage), operations (i.e. frequency, travel time) and quality (i.e. comfort). In a university campus environment, LOS needs are different from the general public due to the location of the campus, all day activity schedules (i.e. class timetables are all day, no 'peak' for students). Perhaps exploring university students' intention to use certain transport modes needs to be estimated, questioned and tested to initiate a contribution in the ecosystem of education mobility. However, understanding intentions only provides a behavioural element which needs to have transport services that reflect and potentially induce public transport use—now and in future.

1.3.1 Research Problem

This study explores the LOS preferences across degrees of intention. The study classifies university student modal preferences between high, medium or low intentions toward a certain mode. Access to public transport in SA is a high priority policy issue. Traditionally this is done through assessing whether prices or comforts are rated as more or less affordable or suitable, respectively—especially in the National Household Travel Survey.

However, if it is assumed that preference manifests from psychological constructs that influence behaviour (observed through constructs) then a deeper understanding of preference beyond LOS is necessary. The inclusion of such constructs[6] should be within a theoretical framework that enables an interpretation of how LOS preference and mode choice manifests from indicators representing such constructs. Bearing in mind that there are instances where responses to surveys are inconsistent with actual behaviour (Hensher, Rose, & Greene, 2005; DeFleur & Westie, 1958), it is assumed that stated behaviour and preference is an approximate observation of true behaviour. Performing such a task may enable more than price and service design interventions—which are important structural barriers to remove (Shannon, et al., 2006) . This approach allows for broader behavioural textures that account for student travel decision making while potentially improving the service design specifications for public transport services.

The research problem investigated in this of this study is:

> *In response to the lack of evidence, policy and institutional frameworks, a deeper understanding of university student travel preferences within a behavioural theory needs to be achieved in the South African context in order to identify the implications for level of service design in public transport services.*

1.3.2 Research Questions

To address this problem the following research questions are investigated:

1. What are the characteristics of a conceptual framework that represents a research process linking discrete choice modelling with behavioural theory in the South African student mobility context?
2. How should behavioural classifications of preference be estimated and incorporated in order to differentiate mode choice preferences within these classifications?
3. What are the potential service design and behaviour modification implications of using behavioural classifications to represent mode choice preferences in the context of public transport use by university students?

1.3.3 Hypotheses Tested

The first research question is described through testing the conceptual framework proposed in 1.4, in the form of Figure 7—which integrates the complex ambitions underlying this study. For the purpose of addressing the quantitative requirements for the second research question, two hypotheses are tested:

> H_0: Students classified by behavioural classes of intention have unique behavioural utility functions influencing their inclination to use bus and minibus taxi.

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[6] The term 'constructs' reflects two important concepts. Travel behavior is a result of certain dispositions individuals have toward various alternatives, and these dispositions can be captured through statements that *construct* a degree of recording these nearly immeasurable *attitudes,* see Ajzen (1991) and DeFleur & Westie (1958).

H_1: Students classified by behavioural classes of intention do not have unique behavioural utility functions influencing their inclination to use bus and minibus taxi.

And

H_0: There are levels of service preference differences between students who have high or low intent to use any public transport mode.

H_1: Preferences toward level of service do not differ between students who have high or low intent to use any public transport mode.

The third research question is explored through testing scenarios that differentiate modal split scenarios for the base model, and the class specific choice model. Neither question one or two require statistical assessment, and as such no hypotheses are tested for them, as they are derived from the effective exploration of the second research question.

1.3.4 Contribution

The aim of this study is therefore to empirically present the classification of individuals based on psychological constructs that characterise individual behaviour in terms of public transport. These groups are then used to differentiate mode choice preferences. The first contribution this study makes is to integrate a stated preference (SP) approach to university students travel preferences with the effect of psychological constructs toward and between bus and minibus taxi choice. **This is done in order to specify service improvements between two *competing* and *complementary* public transport modes.** The second contribution is an application of behavioural theory to account for variations in mode choice preferences. **This is done in order to classify students based on their intention to use a certain public transport mode with respect to the level of service it offers.**

1.3.4.1 Consumer Behaviour and Psychology

Consumer behaviour is prominent in microeconomics, as it assumes rational choice to maximise utility explains how individuals choose between alternatives (Simon, 1956; Pindyck & Rubinfeld, 2009). SP is an empirical methodology used to estimate the utility functions[7] of respondents through a repetitive selection of alternatives presented through hypothetical scenarios (Rose J. M., Bliemer, Hensher, & Collins, 2008; Hensher, Rose, & Greene, 2005). This type of experimentation requires *efficient* survey experiments which tend to constructed, and evaluated through statistical techniques. Such an approach is known to reduce the sample size requirements (Hess & Rose, 2009), expand the scope of surveys in order to willingness to pay (WTP), elasticities and other valuations that household travel surveys normally do not capture (Ortuzar & Willumsen, 2011). Inherently, this type of specification is unique in the context of South African university mobility research, but it has been applied in other studies about university mobility (Rotaris & Danielis, 2014; Nguyen-Phouc, Amoh-Gymah, Tran, &

[7] Kenneth Train presents a comprehensive guide on model estimation within the context of both stated preference and revealed preference research (Train, 2009).

Phan, 2018). From the SP experiments utility functions are estimated based on the choice between bus and minibus taxi for a specific trip. This estimation is performed through discrete choice modelling (DCM), a widely used technique to estimate travel preferences through maximum likelihood estimation (Train, 2009; Hensher, Rose, & Greene, 2005). Within a random utility maximisation framework one of the main assumptions behind DCM, is that respondents aim to maximise their utility (Walker & Ben-Akiva, 2002) which is consistent with microeconomic theory (Pindyck & Rubinfeld, 2009). Patterns underlying preferences may be explored through socio-demographic characteristics but, given the homogeneous nature of university students it is of interest to explore the potential for classifying heterogeneous preferences based on behavioural constructs. Such an attempt is not unique, McFadden (1986) recommended an integration between behavioural indicators and choice and various studies have performed a degree of classification (Gopinath, 1995), or theoretical understanding of behaviour (Belgiawan, Schmöcker, Abou-Zeid, Walker, & Fujii, 2017). The attempt to improve our understanding of mode preferences and choices within the psychology of such decisions in by classifying utilities based on a behavioural theory leads to the second contribution.

1.3.4.2 Behavioural Latent Class Modelling

The second contribution is that the study uniquely, applies a part of the Hybrid Choice Modelling (HCM) framework of preference-behaviour research in South Africa: which has not been done before for university mobility. HCM is a research framework that incorporate behavioural constructs to specify models that have latent variables, and, or classes (Walker & Ben-Akiva, 2002; Greene & Hensher, 2003; Ben-Akiva, et al., 2002). The hybridity stems from specifying the behavioural theory that can be used to estimate unique classes or determinants of behaviour in the form of utility functions; and or latent variables which influence the utility function. The behavioural theory of choice in this study is the Theory of Planned Behaviour (TPB) is adopted because of its relevance with regard to choice making and broad use in the public transport research arena and its applications in university student research (Muromachi, 2017; Kerr, Lennon, & Watson, 2010; Van, Choocharkul, & Fujii, 2014; Belgiawan, Schmöcker, Abou-Zeid, Walker, & Fujii, 2017). The theory argues that behaviour is approximated by intention. Intention is a function of the control over the behaviour, social norms of the behaviour and attitudes toward the behaviour (Adjei & Behrens, 2012; Ajzen, 1991; Ajzen, 2014). The combined effect of integrating HCM with the TPB may lean this study much closer toward behavioural economics in the context of transport economics of university student mobility. A conceptual framework integrating the *analytical research objectives* with the *theoretical dimensions* leading to an understanding of *level of service* intentions is presented in Figure 7, which is elaborated in the next subsection.

1.4 Conceptual Framework and Research Design

At the heart of this study is to test two hypotheses through a combination of analytical objectives listed in 1.3.2 in the form of *research questions.* The conceptual framework presented in Figure 7 underpins the first research question in which the mechanics behind consumer behaviour of university students are described in the form of *analytical objectives, theoretical dimensions, model specification and interactions*.

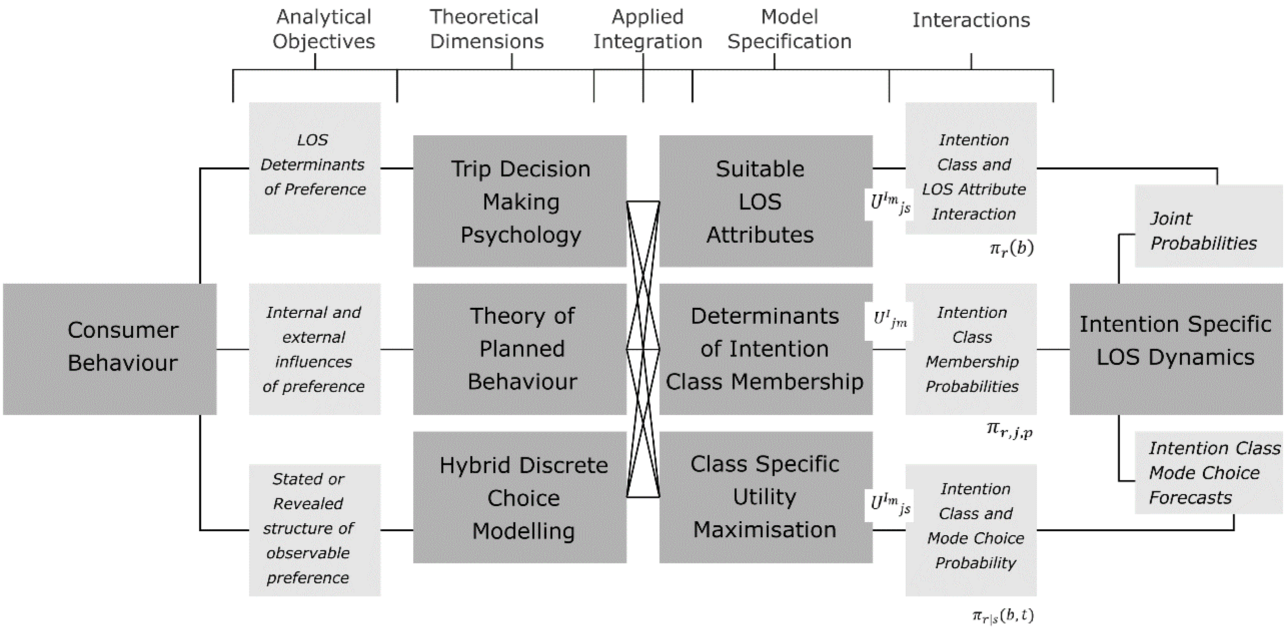

Figure 7: Conceptual Framework for Behaviour Specific Latent Class Modelling

Based on addressing the second research question is related to how level of service design determines the preference toward a certain mode which is subject to analysing the internal and external influences of preference. This requires specific attention on *how trip decisions are made,* an understanding of *the TPB,* and estimating *HCM.* Expected results are derived from the *interactions* between the LOS attributes, the classification of membership, and the utility functions that are specific to unique behavioural classes.

1.4.1 Research Outline

This study flows through five chapters, including this introductory chapter. The next chapter presents a review of literature about university student travel behaviour and mode choice. This review also explores the lack of university student mobility research in South Africa. Chapter 3 describes the research process and methodology applied in this study. It discusses some of the key theoretical concepts about random utility theory, and the construction of the Theory of Planned Behaviour, in the latent class and latent variable modelling. In Chapter 4, the results in this study are presented succinctly and their theoretical conjectures are presented.

CHAPTER 2

A REVIEW OF UNIVERSITY STUDENT TRAVEL BEHAVIOUR RESEARCH AND THE LACK THEREOF IN SOUTH AFRICA

The void between international research about university mobility and the strategic direction of public transport in SA needs to be filled. By discussing literature on university student mode choice and travel behaviour this chapter presents an overview of the various methods and approaches used to study this segment. What makes South Africa and other developing countries unique is the presence of a dominant minibus taxi (paratransit) and highly subsidised scheduled bus service (Nguyen-Phouc, Amoh-Gymah, Tran, & Phan, 2018; Behrens, McCormick, & Mfinanga, 2015; Cervero & Golub, 2007). Understanding how bus and paratransit service offerings inform mode choice may offer an avenue to identify a general intersection between the two modes. Transport policy in SA leans toward the possibility that scheduled bus services, and unscheduled paratransit could be complementary, attractive and effective. However, identifying the principles informing mode choice requires not only an application of consumer behaviour theory but also an approach to collecting the data to specify theoretically consistent utility functions. Stated preference tends to be a widely used approach to investigate mode choice behaviour in transport research. The first subsection of this chapter reviews university student mode choice and travel behaviour. This is followed by a subsection that discusses the intersection between bus and minibus taxi in the land public passenger transport market. The third sub-section describes empirical studies of mode choice through stated preference (SP) research in South Africa. From this review it is found that studies internationally conduct behavioural research about university student mobility within mode choice, travel behaviour and travel demand management contexts. While public transport improvements in SA are taking place, SP research to test the effectiveness of new service designs is lacking. Furthermore, the lack of SP research for mode choice related to university mobility is identified and this study serves to fill the gap. Conclusions are drawn with respect to the importance of university student mobility research, public transport improvements and the application of SP research and behavioural theory.

2.1 University Student Mode Choice and Travel Behaviour

Through understanding mode choice, university student travel behaviour research is growing with focused studies on managing travel demand (Rotaris & Danielis, 2014; Rotaris & Danielis, 2015; Longo, Medeossi, & Padoano, 2015; Molina-Garcia, Castillo, & Sallis, 2010; Gurrutxaga, Iturrate, Oses, & Garcia, 2017; Zhan, Yan, Zhu, & Wang, 2016; Zhou, 2016), and the emissions implications of university mobility (Davison, Ahern, & Hine, 2015; Molina-Garcia, Castillo, & Sallis, 2010). On the other hand, studies also tend to apply behavioural theory to understand current and future mode choice (Belgiawan, Schmöcker, Abou-Zeid, Walker, & Fujii, 2017; Muromachi, 2017; Shannon, et al., 2006). Aspects that make university student mobility and access unique relate to how university students schedule trips within the timetable; where universities are located with respect to major trip attractors; the availability and proximity of accommodation; and transport alternatives. A number of studies place emphasis on the difference between university students and the general public, staff, and faculty (Danaf, Abou-Zeid, & Kaysi, 2014; Khattak, Wang, Son, & Agnello, 2011). The studies reviewed here are divided into two categories: mode choice and travel behaviour. Mode choice provides an indication of the exogenous[8] factors which influence the selection of alternatives; while travel behaviour research tends to be underpinned by a behavioural theory to explain the choice. This subsection reviews a selection of studies on university student mode choice and evidence of university student behavioural research, summarised in Table 1[9]. Similar to other studies that review the segment (Rotaris & Danielis, 2015; Zhou, Wang, & Wu, 2018; Aoun, Abou-Zeid, Kaysi, & Myntti, 2013), the section presents the diversity of university mobility research in particular, it is therefore not an exhaustive review.

Of the 23 studies reviewed here, 7 apply DCM techniques, however each study has a unique research objective, and most of the models are MNL. Transport services considered range from one mode, bus or car, to a vast array of transportation modes. Sample sizes range from 189 to 3976 respondents some are shared across universities (in some universities samples were as small as 100 (Van & Fujii, 2011)), others are from one site. Not all studies are concerned with applying a behavioural theory, regardless of method and approach. Focus areas range from car purchase intentions, to estimating marginal effects of certain changes in interventions to Travel Demand Management (TDM) and travel behaviour modification research. It is of interest in this review to observe the manner in which these studies vary, and reflect the aspects which characterise the case studies, methods and results—and their corresponding interventions. The review is divided to reflect the idea that there is a study of *mode choice*, which is concerned with which modes are chosen based on a number of factors, and a studies of *travel behaviour* which approach the choice making process through some psychological variables and, or behavioural theory. These approaches tend to be intertwined, but they are discussed separately for simplicity.

[8] Exogenous factors here refer to things external of the individual that can be used to characterize them. For instance, socio-demographic characteristics, trip purpose, spatial and land-use related factors. They are *external* because they may influence the individual stated behavioral inclination, but they are not representative of the inclination itself. Behavioral theories aim to enable the explanation of the inclination as it is stated.

[9] Due to a lack of space, only a selection of studies are included in the table, to illustrate the variety of research in the university student mobility context. The studies discussed in this review are not all in the table presented.

Table 1: Selected Literature on University Student Travel Behaviour

DCM?	Main Objective(s)	Method	Transport Services	Sample	Behavioural Theory	Focus Area	Source
No	Differentiate between student travel behaviour in terms of term-time and permanent home residence.	SA	Bus	1049	N/A	MC.	(Davison, Ahern, & Hine, 2015)
Yes	Apply a latent variable model that compares the impact of expectations (SN) of inner and outer circles and the motivation to comply (SSN) with such expectations in student intention to buy a car.	OHCM	Car	1229	TPB & RA	CPI	(Belgiawan, Schmöcker, Abou-Zeid, Walker, & Fujii, 2017)
Yes	Examine the impacts of various factors on mode choice with respect to housing, through estimating their marginal effects of unit changes in attributes and how they affect the probability of choosing a certain mode.	MNL	Driving Alone, Public Transport, Carpooling, Biking/Walking, Telecommuting	769	N/A	ME	(Zhou, 2016)
No	Estimate the impact of psychological constructs on PT use through integrating personal norms in the TPB in order to represent the NAM.	SEM	Public Transport in general	1233	TPB, NAM	TBM	(Bamberg, Hunecke, & Blöbaum, 2007)
No	Produce and implement a safe and sustainable mobility plan for university students.	LSS	All modes.	N/A	N/a	TDM	(Gurrutxaga, Iturrate, Oses, & Garcia, 2017, p. 243)
No	To identify the mobility interventions that are workable for decision makers and users in the context of the university.	AHP	Walking, carpooling, parking, cycle, public transport	3976	N/A-	TDM	(Longo, Medeossi, & Padoano, 2015)
No	Estimates university student trip generation and mode choice across various spatial, demographic and university specific variables in China.	HTBR - CAID	Public transport and bicycle	1343	N/A	TG.	(Zhan, Yan, Zhu, & Wang, 2016)
No	Evaluate whether active commuting to university was associated with overall physical activity.	SEM	Car, motorbike, public transport and non-motorised transport	518	N/A	ACU	(Molina-Garcia, Castillo, & Sallis, 2010)
Yes	Study the relationship between past travel behaviour in school and student intentions to purchase cars through a retrospective survey.	OPM	Walk, bicycle, motorbike, car, bus and rail	351	I	CPI	(Muromachi, 2017)
Yes	Identify the time, costs and modal split aspects related to car and bus use at university and the impact of TDM policies on the modal split.	MNL	Car and bus	372	MP	TDM	(Rotaris & Danielis, 2014)
No	To estimate the efficiency and effectiveness for TDM policies on university travel behaviour.	CBA	Car and bus	N/a	CS	TDM	(Rotaris & Danielis, 2015)
No	To explore whether intentions to travel by car predict car commuting behaviour, and if these commuting habits interact with behavioural intentions.	HMRA	Car	189	TPB	TBM	(Kerr, Lennon & Watson, 2010)
Yes	Determine the extent to which physical environment, service, personal, trip, TDM and psychological factors contribute to students' mode choice.	MNL/NL	Driving alone, car pooling, public transit, biking, and walking.	1661	N/A	TBM	Zhou, Wang & Wu (2018)
Yes	Estimate the behavioural intention of commuting mode choices using" symbolic affective, instrumental and social orderliness factors of attitudes toward the car and public transport."	MNL	Public transport, car	1118	TPB	TBM	(Fujii, Choocharkul, & Van, 2014)

OHCM= Ordered Hybrid Discrete Choice Model; MNL= Multinomial Logit Model; SEM= Structural Equation Model; LSS= Likert Scale Survey; AHP= Analytical Hierarchy Process; HTBR-CAID= Hierarchical Tree-Based Regression (Chi-squared Automatic Interaction Detection); OPM= Ordered Probit Model; HMRA= Hierarchical Multiple Regression Analysis; NL= Nested Logit Model; RA= Reasoned Action; NAM = Norm Activation Theory; I = Intention; MP = Mode Preference; CS= Consumer Surplus; MC= Mode Choice; CPI= Car Purchase Intention; TBM= Travel Behaviour Modification; TDM = Travel Demand Management.

2.1 .1 University Student Mode Choice

Studies highlight the impact of bus ticket pricing structures and service attributes, be it fare-free or discounted (Brown, Hess, & Shoup, 2001; Boyd, Chow, Johnson, & Smith, 2003; Rotaris & Danielis, 2014). With cases in which commuting time may have intrinsic value to university students (Zhou, 2016), and other cases where service design attributes such as interiors and orderliness are key areas of improvement (Nguyen-Phouc, Amoh-Gymah, Tran, & Phan, 2018). Improving public transport may be a highly effective intervention, but mode choice changes through travel demand management measures tend to be most effective when implemented in combination, not as isolated interventions (Rotaris & Danielis, 2015; Barla, Lapierrre, Daziano, & Herrmann, 2012; Gurrutxaga, Iturrate, Oses, & Garcia, 2017). These improvements however, need to account for potential differences between urban and rural universities (Davison, Ahern, & Hine, 2015; Zhou, 2016; Limanond, Butsingkorn, & Chermkhunthod, 2011).

2.1.1.1 Americas

One of the early programmes to integrate universities with transport agencies started in the 1980s, growing to over 35 universities between 1997 and 1998 in the United States of America (US). By 2001, 20 more universities had already introduced such services. The premise is that *Unlimited Access* has far reaching access, mobility, unit cost and land-use benefits. Largely because it augments mode choice by placing upward pressure on the quality of service as ridership increases (Brown, Hess, & Shoup, 2001). Brown et al. (2001) review 35 of these *Unlimited Access* programmes in the US revealing the impacts on universities, and transport agencies. They find that universities benefit from this due to increased transport equity, reduction in parking demand, increased student access. It also attracts and retains students in addition to reducing the cost of attending university—more so for students living at their parents' home, which can be located further away. In the two years before and the two years after implementation, transport agencies experienced an eight fold increase in annual ridership; 3.5% rise in distance of service compared to 0.3%; a 5.1% decline in the cost per ride; and a 8.7% decline in the operating subsidy per ride. The effect of intervening in the university mobility context has far reaching impacts with benefits to existing public transport systems, and these benefits ripple through the broader community as well.

Consider the case of the University of California Los Angeles (UCLA) which only introduced this type of scheme in 2000 through a bus service called BruinGo. The BruinGo bus programme in car dominant Los Angeles, resulted in increased demand for this fare-free bus in 2003, within the first year of implementation. Boyd et al. (2003) compare trip patterns of university students before BruinGo in 2000 and after in 2001. They find that a 51% increase in public transport use, a 33% decrease in solo driving, and a 42% increase in transit use in an already high transit use area (Boyd, Chow, Johnson, & Smith, 2003). A more specific implication was that the effect of the BruinGo bus programme had a greater impact on direct trips to university, especially for students not within walking distance and did not need to transfer on the trip. More recently, UCLA students' mode choices are influenced by factors such as age, commute time, distance to bus stop, proximity to university, level of study and accommodation type (Zhou, 2016). Age increases the likelihood of driving alone. Commuting time increases the likelihood of using transit, which is because it is disutility for university students Zhou's (2016) paper (a similar finding in this study). Distance to bus stops increases the use of biking while, living with family decreases biking by 14%, and increases driving alone by the same percentage. Being an undergraduate student at UCLA, increases the likelihood of biking by 26% and decreases the likelihood of driving alone by 16%. The Zhou (2016) study reveals the interface between multiple transport modes and distance to university, with a focus on access to the university campus. A key finding here is that commuting time for university students may be *of intrinsic value* to them, yielding positive utilities from public transport use, and that undergraduates exhibit unique mode choices.

At the University of Laval, Canada, 705 university commuters were studied using a stated preference experiment to determine the potential impact of TDM interventions on mode choice (Barla, Lapierrre, Daziano, & Herrmann, 2012). The study reveals differences between staff and students, with students being as sensitive to time, parking and PT fares as low income households. Free public transport reduces car use in staff, low and middle income groups (-20%); parking price increases by 60% have the greatest impact on staff and students; and where PT and cars take the same amount of time, low income households are most responsive, followed by students. Through TDM measures, changes in automobile preference are expected to range between at least a 10% change to at most 82% change when interventions are combined. They also attempt to forecast attitudinal changes through education programmes from *pro-car* to *pro-environment,* or to *pro-public transport* with an impact that ranges between 1% and 6% of the modal split change. The study is not underpinned by a behavioural theory, but it does reinforce the importance of tangible service changes in public transport offering, as noted by Shannon, et al., (2006) and the impact is greater when TDM measures are bundled.

2.1.1.2 Europe

Taking a turn to Europe: the University of Trieste is located in a city of 200 000 inhabitants, high densities and significant public transport services, staff and students walk (21%), drive (21%) or use public transport (47% bus or tram)-- parking and cycling infrastructure were the highest ranked solutions in the area (Longo, Medeossi, & Padoano, 2015). Longo et al. (2015) attempt to balance priorities of various decision makers (rector, mayor), users (university students and staff) and experts in order to rank key solutions. Parking is the preferred solution, followed by bicycle infrastructure in Trieste. Probably due to the inconvenience of time spent searching for parking, which adds 6 minutes to the total travel time for students because they do not have parking permits (Rotaris & Danielis, 2014). This is in a city where 41% of trips under 2kms are performed by car, intimating a much deeper layer of dynamics influencing the mode choices in the area. Studying staff and students, Rotaris & Daniells (2014) purport that university students preferred bus over the car and it is reinforced by a bus pass, and location choice with respect to other mobility options—if not the strong difference between university students and faculty staff. They reveal through various TDM interventions, that a fully subsidised bus ticket could increase the bus share from 53% to between 61% and up to 82% depending on the payment type, but overall interventions can impact car share by between decreasing it by 51% and increasing it by 62%. The effects of these policy interventions, which change the service design of car and bus use through influencing attributes, vary across members of the university (students, teach and administrative staff), but are consistent in principle (Rotaris & Danielis, 2014). Their research is continued through a cost-benefit analysis of the recommended TDM alternatives. The follow up study reveals that subsidising bus fares is the most effective and efficient, but it is difficult to implement. The best alternative intervention they find is a mix between bus subsidies and parking restrictions (Rotaris & Danielis, 2015). From the above, it seems that the bus ticket pricing structure seems to have the greatest impact on public transport use, while parking restrictions seem to constrain car use, and cycling might be an alternative for trips under 2km. Policy implementation is a significant inhibitor to the most efficient approach.

Davison, Ahern, & Hine (2015) reveal that there are distinct mode choice and carbon emission implications for universities in rural areas with high propensities for car use, and those located in cities. The study argues that student travel behaviour is changing due to a shift in how higher education is funded in England, Scotland and Northern Ireland. A particular implication is that higher or lower university fees may result in university choices that are closer or further from permanent homes, respectively. Students that have separate term-time and home (permanent) addresses seem to have lower carbon emissions possibly as a result of either or both mode and accommodation location choices. Similar to other studies, those who live in their permanent residence (i.e. family home) in the local area tended to travel further to reach the university (Zhou, 2016). Therefore, spatial distribution of universities and transport networks are increasingly important factors for university development planning[10]. However, the distinctions between rural and urban university mobility seem to exacerbate the lack of effective public transport services (and, or high car preferences) in rural areas.

