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University U-Pass programs: projecting potential quantitative impacts at UWA

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Abstract

A subsidised public transport pass (U-Pass) program has been proposed to address issues of sustainability, equitable access, and parking at the University of Western Australia (UWA). A recent feasibility study found a U-Pass program would be expected to encourage a significant shift toward more sustainable transport modes, and play an important role in mitigating transport-related greenhouse gas emissions and excessive parking demand (Bleechmore, Giles-Corti & Olaru 2011). Building upon these findings, this study statistically analysed the potential quantitative impact of a U-Pass program at the University by assessing reported travel behaviour, barriers and motivations at an individual level. A model was constructed to project the modal share following the implementation of a U-Pass program. The study demonstrates that there is significant potential to encourage more active commuting to and from the University campus.

1. Introduction

A subsidised public transport pass (U-Pass) program has been proposed to address issues of sustainability, equitable access and parking at the University of Western Australia (UWA) Crawley campus. There is expected to be a significant increase in demand for on-campus parking driven by sustained growth in the staff and student population. Unless there is a significant shift to active commuting, campus parking will come under considerable pressure. U-Pass programs in Canada and the United States have proven to be successful in increasing transit ridership and managing parking demand, providing mutual benefits for universities, transit providers and the broader community. A U-Pass program at UWA would be an Australian first and would demonstrate leadership in sustainable campus transportation.

A U-Pass funded by increased parking fees was the most supported among UWA staff and students and considered to be the most likely transport initiative to encourage active commuting to and from the University (French, Giles-Corti & I'Anson 2010a). A recent feasibility study of implementing the initiative at UWA found that a U-Pass, predominantly funded by increased parking fees, would be expected to encourage a significant shift toward more sustainable transport modes, and play an important role in mitigating transport-related greenhouse gas emissions and excessive demand for on-campus parking. The feasibility study projected the number of single-occupancy vehicle users to be reduced by 19.2% while the number of public transport users would grow by 21.1%. It was predicted that a U-Pass program with 9,500 participants would reduce transport-related greenhouse gas emissions by 1,600 tonnes per year (Bleechmore, Giles-Corti & Olaru 2011). The feasibility study had a number of limitations that this study sought to overcome.

To expand upon the findings of the feasibility study, this study used multivariate statistics of the *2010 UWA Commuting Survey* dataset to assess the potential quantitative impact of a U-Pass program at the University. The analysis focused on reported travel behaviour, and perceived barriers and motivators at an individual level in order to provide a more rigorous projection of the modal shift associated with the implementation of a U-Pass program than that given in the *UWA U-Pass Feasibility Study*.

A model was constructed based on personal barriers and motivators that correlated with reported daily trips by transport mode. Staff and students that reported similar barriers and motivators were clustered together according to their levels of restriction. The expected modal shares were based on the reallocation of trips to preferred alternative modes among individuals within clusters most likely to change, i.e. those that are least restricted in terms of objective and subjective constraints.

The paper is structured as follows:

Section 2 reviews the relevant literature on the outcomes of U-Pass programs internationally. Section 3 describes the empirical setting and the methodology used in the study. Results are presented in Section 4 and findings are discussed in Section 5 along with practical implications, limitations and recommendations for future research.

2. Literature review

2.1 U-Pass: benefits and challenges

A U-Pass program provides users with access to significantly subsidised public transport. U-Pass programs at universities encourage staff and students to commute using active transport modes rather than private motorised vehicles. The University of Western Australia currently generates more than 2 million single-occupancy vehicle trips per academic year (French, Giles-Corti & I'Anson 2010a) thereby significantly contributing to local traffic congestion and vehicle emissions in Perth. Demand for on-campus parking exceeds supply and will increase as the University population continues to grow.