In Spain, one university in Donostia-San Sebastian and two universities in Valencia reveal unique issues in mobility management. The University of the Basque Country embarked on a series of mobility management interventions with the aim of understanding university student travel conditions and observing the effect of implemented measures (Gurrutxaga, Iturrate, Oses, & Garcia, 2017). Most of the students in this study use bus transport (50%) and 47% of them are willing to change transport modes and there is a 41.8% chance that they would change modes to use a car. The implemented initiatives are TDM strategies that aim to shift mode choices and encourage sustainable mobility on a structural level. Institutional

[10] Similar impacts of social-spatial context emerge between industrial or traditional areas and urban areas. With traditional areas having different decision infrastructure compared to urban areas even though both have good public transport (Bamberg, Hunecke, & Blöbaum, 2007).

changes include forming mobility management entities; and voluntary efforts attached to promotion campaigns (Gurrutxaga, Iturrate, Oses, & Garcia, 2017, p. 243). The effect of these interventions increased car occupancy from 1.2 to 1.7 persons per car because carpooling improved from 1.4% of all trips to 25%. Similarly, active commuting to university (ACU) in two universities appears to be underpinned by the provision of non-motorised transport facilities, while remaining unrelated to public transport (Molina-Garcia, Castillo, & Sallis, 2010). This counter intuitive result stems from access to the public transport being 6.5 minutes on average, and it is correlated with planning and psychosocial barriers than with ACU. Molina-Garcia, Castillo, & Sallis, (2010) recommend structural improvements and the "planning skills related to ACU" in addition to educational programmes and limiting car use through increasing parking fees for students in order to influence mode choice.

2.1.1.3 Asia

In a study of 8 universities in China, trip frequencies range from 0 to 12 trips per week, with female students (2.25 trips/day) generating more trips than male students (1.91 trips/day), and students in the practical stage (exit level (2.98 trips/day)) generating more trips than those in foundation (first year (2.98 trips/day)) (Zhan, Yan, Zhu, & Wang, 2016). They also find that bicycle ownership can induce more travel, while those without bicycles are more likely to walk. For trips between 1 and 4km, 52.1% of trips are on a bicycle while 44.5% of trips are in public transport. Taken further, students who travel between 7 and 10km may choose to use public transport, but these results vary across universities. One of the major characteristics in the study is that they identify homogenous groups to classify students based on distance, location and socio-demographic characteristics in order to inform a series of TDM proposals (Zhan, Yan, Zhu, & Wang, 2016). Accounting for the enclosed nature of universities in China, and car restrictions around the university, they propose bike sharing within the campus, walking within 1km radius and cycling networks up to a 7km radius of the campuses. However, the study does not reveal any behavioural instruments to nudge certain mode choices, but it does propose interventions that are suitable for managing existing travel demand.

Danang, Vietnam, a city with 30 universities, presents a travel climate dominated by motorcycle use, and poor quality public transport. In a study of 5 universities, Nguyen-Phouc et al. (2018) reveal that mode choices vary as students progress to higher levels—becoming less active and more motorised; while income; and owning a licence, motorcycle or bicycle induce compensatory behaviours to such ownership. Public transport service attributes are competitive to walking and cycling in some respects, but the actual services attributes in terms of access, flexibility, comfort and low coverage are key inihibitors to PT use. Competing against motorcycle use, improving PT interiors, comfort, and coverage are argued to be some of the key service improvements in Danang (Nguyen-Phouc, Amoh-Gymah, Tran, & Phan, 2018). They also recommend increased university accommodation in order to manage current and future travel demand. As such, the study highlights the importance of service quality improvements in the paratransit sector in addition to improvements in transport-land-use integration.

At Dalhousie University, 346 students, staff and faculty were interviewed with the primary aim of determining which modes they use for various activities over a 24-hour period (Daisy, Hafezi, Lui, & Millward, 2018). The findings highlight important distinctions between graduate, undergraduate, faculty and staff across mode choice, trip characteristics and trip purposes. University students tend to have relatively low trip rates, while graduate students tend to perform more frequent caregiving, shop and personal care activities. Staff tend to travel the longest time, while faculty may have longer trips but their choice of transport mode keeps the travel time as the lowest compared to other segments (Daisy, Hafezi, Lui, & Millward, 2018). They also present evidence that female, neighbours with less than a year in the neighbourhood, middle income and older persons make fewer automobile trips; while high schedule flexibility, larger household sizes and low income groups made more trips. In this sense, the university student population is more heterogeneous than one aggregate measure accounts for.

In rural Nakhon Ratchasima students living on campus at the Suranaree University of Technology have unusual travel patterns and mode choice, but can be grouped by gender and driving patterns (Limanond, Butsingkorn, & Chermkhunthod, 2011, pp. 168-169). The study finds that students produce a high number of trips per day, with long distances, with female respondents travelling further. University student trips peak thrice during the week, and only twice on weekends. Not only did student trips start later during the day, they also fit within the global average travel time budget of 1.1h. Most peculiar about this rural university is that most students ride motorcycles, and some share driving roles with motorcycles. The dominance of motorcycles can be reduced through quality bus services, with specific improvements in the network and key service attributes ranging from safety to punctuality to price. Limanond et al., (2011) argues that while the university has a free bus service it is failing mainly due to poor service design, with low frequency and ineffective network design.

2.1.1.4 Lebanon

At the American University of Beirut, student travel has been found to be different from the general population as they have higher values of time, complex trip schedules and having a strong inclination toward car use because public transport is not effective (Danaf, Abou-Zeid, & Kaysi, 2014, pp. 149-151). Danaf et al., (2014) argue that household car ownership induces commuting by private car for university students and private car use is most responsive to parking fee (or restriction) increases and encouraging lower public transport fares. However, public transport fare changes are only effective in the jitney market not in the bus market. A major recommendation in the study is the need for on-demand shuttle services for university students in order to be directly competitive with existing jitney and car use markets while penetrating areas that public transport does not cover.

2.1.2 University Student Travel Behaviour

At universities, behavioural approaches in public transport mode choice have been employed to test whether preferences can be modified, explained, classed and interpreted usefully in strategic mobility management. Modifying mode choices through understanding preferences seems to be subject to changes in tangible service attributes. Studies tend to use behavioural theory in transport to explain behaviour, usually in the form of latent variables (Belgiawan, Schmöcker, Abou-Zeid, Walker, & Fujii, 2017; Van, Choocharkul, & Fujii, 2014). Another approach is to classify choices based on behavioural theory, and explain behaviours of certain segments (Kerr, Lennon, & Watson, 2010; Zhou, Wang, & Wu, 2018). Taken further, some studies use behavioural theory to explore how current preferences emerged from previous behaviour in order to account for the fact that education comes in stages (Muromachi, 2017; Sigurdardottir, Kaplan, Møller, & Teasdale, 2013)[11]. Individuals tend to transition from one level to another, and travel behaviour may vary along the way. Furthermore, it is also plausible to use behavioural theories to explain the acceptability or effect of TDM measures too (Shannon, et al., 2006). These approaches employ behavioural theory to explain travel behaviour, service preferences and related mode choices.

2.1.2.1 Behaviour as a Latent Variable

Through assessing students' intentions to use a car or public transport across 8 universities in China, a series of studies reveal the impact of symbolic, affective and orderliness factors are strongly related to mode choice (Van, Choocharkul, & Fujii, 2014; Van & Fujii, 2011). Gender differences persist such that females are more likely to choose car, in this case. Intentions to use car are more related to these attitudinal factors than public transport use (Van, Choocharkul, & Fujii, 2014). Students had a broad consensus about the symbolic affective value of cars over public transport. There is more variation in responses with regard to instrumental and social orderliness between countries and demographics (Van & Fujii, 2011). In their follow-up study there were differences between developed and developing Asian countries, especially with regard to orderliness of public transport in the mode choice context (Van, Choocharkul, & Fujii, 2014). A distinctive feature in the study was the effect of paratransit in some of these countries and how it influences perceived social orderliness in addition to the instrumental use of public transport. In their first study they recommend that promoting public transport is an important element in the behaviour modification context (Van & Fujii, 2011). A major recommendation for improving intention to use public transport is related to improving the image, etiquette and educating children on cooperative behaviour in public transport (Van, Choocharkul, & Fujii, 2014). Behaviour modification can, therefore be a key instrument to enhancing the perceived quality of public transport—especially when analysists know which specific service attributes need to be improved. However, it is equally important to make actual improvements that are associated with the behaviour attributes

[11] Sigurdardottir et al., (2013) leans more on the behavior of adolescents and their perception of their future travel preferences—which may cut through university travel patterns. It is not reviewed here, but it is included due to the scarcity of papers which cover this topic.

that would make public transport inherently more attractive—as in the case of Japan in these studies.

Comparing university students in eight countries[12], one study looks how student intention to buy a car may be a result of social pressure from parents, family, friends (inner circle) and the broader society (outer circle) in the form of *Subjective Social Norms* (SSN) (Belgiawan, Schmöcker, Abou-Zeid, Walker, & Fujii, 2017). Their findings are two-fold: (1) the magnitude of influence from perceived social pressures to buy a car coming from specific groups; (2) the impact of symbolic affective and independence associated with car ownership. Parents are found to be more influential than peer pressure, and are both most influential across all groups, and least homogenous in their influence. The car seems to be a source of independence (i.e. flexibility) more than a symbolic affective (i.e. prestige) transport mode (Belgiawan, Schmöcker, Abou-Zeid, Walker, & Fujii, 2017). Belgiawan et al. (2017) essentially reveal that the expectations of inner and outer circles are enhanced by observing the motivation to comply with these expectations—and the inner circle is very influential in this regard, more so for developing countries. In terms of the Theory of Planner Behaviour (TPB), the study focuses on one behavioural construct with the primary aim of disaggregating its analysis by including multiple facets embedded in subjective norms[13].

2.1.2.2 Latent Class Approaches to Behaviour

Investigating car use intentions in three campuses of Queensland University of Technology Brisbane, one study argues that travel behaviour change for university students may have much more to do with modifying intentions to use a certain mode in addition to understanding where the propensity to use cars stems from (Kerr, Lennon, & Watson, 2010). They argue that by specifically targeting the social norms underlying other transport modes, could change how mode choices are structured. More specifically, the results reveal a difference between regular and occasional car commuter segments, attitudes are strong for both, but intention and habit means and standard deviations are much higher and lower, respectively, for occasional commuters (Kerr, Lennon, & Watson, 2010, p. 9). Intentions are still strong predictors of behaviour, but behavioural attributes like control are important for car intention. It is therefore useful to consider formulating policy interventions that are specifically responsive to behavioural indicators and their association with service attributes and mode choice.

At the Iowa State University, USA, 33.% of university students use public transport, 36% walk, and 22.9% drive alone, while 58% of them live in a residence shared with other students and friends (Zhou, Wang, & Wu, 2018). Similar to Rotaris & Daniels (2014), Zhou et al. (2018) reveal that car use takes place even in short trips. Mode choice in Zhou et al. (2018) does not vary much over distance—unless if it is public transport or cycling. Bicycle preferences decline

[12] Namely, Beirut, Utrecht, Japan, Berkeley, Taiwan, Indonesia and China.

[13] In this study, a similar disaggregation is used, across all constructs in line with Ajzen (1991). This is discussed in the methodological chapter.

at 5 km or more (from 36.3% to 16.7%), and public transport preferences double at 5km or more (from 4.9% to 11.1%). These results are contrary to another study where public transport use increases with distance (1<10km), while bicycle use contracts as distance increases (Zhan, Yan, Zhu, & Wang, 2016). However, the difference may be because the Iowa State University study is in a college town and not an urban university. In their Multinomial Logit model (MNL), they show inelastic behaviour to commuting distance for non-motorised transport and perceived commuting time having little effect on public transport compared to other modes (Zhou, Wang, & Wu, 2018). In their Nested Logit Model (NLM), mode choice is affected by peers, and when combined with proximity to public transport and shorter commuting time students are more likely to use public and non-motorised transport. They conclude that *"the effectiveness of TDM programs in promoting biking and walking at universities my hinge on the availability of, accessibility to, and level of, transit services"* (Zhou, Wang, & Wu, 2018). As a result, service design interventions seem to transcend the idea that improving service quality will result in higher travel demand, it needs to be accompanied by behavioural and spatial factors nudges as part of a policy mix of interventions.

2.1.2.3 Life Stages and Travel Behaviour

A life oriented approach which retrospectively relates car purchase intentions with how students travelled in elementary, middle and high school across 8 universities in the Tokyo Metropolitan Area reveals intriguing results (Muromachi, 2017). Public transport and bicycle use increase as the students progressed from elementary to high schools. From a parameter estimation perspective, bicycle use contributes positively to car purchasing intentions (0.304), while, public transport such as rail, have a negative impact, but much smaller (-0.009). A primary reason why bicycle use contributes positively to car use is that it offers complete door-to-door mobility habits. The author argues that *"previous experiences of rail use contributed to the formation of a lifestyle centred on the use of rail services instead of cars, which might reduce the student's interest in future car purchase"* (Muromachi, 2017). Improving the quality of public transport for university students may induce a longer term effect in terms of their car purchase intention. This might apply across all levels of education over time.

2.1.2.4 University Behaviour and TDM

Considering the stages of behaviour change and self-efficacy, Shannon et al. (2006) present evidence of potential behaviour change toward NMT and PT accounting for barriers to be redressed and interventions necessary to induce the shift for staff and students. While 16% of students using PT to the University of Western Australia consider using cars, 70.9% will continue walking within 1km of the university, while PT use may rise by 127% between 1 < 8km for staff and students (Shannon, et al., 2006). More than 50%, students are already active in their mobility—peaking at 94.2% within 1km of the campus; PT use is done with confidence 56.3% of the time at distances beyond 8km; confidence in walking and cycling decreases as the distance increases. There is, as a result, little need to change university student travel behaviour, but more emphasis needs to be placed on retaining their active mobility in terms of NMT and PT. The study concludes by recommending a range of TDM interventions with respect to barriers and motivators related to the characteristics of the mode, environment and other factors. Important barriers for university students are travel time, distance the weather and the frequency of public transport services. University students are motivated by the potential to save money through active mobility when already active, followed by avoiding the need to find parking when considering being active. The study essentially argues that it may be more beneficial to reduce barriers over promoting benefits (Shannon, et al., 2006). Improving service design is a core element of inducing behaviour change because it reduces the barriers by making services more attractive, useful and practical over *promoting services that do not meet behavioural and service preferences.*

2.1.3 Prospects for Travel Behaviour Research for University Mobility in South Africa

University mode choice and travel behaviour are intrinsic and interrelated components of mobility management in higher education. From a mode choice perspective using service design attributes to make mobility management solutions more effective seem to have impact on travel behaviour. There are positive implications for service, operations, patronage and coverage combinations for university mobility initiatives that are responsive to local area needs (Brown, Hess, & Shoup, 2001). However, LOS designs that are not suitable results in poor ridership (Danaf, Abou-Zeid, & Kaysi, 2014); and inappropriate penalties and incentives for TDM between for instance parking and transit reduce the effectiveness of TDM measures (Aoun, Abou-Zeid, Kaysi, & Myntti, 2013). Behavioural indicators are used often to explain and describe behaviour for different groups, and this adds value to discussions about mode choice, and where preferences come from. However, the usefulness of these behavioural indicators may well depend on the *psychological theory that they represent* –not just their statistical value. Through effectively employing mode choice and factors and behavioural theory, university student mobility preferences may be better understood.

From an international perspective, university student mobility is an important topic as universities grow, cities and towns expand and travel demand-supply need to be managed. At a university level, many of the studies reviewed highlight mobility management practices at the universities, which would require partnerships between Transport Authorities, Bus Companies and Universities (Zhou, 2016; Gurrutxaga, Iturrate, Oses, & Garcia, 2017; Longo, Medeossi, & Padoano, 2015; Zhou, Wang, & Wu, 2018). Many of the countries reviewed here, have scheduled services and as result describe an expansion of existing bus contracts in an unusual arrangement. But the prerequisites include a secure ticketing system, and flexible municipal financing frameworks. In the context of Africa, and many developing countries reviewed here, there are unscheduled transport services that run parallel to the existing services (Limanond, Butsingkorn, & Chermkhunthod, 2011; Van & Fujii, 2011; Van, Choocharkul, & Fujii, 2014; Aoun, Abou-Zeid, Kaysi, & Myntti, 2013). Integrating them into the mainstream public transport institutional framework requires deeper assessments beyond this paper. However, unveiling the interface between scheduled bus and *paratransit* in South Africa provides both a useful overview of the mode choice dimensions in SA, and some insight about the improvements listed in the existing literature.

2.2 Road Based Public Transport in South Africa

In South Africa, the vision for land passenger transportation services is to spearhead:

"The [promotion] of a safe, reliable, effective, efficient, co-ordinated, integrated, and environmentally friendly land passenger transport system in South African urban and rural areas, and the southern African region, managed in an accountable manner to ensure that people experience improving levels of mobility and accessibility" (DoT, 1996, p. 22).

Within the background of level of service design, and international best practices, the strategic vision for road based public transport has been in response to conventional bus and paratransit services in South Africa. Considering that paratransit (minibus taxi) in Figure 8 dominates the market for education work public transport trips, followed by bus interventions to encourage greater balance and shift toward public transport is necessary.

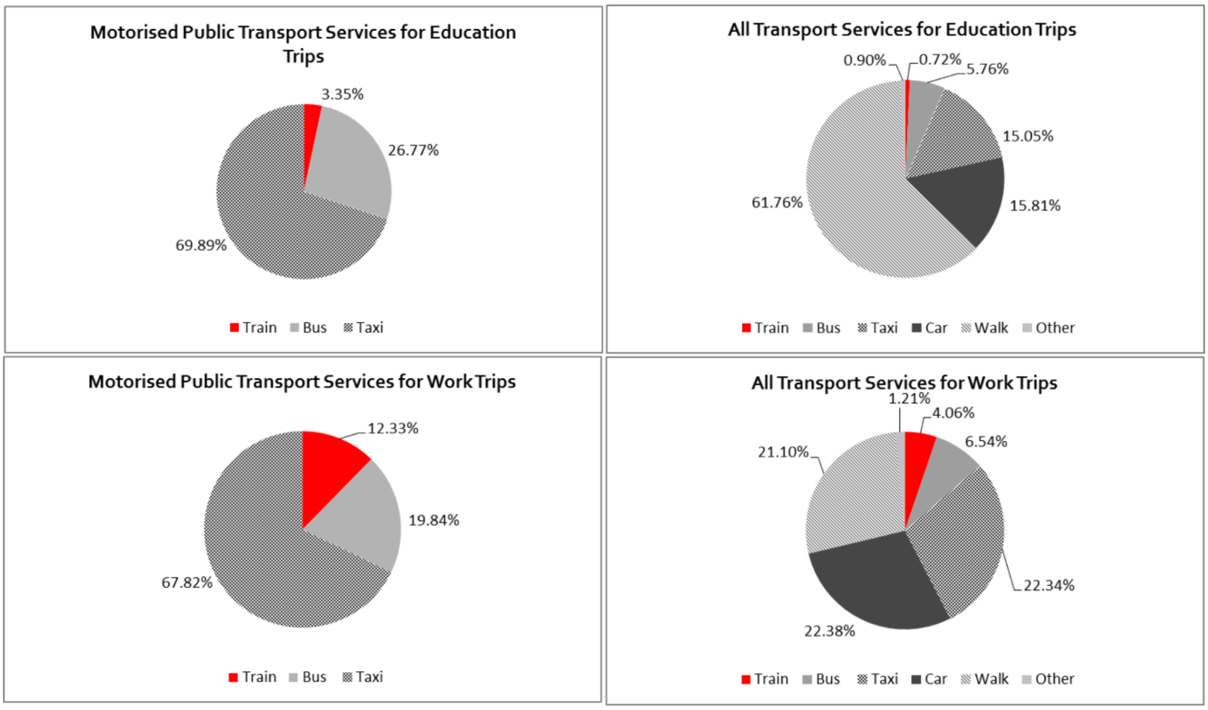

Figure 8: Modal Split in South Africa for Work and Education Trips in Public Transport and the Travel Service Market (StatsSA, 2014)

Education trips are dominated by walking, when all modes are considered. However, private car use is nearly equal to paratransit services and a nearly diminishing share of bus use. The contemporary market shares reflect the travel economy in SA as it emerged beyond 1977. A detailed discussion is necessary to describe the emergence and operational cultures beneath bus and minibus taxi (paratransit) services.

2.2.1 Bus Services

Conventional bus services in South Africa were established to "*mitigate"* the high cost of mobility for 'black' journey makers from residence to major activity centres, bus services are said to have operated for "*their own convenience"*, (McCaul, 1991). In a subsidized fashion buses were known to serve major trunk routes, with "*lifelong"* permits (van Ryneveld, 2008). Furthermore, Khosa (1990) argues that bus services were instrumental to the implementation of segregationist land uses. He also contends that the sustenance of industrial and commercial vitality in South Africa was, in part, facilitated through subsidised buses supplying labour to cities and industrial hubs. In most African countries, post-colonial bus services are dilapidated and are open to free market forces (Kumar & Barrett, 2008). South African bus services continued to survive on government ticket based subsidies, long distance trunk routes and un-adapted services in the midst of changing land-uses and a highly responsive paratransit market. This echoes the notion that if operations are not viable, yet socially necessary then intervention is justified for as long as it pursues maximising welfare relative to the availability of other modes or service designs.

2.2.2 Paratransit Services

In economic terms, paratransit services in South Africa emerged partly as a consequence of (a) the deregulation of road transport in 1977 (McCaul, 1991; Browning, 2006), (b) the under investment in passenger rail services (Mitchell, 2014) and (c) incumbent bus service designs that were trunked to feed the city with labour (Czegledy, 2004) and retain spatial segregation on the grounds of race (Khosa, 1990). The paratransit services are largely minibus operations that capitalize on the average South African commuter's negotiation with the cost of land, access to activities and transport services. Informal and township settlements grow rapidly as migrants incrementally search for opportunities in the city (South African Cities Network, 2006; Turok, 2012). The service offering is however priced to compete against highly subsidised public transport modes (Lombard, Lamprecht, & van Zyl, 2001)—at the cost of good quality service and sustainability. Implicitly, subsidies in scheduled public transport seems to deteriorate the potential welfare gains derivable from unscheduled high frequency services (i.e. lower waiting time sensitivity because waiting time is generally uncertain, unlike in scheduled services (van Reeven, 2008)).

2.2.3 Service Intersection between Paratransit and Bus Services for Competition and Complementarity

Both these modes, in the South African context offer unique services and emerged in a co-dependent manner. Paratransit and bus services in SA are described in terms of *operations*, *service motivators, regulation* and *patronage* in Table 2. Operations between the modes are influenced by the physical design of the transit units, the business model for departure and customer service. Service motivators for paratransit services are profit, the lack of subsidies and poor accountability—whereas for bus services revenue, subsidy and accountability are incorporated into the performance contracts. Hence the regulatory differences between paratransit and bus seem to dictate what motivates service provision.

Table 2: Bus and Paratransit Service Intersections

Descriptor	Attributes	Paratransit (SA)	Bus	Service Intersection
Operations	Vehicle Size	12< 22 Seats	35 < 80 Seats (non-articulated)	Both operators use vehicles with limited seating capacity. Services can be observed in terms of travel time, waiting time etc. Both modes interact with traffic, without transport system priority (ROW C). Both modes have poor customer service compared to BRT for instance.
	Service Type	High Frequency (e.g. <3min headway during peak) Unscheduled	Medium to low Frequency (e.g. 10-15 < headway during peak) Scheduled	
	System Capacity	Limited, and may cause traffic congestion	Can be higher, usually in contact with traffic.	
	Customer Orientation	Not a direct priority.	Traditionally a priority.	
	Boarding at Terminals	Wait for vehicle to depart.	As per service schedule.	Both modes present a degree of waiting to depart, however it is distinguished by the nature of demand in each mode.
Service Motivators	Profit	Yes	Not when subsidized	Both modes need to be financially viable or at least break-even. Operational viability, reasonable load factors or passenger seat kilometres are pivotal.
	Subsidies	No	Yes	
	Accountability	Internal (no audit)	External (contractor)	
Regulation	Market Entry	Professional permits and licensing.	Tendering and contracts.	There are no serious market entry constraints. Regulations and contracts are not customer oriented. Vehicles must comply with safety codes in South Africa
	Ownership	1 individual (numerous drivers), or operator-owners.	Branded Company	
	Corporatization	Possible	Mandatory	
Patronage	Accessibility	High	Low	Both modes play the balancing act of patronage and coverage. These considerations affect the affordability and accessibility of each mode (e.g. high patronage = very accessible = high revenue (and profit) = low operational cost/passenger).
	Affordability	Medium	High	
	Coverage	Demand responsive routes. High coverage at high price (seldom).	Fixed routes, high coverage when subsidies are distance based.	

From a service viability perspective the current legislative infrastructure for treating unscheduled services follows van Reeven (2008)—in that profit maximisation equates to optimality. Being part of the oligopoly of subsidy allocations in public transport, bus companies have the propensity to perpetually hold on to subsidies below the welfare optimum (see and (van Ryneveld, 2008; Walters J. , 2008; Walters J. , 2013). The role of the paratransit sector, which serves most people, may be to redistribute the subsidy gains more optimally. The limited scope for optimising ownership, market entry and corporatisation aspects of the paratransit market has increasingly become a missed opportunity in terms of modal integration—considering its dominance in the public transport market.

Lastly, patronage is a key factor for both modes and is dictated by operations, service motivators and regulatory aspects. Paratransit service are demand responsive by adapting networks to new demand (Neumann, 2014) this contributes to their affordability in addition to pivoting prices close to subsidised services. In most cases, scheduled services are not so responsive, however very affordable due to subsidies and offer limited coverage along trunk routes. The intersection between paratransit and conventional bus services constitute the basis of the level of service design and should has been used as a basis to improve the service offering in various ways. Three policy outputs intended to advance public transportation services include prioritising public transport; contract reforms to lock in the benefits with a focus on customers; and supporting these with changes in land-uses.

2.2.4 Improvements in Motorised Public Transport

2.2.4.1 Prioritising Public Transport

The international community seems to advocate for lower unit cost and higher benefit solutions such as Bus Rapid Transit (BRT) in nations with fiscal constraints, and necessitated circumstances. Shifting to a higher ROW category like C[14], for instance, through dedicated public transport infrastructure which separates transit from most traffic, bus services are sustained and welfare gains increase, *ceteris paribus* (Kutzbach, 2009, pp. 164-165). This can be supplemented by private car restrictions, and tolling to further suppress private car use growth through prioritised public transport services. Hence the emergence of Bus Rapid Transit (BRT) systems in the developing countries such as China, India, Brazil, Mexico, Kenya, Morocco, Nigeria, South Africa (Rodrigue, 2014, pp. 42-44) and more recently Tanzania. In SA, the 'kick-start' toward this BRT shift emanated largely from the international community. Not only through official visits to Curitiba, the activity was financially enabled by the United Nations Development Programme (UNDP) and Global Environment Facility (GEF) financing in view of the 2010 FIFA World Cup. In a letter to the resident representative of United Nations Development Programme dated 07/12/2006 the following is stated:

> *"The Action Agenda is supported by the Finance Minister and the National Treasury with budget allocations to date of R 6.4 billion. These funds have been allocated to the Public Transport Infrastructure Fund for public transport and non-motorised transport infrastructure and systems investment, with priority to venues supporting the 2010 soccer events."*

These policy positions took place at a time in which incumbent paratransit services were undergoing reforms, service standardisation and was preparing to expand its business model and footprint (SANTACO, 2010). The national paratransit fleet underwent a renewal process called "taxi recapitalisation" which involved paratransit specific financing schemes of new vehicles (for a brief review see (Mokwena, 2016)). Parallel to these actions was the emergence of the *Public Transport Strategy 2007* (or *Action Plan in 2010*) which outlined the non-motorised transport (NMT) ambitions, public transport mission and the dedication of bus lanes to public transport services—excluding paratransit. BRT systems were introduced to major cities as catalysts of development (VIVA, 2007) with the World Cup as the key

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[14] ROW C is where 'bus lanes' are painted, and traffic interaction is not inhibited by any structure other than soft strategies (i.e. painted lane, signage etc.) and more advanced implementation of ROW B is where 'busways' are physically segregated lanes that are *"permanently and exclusively for the use of public transport vehicles"* (Wright, 2007, p. 19)—in Kutzbach (2009) bus ways are what is referred to.

backbone, not necessarily addressing travel demand that paratransit services continued to serve.