Many educational institutions in North America have recognised the benefits that U-Pass programs provide to U-Pass users, universities, public transport providers and the broader community at "minimal costs" (Senft 2005, p. 16). U-Pass programs are typically funded by a combination of user fees and adjusted parking rates that more accurately reflect the true cost of providing parking. Subsidised public transport provides financial incentives that reinforce the behaviour of existing public transport users and encourage non-users to change their behaviour. Increased parking fees provide financial disincentives that encourage non-users to change their behaviour and confront negative attitudes toward public transport, carpooling, walking and cycling. U-Pass programs have been shown to "work almost anywhere", including Los Angeles, "a city famous for its addiction to cars" (Brown, Hess & Shoup 2003, p. 79). In many ways, Perth resembles Los Angeles in that it has a heavily automobile-dependent population with limited public transport access.

U-Pass programs in North America have been successful in increasing public transport ridership and reducing on-campus parking demand (Brown, Hess & Shoup 2001; Senft 2005; Toor & Havlick 2004; Transit Cooperative Research Program 2001). At the University of British Columbia and Simon Fraser University, transit ridership increased 68% and 48% respectively within the first two years of U-Pass programs being introduced (Urban Systems 2005). The University of Washington-Seattle increased the modal share for public transport from 21% to 36% during the first year of their program (Toor & Havlick 2004) thereby reducing total vehicle trips by 16% (Litman & Lovegrove 1999). The growth in transit ridership must be managed such that excess service capacity is utilised without overcrowding and pass-ups such as that experienced at the University of British Columbia in 2001 (Toor & Havlick 2004). The cost of public transport service expansion should be evaluated prior to implementation to ensure increased demand can be satisfied within budgetary constraints. Similarly, parking demand must be maintained at a level that provides an adequate revenue base for public transport subsidies.

A survey conducted by Brown, Hess & Shoup (2001) investigated reasons for implementing U-Pass programs. The top five reasons provided by North American university officials were as follows:

1. Reduce parking demand;
2. Improve student access to housing and employment;
3. Improve recruitment and retention of students;
4. Reduce the cost of tertiary education for students; and
5. Improve transport equity.

In addition to the reasons provided by university officials, U-Pass programs have generally improved campus access whilst mutually benefiting universities, public transport providers and communities throughout North America (Transit Cooperative Research Program 2001).

2.2 Improved access

U-Pass programs improve staff and student access to university campuses by:

- Providing an affordable alternative to driving;
- Improving access for those that must drive by managing parking demand, improving public transport and reducing traffic congestion (Fleming 2000; Maclaurin 2004);
- Reducing travel costs for public transport-dependent riders and students experiencing financial hardship (Brown, Hess & Shoup 2001; Toor & Havlick 2004); and,
- Prompting public transport service improvements including more frequent services, extended service hours, new routes and extensions (Fleming 2000; Toor & Havlick 2004).

2.3 University benefits

U-Pass programs have been shown to benefit educational institutions by:

- Providing a cost-effective solution to excess parking demand (Smith et al. 2004);
- Assisting in the recruitment and retention of students (Brown, Hess & Shoup 2001; Toor & Havlick 2004);
- Reducing the need for surface parking thereby allowing University land to be developed for educational purposes;
- Improving community relations by reducing parking and traffic impact on neighbouring areas provided off-campus parking fees are comparable (Toor & Havlick 2004); and,
- Assisting universities in fulfilling their environmental responsibilities.

2.4 Transport provider benefits

U-Pass programs have been shown to benefit public transport providers by:

- Increasing profit through low-cost patronage growth (Toor & Havlick 2004);
- Utilising excess service capacity during off-peak times thereby reducing operating cost per user (Brown, Hess & Shoup 2001);
- Providing revenue for the expansion of public transport services (Toor & Havlick 2004);
- Staff and students using public transport “for trips they previously believed it would not serve” (Brown, Hess & Shoup 2003); and,
- Improving the perception of public transport in the community.

Evidence from the United States highlights that “the travel patterns that students learn while in college are likely to influence their future travel choices” (Toor 2003, p. 131) therefore U-

Pass programs may have a long-term influence on public transport ridership (Toor & Havlick 2004).

2.5 Community, environment and health benefits

Toor (2003) states that "unlike car travel, where adding additional travellers degrades the overall service, adding more riders to transit makes it possible to increase frequency and thus improve service for all other travellers" (p. 139). The surrounding community, including residents, schools and businesses, would benefit from improvements to public transport services prompted by U-Pass programs provided that services do not become overcrowded due to unprecedented demand. In general, the reduction in motorised vehicle trips and increase in active transportation benefits the broader community by increasing physical activity and reducing traffic noise and air pollution (Urban Systems 2005).

2.6 Proposed U-Pass program at UWA

The *UWA U-Pass Feasibility Study* recommended a non-mandatory U-Pass program at UWA, with 75% of the total cost of fares funded by increased parking fees, which would be equivalent to two standard 2-zone public transport fares (see *http://www.transperth.wa.gov.au/TicketsandFares.aspx* for more information about zones and fares), and the remaining 25% funded by U-Pass user fees. The U-Pass user fee would be the same for all U-Pass users irrespective of the zone in which they reside. Following upfront payment of the user fee, SmartRider credit would be provided for five return trips per week during university weeks (36 weeks for students and 46 weeks for staff). Alternatively, the user could periodically add value to their SmartRider and receive additional credit in proportion to their contribution.

It is expected that the proposed parking fee increases will be met with justified opposition from staff and students that are dependent on motorised vehicles for commuting to and from the University. The feasibility study therefore recommended exemptions from parking fee increases for staff and students that meet certain eligibility criteria. Due to the non-mandatory nature of the U-Pass, the program would not be universal and hence the term U-Pass is somewhat misleading.

3. Data and methodology

3.1 Data

In 2010, French, Giles-Corti and I'Anston conducted the *2010 UWA Commuting Survey*, which aimed to assess staff and student commuting behaviour, factors influencing choice of transport mode, and the potential for the University to implement initiatives that would encourage active commuting. The survey dataset provided the basis for the statistical analysis undertaken in this paper.

3.2 Sample

The *2010 Active Commuting Survey* sample consisted of 1,426 staff and 1,105 students of an overall 2010 population of 3,817 staff and 20,396 students working and studying at the UWA Crawley campus (French, Giles-Corti & I'Anston 2010a). Data were collected over five weeks between the final week in April and the first four weeks during May 2010. Rainfall was recorded during only one weekday of the study period therefore "the overall weather conditions are unlikely to have biased commuting behaviour for the participants" (French, Giles-Corti & I'Anston 2010a, p. 2).

The 21-page survey questionnaire (available in the reports at *http://www.sph.uwa.edu.au/research/cbeh/projects/commuting-behaviour/*) consisted of questions concerning current travel behaviour including a travel diary for the previous week; consideration of an alternative transport mode including barriers and motivators for active commuting; and confidence in using active transport modes. Importantly, question choices were tailored depending on the participant's 'main mode' of transport and consideration of an alternative transport mode (see French, Giles-Cori & I'Anston 2010a for classification of 'main mode'). This resulted in a reduced number of responses concerning barriers and motivations for walking, cycling and using public transport to respondents that selected one of these transport modes as the preferred alternative to their current 'main mode'. Many of those who were not considering an alternative transport mode provided reasons for not walking, cycling or using public transport (i.e. active commuting barriers) and factors that would encourage them to use or continue using a mode other than a private vehicle (i.e. active commuting motivators). **Table 1** below shows the response rate to questions concerning barriers and motivations by the transport mode under consideration which significantly restricted the sample size during data analysis. Walking was excluded from the analysis due to the inadequate sample size.

Table 1: Number of responses to questions concerning barriers and motivations for the respective transport mode

	PT	Cycle	Walk	AC (PT, cycle & walk)	
	barriers and motivators	barriers and motivators	barriers and motivators	barriers	motivators
Student	102	64	3	350	858
Staff	171	138	23	674	1,028
TOTAL	273	202	26	1,024	1,886

3.3 Treatment of data

Road distance and travel time for commuting to UWA were not obtained directly in the survey, and were added to the dataset based on respondents' suburb of residence. This allowed both the respondent's trips by transport mode and distance travelled by transport mode to be analysed.