To-date the integration between paratransit and BRT systems has inspired significant investigations into the various options for hybrid trunk and feeder systems (Del Mistro & Behrens, 2012; Ferro, Behrens, & Wilkinson, 2013); institutional reforms from owner-operators to companies; and most recently integration into the corporate operations of the BRT companies. Although the BRT systems are part of the general public transport services, most of them are subsidised and have student ticket prices. However, not all reach the university campuses in general other than paratransit—which is unsubsidised. Changes in public transport services alone are not sufficient for effective mobility reform. In this regard, the National Land Transport Act No. 5 of 2009 has been amended to reflect, and capture the potential role of paratransit services in Integrated Public Transport Network Planning (see Table 3). Various other sections have been amended, but most relevant to this discussion is the change in legislation reflecting the broader scope of practice and planning in public transport services.

Table 3: Expanding the Definition of Integrated Public Transport Networks (DoT(a), 2009; DoT(b), 2016)

Before Amendment 2009	After Amendment 2016
'integrated public transport network' means a system in a particular area that integrates public transport services between modes, with through-ticketing and other appropriate mechanisms to provide users of the system with the optimal solutions to be able to travel from their origins to destinations in a seamless manner.	**'integrated public transport network'** means a system in a particular area that integrates public transport services between modes, including non-motorised transport, with through ticketing and other appropriate mechanisms, that may be implemented in a phased manner, to provide users of the system with optimal solutions to be able to travel from their origins to destinations in a seamless manner with integrated pedestrian access for all passengers, and may, in appropriate municipalities include— a) integrated rapid public transport networks being high-quality networks of car competitive public transport services that are fully integrated regardless of mode, have dedicated right of way if road based, with or without bus rapid transit systems; and b) Bus rapid transit systems, which are high volume bus corridors served by an integrated feeder system.

Modal shift and emission reductions are more visible in the South African context if multiple interventions are applied—not just a silo change in public transport provision. This is placed clearly in the sense that lower emissions are expected if travel demand management (TDM) techniques are implemented in conjunction with operational changes (i.e. sustainable energy sources) (Vanderschuren, Lane, & Wakeford, 2010). Travel behaviour changes in work trips may also be influenced by TDM measures reducing single occupancy private car work trips by ¼th in the City of Cape Town (Behrens, et al., 2015). Although these measures may be implemented and developed by authorities, the potential increases in public transport patronage require acute changes in contracting and subsidy structures such that user needs and satisfaction are accounted for.

2.2.4.2 Customer Service Oriented Contracts

Public transport service contracts are applicable to all transit modes assuming that the regulatory infrastructure to implement and monitor performance is available. The incorporation of perceived service quality in the service offering is part of positioning public transport services more competitively 'against' the car. From a LOS perspective it has been argued that:

"improvements in perceived service quality will contribute to 'reducing' average cost per kilometre, after controlling for fleet size, fleet age, passengers per kilometre and average peak speed" (Hensher D. A., 2014, p. 20).

'Full' BRT systems are very attractive because of the potentially high customer orientation, operational efficiencies (high LOS) and capacities that are comparable to railways at a lower cost—up to a certain point (Wright, 2007, p. 12). It must be noted however, that each country and city or town will have unique requirements for such interventions to be realised: especially regarding rural and urban transport. As alluded to earlier, bus networks in most of SA are unable to penetrate human settlements and activity centres like paratransit services do. Hence the lurch toward feeder and distributor type structures has become an axiom in the BRT discourse across SA. The shift from ticket based to distance based subsidies in SA (Walters J. , 2008; 2013), suggests that there is a shift from patronage based contracts to coverage based contracts. Incumbent city-bus services operate under a negotiated contract scheme which is susceptible to persistent retendering regardless of the level of service offered (Hensher & Wallis, 2005). The bi-products of these actions has resulted in a contracting bus operating model dedicated to lowering costs, increasing fares and delayed public sector investment—making the business increasingly unsustainable (Walters J. , 2010). Although operational downturns are taking place, significant friction between operators, their contracts and vehicle roadworthiness make the headlines—very little has been done to account and encompass customer rating of the level of service in these buses.

Paratransit services are not appropriately designed—they (a) have not been accommodated in the contracting infrastructure; (b) do not have formal performance evaluations and (c) have no account of LOS evaluations from commuters that were translated into their service offerings at large. Mokonyama & Venter (2013) contend that it is easier to retain current users than it is to attract new users however, allowing customers to rate service attributes that operators offer may enable an evidence based mechanism that connects customer satisfaction with operator performance and incentives. With this in mind, paratransit services should also be subsidised with optimal pricing particularly to capture the economies of density and reducing the perpetual accumulation of delay in both supply and demand markets (Arnott, 1996). A proposed framework indicates that meeting the 10% maximum expenditure of transport, with equity, service productivity at the core a subsidy bill between R 34-billion and R 40-billion assuming that there is a 50c/km equity value and excluding environmental factors (Dawood & Mokonyama, 2015). However, such an approach in bus and paratransit level of service design requires substantial context specificity, accurate pricing levels and understanding of how to nudge specific market segments toward retaining their use of public transport into the future.

In order to estimate appropriate level of service designs based on commuter preferences, stated choice research is essential. As mentioned in the first chapter, the approach enables unique assessments of service attributes, consumer groups and pricing regimes in a manner that is not as convenient in other methods.

2.3 Stated Preference Techniques and Public Transport LOS Design

Consumer behaviour is assumed to be based on a choice between at least two alternatives across various combinations of their attributes. There are combinations of attributes which individuals gain the same level of satisfaction from, and thus they are indifferent with regard to those combinations. These indifferences are market baskets, or combinations of alternatives or level of service that provide the same level of satisfaction (utility) (Pindyck & Rubinfeld, 2009). Individuals make choices, or state them, or provide an idea of which alternative is better than the other based on the principles of consumer behaviour. The role of the DCM approach is to statistically represent the likelihood of a sample of individuals choosing an alternative as a function of the decision maker's characteristics and the attributes that describe the available alternatives (Ortuzar & Willumsen, 2011; Hensher, 1994; Hensher, Rose, & Greene, 2005; Train, 2009). SP techniques are intriguing because they offer an approach to construct experiments that can capture consumer behaviour data.

SP techniques in modelling discrete choices have various applications in areas ranging from environmental research, to healthcare, psychology, land-use and transportation. Each SP technique asks a particular form of question (Ortuzar & Willumsen, 2011). The Contingent Valuation (CV) approach asks 'how much are you willing to pay for a certain policy?' to capture the actual price individuals state they would pay. Conjoint Analysis (CA) asks 'how much to you rank or rate a policy alternative?' in order to elicit preferences. And Stated Choice (SC) which asks 'how much are you willing to 'pay' for a variation of attributes between a set of alternatives presented in unique hypothetical situations'. Each approach is estimates a 'value' through direct (CV) and indirect (CA and SC) techniques. There are some specific characteristics worth noting, as each of these approaches have merit in the context of mode choice and travel behaviour research.

2.3.1 General Characteristics of Stated Preference Techniques

CV is a direct approach used to capture willingness to pay (WTP) information for alternatives. It involves respondents stating how much they are willing to pay for a public (i.e. passive use) or private good (i.e. direct use). Relative to the other SP techniques, it has been heavily criticised, one study highlighting that it should not be used for *'damage assessment and* *benefit cost analysis'* (Diamond & Hausman, 1994). For a comprehensive review, readers are referred to Carson et al. (2001). The direct open-ended statement of WTP is used to observe what individuals say they would pay for a good. An indirect approach is through Dichotomous Choice Contingent Valuation (DC-CV) in which single or double layers of 'yes' and 'no' responses to a certain price are captured (Calia & Strazzera, 1999). A recent application of CV involves a DC-CV with three levels applied to assess the sensitivities of attributes and related factors influencing the WTP for stage-based and distance based fare schemes (Chung & Chiou, 2017). Contingent Valuation, may therefore be subject to underlying biases and be non-representative of a realistic scale if respondents are too heterogeneous and unstable in their responses to the survey.

On the other hand, CA is primarily used to observe how respondents rank alternative offerings and, or make choices between multiple factorial alternatives (Green, Krieger, & Wind, 2001). This is observed through part-worth (Green, Krieger, & Wind, 2001) and mathematical properties related to conditional or joint independence and dependence of preferences related to the properties of each treatment ranked (Louviere, Flynn, & Carson, 2010; Krantz & Tversky, 1971). In other words, the survey is interpreted by a predetermined relationship based on the anticipated properties of the preferences in each ranking. Hence there are conditional relationships similar to *Arrow's Law* (i.e. if A>B>C then A>C). The conjoint approach is somewhat 'deterministic' in that it is used to argue a certain form of behaviour within the design of the surveys. The approach has been considered inconsistent with behavioural theory (i.e. utility maximisation) and lacking an associated error theory (Louviere, Flynn, & Carson, 2010, p. 59). However, when Comparing CA choice experiments to CV, CA is a closer measure of the real WTP and the demand curve than CV (Miller, Hofstetter, Krohmer, & Zhang , 2011). Among the factors influencing this is the embedded effect, particularly in public goods. The embedded-effect is where the WTP does not change, although the scale of the alternative changes. Conjoint Analysis is suitable for ranking, but the deterministic structure of the survey may lead to limited scope of application and inflexibility—especially without an appropriate behavioural theory to underpin the ranking, or error.

In SC individual preferences are distributed over iterative responses to varying situations (Louviere, Flynn, & Carson, 2010). Stated choice research is used to populate preference spaces through hypothetical scenarios that respondents interact with through an experiment (Hensher, Rose, & Greene, 2005). The experiment is estimated statistically through measures that improve the efficiency and representativeness of the various scenarios respondents are presented with (Bliemer & Rose, 2010; Rose & Bliemer, Constructing efficient stated choice experimental designs, 2009; Rose J. M., Bliemer, Hensher, & Collins, 2008). Inputs to the experiments could come from the respondents, and then hypothetical scenarios are pivoted around the experiences of commuters. Experiments can also be labelled or unlabelled, and may be subject to lexographic behaviour[15] stemming from looking ahead into the scenarios, having a bias toward a certain labelled alternative, or simply being influenced by another participant in the survey (Soelensminde, 2006). Since participants should be relatively familiar with the preference space they are being asked to populate, the survey design depends on its proximity to realistic experiences with respect to the context and the subject explored (Klojgaard, Bech, & Sogaard, 2012; Hess & Rose, 2009). SC is both consistent with consumer behaviour theory in economics, and has experimental survey properties that are versatile in application and increasingly non-deterministic (random). Discrete choice models estimate the likelihood of choosing one alternative over others based on these responses, or based on revealed preferences (from ordinary surveys). While Contingent Valuation and Conjoint Analysis are not suitable for estimating mode choices within a behavioural theory because while both may be useful, they are not theoretically consistent with the discrete nature of consumer choice. A stated choice approach is adopted here because it can be easily integrated with the TPB, and DCM. The literature on SC applications in transport is vast. For the purpose of this study it is appropriate to consider how SC has been applied in the South African context.

2.3.2 Stated Choice and Discrete Choice Modelling Applications in South African Transport Research

For the purpose of analysing and improving public transport in SA, SC has been applied with the aim of introducing new public transport, evaluating improvements and segmenting markets. In Table 4, 11 studies are reviewed published between 1999 and 2016, predominantly from South Africa, and cases from Tanzania and Egypt are used as reference. 5/11 studies apply SC experiments as inputs to discrete choice models, and only a few studies employ a qualitative survey. 5/11 studies focus on segmenting users and testing scenarios to see their impact, while only 4/11 studies try to introduce a new mode or service attribute. Respondents range from 87 to just over 1600, while choice sets range from 6 hypothetical scenarios per respondent to 16 per respondent with attributes as few as three and as many as eight. Not all studies report their survey quality in terms of efficiency, or the statistical effectiveness of the models (i.e. rho-squared). Various discrete choice models are applied here, but there are no applications that incorporate behavioural theory.

2.3.2.1 Introducing a Mode

Lombard et al. (2001) argue that in Durban minibus taxi prices are *"pitched at a level, which is competitive with the subsidised bus services".* This argument is used as a basis to propose a restructured rail service offering with an integrated feeder service by paratransit operators[16]. They show that the hourly Value of Time (VOT) for low income respondents are higher for bus

[15] Lexographic behaviour—described as "a set of choices in which the respondent consistently chooses the alternative that is best with respect to one particular attribute" (Soelensminde, 2006, p. 332).

[16] A minibus taxi based feeder system and network was envisioned in the original Gautrain plans, similar to what is proposed here in the Lombard et al (2001) study—low floor high-capacity buses were opted for.

and train (R 1.90), than for minibus taxi (R 1.74). VOT estimates for higher income households are almost double those of low income households at R 4.07 and R 4.39 for bus and train, and minibus taxi respectively. To test the potential for a restructured service, they test market sensitivities resulting from individual changes in attributes finding that feeder and distribution fare offers the greatest sensitivity when increased or decreased by 20% (+7% or -5%). In all 6 proposed scenarios of restructured rail services seems to rattle minibus market shares relatively more than bus shares. When train services are improved significantly (beyond travel time, to include safety and security measures) the market shift is more from the minibus market than the bus (captive) market.

Table 4: A Review Stated Choice Studies on Passenger Transport in South Africa

Stated Choice Studies on Passenger Transport in Africa

Description	Clark and Crous (1999)	van Zyl, Lombard & Lamprecht (2001)	Lombard, Lamprecht, van Zyl (2001)	van Zyl & Hugo (2002)	Del Mistro & Arentze (2002)	Arentze et al. (2003)	Lu (2009)	Venter & Venkatesh (2010)	Nkurunziza, Zuidgeest, Brussel and van	Huzayyin and Youssef (2013)	Venter (2016)	Present Study
Application of SC	X	X			X	X		X				X
Qualitative Process			X		X			X				X
Segmenting and Scenario Testing			X	X				X		X	X	X
New Transport Mode/Service Level			X				X	X	X			
Literature/Practice Review	X	X		X								
Bus		X	X	X	X	X	X	X	X	X	X	X
Taxi		X	X	X	X	X	X	X		X	X	X
Train	X	X	X*	X	X	X	X	X*		X	X	
Car	X			X			X	Y*		X	X	
BRT											X	
New Mode							GT		BRT			
No. Respondents			1000	1658	364	167	972	87	684	492	1208	121
No. Choice Sets			9	9 < 16	8, 8	8, 8	8	6	9		9^{+}	16
Attributes	5			4 / 5	5	5	5	6	3	4	8	4
Type of Model	N/S	MNL	RP &SP MNL	MNL	MNL	MNL	MNL\MLM	MNL	MNL	RP/ MNL	RP & SP /MLM	SP/LCCM/TPB
Model Fit (Rho^2)		0.05< 0.27	0.27	0.09< 0.33				0.258 (0.236)	0.164 < 0.134			
Province	WC	KZN	KZN	WC	GP	GP	GP	LM	TZ	EG	GP	NW

X implies that study focused on LOS; GT = Gautrain; BRT = Bus Rapid Transit; Y* = Bakkie; RP = Revealed Preference; MNL = Multi Nominal Logit Model; MLL = Mixed Logit Model, LCCM = Latent Class Choice Model, TZ= Tanzania, EG = Egypt, TPB = Theory of Planned Behaviour. When not mentioned in the paper + indicates that the figure based on correspondence with the author of the report.*

Mode specific preferences, in this study, are used to symptomatically identify and design an ideal level of service for a restructured mode. Lu (2009) investigates the introduction of a new rapid rail link along a corridor that is predominantly used by car users connecting major metros, nodes and the airport. The study shows how the value of time differs not only between modes, but within a mode for different travel purposes. As with the axiom, travelling for business purposes reveals a higher VOT than for non-business purposes, which is consistent with some literature[17]. It is also revealed that the monetary value of time can be misleading if not considered as a portion of personal hourly income. When segments were evaluated, they revealed public transport (27%), car business (94%), car non-business (42%), air business (110%) and air non-business (45%) VOT as a percentage of the hourly rate (Lu, 2009). What is clear is that each segment had a unique VOT. The survey was designed to evaluate the potential market entry for a new mode in an urban market that uses public and private transport.

2.3.2.2 Evaluating and Improving LOS

In the City of Cape Town, one study aimed to compare the existing train, bus and minibus taxi services to improved train, rationalised bus services, car and minibus taxi (van Zyl & Hugo, 2002). The study shows that VOTs are specific to the local area and the commuter segment. The main finding is that although there are modal biases and mode preferences are a string of LOS attributes unique to an area and mode. The study shows the value of service improvements relative to the LOS design of existing services.

In Kgautswane a rural area SA, travellers were found to be captive to walking due to the unavailability of transport modes—not limitations in affordability (Venter & Venkatesh, 2010). In order of preference from the results: bus, minibus, and Bakkie modes are investigated. Of the parameters in the study, certainty, time of day and frequency of vehicles are highly valued service dimensions—over and above fare, walk time and wait time. Hence they also argue that although paratransit permeates the village areas, its unpredictability and long waiting times are not as attractive as the guaranteed services in the scheduled bus. This is in addition to relatively low incomes and long travel distances in the area. The scenario that they test is an introduction of a mobile service to book a minibus ride. The pre-booking service is estimated to increase the minibus mode share by nearly 20% (7% from current taxi users; and 13% from current 'Bakkie' (light delivery vehicle) users). The study is designed to test an improvement in the LOS of minibus taxis through the introduction of a cellular phone pre-booking service in a rural area, with limited mobility options and very low frequencies, and reliability.

2.3.2.3 Segmentation

By spatially segmenting respondents, Nkurunziza et al. (2012) finds that there are differences in utility for travel time and comfort for respondents residing closer and those residing further from the city of Dar es Salaam, Tanzania. Respondents within 5km of the city are willing to pay 18.3Tsh[18] (20.95 TSH in 2014; R0.12) and 745Tsh (852.88 TSH in 2014; R 5.13) for a unit of time and comfort, respectively. Those in the urban periphery (10 < 15km) attach 5.5Tsh (6.3Tsh in 2014; R 0.037) and 291Tsh (333.14Tsh in 2014; R2.00) to travel time and comfort, respectively. The lower values attached may be skewed by the income differences between

[17] The reader is reminded that in one study evidence is shown that University students have higher values of time than employees (Danaf, Abou-Zeid, & Kaysi, 2014, p. 149).
[18] The exchange rate was R 1 = 166 TSH in 2016.

those in the urban area and those further from it, among other factors. In a concomitant study, it is shown that comfort is valued most across all distances, and travel time follows—travel fare is has the lowest weight in utility functions (Nkurunziza, Zuidgeest, Brussel, & Van den Bosch, 2012). What is evident is that segmenting markets spatially urban, urban-periphery and rural trajectories affects the service preferences and should inform how LOS is designed.

In Greater Cairo, Egypt, an investigation of how mode captivity evolved between 2000 and 2009 demonstrates the potential for shifting between modes in response to a percentage change in travel time or cost (Huzayyin & Youssef, 2013). Based on the weight of the alternative specific constant (ASC)[19] significant preference exist toward private car (1.69), over and above bus (-0.848) and shared taxi (-0.916) in 2000; by 2009 the ASC for car is 2.988 and for bus 0.269—shared taxi constant is not reported in 2009. VOT in 2000 was ₤3. (₤ 7.1 in 2016; R 5.26[20]); and by 2009 it was ₤0.077 (₤0.15 in 2016; R 0.11) largely due to an increase in weight of the travel cost from -0.0003 to -0.046056: intimating tighter travel budgets in 2009. The 2009 VOT estimates are within the same range as Nkurunziza et al. (2012). Between the 2000 and 2009 studies in Cairo, car captivity increased from 93.9% to 95% whilst bus captives decreased from 72.2% to 49%. Shared taxi captives increased from 65.4% to 68%, whilst metro (railway) captives increased from 61% to 100%. The study shows that the shared taxi and bus services are substitutes in terms of travel time and travel cost. It also shows that some car users would shift to bus and shared taxi use. The study focuses on analysing the captive segment and purporting on how this segment would respond to a change in an attribute.

A study of the City of Johannesburg, a metropolitan in SA, segments passenger markets and outlines the potential considerations for expanding the existing Bus Rapid Transit (BRT) service (Venter C. , 2016). The study indicates that motorised transport users may be segmented as choosers between modes (22%), car captives (27%) and public transport captives (51%). Public transport captives have a lower VOT for in-vehicle travel than choosers and car captives at R 4.30 and R 5.98, respectively. Waiting time in public transport captive markets is valued at almost double that of choosers and car captives—symptomatic of a service offering deficit. Choosers and car users (R 17.21) find walking more 'expensive' than public transport captives (R 12.39). Delving deeper into the utility weights between minibus taxi services and BRT, indications of negative preference toward taxi are evident in the alternative specific constant (ASC) and that only walking and waiting times are the competitive disadvantage in BRT LOS. This study not only analyses mode captives' valuation of service attributes, it also facilitates an analysis of the competitive position between the dominant incumbent mode and the existing and expanding BRT service.

[19] The alternative specific constant (ASC) reflects the default predisposition toward an alternative.
[20] The 2016 exchange rate for Egypt and South Africa was ₤1 = R 0.74.

2.4 Conclusion

Introducing a new mode, evaluating and improving existing services and segmenting markets are part of the mobility management activities necessary for education mobility in general. The studies reviewed here show the practical usefulness of SC approaches in transport in SA, in accounting for the mode choices between scheduled bus and unscheduled minibus taxis. Integrating these modes is increasing importance, but this needs to be done with respect to the activity area and the preferences of the commuters in a specific area or precinct. For university mobility research to be effective, accounting for mode choice through discrete choice models is not unique and there is no lack of examples. What is intriguing is adopting some of the travel behaviour dimensions in international studies and integrating them with mode choice. The literature on SC in SA shows a gap in applying behavioural theory in describing and segmenting public transport users. University students in particular. Similar to other studies about university mobility, the Theory of Planned Behaviour is adopted as a useful theory partly due to its application in other studies (Kerr, Lennon, & Watson, 2010; Van, Choocharkul, & Fujii, 2014; Belgiawan, Schmöcker, Abou-Zeid, Walker, & Fujii, 2017). The other reason is because the TPB is a close representation of individual choice which is argued to be proceeded by intention (Ajzen, 1991). In terms of service design with the context of mobility in SA, this study adopts the SC survey approach and implements a series of discrete choice models to address the hypotheses tested here. University student mobility research, public transport improvements and the application of SP research and behavioural theory are all interrelated themes aimed at informing an appropriately specified series of interventions. In the next chapter, the integration between behavioural theory and mode choice is discussed in detail.

CHAPTER 3

RESEARCH METHODOLOGY

This study tests if students classified by degrees of intention have class specific utility functions. A second hypotheses is whether level of service preference differences are present in students who have high or low intention to use any of the two transport modes. Shown in Figure 9, the conceptual framework animated here is arguably an applied specification for Hybrid Discrete Choice Models (HCM) that is used in many studies (Ben-Akiva, et al., 1999; Ben-Akiva, et al., 2002; Walker & Ben-Akiva, 2002; Belgiawan, Schmöcker, Abou-Zeid, Walker, & Fujii, 2017). In this form it describes how to estimate consumer behaviour heterogeneity based on a psychological theory about underlying motivations to make a choice and elicit a preference.

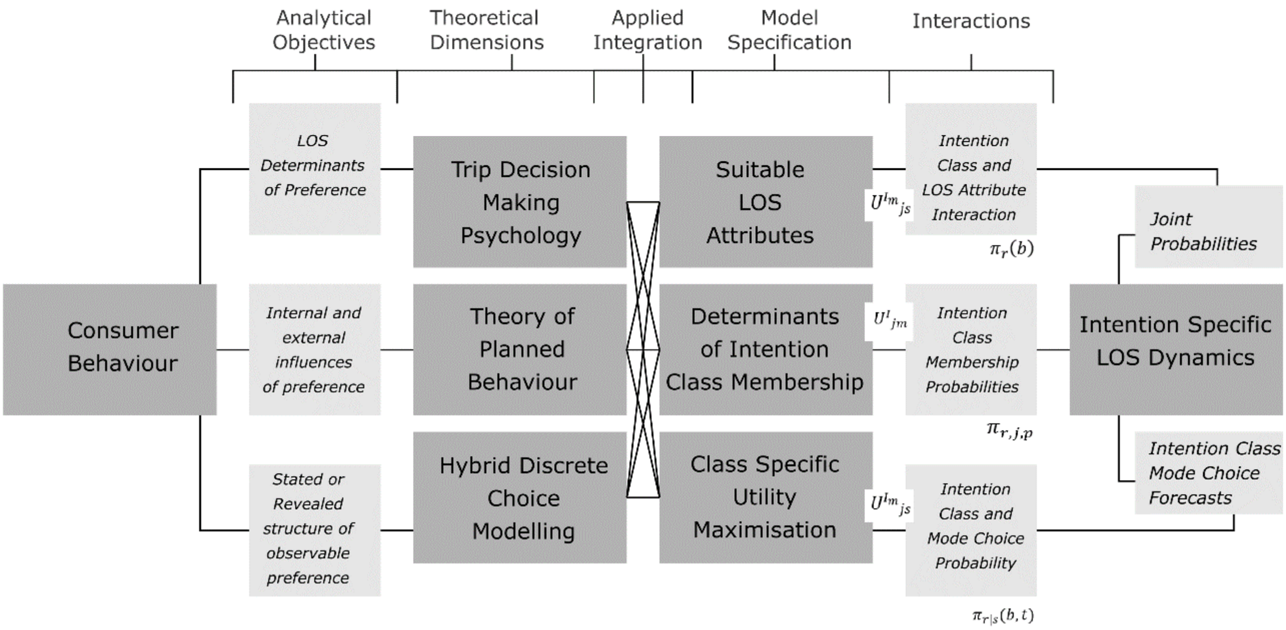

Figure 9: Conceptual Framework for Behaviour Specific Latent Class Choice Modelling

Consumer behaviour, in this framework, is reflected through preference determinants, influencers and stated/revealed preferences. Level of service (LOS) determinants of mode preferences are explored through *trip decision making psychology* on a theoretical level. When specifying the model this translates into the LOS attributes and class specific LOS estimations. Internal and external influences include psychological factors and socio-demographic factors, respectively. The focus in this study is on using the Theory of Planned Behaviour (TPB) to specify behavioural classes, and determine membership probabilities. Stated or revealed preferences that can be observed are used to construct the HCM, in order to estimate intention class specific utility functions. Products of which reveal the probability of students choosing a certain transport mode, based on their degree of intention.

In a manner that animates the framework for Behaviour Specific Choice Modelling, this chapter presents four major components of the methodology, namely: problem refinement, stimuli refinement, choice modelling and sample size underpinned by the research design. The research design is structured around problem refinement, choice modelling and administration. As a result, the chapter first describes how the problem was refined to construct a base Discrete Choice Model (DCM) that is consistent with the random utility model (RUM). This is followed by a description of the survey design, and statistical properties. Following the choice modelling component and experiment design, the chapter introduces behavioural variables through the TPB. Furthermore, intention class specific models of the base DCM are specified within the HCM framework. The chapter concludes with sample size estimations and statistical assessments.

3.1 Research Design

This cross-sectional study is designed over an eight stage process presented in Figure 10. Dividing the design into problem refinement, choice modelling and administration influences the structure of the chapter and model specifications. Problem refinement refers to a systematic process for specifying the research problem, constructing surveys consistent with economic theory, and specifying a base model. The **first stage** in Figure 10 involves refining the problem and locating it within the context of the available approaches, resources and assumptions. The **second stage** specifies the stimuli: the experiment attributes and alternatives. The **third stage** delves into experimental design factors considered and trade-offs made in specifying the attribute levels, the range between levels and choice set design.

The end result is a clear specification of the type of design, the experiment size (the number of choice sets and sample size estimation) and model specification. In the **fourth stage** the experiment is designed using a software package and supplemented by d-optimality estimation of the experiment. In this study the R Software Package is used to design the survey experiment (Groemping, 2014; R Core Team, 2013). **Stage five** is where the survey design output is translated into the experiment developed in stages two and three.

Choice modelling and administration refers to the activities related to implementing the experiment. This phase is particularly more intricate because it integrates behavioural theory with discrete choice. In **stage six** for instance, choice sets are generated based on the specifications and considerations in the preceding stages. **Stage 7** then randomizes the choice sets and changes the sequence of the experiments. The **eighth stage** is where the experiment is constructed, and administered for distribution, while **Stage 9** involves the data capturing and basic analysis component. The survey organisation stages (6, 7, 8 and 9) are performed on Microsoft Excel, while the survey design stage (5) is developed using R Software Package. **Stages 10 to 13** are where the data is cleaned, coded for the BIOGEME package (Bierlaire, 2003), different configurations of models are tested and results are discussed. The final stage is where the acceptance or rejection of the study hypotheses is articulated.

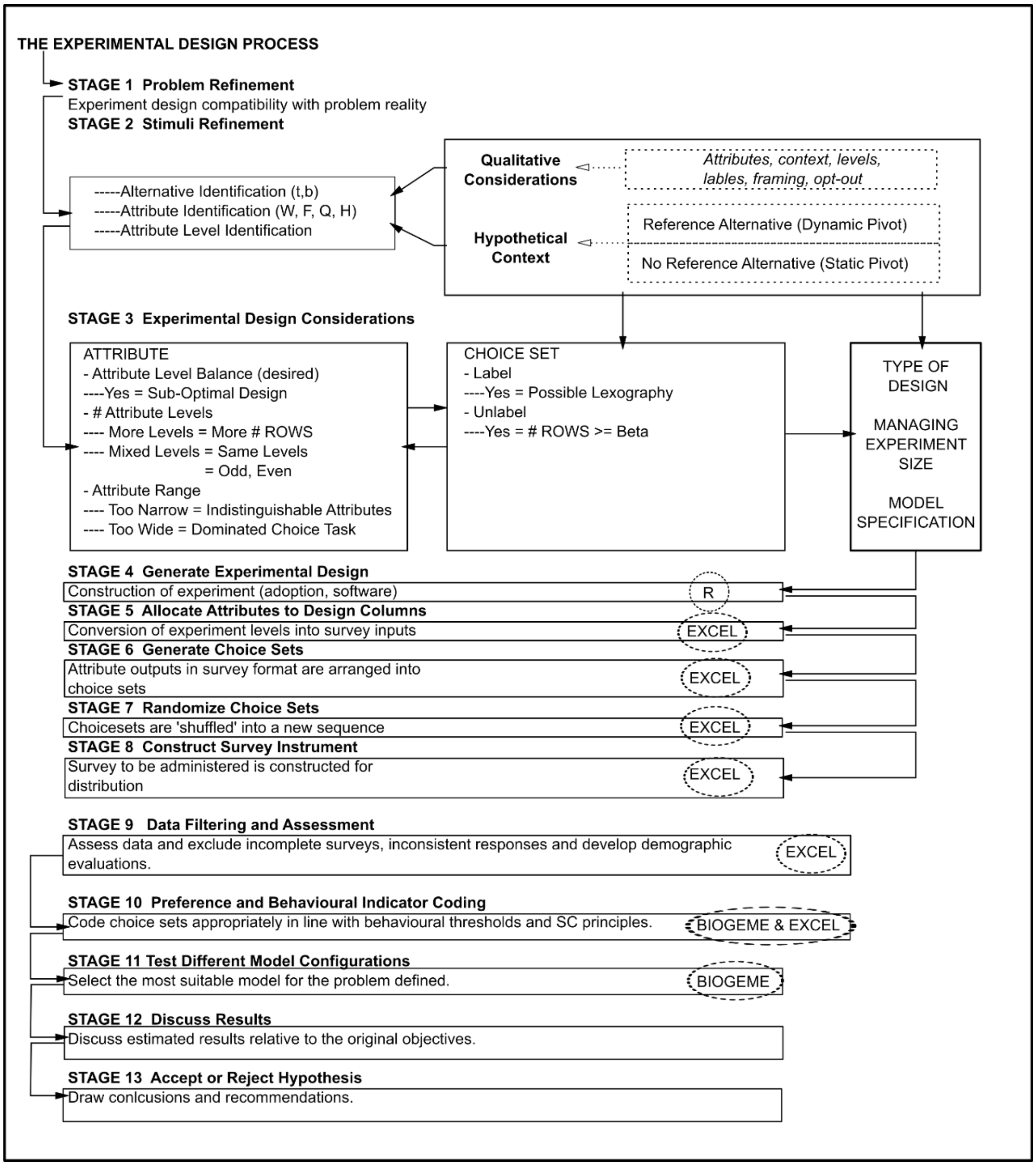

Figure 10: Extended Experimental Design Process Considerations

The demand for public transport tends to be derived from various other needs that travellers wish to satisfy. In pursuit of a preferred 'level of satisfaction' travellers are assumed to assess alternatives which may or may not be chosen for a particular trip (or chain of trips). Commuter decisions could begin with whether an alternative is available to meet the consumer's needs or not. Attributes or 'state of technology' related to each alternative is assumed to have an assigned a level of satisfaction based on how much consumers prefer certain attributes over others, *ceteris paribus* (Hensher, Rose, & Greene, 2005, p. 66). From a service design perspective, Figure 11 presents a synthesis of how trip decisions are made based on the Transit Capacity and Quality of Service Manual (TCQSM) (TRB, 2013, pp. 4-15-4-36).

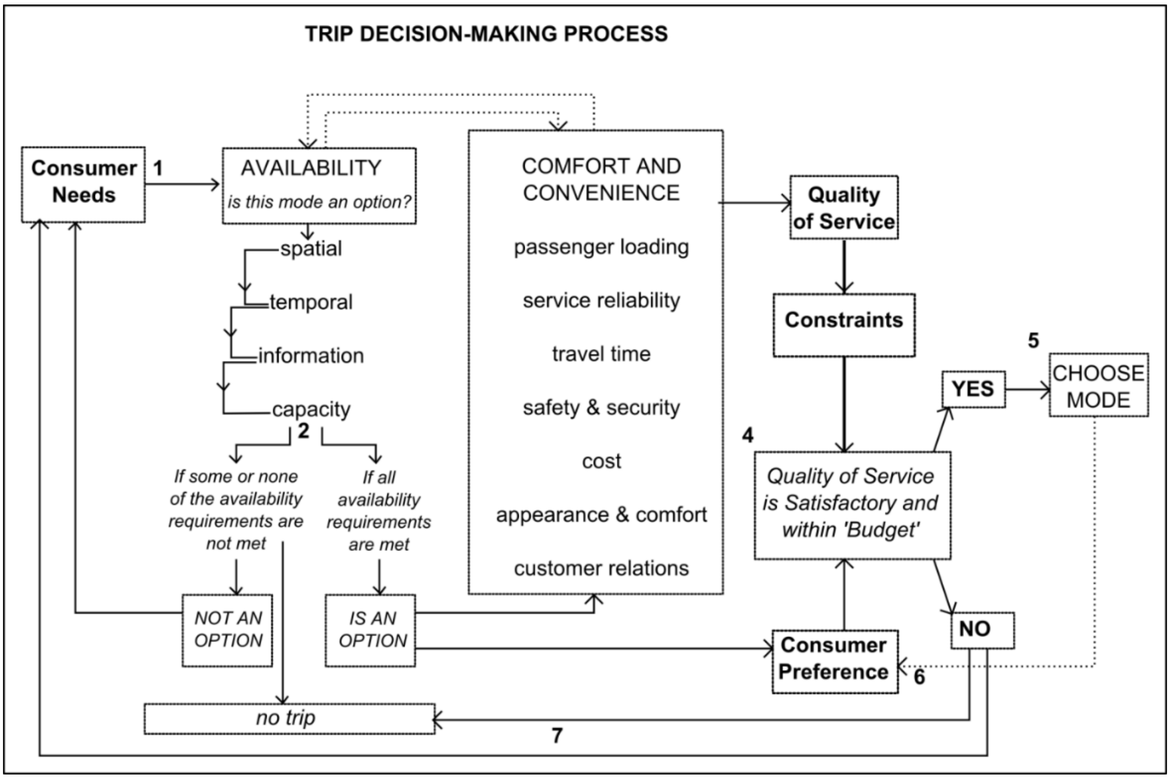

Figure 11: The Trip Decision-Making Process adopted from TCQSM (TRB, 2013, pp. 4-15-4-36)

The process contends that whether an alternative is chosen (5) or not (7) depends on (1) individual needs and dispositions, (2) the availability of the alternative, (3) whether the level of service resonates with individual needs and the effect of constraints (4) on choice and thus preference (6). If a mode is considered available for a particular trip, the level of service design factors related to 'comfort and convenience' are considered—and weighed within a perceived quality of service. The actual choice of a mode is subject to individual constraints and their preferences. In the demand for public transport, capturing and measuring choice is done through experiments wherein individuals make trade-offs between alternatives and the attributes that describe them. Trade-offs are weighed based on the combined utility commuters derive from the mode's availability, LOS, and adherence with selection constraints.

3.2.2 The Random Utility Model: Kernel

Estimating utilities based on individual choices assume rational behaviour by respondents. Discrete Choice Modelling (DCM) postulates that choices may be observed and explanatory variables identified to estimate quantitative relationships. In each observable choice set only one alternative can be chosen based on the attributes attached to each alternative. Choice sets consist of finite and mutually exclusive alternatives, exhaustive choices (Train, 2009, p. 11). Decision makers, respondents, therefore make trade-offs between attributes. At the heart of the assumptions made is that one rational choice is made per set within certain constraints in order to maximise an actual utility that can only be partly explained by the models estimated. Random utility models assume that (Ortuzar & Willumsen, 2009, p. 223):

1. Individuals are part of a homogeneous population with perfect information and act rationally;
2. The choice of an alternative is made to maximize utility;
3. The choice set is predetermined and constraints have already affected the decision rule; and
4. The analyst observes a representative part of the actual utility and a random part of the actual utility.

In the context of consumer behaviour, preferences should be complete, transitive and more is better than less (Pindyck & Rubinfeld, 2009). In principle, only the differences in the utility matter, in order to establish an understanding of the opportunity costs in choice to be evident (Train, 2009). In principle the *differences in utility approach* is the basis of the decision model between alternatives that provide a certain level of utility U and a respondent choosing the one that maximises the utility they wish to derive from an alternative. According to the RUM theory decision maker r has J alternatives $(j = 1, \dots J)$. Each alternative is described by G attributes such that $X_{r,j} = (X_{r,j,1}, \dots X_{r,j,G})$. The decision maker has unknown vectors of tastes and preferences, β_r, with $\beta_{r,g}$ that are associated with $X_{r,j,g}$. It follows then that the observable utility is influenced by function of the vectors and the attributes of an alternative:

Equation 1: Utility Specification

$$U_{r,j} = f\left(\beta_r, X_{r,j}\right)$$

$$\text{i.e. } f\left(\beta_r, X_{r,i}\right) = \beta_{r,1}X_{r,j,1} + \cdots + \beta_{r,G}X_{r,j,G}$$

The decision rule between two alternatives, $i \text{ and } j$, is that an alternative is chosen in order to maximise utility. Alternative i is chosen if $U_{ri} > U_{rj}\ \forall j \neq i.$ The researcher's limited perception of reality only captures a systematic utility, V which is a function of explanatory variables of a decision maker X_r; and the alternative Y_i vectors of unknown parameters β; and random error (disturbances) ε_{ir} distributed within a certain choice model's specification of the density function$(f(\varepsilon_r)d\varepsilon_r)$. Therefore ($U_{ri} \neq V_{ri} \dots V_{rj}$), and the utility equation can be articulated as:

Equation 2: RUM Utility

$$U_{ri} = V(X_r, Y_i, \beta) + \varepsilon_{ri}$$

Equation 3: Observable Utility

Analytically this study can only observe:

$$V_{ri} = \gamma_i + \beta_i^Y Y_i + \beta_r^X X_r + \varepsilon_{ri}$$

in which γ_i is the alternative specific constant. The probability, π, that decision maker r selects alternative i is articulated as:

Equation 4: Probability of Selection[21]

$$\pi_{ri} = Prob(U_{ri} > U_{rj}\ \forall j \neq i)$$

$$= Prob(V_{ri} + \varepsilon_{ri} > V_{rj} + \varepsilon_{rj}\ \forall j \neq i)$$

$$= Prob(\varepsilon_{rj} - \varepsilon_{ri} < V_{ri} - V_{rj}\ \forall j \neq i)$$

Finally, a cumulative distribution that every random term is below the observable utility using a density function related to the error term is described as:

$$\pi_{ri} = Prob(\varepsilon_{rj} - \varepsilon_{ri} < V_{ri} - V_{rj}\ \forall j \neq i)$$

$$= \int_{\varepsilon} \tau(\varepsilon_{rj} - \varepsilon_{ri} < V_{ri} - V_{rj}\ \forall j \neq i) f(\varepsilon_r) d\varepsilon_r$$

Following Train (2009), τ is equal to 1 if the expression in parenthesis is true and 0 if otherwise.

In terms of how alternatives and attributes are treated in disaggregate choice modelling readers are directed elsewhere (Koppelman & Bhat, 2006; Horowitz, Koppelman, & Lerman, 1986). The estimation of the unknown preference vector β, is done through extending the probability that the model would reproduce the observed choice k given by Equation 5, such that log-likelihood form reflects parameters which maximises β:

Equation 5: Probability of the Model Reproducing Choice

$$\pi^k{}_{ri}(\beta) = \pi_{ri}(\beta, X^k{}_{ri})$$

If the whole sample of observations $(k = 1, .. K)$ is captured then the *likelihood* $(LL(\beta))$ that the model would reproduce the sample is given by:

[21] This particular equation reveals the importance of differences in utility at the heart of the RUM. Which almost assumes that individuals weigh alternatives empirically.

Equation 6: Likelihood

$$L(\beta) = \prod_{k=1}^{K} \pi^{k}{}_{ri}(\beta)$$

The log-likelihood function is therefore:

Equation 7: Final Log-Likelihood

$$LL(\beta) = \sum_{k=1}^{K} \text{In}\, \pi^{k}{}_{ri}(\beta)$$

According to Train (2009, pp. 61) the estimator is the value of the preference vector β that maximises this function. The treatment of this estimation processes is described in the context of the BIOGEME package (Bierlaire, 2003, pp. 6-7) and the RUM context as well (Walker & Ben-Akiva, 2002, p. 301). Once the parameter vectors are estimated through the log-likelihood approach, the probability of choosing one mode over another is estimated assuming that ε_{ri} are independent and identically distributed Gumbel random variables:

Equation 8: Multinomial Logit Probability Form

$$\pi_{ri} = \frac{e^{\mu(\beta X_{ri})}}{\sum_{j \in C_r} e^{\mu(\beta, X_{rj})}}$$

Where μ is a scale factor which is used to impose parameter equality—which defeats the purpose of latent class modelling because differences in classes stems from differences in parameters between classes (Boxall & Adamowicz, 2002, p. 426). C_r refers to one of the hypothetical choice sets $(c = 1, \ldots C)$ individual r is responding to in a survey experiment by choosing between modes j . This principle is applied to the latent class form in two ways: (a) to estimate the likelihood of membership in a behavioural class and (b) the likelihood of mode choice within a certain behavioural class. This study aggregates a sample of university students' travel preferences.

3.2.3 Service Design Attributes

Discrete choice model data is captured through the use of stated preference experiments. The experiment design process offers a sequence of stages related to developing such experiments (Hensher, Rose, & Greene, 2005, p. 102). The hypothetical context within which students played the game describes a trip from the recently upgraded Mega City Shopping area to the Mahikeng Town centre.

Survey Statement 1: Hypothetical Context

> *"Imagine that you are performing your usual trips. One for the trips involves you travelling from Mega City to Mahikeng town centre. There are no big events, or bad weather. Look at the hypothetical scenarios and choose the service you think is the best one in each scenario. "*

The model and service estimates were calibrated based on the actual prices of the trip, R 10 and R7.50 by minibus taxi and bus, respectively in 2016.

In the North West Province (NWP) travel time (43.4%), travel cost (19.3%), safety from accidents (8.8%), flexibility (7%), access distance (6.8%), reliability (6%), and comfort (4.7%) are rated among the most important factors influencing household mode choice (StatsSA, 2014, p. 90). On the aggregate level, this places an emphasis on time and cost factors. Table 5 describes the attribute levels used in this study.

Table 5: Specific Attribute Levels[22]

	Bus			Taxi		
Seating Availability (Q)	Many Seats Available	Few seats available	There is only space for you to stand	Many seats and space available	Few sets little space available	Very full and no personal space
Survey[23] Variable	3	2	1	3	2	1
Fare Price (F)	R 15 US$ 1.15 (+54%)	R 9.70 US$ 0.75 (0%)	R 7.30 US$ 0.56 (-24.7%)	R 15 US$ 1.15 (+50%)	R 10 US$ 0.78 (0%)	R 7.50 US$ 0.57 (-25%)
In Vehicle Travel Time (H)	20min (-33%)	30min (0%)	40min (+33%)	10min (-33%)	15min (0%)	20min (-33%)
Waiting To Depart (W)	5min (-50%)	10min (0%)	15min (+50%)	10min (-100%)	20min (0%)	30min (+100%)

Waiting, travel time and travel costs were included because of their presence in various other studies and importance in the NWP. Seating availability is a measure of both perceived comfort and service frequency. Long waiting times are assumed to be associated with unreliable transit service (also due to the lack of a schedule in terms of minibus taxi). Resource limitations could not permit a qualitative process to identify key attributes for students in line with practice (Klojgaard, Bech, & Sogaard, 2012). Therefore, this study imposes generic attributes based on the author's observations and use of transit modes in the area. Attribute level ranges are specified based on realistic differences between levels—but not too extreme (Rose & Bliemer, 2009, p. 590; Hensher, Rose, & Greene, 2005). The selected attributes are among the *comfort and convenience* characteristics in the trip decision making process described earlier.

[22] Percentage deviation from the base in parenthesis; and US $ 1 = R 13.00 in 2016.

[23] The 3,2,1 specification is used to reflect the high value of having many seats available (3) and the low value of only having the discomfort of standing or lacking personal space (1) for a trip. Bipolar estimate format was attempted in which the highest level of comfort was 1, and the lowest -1. The d-error for this formation was no different from the unipolar estimate.

3.2.4 Discrete Choice Model

3.2.4.1 Non-Class Specific Mode Choice Model

The non-class specific mode choice model is a general model used as a reference point to observe whether there is a difference between the general modal split probabilities and the behaviour specific modal split probabilities. As there are no behavioural classes the model follows a basic kernel form such that the utility gained by individual r from choosing mode j is a function of a preference vector β estimated for demographic characteristics Y , and each level of service attribute X as shown in Equation 9. The attributes or explanatory variables of the utility stem from Table 5.

Equation 9: Non-Class Specific Utility

$$U_{n,j} = V_j\left(\gamma_j, \beta_r^Y, Y_r, \beta_j^X, X_j\right) + \varepsilon_{r,j}$$

With the established form, bus and taxi choice is specified through level of service vectors described as seating availability (Q), service price (F), in vehicle travel time (H) and waiting to depart (W) the observed utility in Equation 10.

Equation 10: Non-Class Specific Observed Utility

$$V_b = \gamma_b + \beta^Q Q_b + \beta^F F_b + \beta^H H_b + \beta^W W_b + \beta_r^Y Y_r$$

$$V_t = \beta^Q Q_t + \beta^F F_t + \beta^H H_t + \beta^W W_t + \beta_r^Y Y_r$$

Following the preceding discussion in 3.2.2, the resulting estimation is used to observe both the modal split probability between two modes:

$$\pi_{rb} = \frac{e^{(\beta_r^Y, Y_r, \beta_b^X, X_b)}}{\sum_{j \in C_r} e^{(\beta_r^Y, Y_r, \beta_b^X, X_b)}}$$

3.3 Stimuli Refinement: Discrete Choice Experiment

SP surveys may be labelled or unlabelled. Labelled surveys are where hypothetical scenarios offer a choice between bus and taxi; unlabelled surveys are where the scenarios are choices between Transport A and Transport B. Although labelled designs are argued to be applicable where alternative labels are real (de Bekker-Grob, et al., 2010, p. 322), and new modes are considered. However, since the label may become an influential variable in the choice game, it may present some problems with regard to the alternative specific constant γ_j (Hensher, Rose, & Greene, 2005, p. 113).

Firstly, the label attached may act as an attribute for an alternative thus influencing the choice because of inherent preference toward a mode (Hensher, Rose, & Greene, 2005, p. 113) which is in line with de Bekker-Grob, et al. (2010, p. 322) finding that *"the inclusion of labels [appears] to play a significant role in individual choice but reduced the attention respondents* *give to the attributes"*. Thus, the label itself becomes a 'sorting attribute' in lexographic (bias) choice stating (Soelensminde, 2006, p. 336). Secondly, this weakens the IID assumption in choice models because the independence may be influenced by the label.

In this study respondents did not know they were in fact choosing between two motorised public transport modes-- bus and taxi, they were making choices in hypothetical scenarios between 'Transport A' and 'Transport B' (see Figure 12) based on the level of service offered. The use of unlabelled experiments takes the form of (a) alternatives not being explicitly stated in hypothetical scenarios of the survey and (b) where *"alternatives represent different versions of the same type or brand"* (Rose & Bliemer, Constructing efficient stated choice experimental designs, 2009, p. 613). An unlabelled experiment is developed to avoid alternative bias (i.e. students may favour one mode over another if the labels are included) and *"investigate trade-offs between attributes*" (de Bekker-Grob, et al., 2010, p. 322). This approach is suitable for the purpose of this study as it provides a clear description of the LOS preferred between two unknown modes for the respondent, while they are known by analyst. A d-optimal survey structure is most suitable for the unlabelled experiment form.

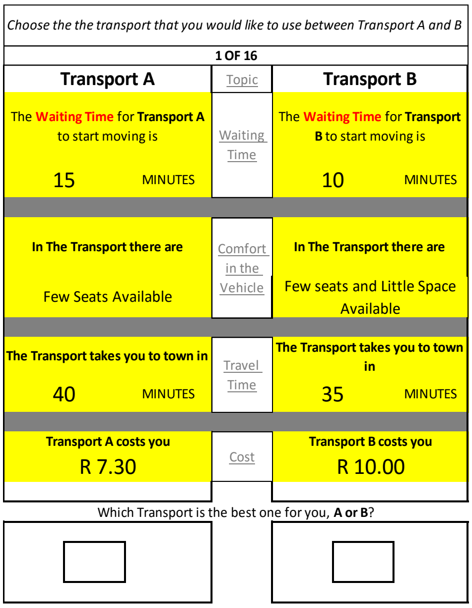

Figure 12: Example of Choice Set

3.2.1 Constructing a D-Optimal Survey

Survey designs or experiments are developed based on the (a) utility function specified in terms of attributes of alternatives and (b) parameter priors or β estimated from a pilot study or other sources. With respect to microeconomic theory Stated Choice Experiments (SCEs), or Discrete Choice Experiments (DCEs) enable the construction preference spaces in which indifference curves are estimated to determine the utility functions (Hensher, Rose, & Greene, 2005). These experiments take four major forms: full factorial, fractional factorial, d-optimal and d-efficient designs (Sanko, 2001; Rose & Bliemer, 2009; Huber & Zwerina, 1996;

Goos & Jones, 2011; Zwerina, Huber, & Kuhfeld, 1996). Described in Table 6, the survey designs vary based on their assumptions and the manner in which attribute levels are specified. This results in unique advantages and disadvantages for each survey design.

Table 6: General Stated Choice Survey Design Methods

	Conceptual Overview Stated Choice Survey Designs			
Design	Full factorial	Fractional Factorial	D-Optimal	D-Efficient
Model Assumption	Respondents are capable of completing all possible choice tasks—without fatigue.	Reduces the number of treatments per respondent to a representative percentage of the full factorial (Sanko, 2001).	"...increase the trade-offs that respondents are forced to make across all attributes maximising the information obtained in terms of the importance each attribute plays on choice" assuming parameter priors are zero (Rose & Bliemer, 2009).	"Minimise the elements of the [asymptotic variance co-variance] matrix" assuming parameter priors are non-zero (Rose & Bliemer, 2009).
Attribute Level Selection	Orthogonal	Orthogonal	Non/Orthogonal (Rose & Bliemer, 2009)	Orthogonality unlikely but ideal (Huber & Zwerina, 1996).
PRO'S	Allows for a complete representation of all response possibilities. Computationally easy to construct.	Allows for a significant use of a fraction of all possibilities to the extent that users can still respond at a reasonable level. Thus reducing the likelihood of respondent fatigue—especially through a blocked design.	With large samples, it pulls the D-efficient estimates towards a reasonable scale, at the cost of some statistical significance in some variables than others. High variance between attribute alternatives. Can be built from an existing fractional-factorial survey.	Increases the magnitude of Alternative Specific Constants. It is also used to compare "the determinant of the information matrix of that design to an ideal determinant corresponding to an orthogonal design" (Goos & Jones, 2011). Can incorporate parameter priors.
CON'S	Too many responses compared to other designs. Unlikely to be possible under real circumstances with complex choice problems.	May need to be modified by the researcher to make choices more realistic and reduce dominance.	Suitable only for unlabelled experiments. May promote lexographic behaviour in choice making of respondents.	Predictive limitations for variables with the smallest sample size.

Efficiency in stated choice surveys is fundamentally measured within three principles: (1) orthogonality; (2) level balance and (3) minimal overlap (Huber & Zwerina, 1996; Zwerina, Huber, & Kuhfeld, 1996). The absolute value of the survey design is related to minimizing the covariance (Hensher, Rose, & Greene, 2005; Sanko, 2001). The principles behind survey design efficiency are impossible to adhere to in totality, however leaning closer toward such designs has shown to reduce d-error. Efficient designs that use a fraction of the choice problems in full designs are *"primarily relevant to studies involving small finite samples"* (Rose & Bliemer, 2009, p. 612). In terms of the size of the design *"what is important is how much information each choice task provides in terms of the trade-offs respondents are required to make"* (Hess & Rose, 2009, p. 19). An efficient design enables the effective use of smaller sample sizes while maximising the amount of information and plausible variation in the choice sets. This results in a survey design that forms the basis of better quality preference spaces.

As a result the importance of orthogonality is largely for design purposes, once respondents participate in the survey, responses are scatter the initial survey form. This reduces the value of full factorial and fractional factorial designs that are oriented toward ensuring orthogonality. Some researchers reveal that deviating from orthogonality may enable the analyst to strike a balance between response efficiency (i.e. user's cognitive ability, dominant choices, preventing lexography etc.) and the efficiency of the survey (i.e. maximising trade-offs realistically) (Johnson, et al., 2013). But orthogonality is a constraint to the survey design, and may deviate the design from reflecting choice scenarios that respondents realistically relate to, hence it is avoided.

For the purposes of capturing greater attribute variation; implementing an unlabelled survey; and having a fractional factorial design base a d-optimal survey design was chosen with due awareness of its disadvantages. More specifically, the design is an optimal choice probability design particularly because it is not orthogonal, by design or in view of the covariance in Table 8. Rose & Bliemer (2009 pp. 605-607) present a number of case studies where zero and non-zero parameter priors are used on different survey designs. They show an optimal orthogonal design with zero parameter priors would result in minimised covariance between attributes, and thus only diagonal relationships.