Where possible, the dataset was split into staff and students segments. Importantly, the dataset could not be split for the cluster analysis and modal share projections, as the sample size was insufficient to provide meaningful results. As a result, staff are inevitably overrepresented in the cluster analysis and modal share projections.

3.4 Data analysis

This study applied a combination of factor analysis, multiple linear regression, and cluster analysis to identify motivations for using current modes for travelling between place of residence and the university campus, as well as the barriers and motivators for using active modes of transport, namely public transport, cycling or walking. This assessment provides a better understanding of the objective and subjective factors contributing to modal shift and consequently a more rigorous projection of the potential impacts of the implementation of a U-Pass program.

All analyses were conducted in IBM SPSS Statistics Version 19.

Factor analysis was used to reduce the dimensionality of the stated barriers and motivators in using each transport mode. 83 questions were included in the survey to assess the importance of factors in influencing the respondent's choice of transport mode. By using factor analysis we created composite constructs reflecting categories of enablers or constraints for using more active travel modes, based on their commonality (reflecting infrastructure requirements, personal circumstances, attitudes etc.). Not all measures had the same importance in influencing travel choice. The factor analysis provided 'loadings', which show the relative contribution of the individual measures within the construct and reflect the strength of the relationship between the overall construct and the individual measure (i.e. one of the 83 variables).

Following an exploratory stage, our confirmatory factor analysis (CFA) produced 18 uni-dimensional constructs. 15 of the 18 have reliabilities above 0.7, and 3 have reliabilities of about 0.5 (planning requirements and weather concerns for using PT; road safety concerns when cycling and enjoyment; health and social benefits of cycling). **Table 1A – Appendix A** presents the factor loadings for each construct.

Regression analysis was then applied to explore the relationship between current travel distances by mode, and barriers and motivators for their use.

Finally, cluster analysis allowed us to categorise individuals with similar constraints and attitudes without preconceptions of their defining attributes. This interdependence technique calculates Euclidean distances between respondents, and groups respondents with similar motivators and barriers into the same cluster. The resulting clusters are relatively homogenous and can be used to compare travel behaviour. We contrasted the clusters of individuals based on their travel, using multiple analysis of variance (MANOVA). The purpose of this technique was to compare the vectors of motivators, barriers and travel across clusters and to test whether the means for groups are the same (from the same sampling distribution). Here we assessed whether the travel behaviour indicators are the same between groups with lower and higher levels of motivators and barriers.

All these approaches informed our modal shift projections, which were established by reallocating trips to the transport modes considered to be the preferred alternative by those respondents which were contained within the least restricted clusters in terms of ability to change transport modes.

4. Results

4.1 General descriptive statistics

Table 2 provides summary statistics for the sample of *2010 UWA Commuting Survey* respondents. As expected, there is a significantly higher number of individual weekly trips to UWA by staff compared to students ($p<0.01$). There is also a significantly higher average distance travelled weekly to UWA by staff compared to students ($p<0.01$), explained by the larger geographical spread of the staff residences and the significant number of students living in residential colleges around the campus or residing in the surrounding neighbourhoods.

Table 2: General descriptive statistics for the 2010 UWA Commuting Survey

	Student (n=1,081)		Staff (n=1,418)	
	Mean	Std. Dev	Mean	Std. Dev
Age (years)**	22.93	7.47	43.76	11.48
Commute distance (km)*	11.91	8.166	12.78	10.579
Total commuting trips per week**	7.85	2.415	8.81	2.296
Total commuting distance per week (km)**	91.93	70.21	112.36	98.75

Note: ** statistically significant at 0.01 level, * statistically significant at 0.1 level.

There was no significant difference in gender representation between students and staff, with 43.81% of students and 45.40% of staff being male. **Table 3** shows a significantly higher proportion of staff members with parking permits compared to students. The high ineligibility for parking permits among students is due to the restriction on permit ownership for first year students and those within close proximity to the University campus.

Table 3: Parking permit ownership by staff and students

Parking permit	Student (n=1,081)	Staff (n=1,418)
Yes	16.1%	70.0%
No (ineligible)	38.0%	2.4%
No (choice)	45.9%	27.6%

4.2 Factor Analysis

The analysis of **Table 1A – Appendix A** reveals consistently higher loadings (above 0.7) for the constructs reflecting parking availability for cars and bicycles, and infrastructure facilities required for walking and cycling. When analysed by transport mode, some additional insights are provided: for public transport use (constructs 1-5), there is considerable variability in the loadings for impedance and unpreparedness/weather concerns, but relative consistency for avoiding parking or enjoyment constructs. Similarly, we notice variation for comfort, convenience, and safety when walking and cycling (constructs 6-8 and 10). Lack of dedicated cycling or pedestrian paths and of secure lockers seems to have higher contribution to the constructs than changing/showering facilities and need for their use, which is reflected by lower values for loadings. This is a useful indication for planning the essential elements required to encourage more active travel. Interestingly, avoiding parking (constructs 4, 9, and 10) displays the highest loadings, demonstrating the current car-use limitations, particularly for students.

The factors were then applied to examine their correlation with the weekly commuting distance by mode for students and staff.

4.3 Factors influencing travel behaviour

In order to understand the objective and subjective barriers and motivators for travel mode change, we investigated the relationship between weekly commuting (calculated distance in km) by motorised travel, public transport, and cycling, and the reported barriers and motivators. **Table 4** provides the statistics for the distances and proportions of travel by mode.[1] Students at UWA rely significantly more on public transport, whereas staff drive and cycle more.

Table 4: Distance travelled in km for a 5-day week and proportion of weekly travel by various transport modes

	Car-based travel		Public transport		Walking		Cycling	
Students	46.39 **	50.36% **	39.31 **	35.46% **	2.39	7.27% *	2.68 **	5.67%
Staff	83.23	72.76%	20.67	12.87%	2.31	5.53%	5.42	8.09%

Note: ** statistically significant at 0.01 level, * statistically significant at 0.1 level.

Table 5 shows that car-based travel is positively associated with greater distance from UWA, being a staff member, being female, and reporting barriers to active commuting such as impedance and lack of road safety associated with active transport alternatives. However,

[1] The regressions for public transport are not included due to the very low predictive power.

inconvenience, parking, and attitudes towards active travel were not significant in predicting the amount of travel by motorised modes.

Table 5: Regression analysis of distance travelled by car (R^2_{adj} = 0.75; N = 1,024) and potential factors

Variables	Coefficients		t	Sig.
	B	Beta		
(Constant)	6.512		1.210	0.227
Staff (1) or student (0)**	27.313	0.160	7.112	**0.000**
Gender – male (1) / female (0)*	-6.674	-0.041	-2.527	**0.012**
Age group*	-1.061	-0.037	-1.738	**0.083**
Distance from UWA (km)**	7.435	0.827	49.087	**0.000**
Lack of road safety (AC)*	-3.058	-0.036	-1.904	**0.057**
Impedance for AC**	6.477	0.068	3.810	**0.000**
Inconvenience of AC	1.290	0.014	0.758	0.449
Avoid parking by AC	0.888	0.010	0.545	0.586
Enjoyment, health and environmental benefits of AC	1.333	0.014	0.736	0.462

Note: ** statistically significant at 0.01 level, * statistically significant at 0.1 level.

When exploring the relation between cycling and potential predictors, we found that only distance and positive attitudes toward active lifestyles explained the decision to cycle to and from the University (see **Table 6**).

Table 6: Regression analysis of distance travelled by bicycle (R^2_{adj} = 0.32; N = 202) and potential predictors

Variables	Coefficients		t	Sig.
	B	Beta		
(Constant)	0.885		0.274	0.784
Staff (1) or student (0)	-0.914	-0.040	-0.410	0.682
Gender – male (1) / female (0)	0.186	0.009	0.120	0.905
Age group	0.018	0.004	0.046	0.964
Distance from UWA (km)**	-0.389	-0.205	-2.898	**0.004**
Infrastructure barriers and weather concerns for cycling	-1.317	-0.111	-1.398	0.164
Inconvenience of cycling	0.278	0.022	0.288	0.774
Lack of road safety and parenting needs	-0.917	-0.082	-1.065	0.288
Avoid parking by cycling	-0.091	-0.008	-0.102	0.919
Enjoyment, health and social benefits of cycling*	1.862	0.173	2.472	**0.014**

Note: ** statistically significant at 0.01 level, * statistically significant at 0.1 level.