In the MNL context, an optimal orthogonal design may perform worse than a D-efficient design, engendering manual inspection of the design (Bliemer & Rose, 2010, p. 729)—which was performed in this study. In line with best practice, the quality of a survey is evaluated before and after the data is collected. Each time taking a specific form but producing at least a variance covariance matrix and a statistical measure of the quality of the survey, namely D-error among other measures (i.e. A-error (inverse of D-error)). The statistical evaluation of the survey is discussed in the next sub-section.

Through the R Package (R Core Team, 2013)[24] a d-optimal design, with no parameter priors was developed for an unlabelled experiment. Only expected relationships between priors were specified (which had no bearing on the design). The base of the survey was a fractional factorial design, in which the d-optimal estimation procedure produced an outcome that maximised variances between alternatives.

The attribute levels presented in Table 5 are used to populate the survey design shown in Table 7. Consisting of 16 choice sets (C) wherein respondents choose between alternatives$j$, L is the number of levels and A the number of attributes then L^A is the number of possible choice sets $(C = 81)$ for an unlabelled experiment (Hensher, Rose, & Greene, 2005, p. 112; de Bekker-Grob, et al., 2010, p. 316). The end result is a d-optimal survey design that needs to be assessed through d-error estimations, in order to determine its quality and thus the quality of the preference space upon which utility functions are estimated.

[24] More specifically the *R Commander Plugin for (industrial) Design of Experiments* (RcmdrPlugin.DoE) plugin is employed to design the experiment (Groemping, 2014).

Table 7: D-Optimal Survey Design

C	j 1(bus) 2 ($taxi$	W_j	Q_j	F_j	H_j
1	1	15	2	7.3	40
	2	10	2	10	35
2	1	5	2	15	40
	2	10	2	10	35
3	1	10	2	9.7	40
	2	20	2	10	35
4	1	10	3	9.7	40
	2	10	2	15	35
5	1	10	2	9.7	40
	2	30	2	10	50
6	1	10	2	9.7	40
	2	10	2	10	20
7	1	15	1	15	55
	2	30	1	15	50
8	1	10	3	9.7	40
	2	30	2	7.5	35
9	1	5	3	15	55
	2	10	3	15	50
10	1	10	1	9.7	40
	2	30	2	15	35
11	1	15	3	9.7	25
	2	20	2	10	35
12	1	5	3	7.3	55
	2	30	1	7.5	20
13	1	10	1	9.7	40
	2	10	2	7.5	35
14	1	15	3	15	25
	2	30	3	7.5	50
15	1	5	1	9.7	25
	2	20	2	10	35
16	1	10	3	9.7	40

3.2.2 Statistical Evaluation of Survey

This study adopts the D-error estimate, particularly because there were no parameter priors, and no intention to minimise t-statistics either. From a survey design perspective, the utility function specified informs the evaluation of the design. The quality of the design can be assessed with or without parameters β and consistent with the observable utility (V) function of the model (Huber & Zwerina, 1996; Rose & Bliemer, 2009). This quality is determinable based on the d-error estimate, among other measures, which is derived from the asymptotic variance covariance matrix (AVC). In this sub-section the d-error estimate is calculated for the survey design presented in Table 7.

For the purpose of the survey design, B_{jk} is the sum-product of parameter priors β_{jc} and choice observations g_{jck}.

Equation 11: Sum-Product of Choosing an Alternative Specific Level in Choice Set

$$\mathrm{B}_{jk} = \sum_{c=1}^{c_j} \beta_{jc}\, g_{jck}$$

The probability, π_{jk}, of observing choice k between alternatives j in choice set c is specified as:

Equation 12: Probability of Observing a Choice Between Alternatives in a Specific Choice Set

$$\pi_{jk} = \frac{e^{\mathrm{B}_{jk}}}{\sum_{i=1}^{J} e^{\mathrm{B}_{ik}}}$$

In order to estimate the variance covariance of the survey the un-weighted alternative choice and mode specific attributes (g_{jkc}) are weighted by the probability of the respective mode (π_{ic}) and scaled to the root of the mode in question (π_{jk}) as shown in Equation 13:

Equation 13: $\boldsymbol{A} \times \boldsymbol{C}$ Matrix

$$\Theta_{jkc} = \left[g_{jkc} - \sum_{i=1}^{J} g_{ikc}\, \pi_{ic} \right] \sqrt{\pi_{jk}}$$

In Equation 14 the Fischer information matrix is estimated through matrix-multiplication of the transposed $A \times C$ matrix.

Equation 14: Fischer Information Matrix

$$\Gamma = \Theta_{kj}^{T} \Theta_{jk}$$

The asymptotic variance covariance (AVC) is estimated through Equation 15, and the estimation for the survey design is presented in Table 8.

Equation 15: Asymptotic Variance Covariance (AVC)

$$\Omega = \Gamma^{-1}$$

Presented in Table 8, AVC measures the extent to which variables are moving 'together', somewhat similar to correlation. The AVC between Q_j is significantly higher than most of the other service attributes. This skewedness may be because of the structure of the survey when estimating d-optimality and the categorical nature of the variable (i.e. 1,2,3) relative to the continuous nature of other variables.

Table 8: The Asymptotic Variance-Covariance Matrix

	W_j	Q_j	F_j	H_j
W_j	0.28	-2.68	-0.13	0.41
Q_j	-2.68	41.78	2.76	-4.63
F_j	-0.13	2.76	0.28	-0.26
H_j	0.41	-4.63	-0.26	0.67

This is an example of the trade-offs made in SCS design. Various specifications of the survey were tested (i.e. decimal, binary and continuous levels) and a continuous form was chosen due to the low D-error estimate calculated through Equation 16.

Equation 16: D-error

$$D - error = det\ \Omega^{1/G}$$

Table 9 presents the various specifications tested for the survey, their corresponding D-error and an example of the specification. The ideal choice is a continuous specification since it offers the lowest D-error.

Table 9: D-Error Estimates for the Survey

D-error	Example
$Continious/Binormal\ (reordered)\ D - error = 0.346$	1,2,3; 10,15; etc.
$Continious\ D - error = 0.384$	1,2,3; 10,15; etc.
$Binormal \quad D - error = 0.574$	-1;0;1
$Decimal \quad D - error = 4.73$	0.7;1;1.2

The considerations discussed above within the experimental design process enable a more statistically and practically applicable survey instrument. However, this is subject to the context of the application from a travel behaviour and mode choice perspective. The next subsection, expands on the introduction of HCM in Chapter 1, and specifies the latent class and latent variable models used in the study.

3.3 Hybrid Choice Modelling Framework

The HCM framework, shown in Figure 13, expands the scope of understanding choice by incorporating *immeasurable variables* related to the choice experiment. *Indicators* are used to 'measure' constructs that reflect behavioural constructs. In the HCM context, such models are between latent class and latent variable models—including both extremes. This subsection describes how the TPB is incorporated in the HCM framework in a LCCM specified choice model.

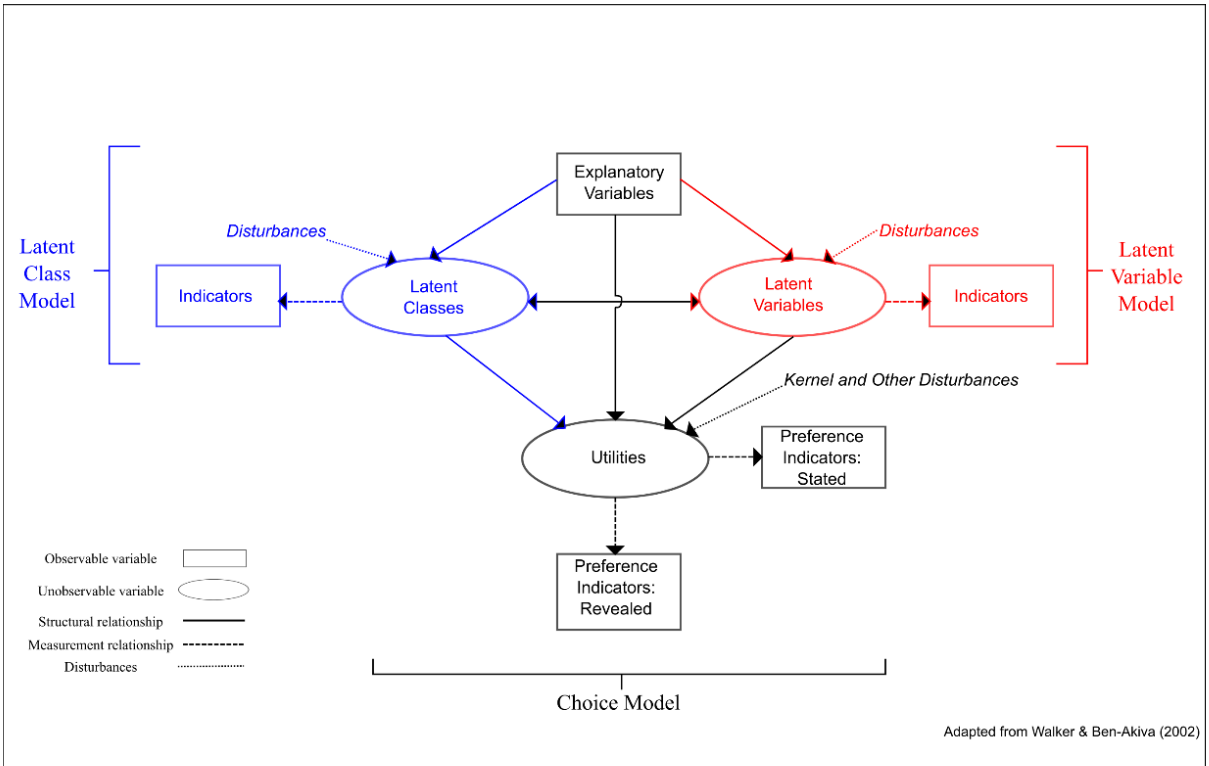

Figure 13: Hybrid Choice Modelling Framework

Market behaviour is constrained by internal and external factors some known and others traditionally unknown to analysts. The internal workings of consumer decision making can be included in choice models through indicators that represent attributes from the *black box* ranging from individual decision protocols, psychological, attitudinal and other indicators (McFadden, 1986). HCM fills the gap between discrete choice models and behavioural complexity as an integrated framework to represent external and observable attributes as *explanatory variables*; underlying characteristics of behaviour through *latent variables,* and segments that represent the underlying characteristics through *latent classes* (Walker J. L., 2001). Whether these are memory, involvement/affect, constraint, perception, taste, and or process indicators choice behaviour represented in this form is an extension of discrete choice models, but also a challenging voyage to incorporate psychological indicators to explain behaviour (Ben-Akiva, et al., 1999). Latent variables, classes and utilities are unobservable variables, but they can be estimated through indicators and observable utilities (i.e. V). Efforts to estimate this integrated approach extend the random utility model both conceptually and empirically through the model specification following the framework and estimation procedures for a more Generalised Random Utility Model (Walker J. L., 2001; Walker & Ben-Akiva, 2002). In this study, the focus is on observing each of these model structures separately—latent class, and latent variable models through the Theory of Planned Behaviour conceptually. As a result a GRUM is not estimated, but latent class, and latent variable model is estimated. The subsection therefore presents three structures presented in Figure 14:

1. The specification for the TPB models in order to incorporate them into the DCM;
2. Latent class choice model specification that segments choice models based on the intensity of the intention to choose one mode over another; and
3. Latent variable model estimation to include the behavioural indicators from the TPB in the DCM model.

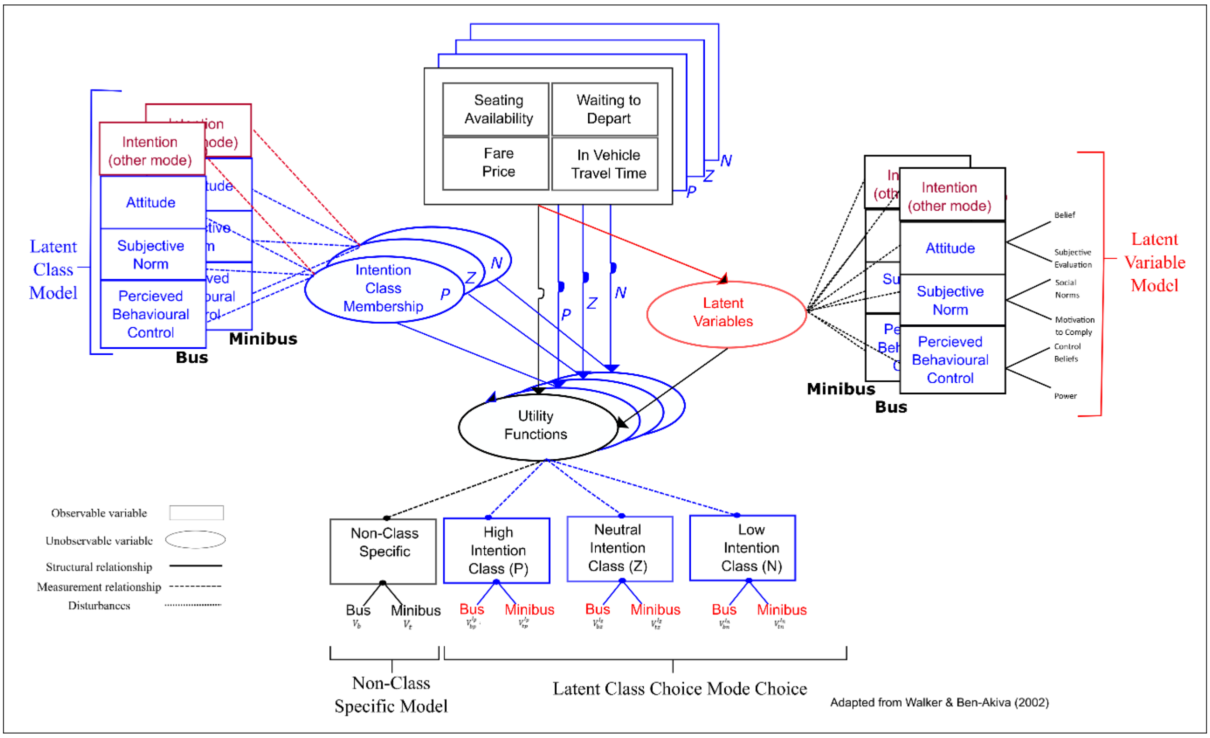

Figure 14: Latent Class Choice and Latent Variable Models in this Study

3.3.1 Specifications for the Theory of Planned Behaviour

The Theory of Planned Behaviour (TPB) uses psychological indicators to reveal a path dependency between behavioural constructs and their impact actual behaviour (Ajzen, 1991). It is among the behavioural theories related to travel demand that explain factors that affect choice-making (Adjei & Behrens, 2012, p. 59). The theory contends that *intention* (I) key determinant of behaviour. It also argues that indicators of *intention* manifest from attitude (A) (behavioural beliefs), subjective norm (S) (normative beliefs) and perceived behavioural control (PBC) (also influencing behaviour). These are the primary indicators presented in **Error! Reference source not found.**, however there are a number of underlying empirical models that are used to specify the primary indicators for the TPB which are used to construct the Likert-survey statements.

3.3.1.1 Empirical Models for the TPB Analysis

Ajzen (1991) presents various analytical forms within which (a) correlations between control, attitudinal and norm variables are related to intention; and (b) regression coefficients are estimated for the underlying relationships with intention or control variables as the dependent variable. Other studies have explored the integration of TPB with other theoretical models (Bamberg, Hunecke, & Blöbaum, 2007), and one attempts to estimate the specific nature of subjective norms in the context of university students (Belgiawan, Schmöcker, Abou-Zeid, Walker, & Fujii, 2017). In this subsection, a description of the underlying interactions between statements in the survey and their behavioural specifications is presented. Analysing TPB dynamics combines unimodal and bimodal scales for underlying statements to construct *attitudes, subjective norms,* and *perceived behavioural control*.

Attitudes. Salient beliefs, u, underlying the TPB are identified in the survey statements. The combined effect of belief statements ϱ_i (unimodal) and subjective evaluation σ_i (bimodal) of the belief is expected to be directly proportional to the summative index of attitudes, A.

Equation 17: Attitude Model

$$A \propto \sum_{i=1}^{u} \varrho_i \sigma_i$$

Subjective norms. Similarly, subjective norms are expected to emanate from the combined effect of social norms $\aleph_i$ (bimodal) and individual motivation to comply $\mathcal{M}_i$ (unimodal). Social norm statements relate to what other people believe or approve of with regard to a specific behaviour. Motivation to comply relates to how the individual rates their propensity to comply with social norms from friends, or family—or both (Belgiawan, Schmöcker, Abou-Zeid, Walker, & Fujii, 2017).

Equation 18: Subjective Norm Model

$$SN \propto \sum_{i=1}^{u} \aleph_i \mathcal{M}_i$$

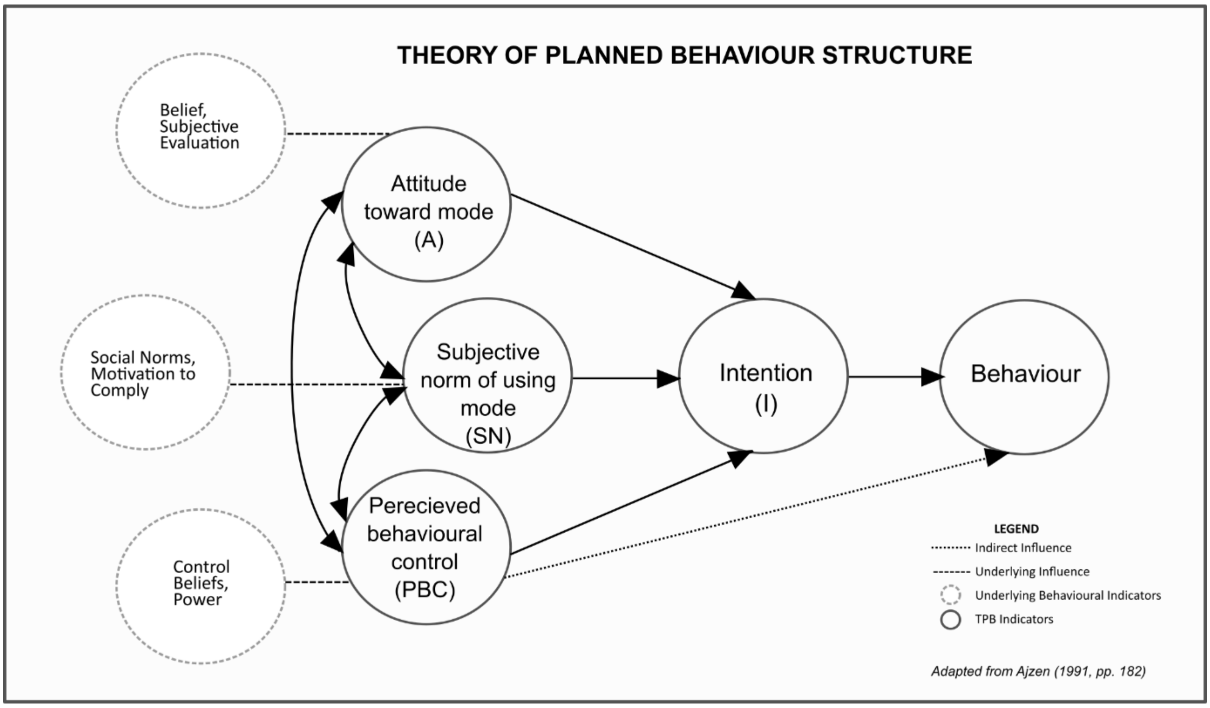

Figure 15: The Theory of Planned Behaviour Indicators and Underlying Behavioural Indicators

Perceived behavioural control. Control beliefs are in some respects interchangeable with intention because where individuals have no real control over a behaviour or lack power over a certain behaviour their intention may not be a good measure. Perceived control is therefore a combination of control beliefs C_i (unimodal) and statements related to *power* over a behaviour P_i (bimodal).

Equation 19: Perceived Behavioural Control Model

$$PBC \propto \sum_{i=1}^{u} \text{C}_i \text{P}_i$$

Intention. Intention is therefore a function of:

Equation 20: Intention Specification

$$I = f(A, SN, PBC)$$

In this form, the specification of intention could take the form of regression analysis, structural equation assessments or even treating the behavioural indicator as a choice and estimating a behavioural utility. In this study, intention is used as a dependent variable in the class membership model, and an indicator used to allocate responses between behavioural classes.

Effect of the analysis. In general, the latent effect of this form of application is specifically for ensuring that a behavioural analysis underpins the discrete choice models. Furthermore, understanding the aggregate TPB enables improved assessments of the decision frameworks employed by respondents in the survey. These constructs are captured through Likert-scale responses to specific statements.

3.3.1.2 Likert Scale Survey for the TPB

Underlying the likert-scale class membership thresholds is the application of the TPB in its most basic form. Following a number of studies (Ajzen, 2002; Bamberg, Ajzen, & Schmidt, 2003), the hypothetical scenario, and statements are outlined in Table 10. Statements are sensitive to the theoretical constructs (i.e. attitudinal = adjective pairs; subjective norm = injunctive and descriptive terms); scales have counter balanced end points of positive and negative (Ajzen, 2002, pp. 5-10); and the questions are split between two modes: bus (b) and taxi (t).

The counter balancing of questions implied that some ends were not always rationally consistent: higher rating for one question corresponded with a low number and a high number for the next[25]. This in psychology research, according to the guideline (Ajzen, 2002), ensures respondent attention and no fleeting responses. From a choice modelling perspective it may generate some incongruence in some of the respondents. The scenario statement focuses on *home* trips, which may for some respondents imply ‘going back home when not from Mahikeng’ or ‘making a trip to one’s parents as residence may not be considered as home’. Likert scale indicators are used to inform the TPB indicators, and it is used to structure the level of intention used for latent classes.

[25] This type of specification in the survey may have resulted in a loss of respondents, as a number of surveys were removed because some responses were not consistent, or incomplete potentially due to this characteristic.

Table 10: Behavioural Statements in the Survey

Behavioral Variable		Behavioral Statement in Survey	Likert-Scaling		
			>4	4	4<
Intention (INT)		I intend to travel by taxi 3 days (or more) per week to go home.	Very False	May Be	Very True
		I will try to travel by bus 3 days (or more) per week to go home.	Definitely Not	Unsure	Definitely Will
		I plan to travel by taxi this week to go home.*	Strongly Agree	Unsure	Strongly Disagree
		I would like to use the bus this week to go home.*	Very True	Unsure	Very False
Attitude (ATT)	ϱ_t	For me to travel by taxi 3 days (or more) per week to go home in the next month is	Harmful	Unsure	Beneficial
	σ_t	(sub-rating)*	Very Good	Unsure	Very Bad
	ϱ_t	(sub-rating)	Unenjoyable	Unsure	Enjoyable
	ϱ_b	For me to travel by bus 3 days (or more) per week to go home in the next month is	Harmful	Unsure	Beneficial
	σ_b	(sub-rating)*	Very Good	Unsure	Very Bad
	ϱ_b	(sub-rating)	Unenjoyable	Unsure	Enjoyable
Subjective Norm (SN)	$\aleph_t$	Most people who are important to me would think that for me to travel by taxi 3 days (or more) per week is *	Very Good	Unsure	Very Bad
	$\aleph_b$	If I use a bus to go home 3 days (or more) per week most of my friends and family would	Completely Disapprove	Unsure	Completely Approve
	$\aleph_b$	People close to me think that me using the bus to travel home 3 days (or more) per week is	Very Bad	(blank)	Very Good
	$\aleph_t$	My friends and family travel by taxi to go home 3 or more times per week.*	Completely True		Completely False
Perceived Behavioral Control (PBC)	P_b	For me to travel by bus for at 3 days (or more) per week would be	Impossible	(blank)	Possible
	C_t	It is mostly up to me whether or not I use a taxi to travel home 3 days (or more) per week*	Strongly Agree	Unsure	Strongly Disagree
	C_b	How much control do you believe you have over traveling by bus 3 days (or more) per week	No Control	Neutral	Complete Control
	P_t	If I wanted I could use the taxi to travel home 3 days (or more) per week*	Definitely True	Neutral	Definitely False
	$\mathcal{M}_i$	In general, do you do what people close to you want you to do?	Never	(blank)	Always
Transport Budget Control	YY_t	My using a taxi to travel home 3 days (or more) per week in the next month will help me keep to my budget for transport*	Definitely True	Neutral	Definitely False
	YY_b	My using a bus to travel home 3 days (or more) per week in the next month will help me keep to my budget for transport*	Definitely True	Neutral	Definitely False
	YY_i	Keeping to a monthly transport budget is	Extremely Bad	(blank)	Extremely Good

* Indicates that the variable was reversed in the survey and in model estimation it followed the sequence of negative to positive statement, while in the survey it is presented as a positive to negative rating statement.

3.3.1.3 Latent Class Specification for the TPB

Behavioural indicators for each construct reflect a high or low inclination depending on how each statement is scaled by respondents. In the LCCM context of this study, Likert-scale indicators m responded to in the survey were moderated within m^{th} rating for each question averaged within a behavioural construct. The behavioural survey response is comprised of m^{th} indicator taking on $1, \dots, L_m$ levels (Gopinath, 1995, pp. 49-50). With $L_m = 7$ then higher ratings in attitude (A) related statements indicate a high inclination toward having a positive attitude toward a certain action. The average of behavioural indicators, for each construct, are used to specify behavioural construct specific groups such that high intention[26] (P) , low intention (N) or neutral (indifferent) intention (Z) are specified as:

$N = m^{th} < 4$

$Z = m^{th} = 4$

$P = m^{th} > 4.$

In terms of intention, attitudes may be negative, or positive; intention can be high or low. Hence the term "high intention" reflects a positive inclination and "low intention" reflects a negative inclination. The treatment of these thresholds is based on a simplified ordinal criteria (Gopinath, 1995, pp. 86-88). These behavioural thresholds constitute the latent classes $(s = 1, \dots, S)$ in this study.

3.3.2 Latent Class Choice Model

Class specific mode choice probabilities are specified as the probability that individual r belonging to class s would choose mode j, of which it is known is a choice between bus and minibus taxi. Such a specification results in separate preference vectors β for each class and service attributes X associated with the mode in question. The utility $U^{I_m}{}_{js}$ is based on an intention (I) falling in threshold m to use a certain mode j—the threshold corresponds with class s within a margin of error $\varepsilon_{j,s}$ as shown in Equation 21.

Equation 21: Class Specific Mode Choice Utility

$$U^{I_m}{}_{js} = V_{js}^{I_m}\left(X_{j,s}; \beta^X{}_{j,s}\right) + \varepsilon_{j,s}$$

The observed class specific utility in the mode choice context, with the corresponding level of service attributes are shown in Equation 22 for high intention; Equation 23 for neutral intention class and Equation 24 for low intention class.

[26] Intention is used here as a core measure, however, other behavioral constructs in the TPB could be used to estimate similar models, but this would have very different meaning on a theoretical level.

Equation 22: High Intention Class Specific Observed Utility

$$V_{bp}^{I_p} = \gamma_{bp} + {\beta_p}^Q Q_{bp} + {\beta_p}^F F_{bp} + {\beta_p}^H H_{bp} + {\beta_p}^W W_{bp}$$

$$V_{tp}^{I_p} = {\beta_p}^Q Q_{tp} + {\beta_p}^F F_{tp} + {\beta_p}^H H_{tp} + {\beta_p}^W W_{tp}$$

Equation 23: Neutral Intention Class Specific Observed Utility

$$V_{bz}^{I_z} = \gamma_{bz} + {\beta_z}^Q Q_{bz} + {\beta_z}^F F_{bz} + {\beta_z}^H H_{bz} + {\beta_z}^W W_{bz}$$

$$V_{tz}^{I_z} = {\beta_z}^Q Q_t + {\beta_z}^F F_{tz} + {\beta_z}^H H_{tz} + {\beta_z}^W W_{tz}$$

Equation 24: Low Intention Class Specific Observed Utility

$$V_{bn}^{I_n} = \gamma_{bn} + {\beta_n}^Q Q_{bn} + {\beta_s}^F F_{bn} + {\beta_n}^H H_{bn} + {\beta_n}^W W_{bn}$$

$$V_{tn}^{I_n} = {\beta_n}^Q Q_t + {\beta_n}^F F_{tn} + {\beta_n}^H H_{tn} + {\beta_n}^W W_{tn}$$

Furthermore, the probability that individual r would belonging to class s would choose bus (b) is specified in the multinomial form shown in Equation 25.