4.4 Clustering

Cluster analysis was performed in two stages: a hierarchical step for identifying the likely number of homogeneous groups, followed by k-means cluster analysis using the seeds from the first stage. Solutions with two and three clusters were compared. This paper provides the three-cluster solution, deemed more appropriate for interpretation.

Tables 7 to **9** present the characteristics of the respondent groups according to their reported motivators and barriers for public transport, cycling, and active transport modes generally. As previously mentioned, the response rate was limited due to the structure of the survey. For each mode, we identified a highly restricted group (cluster 1), which is mostly represented by staff (and to a lesser extent students) living further from the university. A U-Pass program funded by increased parking fees is expected to encourage not only public transport use, but also cycling and walking.

Table 7: Clusters of respondents based on reported motivators and barriers to public transport use (N=273)

	Cluster 1	Cluster 2	Cluster 3	p
Distance from home to UWA (km)**	16.51	13.03	13.07	**0.001**
Total commuting distance travelled weekly (km)**	146.09	104.24	100.97	**0.000**
Weekly distance by PT (km)	6.18	7.74	10.63	0.420
Weekly distance by car (km)**	139.45	94.54	85.38	**0.000**
Percentage males (%)*	28.00	31.00	45.00	**0.036**
Average age (median)**	40.9	27.8	41.1	**0.000**
Percentage staff (%)**	79.50	35.50	80.70	**0.000**
Percentage with parking permits (%)**	84.40	38.30	75.00	**0.000**
Impedance to PT use**	0.66	0.09	-0.70	**0.000**
Unpreparedness and weather concerns for PT**	0.16	0.32	-0.53	**0.000**
Inconvenience of PT**	0.42	0.21	-0.63	**0.000**
Avoid parking by using PT**	-0.58	0.98	-0.68	**0.000**
Enjoyment, health and social benefits of PT	0.08	0.02	-0.09	0.324
N	**78**	**107**	**88**	

Note: ** statistically significant at 0.01 level, * statistically significant at 0.1 level.

In **Table 7**, cluster 1 represents a highly restricted group, the least likely to use public transport on a regular basis. This group typically resides at a greater distance from the University campus and travels the greatest distance by car. Cluster 2 represents a group that is particularly responsive to parking issues and is moderately likely to switch to public transport with the encouragement of a U-Pass program. Cluster 3 represents an unrestricted group, potentially likely to switch to public transport.

Table 8: Clusters of respondents based on reported motivators and barriers to cycling (N=202)

	Cluster 1	Cluster 2	Cluster 3	p
Distance from home to UWA (km)	8.72	8.70	7.02	0.205
Total commuting distance travelled weekly (km)	76.54	72.02	61.31	0.301
Weekly distance cycling (km)**	2.15	7.02	0.89	**0.002**
Weekly distance by car (km)	62.39	53.01	41.71	0.118
Percentage males (%)	54.00	57.00	48.00	0.633
Average age (median)	34.08	37.42	37.50	0.190
Percentage staff (%)	60.56	71.08	75.00	0.199
Percentage with parking permits (%)	54.17	46.48	60.24	0.235
Infrastructure barriers and weather concerns**	0.83	-0.48	-0.39	**0.000**
Inconvenience of cycling**	0.44	-0.07	-0.52	**0.000**
Lack of road safety and parenting needs**	0.83	-0.48	-0.40	**0.000**
Avoid parking by cycling**	0.69	-0.29	-0.50	**0.000**
Enjoyment, health and social benefits of cycling	0.09	0.62	-1.20	0.324
N	**71**	**83**	**48**	

Note: ** statistically significant at 0.01 level, * statistically significant at 0.1 level.

Similar to the public transport clusters, cluster 1 in **Table 8** represents a highly restricted group and is therefore unlikely to change its commuting mode to cycling on a regular basis. Cluster 2 represents a group that are particularly responsive to parking issues and moderately likely to switch to cycling regularly in response to increased parking fees. Cluster 3 represents an unrestricted group that is most likely to switch to cycling, provided that its negative attitudes to cycling are overcome.

Table 9: Clusters of respondents based on reported motivators and barriers to active transport modes (AC) (N=1,024)

	Cluster 1	Cluster 2	Cluster 3	p
Distance from home to UWA (km)**	13.95	14.31	11.50	**0.000**
Total commuting distance travelled weekly (km)*	98.83	114.45	116.33	**0.013**
Weekly distance PT, walking, cycling (km)	2.16	3.48	2.36	0.241

Weekly distance by car (km)*	96.67	110.97	113.96	**0.017**
Percentage males (%)**	39.00	50.00	36.00	**0.001**
Average age (median)**	38.24	41.05	34.54	**0.000**
Percentage staff (%)**	71.43	74.46	52.60	**0.000**
Percentage with parking permits (%)**	80.14	63.29	70.44	**0.000**
Infrastructure barriers for AC**	1.01	-0.32	-0.50	**0.000**
Lack of road safety**	1.16	-0.47	-0.47	**0.000**
Impedance for AC**	0.28	0.11	-0.34	**0.000**
Inconvenience of AC**	0.40	0.14	-0.47	**0.000**
Avoid parking by AC**	0.12	0.45	-1.02	**0.000**
Enjoyment, health and environmental benefits of AC**	0.37	0.15	-0.66	**0.000**
N	**296**	**369**	**359**	

Note: ** statistically significant at 0.01 level, * statistically significant at 0.1 level.

Table 9 provides the cluster profiles for active modes (AC) considered together. Cluster 1, of highly restricted individuals, has the most positive attitudes towards AC. The strong objective limitations make this group the least likely to switch to active modes on a regular basis, despite their attitudes towards public transport, walking and cycling. Again, cluster 2 includes individuals particularly responsive to parking issues. This group is considered moderately likely to switch to active modes regularly in response to increased parking fees. The students in cluster 2, which make up approximately one quarter of the cluster, are considered more likely to change than the staff. This provided the rationale for the high projection (H) presented below. Cluster 3 represents the least restricted group, but with a negative attitude to active commuting. This group could adjust their commuting by adopting active transport modes provided their negative attitudes are overcome.

4.5 Modal share projections

If a U-Pass were implemented at the University, increased parking fees and public transport subsidies would encourage staff and students to switch to more active transport modes (public transport, walking, and cycling). Individuals that are less restricted, in terms of objective and subjective barriers, are most likely to respond to incentives by changing to alternative transport modes. It was assumed that the modal shift would be one-way; that is, from less active modes (single-occupant and multi-occupant car, motorcycle, or scooter) to more active modes (public transport, cycling, or walking). In reality, improved access to parking provides a reversed enticement that negates the financial incentives for alternative transport modes.

For respondents capable of changing to ‘active modes’, 80% of their trips were reallocated to public transport and 20% were reallocated to walking and cycling, based on the current mode split. The potential for single-occupant vehicle users to change to carpooling, being dropped off, motorcycling, or scootering could not be assessed, as the survey did not address the barriers and motivators for these modes. In this respect, the results are conservative.

The modal share projection for the sample is shown in **Table 10**. In projecting modal shares, three scenarios were considered:

- The low projection (L) represents half of cluster 3 for each transport mode changing to more active modes;
- The moderate projection (M) represents all of cluster 3 for each transport mode changing to more active modes; and,
- The high projection (H) represents cluster 3 and 25% of cluster 2 (based on the proportion of students in the cluster) for each transport mode changing to more active modes.

Even with pessimistic projections, the U-Pass at UWA has the potential to increase the public transport ridership and reduce reliance on car travel by more than 8%. The high projection may seem too optimistic, however with concerted efforts to improve access by active transport modes, it is not out of reach in the medium to long term.