Equation 25: Class Specific Mode Choice Probability[27]

$$\pi_{r|s}(b) = \frac{e^{(X_{b,s}, {\beta^X}_{b,s}, \varepsilon_{b,s})}}{\sum_{s \in C} e^{(X_{j,s}, {\beta^X}_{j,s}, \varepsilon_{j,s})}}$$

3.3.3 Latent Variable Model

Following the non-class specific model form presented at the early stages of this chapter in section 3.2.4, a latent variable model (LVM) is estimated. This LVM incorporates behavioural indicators T_j and the related parameter α_j^T as part of the mode choice decision, in addition to socio-demographic indicators, Y. The result is a utility function described in Equation 26:

Equation 26: Latent Variable Model Utility

$$U_{n,j} = V_j\left(\gamma_j, \beta_r^Y, Y_r, \beta_j^X, X_j, \alpha_j^T, T_j\right) + \varepsilon_{r,j}$$

The observed utility function is as follows:

Equation 27: Latent Variable Model Observed Utility

$$V_b = \gamma_b + \beta^Q Q_b + \beta^F F_b + \beta^H H_b + \beta^W W_b + \beta_r^Y Y_r + \alpha_j^T T_j$$

---

[27] The specification that $j \in C$ implies that the sum is based on the set of responses choosing mode j on the choice set given a certain class. This practically separates choice sets based on the behavioural class under observation.

$$V_t = \beta^Q Q_t + \beta^F F_t + \beta^H H_t + \beta^W W_t + \beta_r^Y Y_r + \alpha_j^T T_j$$

In Equation 28 a description of the TPB empirical models discussed in 3.3.1.1 is presented. Included in the model are indicators related to salient beliefs (u, ϱ), evaluations (σ), subjective norms $(\aleph)$, motivation to comply $(\mathcal{M})$, control $(\complement)$ and power (P) that are used to construct behavioural constructs for the TPB—primary indicators. The primary behavioural indicators are also included in the model in form of A_j, SN_j and I, and PBC_j. This form will enable an assessment of whether behavioural indicators have a bearing on the choice itself, not only if service preferences can be differentiated based on behavioural classes.

Equation 28: Theory of Planned Behaviour Indicators

$$\alpha_j^T T_j = f(\alpha_j^A A_j, \alpha_j^I I_j, \alpha_j^{SN} SN_j, \alpha_j^{PBC} PBC_j, \alpha_j^u u_j, \alpha_j^\varrho \varrho_j, \alpha_j^\sigma \sigma_j, \alpha_j^\aleph \aleph_j, \alpha_j^{\mathcal{M}} \mathcal{M}_j, \alpha_j^\complement \complement_j, \alpha_j^P P_j)$$

The resulting estimation is used to observe the modal split probability between two modes:

Equation 29: Latent Variable Mode Choice Probability

$$\pi_{rb} = \frac{e^{(\beta_r^Y, Y_r, \beta_j^X, X_j, \alpha_j^T, T_j)}}{\sum_{j \in C_r} e^{(\beta_r^Y, Y_r, \beta_j^X, X_j, \alpha_j^T, T_j)}}$$

The LVM estimation complements the intermodal and intermodal behavioural models, and may be useful in analysing the latent class choice models. However, it does not seem sufficient in determining the influence of both mode choice probabilities for each class and their related class membership. To estimate this, a joint probability approach is proposed next.

3.4 Sample Size Considerations

Hensher et al. (2005, p184-196) describe three approaches for estimating sample sizes: (a) simple random sampling, (b) stratified random sampling and (c) choice based sampling, which is largely useful for revealed preference data—not stated preference (ibid-pg. 95-96).

Both (a) and (b) estimate the sample size (n) in a normally distributed environment in the form of an inversed cumulative distribution function of the standard normal $\emptyset^{-1}\left(\mathbf{1} - \frac{\delta}{2}\right) = Z^2$, see Equation 30. This effort is developed based on an assumed absolute difference of 0.05, for instance, represented by allowable error (a) in Equation 31. δ is the selected sum of z-tail estimates, it specifies and is equal to a. This allowable error is alternative specific; subject to knowledge of the true modal split between alternatives (p) where $q = 1 - p$. Through Equation 31 it is the analysts' prerogative to select a sample size that minimises this error relative to his/her available resources.

Choice based sampling involves drawing from chosen alternatives with available mode split information (probability) and observing *"the characteristics of the decision makers selecting those alternatives"* (Manski & Lerman, 1977; Ortuzar & Willumsen, 2009, p. 271).

Equation 30: Sample Size Approach 2

$$n \geq \frac{q}{pa^2}\left[\emptyset^{-1}\left(1-\frac{\delta}{2}\right)\right]^2$$

Equation 31: Allowable Error

$$a \geq \sqrt{\frac{q}{pn}\left[\emptyset^{-1}\left(1-\frac{\delta}{2}\right)\right]^2}$$

In Hess' (2015) lecture series, Orne's (1988) sample size rule of thumb was presented. It argues that the sample size is a *portion increase or decrease* from 500 where the highest number of levels (I^*) are spread over the product of the number of alternatives (J) and the number of rows in the design (S).

Equation 32: Sampling Approach 3

$$n = 500\frac{I}{JS}$$

Hensher et al. (2005 pp. 193-169) also discuss, more qualitatively that statistical models depend largely on response variation. They recommend that a minimum sample size of 50 respondents should be (based on experience) sufficient for robust models to be developed. Estimating robust results from service attributes seems easier to attain than for the respondent characteristics. In the pilot study with less than 50 respondents, models based on the service attributes were more significant than those with respondent characteristics—wherein statistical significance was not found. Hence, *"whether the analyst intends to estimate models using the design attributes only, or the design attributes combine with covariates"* affects the minimum sample size necessary (Hensher, Rose, & Greene, 2005). They further contend that flexible sample, snowballing, and quota strategies are alternative approaches to administering the survey—vouching for quota strategies as applied in Lu (2009).

3.4.1 Sample Size Estimates

For this study a simple Hess' (2015) approach is used as a sample size minimum, Hensher et al. (2005) position that 50 or more respondents is used as an ideal, and Equation 30 and Equation 31 is used to develop an empirical sample size within an allowable error. Table 11 presents the results of user market sample size estimates.

District level modal splits were used in the estimation for the case study area because they were most recent and readily available for quality checks as extracted from the National Household Travel Survey. The larger the responses (R) per choice set the smaller the number of respondents (N/R). High error implies a low sample size—and vice versa. The minibus taxi sample size as a mid-point to a reasonable sample for the user market since it dominates. Assuming that user market estimates for empirical sample size is correct then at least 50 (Equation 32) students are necessary. However based on Table 11, if the largest sample size is preferred then 138 (Equation 30) respondents are necessary; if the lowest error is preferred then a sample of 18 respondents is necessary; and if the known preference is for minibus taxi then the sample size should be 72 respondents. It is statistically feasible to run an MNL model with a sample size of as few as 15 respondents (Rose & Bliemer, 2005). Therefore the results are essentially dependent on their statistical properties, which reflects the quality of the survey design, stability of the sample (i.e. homogeneity) and not necessarily the sample size.

Table 11: Sample Size Estimates Based on 16 Responses per Choice Set

Assuming that the preferred sample size is the largest one								
Alt	P	α	Q	N(Preferred)	R	Z^2	A (Tolerable Error)	N/R
Car	0.11	0.05	0.89	2199.71	16.00	3.84	0.12	138
Bus	0.21	0.05	0.79	2199.71	16.00	3.84	0.08	138
Commuter Taxi	0.19	0.05	0.81	2199.71	16.00	3.84	0.09	138
Walking	0.49	0.05	0.51	2199.71	16.00	3.84	0.04	138
						Average	0.08	
What if the analyst prefers the lowest error?								
Alt	P	α	Q	N(Preferred)	R	Z^2	A (Tolerable Error)	N/R
Car	0.11	0.05	0.89	283.29	16.00	3.84	0.33	18
Bus	0.21	0.05	0.79	283.29	16.00	3.84	0.23	18
Commuter Taxi	0.19	0.05	0.81	283.29	16.00	3.84	0.24	18
Walking	0.49	0.05	0.51	283.29	16.00	3.84	0.12	18
						Average	0.23	
Assuming a preference for Minibus Taxis?								
Alt	P	α	Q	N(Preferred)	R	Z^2	A (Tolerable Error)	N/R
Car	0.11	0.05	0.89	1145.14	16.00	3.84	0.16	72
Bus	0.21	0.05	0.79	1145.14	16.00	3.84	0.11	72
Commuter Taxi	0.19	0.05	0.81	1145.14	16.00	3.84	0.12	72
						Average	0.11	

3.4.2 Statistical Analysis Requirements

The BIOGEME software package (Bierlaire, 2003) will be used to estimate the parameters for behavioural class probabilities and class specific preferences. Statistical outputs such as standard errors, t-statistic, p-value, log-likelihood, correlation and rho-squared between parameters are among the outputs in the BIOGEME package. A 95% confidence interval is adopted as the acceptable margin of error.

The log-likelihood shows the relative quality of the model in terms of cumulative probabilities Rho-squared shows the quality of the model fit. The t-statistic describes the statistical significance of the model within the distribution of the sample. The p-value describes the statistical significance of each parameter in terms of the model. Each one is statistically described in **Error! Reference source not found.**.

Table 12: Statistical Estimates and their Region of Acceptance

Statistical Property	Region of Acceptance
Log-Likelihood	Used to compare one model with the next. The smaller the result compared to the previous estimate the better the model fit over the previous (Hess, 2015).
Rho-Squared	Koppelman and Bhat (2006) clearly contend that it should be used with caution, and that it should be used in conjunction with the log-likelihood. A perfect model is one where the result is 1.
t-test (robust t-test)	Reject when within -1 < t < 1 (Horowitz, Koppleman, & Lerman, 1986).
p-value	Acceptable when within < 0.05 for 99% level goodness of fit (Hess, 2015)

3.5 Conclusion

This Chapter outlines the research method and process applied in this study. Through a research design underpinned by the random utility theory, discrete choice models are described. The characteristics of the survey designed are presented and the d-error estimate is calculated to evaluate the quality of the design[28]. Hybrid discrete choice models are described and the broad framework applied in this study is presented. It is a mix between latent class choice and latent variable models specifically aimed at exploring the behavioural compositions represented in the TPB. Particular aspects of the sample size are described to close the chapter.

HCM

[28] Prof M. C. Bliemer must be acknowledged for sharing the calculation tool.

CHAPTER 4

RESULTS & DISCUSSION

This chapter presents the results from the core models presented in the research design and the preceding chapter. It reveals the case study area; descriptive statistics from demographic responses; and TPB responses. Results from the TPB are discussed through regression analysis similar to other studies (Ajzen, 1991; Ajzen, 2005). These regressions are for bus and minibus taxi, and for intention and perceived behavioural control to facilitate an understanding of intention and level of service preference. This is followed by a latent class choice model estimation and a latent variable model estimation. Each of the latent class results are concluded with a series of conjectures which aim to contextualise the findings within the theoretical principles of the TPB.

6.1 Case Study Area: North West University Mahikeng Campus

The gap in literature and practical knowledge on student travel preferences is significant in the North West Province, where one university with three sites-of-delivery (SoD) attracts nearly 73 000 students from all over the country. In the capital city of the province, Mahikeng, pressure has emerged to improve the public transport services available: bus and minibus taxi. The city is a base for one of the three SoDs of the North West University (NWU). The Mahikeng campus is the geographic location of the study and makes for a unique area to test the hypotheses envisioned in this study.

6.1.4 North West University

The university is a three campus structure with large distances between campuses, and part-time and full-time students: Vaal Triangle, Mahikeng and Potchefstroom—these will be transitioned to 'delivery sites' by 2018. In 2016 the institution is composed of 67% female students; 77% undergraduate; and a demography that is 70% African, 25% White. The student population across SoDs is shown in **Error! Reference source not found.**. From a population perspective, Mahikeng is second to Potchefstroom. For 2016 11 333 students are estimated at the Mahikeng campus—which is where this study is located. The campus has a bus stop facility with shelter and enough bays for 3 65 seater buses. Motorised public transport services in the area for students to access the city centre are buses and minibus taxis. However, there are other amenities close by that are at a walking distance. One in particular is Mega City, which has undergone infrastructure upgrades and houses the central bus terminal for townships, suburbs and villages with nearly a 60km radius. The bus terminal currently being used had the shading and other amenities removed during the process of upgrading—no information related to improvements is available.

Minibus taxis to town also exist there but tend to gather outside of the campus to take students to town, Mega City and other activity centres and residential areas. Other universities justify the need for transit services based on connecting official university residences, campuses and other facilities. With no official residences off-campus, and sister campuses Vaal and Potchefstroom located at some distance, one may argue that the need for public transport service accessing to the bus terminal on campus has not arisen. However, public transport services for university students offered commercially or through the university require good quality service design: especially with the prospects of new bus services. As the university is a significant trip generator and attractor—little is known about the value of the services offered and whether they are in line with the travel preferences of students.

Table 13: North West University Campuses[29]

	2010	2011	2012	2013	2014	2015	2016
Potchefstroom	41965	41894	42338	43750	45533	45947	53807
Vaal Triangle	5213	5536	6157	6511	6577	7321	7765
Mahikeng (Mafikeng)	8554	9211	10257	10714	11025	10802	11842
Total	55732	56641	58752	60975	63135	64070	73414

6.2 Descriptive Statistics

Of the 150 surveys distributed, 121 of them were completed. A thorough assessment of the datasets resulted in 40 of the remaining surveys being removed as a result of non-responses in some of the TPB salient beliefs. The total number of surveys included in this study totalled to 81, which is a 54% response rate. In the choice models estimated with BIOGEME, some responses are not included in the estimation due to an error, which results in a loss of a further 37 respondents. For the regression analysis, 81 responses are included and in the choice models there are 704 observations from 44 respondents in the model estimate. The demographic characteristics of respondents are presented in Table 14. In Mahikeng, university students prefer minibus taxis 94% of the time. 64% of the respondents are female, and 64% of students live outside of campus housing.

Long distance transport cost between R 77 and R 480, while the local transport mode used cost on R 12.00 on average, which is within the range of the stated choice experiment between R 7.50 and R 15.00. Expected and perceived actual travel times for the local mode to commute to campus are 14 minutes and 16 minutes on average, times of which do not reflect waiting time and other travel factors. Students' monthly allowance is R 850.00 on average, peaking at R 1 850.00. 60% of university students' families own at least one car, while car ownership is 1.22 vehicles on average. Students in the survey have already spent 2.5 years at the university and they expect to own a car within 2 years and four months after graduating. The car is rated as the most favoured transport mode, while in high school most

[29] Data Sourced from : http://www.nwu.ac.za/content/student-statistics-information-nwu

students report that they walked to school. Students in this survey are inclined to use minibus taxi, and potentially have an awareness of the value of the car and its convenience—which could explain their preference to use minibus taxis and their favour to having or using cars. Public transport level of service design, in this sense, might need to pivot around minibus taxis, and elements of private cars. However, given the subsidies toward bus transport and the long term benefits of mass transit, understanding how preferences are structured between bus and minibus taxi is important. From a behavioural point of view, the characteristics of behavioural responses are presented in Table 15, with the salient TPB beliefs defined in parenthesis.

Table 14: Demographic Characteristics of Students in Survey (n=81)

Variable	Description	Mean	Standard Deviation	Mode
M_pref	Mode used often (1=Bus, 0= Taxi)	6%	0.241	
GEN	Gender (1= Female, 0= Male)	64%	0.480	
Age	Age	19.79	5.796	21
Res_On	Residing on campus (1, yes), (0, no)	36%	0.480	
Ress_Off	Residing off campus (1, yes), (0, no)	64%	0.480	
LD_M	Main mode to travel for recess	1.01	1.436	
LD_M_cost	Cost of long distance mode (Rand)	71.89	130.19	
LD_M_time	Travel time for long distance mode (minutes)	77.27	121.82	
LMODE	Local mode of transport used	2.32	3.019	2
LM_cost	Local mode cost (Rand)	12.27	66.004	
eLM_time	Perceived expected travel time of local mode (min)	14.59	17.121	
aLM_time	Perceived actual travel time of local mode (min)	16.89	23.040	
INCOME	Monthly allowance (Rand)	851.43	408.80	850
Car_Own	Car ownership (Yes =1), (no=2)	60%	0.489	
Car_NUM	Number of cars in household (1<5+	1.22	1.238	
DGR_Lev	Level of study (1<5+)	2.49	1.146	2
SCH_mode	Main mode during high school	2.60	1.312	3
YRS_Car	Expected number of years after graduating to buy a car	2.32	1.314	2
FAV_mode	Favourite transport mode	2.98	1.155	3
CTT_mode	Mode from campus to town	2.11	0.648	2
CTT_time	Perceived travel time from campus to town (min)	19.81	9.345	15
CTM_mode	Mode trip from Campus to Megacity	4.17	1.359	5
CTM_time	Perceived travel time from Campus to Mega City	13.30	7.734	15
DEVexp	Deviation expected and perceived actual travel time (locally)	-14%	0.356	

6.3 Theory of Planned Behaviour Results

6.3.1 Behavioural Ratings for Survey Statements

Intention. Response averages in the table range between 2.46 for planning to use a minibus taxi (intention) and 5.12 for the importance of keeping to one's budget. Intention to use minibus is on average higher than for bus. Traveling by minibus per week is more likely than travel by bus for three days or more. Intention to use bus in general is higher at 4.64 than for minibus at 3.09 on average. There is less variation with regard to bus intention than minibus taxi intention for using either service this week and intending to do so.

Table 15: Characteristics of Theory of Planned Behaviour Responses

		Description	Mea n	Standard Deviation
Intention	IT_1	I intend to travel by taxi 3 days (or more) per week to go home.	3.56	2.18
	IT_2	I plan to travel by taxi this week to go home.*	4.64	1.87
	IB_1	I will try to travel by bus 3 days (or more) per week to go home.	2.46	2.18
	IB_2	I would like to use the bus this week to go home.*	3.09	2.49
Attitude	AT_1 (e1T)	For me to travel by taxi 3 days (or more) per week to go home in the next month is (Harmful =1, Beneficial = 7)	4.32	1.87
	AT_2 (bT)	(sub-rating)*(Very Bad= 1, Very Good= 7)	4.35	1.77
	AT_3	(sub-rating) (Unenjoyable=1, Enjoyable=7)	4.01	2.08
	AB_1 (e1B)	For me to travel by bus 3 days (or more) per week to go home in the next month is (Harmful =1, Beneficial = 7)	4.01	1.91
	AB_2 (bB)	(sub-rating)* (Very Bad= 1, Very Good= 7)	3.58	1.93
	AB_3	(sub-rating) (Unenjoyable=1, Enjoyable=7)	2.96	1.88
Subjective Norm	ST_1	Most people who are important to me would think that for me to travel by taxi 3 days (or more) per week is * (Very Bad =1, Very Good = 7)	4.15	2.09
	SB_1	If I use a bus to go home 3 days (or more) per week most of my friends and family would (Completely Disapprove= 1, Completely Approve =7)	3.79	2.20
	SB_2 (n2B)	People close to me think that me using the bus to travel home 3 days (or more) per week is (Very Bad =1, Very Good = 7)	3.79	2.10
	ST_2 (n2T)	My friends and family travel by taxi to go home 3 or more times per week.* (Completely False = 1, Completely True = 7)	4.52	2.22
Perceived Behavioural Control	PB_1 (p1B)	For me to travel by bus for at 3 days (or more) per week would be (Impossible =1, Possible=7)	3.32	2.24
	PT_1 (c1T)	It is mostly up to me whether or not I use a taxi to travel home 3 days (or more) per week* (Strongly disagree=1, Strongly agree=7)	5.11	1.93
	PB_2 (c1B)	How much control do you believe you have over traveling by bus 3 days (or more) per week (No control=1, Complete control=7)	4.04	1.93
	PT_2 (p1T)	If I wanted I could use the taxi to travel home 3 days (or more) per week* (Definitely false=1, Definitely true=7)	4.93	2.05
	PP_1 (m1)	In general, do you do what people close to you want you to do? (Never=1, Always=7)	3.78	1.90
Budget Constraint	YT_1	My using a taxi to travel home 3 days (or more) per week in the next month will help me keep to my budget for transport*	3.54	2.13
	YB_1	My using a bus to travel home 3 days (or more) per week in the next month will help me keep to my budget for transport*	4.47	2.17
	YY_1	Keeping to a monthly transport budget is	5.12	1.96

Attitude. Attitude is comprised of salient beliefs represented by evaluation statements (e1T, bT, e1B, bB), and belief statements. Evaluation statements for minibus are higher (4.32) than the benefits of using bus often (4.01). Respondents believe that using minibus taxi leans toward being good (4.35) while bus use is closer to being bad (3.58)—while both responses revolve around the median. Students rated using minibus taxi more enjoyable than using bus, with bus rated very poorly (2.96). The attitudinal rating toward bus and minibus taxi reveal that minibus taxi ratings are similar on average, with much lower standard deviations than bus.

Subjective norms. Salient beliefs for subjective norms emanate from social norms (n2B, n2T) and motivation to comply (m1). Social norms for taxi use are much higher (4.15), than for bus use (3.79). Minibus taxis are used by friends and family (4.52) and bus use is disapproved (3.79). To a marginal extent, bus use is not the social norm—however public transport in general is not rated very highly from a social norm perspective. To a large extent, respondents state that they are on average below the median in terms of compliance, the question now is whether students believe they have control over their mode choices.

Perceived behavioural control. In terms of perceived behavioural control (PBC), power and control salient beliefs were reflected in the survey. University students indicate that they have more power over using minibus taxi three times or more per week than using bus (3.32). They also show that there is more control over using minibus taxi (5.11) over using bus (4.04). This reveals a difference between the two modes highlighting the lack of control students seem to have over using bus. It could be an issue related to budgetary constraints, and other factors that may render bus use as a captive alternative. Students rate keeping their monthly budget very highly (5.12), but to keep within the budget they seem to rate minibus and bus differently. Using a minibus taxi to travel home for three or more days per week does not help students keep to budget as much as using bus (4.47). Students reveal that using minibus taxi has a higher impact on their budget, but this does not outweigh their preference for using minibus taxi. From the average indicators, their attitudes, norms, and control beliefs lean more favourably toward minibus taxi than buses which might have to do with the service design and behavioural factors combined.

6.3.2 Regression Analysis for the Theory of Planned Behaviour

In terms of the TPB, intention and perceived behavioural control are related and should be observed in conjunction because individuals without control over a behaviour may not necessarily be in a position to form, let alone express, their intention (Ajzen, 1991; Ajzen, 2005). Consumer behaviour literature argues that market participants should be both willing and able to make a choice that corresponds with what they prefer (Pindyck & Rubinfeld, 2009). Mode choice is also subject to individual’s willingness to perform a task, and their ability to do so. If public transport users are captive, they may not have any control over choosing an alternative and as a result their intentions would not appropriately reflect their behaviour. If public transport users are choice users, then intention would dictate preference and choice more than control, because control is already established. Given the differences in ratings for bus and minibus taxi, and knowledge that bus is usually used by captive users, it is of interest to determine the nature of travel behaviour with respect to intention and control. The results from a regression analysis of the behavioural constructs estimated from the salient beliefs, is presented in Table 16 and Table 17. The table reveals correlation between intention and the dependent variables and coefficients estimated for minibus taxi and bus, with intention and perceived behavioural control as the dependent variables.

Minibus Taxi. Based on Table 16 minibus taxi regressions have an intercept of 4.69 for the intention to use minibus taxi. The intention to use minibus taxi is positively influenced by subjective norms (0.055), then the affordability (0.046) and PBC (0.043). The intention to use bus has a negative effect on the intention to use minibus (-0.24), while keeping budget also has a negative influence (-0.054). Subjective norms for minibus taxi intention are an important factor, in addition to the value of an option, like bus. Intention to use minibus is positively correlated to social norms (0.301) and evaluations of using minibus (0.298), and to the least extent PBC (0.228). It purports that minibus taxi use is underpinned by norms and attitudinal evaluations of the mode, more than the control over behaviour.

Table 16: Regression Analysis of TPB Indicators (without Demographic Variables) for Minibus Taxi

Minibus Taxi								
	Regression Coefficients							
Dependent Variable	Intention				PBC			
	Correlations[30]	Coefficient	t-stat	p-value	Correlations	Coefficient	t-stat	p-value
Global Attitude	0.274	0.022	4.633	0	0.004	-0.028	-0.831	0.406
Beliefs	0.188				0.065			
Evaluation	0.298				0.079			
Global Subjective Norms	0.307	0.055	11.846	0	-0.139	-0.508	-3.536	0
Social Norms	0.301				-0.037			
Motivation to comply	0.033				-0.302			
Intention to use Alternative	-0.259	-0.24	-9.921	0	0.222	0.316	1.775	0.076
Intention to use Minibus Taxi	-				0.228	1.939	10.221	0
Global Perceived Behavioural Control	0.228	0.043	11.592	0	-			
Power	0.29				0.148			
Control	0.169				0.923			
Affordability	0.096	0.046	2.364	0.018	-0.132	-0.694	-4.978	0
Keeping Budget	-0.03	-0.054	-2.584	0.01	0.144	0.875	5.888	0
Intercept		4.691	31.856	0		-9.469	-6.914	0
Multiple R^2		0.513				0.333		
R^2		0.263				0.111		
Adjusted R^2		0.26				0.107		

When viewed from a PBC perspective intention to use minibus taxi has the greatest positive impact on PBC, followed by subjective norms (-0.508), affordability (-0.694) and attitudes (-0.028) which have negative impacts on PBC. This suggests that norms, prices and general attitudes influence the control university students perceive to have over using minibus taxi. Keeping to one's budget (0.875) and the intention to use an alternative (0.316) give greater control over minibus taxi use. However, with an intercept of -9.4 and an adjuster R^2 of 0.107

[30] The correlations are generally low, but they are just above the average for general attitudes (0.13) but well below some reviews in which results range from 0.53 to 0.8. This could potentially imply that the statements in the survey are too general for the trip decision—not specific enough. Ajzen argues that "*compatibility principle suggests that broad values will account for relatively little variance in attitudes and hence cannot serve as a satisfactory explanation for those attitudes, much less for specific intentions or behaviors"* (Ajzen, 2005, p. 6). Which could mean that for the TPB correlations to be strong, service design attributes might need to be confronted with regard to intention to use a certain mode. This could potentially improve the belief congruence in future research. However, subjective norm correlations with intention range from 0.34 to 0.42; and for perceived behavioral control they range from 0.35 to 0.46 (Ajzen, 2005, p. 6).

compared to 0.26 in the intention model, there is much that is unexplained about the much less control students reveal about using minibus taxis.

Table 17: Regression Analysis of TPB Indicators (without Demographic Variables) for Bus

	Bus							
	Regression Coefficients							
Dependent Variable	Intention				Perceived Behavioural Control			
	Correlations	Coefficient	t-stat	p-value	Correlations	Coefficient	t-stat	p-value
Global Attitude	0.28	0.038	6.302	0	0.039	-0.094	-3.014	0.003
Beliefs	0.369				0.115			
Evaluation	0.305				-0.007			
Global Subjective Norms	0.181	0.021	4.052	0	0.297	0.781	6.45	0
Social Norms	0.276				0.256			
Motivation to comply	-0.142				-0.170			
Intention to use Alternative	-0.259	0.021	4.052	0	0.222	0.772	5.609	0
Intention to use Bus	-				0.038	0.035	0.256	
Global Perceived Behavioural Control	0.038	0.004	0.629	0.529	-			
Power	0.147				0.433			
Control	0.069				0.776			
Affordability	0.171	0.101	4.524	0	0.306	0.878	8.166	0
Keeping Budget	0.049	-0.004	-0.172	0.863	0.079	0.198	1.796	0.073
Intercept		3.431	19.29			-4.424	-4.434	0
Multiple R^2		0.403	0			0.395		
R^2		0.163	0			0.156		
Adjusted R^2		0.159	0			0.152		

Bus. In view of Table 17, the regression starts with a much lower intercept (3.431), the intention to use bus is largely influenced by affordability (0.101) and then attitude (0.038). For university students, the intention to use bus is subject to the price and the general attitudes—if affordability and attitudes improve, bus might be an option. However, subjective norms and the intention to use the alternative share the same coefficient and t-stat of 0.021 and 4.052, respectively. This suggests that university students intent to use minibus taxi is *equivalent* to the norms when it comes to the intention to use bus (it might also imply that it is the norm to use minibus taxis over bus). The PBC coefficient (0.004) is as low as the importance of keeping to a budget (-0.004), implying that control over using bus is minimal, and that the importance of keeping to a budget has little effect on bus intention. In a salient manner, this could mean that the importance of keeping to a budget reduces the intention to use bus, but only to a small degree.

In terms of PBC, intention to use minibus taxi has the largest effect on the control students believe they have over controlling minibus. The intention to use bus, as a minimal effect (0.035). Subjective norms (0.78) related to bus use positively impact the control students believe they have over bus. Attitudes negatively impact on control, while affordability (0.878) improves control over using bus more than all other indicators. The importance of keeping to a monthly budget (0.198) is much more influential than the negative impact of attitudes toward bus on PBC (-0.028). The intention model and the PBC results are nearly similar for bus with an R^2 estimate of 0.159 and 0.152, respectively. As a result, while the dynamics of the coefficients are different, specifications for both intention and PBC are similar for bus, but for minibus taxi the intention approach is much more representative. Considering both of intention and PBC approaches might enable an understanding of *choice-use* and *captive-use,* respectively.

6.4 Behavioural Latent Class Choice Models

With this behavioural narrative presented above, the next step is to assess the manner in which service design preferences for public transport vary between classes of behaviour. Intention based and PBC based Behavioural Latent Class Choice Models are presented in Table 18 and Table 19. The non-class specific choice model is the base model with a bus constant of 0.194, which suggests that the positive inclination toward bus level of service design is unexplained by the model. However compared with 9.25 in the high intention class, and 0.0967 in the neutral intention class and 0.238 in the low intention class it seems that the high intention class' positive inclination to bus use is the most unexplained. However, this alternative specific constant (ASC) is the only one that is statistically significant. Comparing the ASC of bus in the base model with the PBC, high and low perceived behavioural control classes explain much more of the model. While the negative perception of control with respect to mode choice in the neutral class is the least explained (-4.72). The ASC for the neutral class is the only statistically significant constant based on the robust p-value. From a latent class perspective only the high intention class and neutral perceived behavioural control class have significant constants.

The base model. In the base model seating availability has a positive impact on LOS utility, and it has the greatest impact on mode choice. This is followed by disutilities in price (-0.308), in-vehicle travel time (-0.079), and waiting to depart (-0.0446). The choice between bus and minibus taxi LOS in the base model is therefore highly responsive to seating availability, but price is a significant factor too. Seating availability gives students some value at R 2.66 if a seat is available. To save travel time students are willing to pay 26c/min and to avoid waiting, students are willing to pay 14c per minute. In the base model, students prefer minibus taxi level of service over bus, which reflects the aggregate measures presented in the TPB. The model results in improvements in the final log-likelihood and a rho-square of 0.198, which suggests that the model is a good fit.

6.4.1 Behavioural Latent Class Choice Model of Intention

Latent class models. The behavioural latent class choice models in Table 18 are a little less straightforward statistically because they estimate class-specific choice by separating respondents into smaller groups reflective of the number of responses within the specific class. The high intention class utility is mostly sensitive price (-5.39) and then to waiting time (-4.04), while seating availability (-3.58) and travel time (-3.39) follow. Price is a key part of the utility decision for the high intention class, but based on the VOT estimates and these parameters this class is very specific and value all aspects of the LOS in similar ways.

Table 18: Behavioural Latent Class Choice Model of Intention

	MNL Model	Behavioural Latent Class Model of Intention		
	Full Model	High Intent (m >4) HIC	Neutral Intent (m = 4) NIC	Low Intent (m<4) LIC
Bus Specific Constant	**0.194**	**9.25**	**0.0967**	**0.238**
Robust t-stat	1.35	10.07	0.18	0.74
Robust p-value	0.18	0	0.86	0.46*
Seating Availability	**0.82**	**-3.58**	**1.63**	**1.04**
Robust t-stat	6.58	-2.96	3.77	3.78
Robust p-value	0	0	0	0
Service Price	**-0.308**	**-5.39**	**-0.416**	**-0.263**
Robust t-stat	-9.15	-19.17	-3.57	-3.27
Robust p-value	0	0	0	0
In Vehicle Travel Time	**-0.079**	**-3.39**	**-0.0769**	**-0.098**
Robust t-stat	-10.03	-25.29	-2.49	-5.11
Robust p-value	0	0	0.01	0
Waiting to Depart	**-0.0446**	**-4.04**	**-0.0276**	**-0.048**
Robust t-stat	-3.96	-21.08	-0.68	-1.96
Robust p-value	0	0	0.5*	0.05*
Null Log-Likelihood	-487.976***	-11.784***	-44.361***	-99.813***
Final Log-Likelihood	-373.473	0	-31.191	-72.686
rho-square	0.198	1	0.297	0.272
Adjusted rho-square	0.185	-0.018	0.026	0.152
Observations	704	167	145	392
	44	10	9	25
Value of Seating Availability (per few seats)	-R 2.66	R 0.66	-R 3.92	-R 3.95
Value of Travel Time	R 0.26	R 0.63	R 0.18	R 0.37
Value of Waiting Time	R 0.14	R 0.75	R 0.07	R 0.18
Probability of Choosing Bus	15%	68%	15%	15%
Probability of Choosing Taxi	85%	32%	85%	85%

* statistically insignificant at 95%;

** statistically significant in robust p-value

*** Demographic variables included but are equivalent to zero

Students who fall within the neutral intention class are fewer than those in the high intention class. Seating availability has a positive impact on the utility derived from a journey, while price (-0.416), travel time (-0.0769) and waiting to depart (-0.0276) have the least bearing. This implies that to avoid these disutilities related to time students would pay more in the neutral class. The high intention class is 68% more likely to choose bus LOS, than minibus taxi, while other latent class models share the same LOS preference as the base model. Lastly, the low intention class follows a similar model structure as the neutral intention class. The only difference is that the disutility related to price is lower (-0.263), while travel time (-0.098) and waiting time (-0.048) have increased. Seating availability remains a key factor in the utility derived from the trip contributing positively to the utility derived. The models vary with regard to rho-squared estimates and log-likelihood. In this case, the high intention class has a rho-square of 1 and -0.018 when adjusted. Which intimates that this could be a nearly perfect model (Koppelman & Bhat, 2006, p. 80)—but rho-square estimates are seldom this high, and when adjusted it is a very low estimate. The low intention class is a good fit according to the rho-square norms in which it is 0.272, and 0.152 when adjusted.

Willingness to pay. Willingness to pay estimates range from 7c for waiting time in the NIC and -R 3.95 in the LIC for seating availability. The high intention class (HIC) is willing to pay 66c for a seat, 63c/min of travel time and 75c/min of waiting. For the NIC, 18c/min for travel time and 7c/min of waiting time reflect their willingness to pay. While the value derived from having a seat is R 3.92, which is equivalent to 56 minutes of waiting to have a seat (3.92/0.07=56min) for taxi, or standing in a bus. In the LIC, seating availability provides significant value to the trip to the tune of R 3.95, compared with WTP 37c/min for travel time and 18c/min for waiting time. In this sense, those in the LIC are deriving 10 minutes of travel time for a seat.

6.4.2 Behavioural Latent Class Choice Model of Perceived Behavioural Control

Latent class models. In Table 19 the high control[31] class' utility is derived from seating availability (1.23), while disutilities from price (-0.412), in vehicle travel time (-0.11) and waiting to depart (-0.0394). Price is the primary disutility students are willing to avoid, but waiting time seems to be insensitive to change—making it of high value. In the neutral control class seating is a significantly more impactful in the utility decision. However, travel time (0.975) and price (0.0677) are not disutilities which implies that the neutral control class derives a benefit from prices and travel time as sources of control over LOS preferences. Waiting to depart is the only source of disutility in this class at -2.98, compared with the estimate in the low control class (-0.0293) the value is much larger. The low intention class is highly influenced by the seating availability (0.541), followed by price (-0.152) and then travel time (-0.0522) and waiting time. The low intention takes on a similar structural form as the

[31] "Control" will be used as a proxy for Perceived Behavioral Control

base model. The HCC and LCC are 3% and 2% more likely to choose bus than the base model, respectively. The neutral control class prefers minibus taxi LOS 94% of the time.

The most distinct latent class choice model for control is the NCC, but has similarly confounding statistical characteristics of the high intention class. The high control class reveals a rho-square of 0.352 when unadjusted, compared to 1, and 0.105 in the neutral and low control classes, respectively. A rho-square of one implies that the model is a perfect fit (Koppelman & Bhat, 2006), therefore for the latent class choice model of PBC, the neutral intention class is a perfect fit based on the unadjusted rho-square.

Table 19: Behavioural Latent Class Choice Model of Perceived Behavioural Control

	MNL Model	Behavioural Latent Class Model of PBC		
	Full Model	High PBC (m>4) HCC	Neutral PBC (m=4) NCC	Low PBC (m<4) LCC
Bus Specific Constant	**0.194**	**0.682**	**-4.72**	**0.0569**
Robust t-stat	1.35	1.8	-9	0.17
Robust p-value	0.18*	0.07*	0	0.87*
Seating Availability	**0.82**	**1.23**	**15.2**	**0.541**
Robust t-stat	6.58	3.4	26.39	1.99
Robust p-value	0	0	0	0.05*
Service Price	**-0.308**	**-0.412**	**0.0677**	**-0.152**
Robust t-stat	-9.15	-4.9	0.57*	-2.01
Robust p-value	0	0	0.57*	0.04
In Vehicle Travel Time	**-0.079**	**-0.11**	**0.975**	**-0.0522**
Robust t-stat	-10.03	-5.7	20.07	-2.72
Robust p-value	0	0	0	0.01
Waiting to Depart	**-0.0446**	**-0.0394**	**-2.98**	**-0.0293**
Robust t-stat	-3.96	-1.34	-32.04	-1.15
Robust p-value	0	0.18*	0	0.25*
Null Log-Likelihood	-487.976***	-110.904***	-11.784***	-66.542***
Final Log-Likelihood	-373.473	-71.837	0	-59.531
rho-square	0.198	0.352	1	0.105
Adjusted rho-square	0.185	0.244	-0.018	-0.0705
Observations	704	316	116	272
Value of Seating Availability (per few seats)	-R 2.66	-R 2.99	R 224.52	-R 3.56
Value of Travel Time	R 0.26	R 0.27	R 14.40	R 0.34
Value of Waiting Time	R 0.14	R 0.10	-R 44.02	R 0.19
Probability of Choosing Bus	15%	18%	6%	17%
Probability of Choosing Taxi	85%	82%	94%	83%

* statistically insignificant at 95%;

** statistically significant in robust p-value

*** Demographic variables included but are equivalent to zero

Willingness to pay. WTP in the perceived behavioural control classes ranges from 10c for the high control class (HCC), and R 224.52 for the neutral control class (NCC). Students in the HCC derive R 2.99c of value from seating availability, and are willing to pay 27c/min for travel time and 10c/min to reduce waiting time. The NCC has a high wiliness to pay for a seat at R 224.52, which is reflected in the value of travel time of R 14.40/min. This class is unique as it derives value from waiting at R 44.02/min. As a class, VOT estimates are probably inaccurate because the price parameter is statistically insignificant—hence the direction and size of WTP are inflated. But the LCC takes a similar WTP structure as the HCC, but this class has a higher WTP. Deriving R 3.56 of value from a seat, and willing to pay 34c/min and 19c/min for travel time and waiting time savings.

6.4.3 Conjectures Regarding Intention and Perceived Behavioural Control

The primary objective of Hybrid Discrete Choice Models (HCM), is to enable analysis of choice on the basis of a behavioural theory. In order to construct a formidable analysis of the results, it is reasonable to present a discussion through the lens of the TPB. Icek Ajzen argues that:

"As a general rule, the more favourable the attitude and subjective norm, and the greater the perceived behavioural control, the stronger should be the person's intention to perform the behaviour in question. Finally, given a sufficient degree of actual control over the behaviour, people are expected to carry out their intentions when the opportunity arises. However, because many behaviors pose difficulties of execution that can limit volitional control, it is useful to consider perceived behavioural control in addition to intention" (Ajzen, 2005, p. 8). Based on this, argument, three major interactions between intention and perceived behavioural control latent class choice models are described, namely: neutral intention and high control; low control and low intention; and high intention and neutral control.

Neutral intention and high control. Students with neutral intention to use either mode, may be indifferent because they have options and are not willing to pay much for time savings, but derive value from seating. This indifference in terms of intention could reflect a degree of control as a choice user. Students who believe that they have high control over using public transport value seating, and time less than all the other classes. This implies that they are not willing to pay much because they already have some degree of control, possibly because they could use bus or taxi or both. This explains the indifference class in the context of intention.

Low control and low intention. Students who believe that they lack control over using either mode, are willing to pay much more than the base model for time LOS attributes and derive more value from having a seat. Their WTP behaviour is similar to the low intention class because they too derive more value from a seat, and are willing to pay much more for time savings than the base model. If a degree of control is a prerequisite to intend to perform a behaviour (as premised earlier), then students with low intention and low control could be related. These are probably the captive user, because they do not believe they have control over which mode they use; and therefore cannot express their intention.

High intention and neutral control[32]*.* The high intention class is willing to pay for all LOS aspects. They are willing to pay more than the other classes to save time; and they are willing to pay for a seat that all other classes derive value from and are not willing to pay for (rather wait). Students in this class experience a higher disutility if a seat is not available than for travel time. Intention is high, because they derive a benefit from using public transport and are willing to pay highly from it. Continuing the conjecture in the premise of this chapter, assume that control is a prerequisite for the ability to express intention. It could be that if students have high intention to use public transport, they might not be concerned about having control because intention is already high.

The neutral control class is confounding because of the VOT estimates, but generally this class can be described as students who are indifferent with regard to control. The value time variables highly, and are willing to pay for seating to a very large extent. In this sense, students in this class value having a seat, are not willing to wait and derive value from travel time. By virtue of deriving value from travel time, having a high parameter for a seat (higher than all other indicators) this class is similar to the high intention class. Used together, it seems the choice to use public transport has something to do with having a seat and travelling quickly. This class of students could be the public transport lifestyle users, who simply values public transport, intends to use it and are indifferent or unsure with regard to having control and power. Further research is necessary to specify these classes.

6.5 Behavioural Latent Variable Model

The latent variable model presented in Table 20 enables an assessment of discrete choices and the impact of latent variables on them. The inclusion of latent variable models improves the base model's statistical properties significantly. The bus specific constant is now significant; the unadjusted rho-square rises to 0.253, and the final log-likelihood is a 2% improvement from the base model. These indicate that the behavioural latent variable model explains the mode choice behaviour with these behavioural variables.

Service attributes. The bus specific constant is much higher than in the base model, at 0.37 suggesting that much more of the positive inclination toward bus preference is unexplained. Seating availability (0.849) leads in adding value to the utility of choosing between bus and minibus taxi, while the greatest disutility stems from prices with a magnitude of -0.32. Service attributes related to time are disutilities with in vehicle travel time (-0.082) being highly influential, followed by waiting to depart at -0.047. This structural form of the utility is similar to most of the latent class models other than the high intention class in particular.

[32] As a caveat, the statistical properties of these two models are similar, both models have nearly perfect results based on the unadjusted rho-square. Observations vary, with the HIC representing 167 and the NCC representing 116, and the same log-likelihood (-11.784). It is likely that these are the same group of students.

Table 20: Latent Variable Model Estimate

	Non-Class Specific Choice Model			Behavioural Latent Variable Model		
	Parameters	Robust T	p-value	Parameters	Robust T	p-value
Bus Specific Constant	0.194	1.350	0.180	0.370	4.000	0.000*
Seating Availability	0.820	6.580	0.000*	0.849	6.680	0.000*
Service Price	-0.308	-9.150	0.000*	-0.320	-9.200	0.000*
In Vehicle Travel Time	-0.079	-10.030	0.000*	-0.082	-10.190	0.000*
Waiting to Depart	-0.045	-3.960	0.000*	-0.047	-4.000	0.000*
Intention to Use Bus(alt)				0.002	0.030	0.970
Intention to Use Taxi (alt)				-0.048	-0.640	0.520
Attitude toward Bus				-0.053	-1.640	0.100
Attitude toward Taxi				-0.027	-0.860	0.390
Perceived Control over Bus Use				**0.062**	**2.260**	**0.020***
Perceived Control over Taxi Use				-0.021	-0.680	0.500
Subjective Norm of Bus Use				0.044	1.490	0.140
SSN of Bus Use				-0.502	0.000	1.000
Subjective Norm of Taxi Use				0.041	1.680	0.090
SSN of Taxi Use				0.752	0.000	1.000
Belief statement for taxi use				0.087	0.840	0.400
Belief statement for bus use				**0.167**	**2.240**	**0.020***
Control over bus use				-0.102	-0.590	0.550
Control over taxi use				0.071	0.380	0.700
Evaluation statement for bus				**0.279**	**2.200**	**0.030***
Evaluation statement for taxi				0.138	1.050	0.300
Motivation to comply				0.000	0.000	1.000
Social Norms of Bus Use				0.302	0.000	1.000
Social Norm of Taxi Use				-0.944	0.000	1.000
Power over bus use				**-0.167**	**-2.050**	**0.040***
Power over taxi use				0.055	0.500	0.610
Null Log-Likelihood	-487.976***			-487.976		
Final Log-Likelihood	-373.473			-364.286		
rho-square	0.198			0.253		
Adjusted rho-square	0.185			0.169		
Observations	704			704		

* statistically significant at 95%;

Latent variables. While the latent variables have parameter estimates, many of them are not suitably represented in the model, nor are they distributed significantly. Only four behavioural constructs are significantly. The Global Perceived Behavioural Control (0.062) over bus use construct adds value to the utility weighing process that students are assumed to undergo when choosing between bus and minibus taxi. Belief and evaluation statements related to bus use are salient in the attitude construct, they contribute positively to the utility with parameter estimates of 0.167 and 0.279 respectively. Power over bus use is a salient factor in the PBC construct which influences the utility of choosing between bus and minibus taxi negatively (-0.167). The estimates suggest that control, beliefs and evaluations of bus services can improve the utility derived from bus services, but power over bus use is a confounding estimate. If LOS designs improve PBC, beliefs and evaluation then it might improve the utility derived from the service. Power over bus use seems to be a disutility in the context of mode choice, which implies that increasing students' possibility of using bus is something students may wish to avoid.

Willingness to pay. Two types of willingness to pay are estimated, the first is related to the service attributes; and the second is related to the statistically significant behavioural variables. Seating availability adds value to the utility in that students derive R 2.65 from the availability of a seat. Students are willing to pay 26c per minute to save on travel time; and 15c/min to avoid waiting time. The estimates are very similar to the base model. From a behavioural perspective, students derive value from PBC, their low[33] beliefs in bus use, and low service evaluations of bus use. While they are willing to pay 52c to avoid the possibility of using bus.

6.5.1 Conjectures Related to the Latent Variable Model

From a behavioural perspective, the TPB postulates that salient beliefs are activated in different ways through various circumstances (Ajzen, 2005). For rational choice or at least satisficing choice behaviour to occur the environment within which the choices are made is an important element in the decision making process (Simon, 1956). Discrete choice models construct a preference space which is constructed by service attributes in most cases (Hensher, Rose, & Greene, 2005). However, salient beliefs embedded in the decision making process underpin the preference elicitation and the preference space constructed to reveal how stated choices interact with behavioural indicators. Therefore, while seating is a strong value added that students simply derive value from the seat's existence—which is a prerequisite for minibus taxi trips; but in buses people can stand without a seat. All the service attributes are similar to the base model in terms of WTP.

Table 21: Willingness to Pay for Service Attributes and Behavioural Changes

Value of Seating Availability (per few seats)	-R	2.65
Value of Travel Time	R	0.26
Value of Waiting Time	R	0.15
Value of Perceived Control (Global)	-R	0.19
Value of Belief in Bus Use	-R	0.52
Value of Service Evaluation	-R	0.87
Value of Power Over Bus Use	R	0.52

[33] This is based on student's Likert scale ratings.

Behaviourally, a unique finding is that students are not inclined to use buses and derive significant value from maintaining their beliefs. Beliefs have no units of measurement, and therefore the WTP estimates are useful only to support decisions. However, students seem to be willing to pay to reduce the possibility of bus use. As a result, it can be argued that behavioural variables in mode choice enrich the analysis especially when supplemented by behavioural theory.

6.6 Conclusion

This chapter presents a series of results from the estimated models. University students prefer minibus taxis, and are favourable toward car ownership now and in future. 60% of the students have access to a car and thus have some experience with the nuances of that level of mobility and access. The TPB indicators suggest that on a behavioural level, bus is not favoured, but most of the rating responses for the constructs are near the median. In the regression analysis, their structure is built based on Ajzen's (1991) work—which is not simply through averages. The regression results reveal that minibus taxis can be analysed through intention and perceived behavioural control, while bus services might lean toward a perceived behavioural control construct. Taken much further, the discrete choice models estimated reveal significant differences between the LOS preferences by latent class and behavioural construct (intention and perceived behavioural control). The results suggest that there is behavioural and service related preference structures that could reveal captive and choice users. In particular, there is evidence that intention to choose a certain mode is subject to the perceived behavioural control individuals have over that behaviour. This is consistent with both the TPB and consumer behaviour theory. In the latent variable model, it was found that LOS preference is significantly related to bus specific behavioural constructs—especially salient beliefs for attitude and PBC. As a result, students derive benefit from maintaining their behavioural inclinations toward bus, and are willing to pay in order to avoid the possibility of using bus.

HCMHCM

CHAPTER 5

CONCLUSION

University student behaviour is arguably an accumulation of societal dispositions, their environment and experience of parenting conditions. Students are a travel segment that is most likely to have access to private car use, as drivers or passengers after completing a qualification and securing a stable income. National transport policies are leaning toward a much more public transport oriented society and the need for behaviour change is commonly mentioned as a shift from private car to public and non-motorised transport. This study responded to a broad set of questions:

> *In response to the lack of evidence, policy and institutional frameworks, a deeper understanding of university student travel preferences within a behavioural theory needs to be achieved in the South African context in order to identify the implications for level of service design in public transport services.*

Universities across South Africa provide contracted university student motorised passenger transport services. Meanwhile the learner transport policy only caters for basic education learners and not those actively moving between post schooling facilities. This study contributed to the understanding of university student travel preferences. A particular focus was placed on LOS preferences and how student intentions to use a mode informed or related to mode choice preferences. The North West University, Mahikeng site of delivery is used as a case study.

This concluding chapter discusses the extent to which the main objective of this study was achieved. The chapter draws behavioural LOS implications from the findings in the university student context. A balance between travel preferences, LOS design and policy issues was attempted throughout the study, and will therefore be concluded in this chapter.

5.1 University Student Travel Preferences

In this study, university students were classified based on their intention to use bus or minibus taxi. Intention as a behavioural construct was estimated based on the influences that other behavioural constructs explain the intention for a particular mode. The Theory of Planned Behaviour was used to construct the behavioural relationships between attitude, subjective normality and perceived behavioural control. These constructs therefore, characterised behaviour and were used to inform intention. Whether individuals had high, low or neutral intention to use bus or minibus taxi was used to classify the students. In order to supplement the narrative behind intention, perceived behaviour control was also analysed. The Hybrid Choice Modelling (HCM) framework was used as a conduit for linking the discrete choice modelling process with latent classes based on behavioural theory. The HCM approach was found to be an appropriate framework as it leans toward behavioural interpretations of choice models. Table 22 outlines the hypotheses tested with respect to the major findings in this study. The findings confirm the principles of the TPB in line with other studies that apply it for university student mobility (Belgiawan, Schmöcker, Abou-Zeid, Walker, & Fujii, 2017; Muromachi, 2017; Kerr, Lennon, & Watson, 2010; Van, Choocharkul, & Fujii, 2014). Based on the literature reviewed, and other reviews the study is unique in integrating the use of the HCM framework empirically with the TPB for university student travel mobility.

Table 22: Decision to Accept or Reject Hypotheses Tested

Hypothesis Tested	
H_0: Students classified by behavioural classes of intention have unique behavioural utility functions influencing their inclination to use bus and minibus taxi. H_1: Students classified by behavioural classes of intention do not have unique behavioural utility functions influencing their inclination to use bus and minibus taxi.	H_0: There are levels of service preference differences between students who have high or low intent to use any public transport mode. H_1: Preferences toward level of service do not differ between students who have high or low intent to use any public transport mode.
Summary of Findings	
Intention based behavioural classes and the subsequent perceived behavioural control classes reveal unique LOS preferences across classes. Between behavioural models, intention and PBC are interrelated in terms of willingness to pay.	LOS preferences varied based on the behavioural class under observation. Each class of intention had unique magnitudes for LOS attributes that influenced their mode choice. When observed in conjunction with PBC LOS preferences, it is evident that the service preference choices between bus and minibus reverberate the uniqueness. Specifically, in the PBC model, but to a much lesser extent in the intention class model.
Class specific choice models exhibited significant differences between high, medium and low intention to use bus or taxi in all the scenarios tested and between these two classes unique sensitivities were also found.	Willingness to pay estimations were unique between the high intention class and other classes. The high intention class had similar preference structures as PBC classes.
The non-class specific choice model seems to aggregate university student travel preferences toward the medium and low intention classes. This was evidence that analysts not using behavioural classes might miss the high intention class' unique behaviour. However, when supplemented with the PBC models it becomes clear that the high intention class goes hand in glove with the neutral PBC class. Studies in choice modelling may miss this class due to a lack of behaviour specific estimations.	The latent variable model reinforces the behavioural composition of LOS preferences. It reveals that service preferences in public transport are related influenced by behavioural indicators. The main finding here is that behavioural inclinations toward bus are significantly influential on LOS preferences. Students reveal that they would rather maintain their current behavioural dispositions (beliefs) towards bus, and are willing to pay not to use bus.
Accept the Null Hypothesis H_0, and reject H_1	Accept the Null Hypothesis H_0, and reject H_1

Based on the findings, it follows that both null hypotheses are accepted within the university student context. Therefore, service design may need to account for behavioural constructs in a manner that has practical meaning through a behavioural theory. In order to manage university student travel behaviour a need to balance infrastructure, service design needs and mobility management policy at universities is a consistent theme in many studies (Zhan, Yan, Zhu, & Wang, 2016; Molina-Garcia, Castillo, & Sallis, 2010; Gurrutxaga, Iturrate, Oses, & Garcia, 2017; Longo, Medeossi, & Padoano, 2015; Rotaris & Danielis, 2014; Zhou, Wang, & Wu, 2018; Zhou, 2016). Few studies offer a behavioural classification related to the sensitivity of LOS preferences, a gap which this study fills.

5.2 Behaviour Change

It has been shown that after a temporary switch to public transport some car users' attitudes improve and some continue to use public transport even after the experiment (Abou-Zeid, Witter, Bierlaire, Kaufmann, & Ben-Akiva, 2012). Temporary interventions are also useful in developing, informing and monitoring transport policy outputs by means of involving multiple stakeholders (Naudé, Velasco, Mokwena, & Nicks, 2017). This study, uniquely presents behavioural triggers that indicate which behavioural factors influence intention and perceived behavioural control. These are particularly useful in terms of nudging users at a behavioural level (i.e. marketing, and other campaigns) and at a level of service preference design. Based on the latent variable model, it is might be useful to improve the dispositions students have toward bus use—especially those related to plausibility, service quality and design.

5.3 Level of Service Offering

Attracting and retaining public transport users is a key priority in mobility and access planning. The emerging trends in SA focus on identifying public transport users who see it as a mobility option among other alternatives (i.e. choice users in Venter (2016)) and as part of their lifestyle (van Dijk & Hitge, 2012). It is not possible to distinguish different behavioural groups if they are aggregated with classes that have different behavioural inclinations, and beliefs (Van, Choocharkul, & Fujii, 2014). Furthermore, the service design problem is exacerbated by the need to integrate bus and minibus services as feeders; and also encourage integrated public transport planning in the face of captive bus users and high minibus taxi use prominent in SA.

The level of service preference classes show that there are three main behavioural interactions between intention and control. Following microeconomic theory students should be willing and able to pay for a level of service that they prefer (Pindyck & Rubinfeld, 2009)—which implies that they must intend to use the mode and have control over using the mode through a payment. Behaviourally, intention and perceived control are interrelated through an argument similar to the behavioural theory. Expressing the intended preference depends on the amount of perceived control individuals have over the behaviour (Ajzen, 2005). Three interrelated level of service segments were identified through the behavioural theory. The first is the *neutral intention and high control* segment are probably choice users because they are indifferent with regard to either bus or minibus, but they pursue a high degree of control. *Low control and low intention* segment are students who are captive users because the generally have no real intention to use either mode, but they have limited control over their choices. *High intention and neutral control* segment is a group in which students have high intention to use either mode, but are indifferent with respect to having control over the service they use. This is potentially the *public transport lifestyle* segment discussed in another study (van Dijk & Hitge, 2012). While policy measures seem intriguing, it is important to highlight that further research is needed to validate these findings, although they seem consistent with both microeconomic and behavioural theory.

5.4 Policy Recommendations

The policy recommendations in this study are framed within customer oriented transport service design and accounting for behavioural dispositions in transport policy and planning. Firstly, this approach to understanding level of service preferences within the context of behavioural inclinations may be an important tool for evaluating the performance of subsidised and unsubsidised motorised public transport contracts offered to university students. A more accurate measure of household, learner and student sensitivities to level of service offerings classified based behaviour (or other response scale indicator) may be used to estimate equitable subsidy allocations for each type of user. In this sense policies may specify thresholds to guide the pricing, subsidy and service offering for various household types in a transparent and fair manner. At the same time, operators may be held more accountable and be capacitated to design services that suit household, learner and or student needs on a contractual basis. Of particular interest is the potential use estimating a deeper customer service contract that is segment specific in for instance the Service Quality Index (SQI) (Hensher & Prioni, 2002; Mokonyama & Venter, 2013) and the development of minibus taxi subsidy regimes (Dawood & Mokonyama, 2015). Secondly, with behavioural inclinations in mind, policies may through hybrid choice approaches focus on long term behaviour change initiatives that have empirical evidence to support, estimate and understand mode choice, service preference and behaviour.

A life-style focused area of research should capture (a) life changes may be anticipated and potential impacts on level of service requirements accounted for (i.e. see travel behaviour change over time in Cape Town (Behrens & Del Mistro, 2010); and the propensity for neighbourhood relationships by type of household (i.e. behavioural household classes (Kaufmann, 2011)) and local interaction or even stated liveability relative to the type of roadway separating the neighbourhood (i.e. see Appleyard's themes in Hanoi (Sanders, Zuidgeest, & Geurs, 2015)) . And (b) transit services may be designed or communicated (through marketing and content) to *search* for an optimum in preference in line individual personality traits as described in Scitovsky (1979). In this sense behaviour change interventions can be targeted at specific user groups in certain medium of communication and intervention—especially targeting social norms (Bamberg, Hunecke, & Blöbaum, 2007; Belgiawan, Schmöcker, Abou-Zeid, Walker, & Fujii, 2017) and specifically enhancing the intention to use both minibus and bus transport by modifying the factors which are shown to contribute negatively to intention and perceived control (see (Kerr, Lennon, & Watson, 2010)). This is consistent with market segmentation and segment specific customer service design. In the long term, a generation of life-style public transport users may become feasible due to accurately developed content, experiences and level of service offerings suitable for a mix of users. This type of strategy is highly beneficial to public transport operators who currently compete with highly marketed private car use cultures[34]. Other studies note the importance of university student travel habits on their long term travel choices after university (Van, Choocharkul, & Fujii, 2014), and the retrospective influence of travel behaviour in school before university (Muromachi, 2017) . The approach employed in this study may be applied at small university student population, but the potential applications exceed these confines. The key recommendations in this study are that:

1. University students (post-schooling) mobility issues be included in the learner transport policy;
2. Level of service performance contracts, and service design could account for travel behaviour and preferences through annual travel behaviour surveys; and
3. Research connecting preference with behaviour targets specific policy, strategy and practical local are needs in order to formulate interventions;
4. Mobility management at universities needs to be explored as the TDM needs of higher education facilities will be of increasing importance as access to higher education increases.

5.5 General Conclusions and Future Research

The overarching finding in this study is that travel behaviour and choice making can be grounded on behavioural theories and analysed within such frameworks. However, the depth, breadth and extent to which analysis is possible depend on the detail in collecting travel and behavioural data. Behaviour specific classification can be useful for understanding university student travel behaviour, herein it was found that emotive qualities of the service were strongly related to its choice. LOS design for public transport modes can be assessed empirically within the behavioural classes. Students with high intentions to use public transport in general, are a unique market segment with specific service design needs. Future research should at least reform the utility function specification such that it reflects a behavioural theory through which analysis will take place. Furthermore, understanding car purchase and car use intentions for university students may need a longitudinal analysis. It is recommended that universities in South Africa explore the need for implementing travel demand management strategies—such as enhancing the use of bus and minibus taxis through improved service design. At a policy level the study recommends that higher education students be included in the Learner Transport Policy.

[34] The mobility footprint of car use is expanding through technology and dynamic hail-a-ride type systems and automated driving solutions. These services pose a threat and present opportunities to public transport use if level of service designs do not adapt to the emerging environment.

5.6 Limitations

The behavioural statements were developed to test a general preference, with reference to *home.* This encourages a much broader sense of the attitudes that individuals present, over and above a trip to town. Most students make few trips to town on the weekday mainly because key amenities (i.e. shopping, religion and recreation) are close to the university precinct. On the other hand, this may also be a limitation: could behavioural inclinations be trip specific? Do students prefer one mode to go home and another to visit key amenities? Do the network limitations of bus services discourage university students from considering bus as a viable alternative? These are questions that outline major limitations in the *behavioural* estimates in this study. The statistical insignificance of demographic variables is also a limitation, which could be a result of the respondent stability and the sample size. A much larger sample size is necessary to have the demographic variables at the appropriate scale. Lastly, this study does not estimate class membership models due to a response size limit within the latent classes, however it is possible in future studies.

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ANNEXURE 1: SURVEY

Research Title	**STUDENT TRAVEL BEHAVIOR IN MAHIKENG**							
Author	Ofentse Hlulani Mokwena							
Supervisor	Prof Mark Zuidgeest							
Affiliation	North-West University, University of Cape Town							
Document	Final Survey							
Respondent Group	Public Transport Users							
Date								

Purpose Of This Survey

This survey is intended to compare decision making styles of transport users in the Mahikeng area. Given the resource limitations, this study only covers students of the North West University Mafikeng Campus. The survey is divided into three sections. The first section requires you to read the disclaimer and respond accordingly. The second section requires you to select between two options (1 and 2) the one you would prefer. The third section requires you to complete some demographic questions. The fourth section asks about your travel behaviour. The survey takes no more than 20 min to complete. **Please respond honestly, better the quality of your responses, the better the quality of the results.**

Your participation in this study is anonymous, valued and appreciated.

1 Disclaimer

For ethical purposes, the following points are important for the respondent to understand prior to participating in this survey (surveyor may read and explain this to each respondent:

1. Your identity is not required to complete this study, you are considered as an **anonymous participant** in the study and the views you express are, unaccountably, your own.

2. You are not forced to participate in this study, **all your participation is voluntary** and without compensation.
3. This study is not intended to harm you in anyway. **It only records your responses to scenarios**.
4. If, however, any harm directly or indirectly from the survey is experienced or expected the researcher (author), the supervisor, affiliated institutions or companies are not to be held liable.
5. This study is not directed to any specific action, beyond the researcher or affiliated institutions. It is intended to relate and inform the research objectives and goals, and future research objectives emanating from this study.

I understand the above, and am willing to be part of this anonymous survey.

YES	**NO**

2 Choice Scenarios

Which mode do you use most of the time?

Bus	**Taxi**

Situation

For this section imagine that it is a weekday and you are performing your usual trips. One of the trips involves you ***travelling from Mega City to Mahikeng town Centre****. There are no big events, or bad weather.* ***In the next section look at the hypothetical scenarios and choose the choice that you think is the best one.***

Choose the the transport that you would like to use between Transport A and B		
1 OF 16		
Transport A	Topic	**Transport B**
The **Waiting Time** for **Transport A** to start moving is 15 MINUTES	Waiting Time	The **Waiting Time** for **Transport B** to start moving is 10 MINUTES
In The Transport there are Few Seats Available	Comfort in the Vehicle	**In The Transport there are** Few seats and Little Space Available
The Transport takes you to town in 40 MINUTES	Travel Time	**The Transport takes you to town in** 35 MINUTES
Transport A costs you R 7.30	Cost	**Transport B costs you** R 10.00

Which Transport is the best one for you, **A or B**?

A ☐	B ☐

Choose the the transport that you would like to use between Transport A and B		
2 OF 16		
Transport A	Topic	**Transport B**
The **Waiting Time** for **Transport A** to start moving is 5 MINUTES	Waiting Time	The **Waiting Time** for **Transport B** to start moving is 10 MINUTES
In The Transport there are Few Seats Available	Comfort in the Vehicle	**In The Transport there are** Few seats and Little Space Available
The Transport takes you to town in 40 MINUTES	Travel Time	**The Transport takes you to town in** 35 MINUTES
Transport A costs you R 15.00	Cost	**Transport B costs you** R 10.00

Which Transport is the best one for you, **A or B**?

☐	☐

Choose the the transport that you would like to use between Transport A and B		
3 OF 16		
Transport A	Topic	**Transport B**
The **Waiting Time** for **Transport A** to start moving is 10 MINUTES	Waiting Time	The **Waiting Time** for **Transport B** to start moving is 20 MINUTES
In The Transport there are Few Seats Available	Comfort in the Vehicle	**In The Transport there are** Few seats and Little Space Available
The Transport takes you to town in 40 MINUTES	Travel Time	**The Transport takes you to town in** 35 MINUTES
Transport A costs you R 9.70	Cost	**Transport B costs you** R 10.00

Which Transport is the best one for you, **A or B**?

A ☐	B ☐

Choose the the transport that you would like to use between Transport A and B		
4 OF 16		
Transport A	Topic	**Transport B**
The **Waiting Time** for **Transport A** to start moving is 10 MINUTES	Waiting Time	The **Waiting Time** for **Transport B** to start moving is 10 MINUTES
In The Transport there are Many Seats Available	Comfort in the Vehicle	**In The Transport there are** Few seats and Little Space Available
The Transport takes you to town in 40 MINUTES	Travel Time	**The Transport takes you to town in** 50 MINUTES
Transport A costs you R 9.70	Cost	**Transport B costs you** R 15.00

Which Transport is the best one for you, **A or B**?

☐ ☐

Choose the the transport that you would like to use between Transport A and B

5 OF 16

Transport A	Topic	**Transport B**
The **Waiting Time** for **Transport A** to start moving is 10 MINUTES	Waiting Time	The **Waiting Time** for **Transport B** to start moving is 30 MINUTES
In The Transport there are Few Seats Available	Comfort in the Vehicle	**In The Transport there are** Few seats and Little Space Available
The Transport takes you to town in 40 MINUTES	Travel Time	**The Transport takes you to town in** 50 MINUTES
Transport A costs you R 9.70	Cost	**Transport B costs you** R 10.00

Which Transport is the best one for you, **A or B**?

A	B
☐	☐

Choose the the transport that you would like to use between Transport A and B

6 OF 16

Transport A	Topic	**Transport B**
The **Waiting Time** for **Transport A** to start moving is 10 MINUTES	Waiting Time	The **Waiting Time** for **Transport B** to start moving is 10 MINUTES
In The Transport there are Few Seats Available	Comfort in the Vehicle	**In The Transport there are** Few seats and Little Space Available
The Transport takes you to town in 40 MINUTES	Travel Time	**The Transport takes you to town in** 20 MINUTES
Transport A costs you R 9.70	Cost	**Transport B costs you** R 10.00

Which Transport is the best one for you, **A or B**?

☐ ☐

Choose the the transport that you would like to use between Transport A and B		
7 OF 16		
Transport A	Topic	**Transport B**
The **Waiting Time** for **Transport A** to start moving is 15 MINUTES	Waiting Time	The **Waiting Time** for **Transport B** to start moving is 30 MINUTES
In The Transport there are There is only space for you to stand	Comfort in the Vehicle	**In The Transport there are** Very full and no personal space
The Transport takes you to town in 55 MINUTES	Travel Time	**The Transport takes you to town in** 50 MINUTES
Transport A costs you R 15.00	Cost	**Transport B costs you** R 15.00

Which Transport is the best one for you, **A or B**?

☐ ☐

Choose the the transport that you would like to use between Transport A and B		
8 OF 16		
Transport A	Topic	**Transport B**
The **Waiting Time** for **Transport A** to start moving is 10 MINUTES	Waiting Time	The **Waiting Time** for **Transport B** to start moving is 30 MINUTES
In The Transport there are Many Seats Available	Comfort in the Vehicle	**In The Transport there are** Few seats and Little Space Available
The Transport takes you to town in 40 MINUTES	Travel Time	**The Transport takes you to town in** 35 MINUTES
Transport A costs you R 9.70	Cost	**Transport B costs you** R 7.50

Which Transport is the best one for you, **A or B**?

☐	☐

Choose the the transport that you would like to use between Transport A and B		
9 OF 16		
Transport A	Topic	**Transport B**
The **Waiting Time** for **Transport A** to start moving is 5 MINUTES	Waiting Time	The **Waiting Time** for **Transport B** to start moving is 10 MINUTES
In The Transport there are Many Seats Available	Comfort in the Vehicle	**In The Transport there are** Many Seats and Space Available
The Transport takes you to town in 55 MINUTES	Travel Time	**The Transport takes you to town in** 50 MINUTES
Transport A costs you R 15.00	Cost	**Transport B costs you** R 15.00

Which Transport is the best one for you, **A or B**?

☐ ☐

Choose the the transport that you would like to use between Transport A and B

10 OF 16

Transport A	Topic	**Transport B**
The **Waiting Time** for **Transport A** to start moving is 10 MINUTES	Waiting Time	The **Waiting Time** for **Transport B** to start moving is 30 MINUTES
In The Transport there are There is only space for you to stand	Comfort in the Vehicle	**In The Transport there are** Few seats and Little Space Available
The Transport takes you to town in 40 MINUTES	Travel Time	**The Transport takes you to town in** 35 MINUTES
Transport A costs you R 9.70	Cost	**Transport B costs you** R 15.00

Which Transport is the best one for you, **A or B**?

☐	☐

Choose the the transport that you would like to use between Transport A and B		
11 OF 16		
Transport A	Topic	**Transport B**
The **Waiting Time** for **Transport A** to start moving is 15 MINUTES	Waiting Time	The **Waiting Time** for **Transport B** to start moving is 20 MINUTES
In The Transport there are Many Seats Available	Comfort in the Vehicle	**In The Transport there are** Few seats and Little Space Available
The Transport takes you to town in 25 MINUTES	Travel Time	**The Transport takes you to town in** 35 MINUTES
Transport A costs you R 9.70	Cost	**Transport B costs you** R 10.00

Which Transport is the best one for you, **A or B**?

☐	☐

Choose the the transport that you would like to use between Transport A and B		
12 OF 16		
Transport A	Topic	**Transport B**
The **Waiting Time** for **Transport A** to start moving is 5 MINUTES	Waiting Time	The **Waiting Time** for **Transport B** to start moving is 30 MINUTES
In The Transport there are Many Seats Available	Comfort in the Vehicle	**In The Transport there are** Very full and no personal space
The Transport takes you to town in 55 MINUTES	Travel Time	**The Transport takes you to town in** 20 MINUTES
Transport A costs you R 7.30	Cost	**Transport B costs you** R 7.50

Which Transport is the best one for you, **A or B**?

☐	☐

Choose the the transport that you would like to use between Transport A and B		
13 OF 16		
Transport A	Topic	**Transport B**
The **Waiting Time** for **Transport A** to start moving is 10 MINUTES	Waiting Time	The **Waiting Time** for **Transport B** to start moving is 10 MINUTES
In The Transport there are There is only space for you to stand	Comfort in the Vehicle	**In The Transport there are** Few seats and Little Space Available
The Transport takes you to town in 40 MINUTES	Travel Time	**The Transport takes you to town in** 35 MINUTES
Transport A costs you R 9.70	Cost	**Transport B costs you** R 7.50

Which Transport is the best one for you, **A or B**?

Choose the the transport that you would like to use between Transport A and B

14 OF 16

Transport A	Topic	Transport B
The **Waiting Time** for **Transport A** to start moving is 15 MINUTES	Waiting Time	The **Waiting Time** for **Transport B** to start moving is 30 MINUTES
In The Transport there are Many Seats Available	Comfort in the Vehicle	**In The Transport there are** Many Seats and Space Available
The Transport takes you to town in 25 MINUTES	Travel Time	**The Transport takes you to town in** 50 MINUTES
Transport A costs you R 15.00	Cost	**Transport B costs you** R 7.50

Which Transport is the best one for you, **A or B**?

☐ ☐

Choose the the transport that you would like to use between Transport A and B		
15 OF 16		
Transport A	Topic	**Transport B**
The **Waiting Time** for **Transport A** to start moving is 5 MINUTES	Waiting Time	The **Waiting Time** for **Transport B** to start moving is 20 MINUTES
In The Transport there are There is only space for you to stand	Comfort in the Vehicle	**In The Transport there are** Few seats and Little Space Available
The Transport takes you to town in 25 MINUTES	Travel Time	**The Transport takes you to town in** 35 MINUTES
Transport A costs you R 9.70	Cost	**Transport B costs you** R 10.00

Which Transport is the best one for you, **A or B**?

☐ ☐

Choose the the transport that you would like to use between Transport A and B		
16 OF 16		
Transport A	Topic	**Transport B**
The **Waiting Time** for **Transport A** to start moving is 10 MINUTES	Waiting Time	The **Waiting Time** for **Transport B** to start moving is 20 MINUTES
In The Transport there are Many Seats Available	Comfort in the Vehicle	**In The Transport there are** Few seats and Little Space Available
The Transport takes you to town in 40 MINUTES	Travel Time	**The Transport takes you to town in** 50 MINUTES
Transport A costs you R 9.70	Cost	**Transport B costs you** R 10.00

Which Transport is the best one for you, **A or B**?

☐	☐

3 Demographics

Kindly respond to all the questions, and mark with an X the option that best represents your answer.

3.1 Indicate the **<u>gender</u>** that best describes you.

Female			**Male**		

3.2 In which **<u>age group</u>** do you belong?

18	19	20	21	22	23	24	25	26	Other

3.3 Indicate your **<u>main place of residence</u>** and complete the boxes below.

On Campus ◯	Off-Campus ◯
Please indicate the ***name of your residence****.*	*Please indicate the* ***name of the area*** *(i.e. Unit 2)* ....
Kindly specify your ***home-town/village****:* Name of Province:................................... Name of Town/Village................................	*Kindly specify the* ***characteristics of the mode of transport you used most to come to Mafikeng Campus*** *this week (walking is also a mode of transport):* Transport Mode....................................... Transport Mode Cost (Price) R................. Expected Travel Time.....................Minutes

	Actual Travel Time............................Minutes
Kindly specify the ***characteristics of the mode of transport you use most to travel home during holidays*** *or end of year.* Transport Mode.. Transport Mode Cost (Price) R.................... Average Travel Time..Minutes	*(empty)*

3.3 Indicate the **average monthly allowance** you receive

<R300	**R301<R500**	**R501<R700**	**R701<R1000**	**R1001<R1300**	**R1301<R1500**	**R1501<1700**	**R1701<**

3.4 Do your **parents/guardians own a car**?

Yes	No
	(Continue to 3.5)

Kindly indicate the number of cars.					
1	2	3	4	5<	

3.5 Specify your **degree and level of study** below

Programme/Course Registered for	…………………………………………………………
Degree Level (1st Year; 2nd Year; 3rd Year; 4th year etc)	……………………………………………………………

3.6 Specify which **mode of transport you used during high school** to get to school.

BUS	TAXI	WALK	BICYCLE	CAR	TRAIN	OTHER

3.8 **How many years after graduating would you want to buy a car of your own**?

1 year	2 years	3 years	4 years	5 years or more	Never (always use public transport)

3.8 What is your **<u>favourite transport mode currently</u>**?

BUS	TAXI	CAR	TRAIN	WALKING	CYCLING	OTHER

3.9 From your experience, **<u>how long does it take to make the following trips</u>**?

Mafikeng Campus to Town	Mafikeng Campus to Mega City
Preferred Transport Mode..	Preferred Transport Mode..
Travel Time...Minutes	Travel Time..Minutes

4 Travel Behaviour Evaluation

In the next section, we are considering your experience with public transport. The section is made up of statements that need to be rated.

Imagine that you are travelling by taxi or bus 3 days (or more) per week to go home. Rate the degree to which the statement is true, or false.

For the next few rating statements, assume that you are travelling by taxi or bus 3 days (or more) per week to go home. Rate the degree to which the statement is true, or false.

1.1

I intend to travel by taxi 3 days (or more) per week to go home.						
Very False			May Be			Very True
1	2	3	4	5	6	7

1.2

I will try to travel by bus 3 days (or more) per week to go home.						
Definitely Not			Unsure			Definitely Will
1	2	3	4	5	6	7

1..3

I plan to travel by taxi this week to go home.

Strongly Agree			Unsure			Strongly Disagree
1	2	3	4	5	6	7

1..4

I would like to use the bus this week to go home.						
Very True			Unsure			Very False
1	2	3	4	5	6	7

2.1

For me to travel by taxi 3 days (or more) per week to go home in the next month is						
Harmful			Unsure			Beneficial
1	2	3	4	5	6	7
Very Good			Unsure			Very Bad
1	2	3	4	5	6	7
Unenjoyabl e			Unsure			Enjoyable
1	2	3	4	5	6	7

2.2

For me to travel by bus 3 days (or more) per week to go home in the next month is						
Harmful			Unsure			Beneficial
1	2	3	4	5	6	7
Very Good			Unsure			Very Bad
1	2	3	4	5	6	7
Unenjoyabl e			Unsure			Enjoyable
1	2	3	4	5	6	7

3.1

Most people who are important to me would think that for me to travel by taxi 3 days (or more) per week is						
Very Good			Unsure			Very Bad
1	2	3	4	5	6	7

3.2

If I use a bus to go home 3 days (or more) per week most of my friends and family would						
Completel y Dissaprove			Unsure			Completel y Approve
1	2	3	4	5	6	7

3.3

People close to me think that me using the bus to travel home 3 days (or more) per week is						
Very Bad						Very Good
1	2	3	4	5	6	7

3.4

My friends and family travel by taxi to go home 3 or more times per week.						
Completel y True						Completel y False
1	2	3	4	5	6	7

4.1

For me to travel by bus for at 3 days (or more) per week would be						
Impossible						Possible
1	2	3	4	5	6	7

4.2

It is mostly up to me whether or not I use a taxi to travel home 3 days (or more) per week						
Stronly Agree			Unsure			Strongly Disagree
1	2	3	4	5	6	7

4.3

How much control do you believe you have over traveling by bus 3 days (or more) per week						
No Control			Neutral			Complete Control
1	2	3	4	5	6	7

4.4

If I wanted I could use the taxi to travel home 3 days (or more) per week						
Definitely True			Neutral			Definitely False
1	2	3	4	5	6	7

4.5

In general, do you do what people close to you want you to do?						
Never						Always
1	2	3	4	5	6	7

5.1

My using a taxi to travel home 3 days (or more) per week in the next month will help me keep to my budget for transport						
Definitely True			Neutral			Definitely False
1	2	3	4	5	6	7

5.2

My using a bus to travel home 3 days (or more) per week in the next month will help me keep to my budget for transport						
Definitely True			Neutral			Definitely False
1	2	3	4	5	6	7

5.3

Keeping to a monthly transport budget is						
Extremely Bad						Extremely Good
1	2	3	4	5	6	7

Thank you for your participation

ANNEXURE 3: ETHICAL CLEARANCE

EBE Faculty: Assessment of Ethics in Research Projects

Any person planning to undertake research in the Faculty of Engineering and the Built Environment at the University of Cape Town is required to complete this form before collecting or analysing data. When completed it should be submitted to the supervisor (where applicable) and from there to the Head of Department. If any of the questions below have been answered YES, and the applicant is NOT a fourth year student, the Head should forward this form for approval by the Faculty EIR committee: submit to Ms Zakiya Chikte (Zakiya.chikte@uct.ac.za); New EBE Building, Ph 021 650 5739). Students must include a copy of the completed form with the dissertation/thesis when it is submitted for examination.

Name of Principal Researcher/Student: Ofentse Hlulani Mokwena **Department:** Centre for Transport Studies

If a Student: **Degree:** MPhil Transport Studies **Supervisor:** A/Prof Mark Zuidgeest

If a Research Contract indicate source of funding/sponsorship:

Research Project Title:
VALUE OF SERVICE ATTRIBUTES BETWEEN OPERATORS AND USERS: A COMPARISON

Overview of ethics issues in your research project:

Question 1: Is there a possibility that your research could cause harm to a third party (i.e. a person not involved in your project)?	YES	<u>NO</u>
Question 2: Is your research making use of human subjects as sources of data? If your answer is YES, please complete Addendum 2.	<u>YES</u>	NO
Question 3: Does your research involve the participation of or provision of services to communities? If your answer is YES, please complete Addendum 3.	~~YES~~	<u>NO</u>
Question 4: If your research is sponsored, is there any potential for conflicts of interest? If your answer is YES, please complete Addendum 4.	YES	<u>NO</u>

If you have answered YES to any of the above questions, please append a copy of your research proposal, as well as any interview schedules or questionnaires (Addendum 1) and please complete further addenda as appropriate.

I hereby undertake to carry out my research in such a way that

- there is no apparent legal objection to the nature or the method of research; and
- the research will not compromise staff or students or the other responsibilities of the University;
- the stated objective will be achieved, and the findings will have a high degree of validity;
- limitations and alternative interpretations will be considered;
- the findings could be subject to peer review and publicly available; and
- I will comply with the conventions of copyright and avoid any practice that would constitute plagiarism.

Signed by:

	Full name and signature	Date
Principal Researcher/Student:	OFENTSE HLULANI MOKWENA	26/11/2015

This application is approved by:

Supervisor (if applicable):	Zuidgeest	27/11/2015
HOD (or delegated nominee): Final authority for all assessments with NO to all questions and for all undergraduate research.	R. BEHRENS	27 NOV 15
Chair: Faculty EIR Committee For applicants other than undergraduate students who have answered YES to any of the above questions.		