The moderate projection corresponds closely with the actual modal shift during the first year of the comprehensive program implemented at the University of Washington-Seattle (Toor & Havlick 2004) and is therefore considered to be the most accurate projection. The fact that our projections account for the subjective and objective barriers in implementation and do not rely solely on the confidence to change travel modes, makes them more robust than previously reported quantitative impacts (see French, Giles-Corti & I'Anson 2010a and Bleechmore, Giles-Corti & Olaru 2011).

Table 10: Modal share projection for sample only

	Actual	L	M	H
Single-occupant vehicle	51.1%	42.8%	34.5%	30.9%
PT	22.7%	29.8%	36.9%	40.1%
Walk/cycle	14.3%	16.6%	18.9%	19.9%
Carpool/drop off/ motorcycle/scooter	11.0%	9.8%	8.7%	8.1%
Other	0.9%	0.9%	0.9%	0.9%
TOTAL	**100.0%**	**100.0%**	**100.0%**	**100.0%**

5. Discussion

5.1 Implications

The move from transport supply management to travel demand management measures requires increased use of travel behaviour modelling to ensure appropriate decision processes are utilised. Policy measures such as U-Pass programs, parking restrictions and pricing measures rely on a detailed understanding of travel patterns, and the motivators and barriers associated with alternative transport modes. This study contributes to the existing literature by providing additional insights into objective and subjective factors associated with commuting to the University campus, and demonstrates that the implementation of a U-Pass program has the potential to reduce car driving and increase the uptake of active transport modes. A shift towards more active transport modes would also assist in reducing greenhouse gas emissions and alleviating excess parking demand.

Relying on regression and cluster analysis, the results indicate that there are effectively two target groups for active transport measures: those that are particularly motivated to avoid campus parking issues with moderate objective barriers, and those with less significant objective barrier but strong subjective barriers (negative attitudes toward active transport). A U-Pass program should ensure both target groups are encouraged to adopt active transport modes on a regular basis by providing appropriate parking disincentives and encouraging more positive attitudes toward active commuting.

5.2 Limitations

The modal share projections demonstrate the potential for a significant shift from motorised modes toward public transport and cycling under each scenario. However, the projections should be interpreted with caution. The sample to which the modal shift projections are applied is highly unrepresentative of the population as a result of the staff and students survey responses being combined. The most significant difference is the ratio of staff to students: in the sample the ratio is 1 staff to 0.76 students (1,418 : 1,081) whilst in the population the ratio is 1 staff to 5.34 students (3,817 : 20,396). The number of survey respondents was insufficient to allow the dataset to be split by staff and students, and provide statistically significant results. In addition, insufficient information was available to compare domestic and international student travel behaviour and barriers and motivators for active commuting. Finally, the analysis does not account for potential costs to Transperth and the University arising from required service improvements.

5.3 Future research

In future commuting surveys, all respondents should provide barriers and motivators for public transport, walking, cycling, and motorised modes in order to overcome the sample limitations discussed above. This would allow the dataset to be split by staff and students such that the modal share projections could be generalised to the broader campus population. It would also allow all modal shifts to be modelled including those beyond the scope of this study, such as shifts from single- to multiple- occupant vehicles, motorcycling or scootering. Moreover, analysis of costs and impacts of implementing the initiative for the University and transport operator should be assessed.

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Appendix A

Table A1: Structure of the latent constructs consider in the factor analysis

Factor	Latent construct	Variance explained (reliability)	Questions and factor loadings
1	Impedance to public transport (PT) use	54.94% (0.723)	"Public transport between my home and UWA is too infrequent" (0.654), "time involved" (0.556), "distance to UWA is too far" (0.622), "public transport route has too many connections" (0.695)
2	Unpreparedness/weathe r concerns for PT	53.48% (0.562)	"Weather (rain, wind or heat)" (0.451), "additional forward planning would be required" (0.790), "lack of knowledge of quickest and easiest route" (0.473)
3	Inconvenience of PT	46.31 % (0.711)	"Need to travel to/from UWA at night" (0.648), "need to run errands before, during or after work/classes" (0.512), "need vehicle for work/study purposes" (0.622), "too much to carry" (0.514), "need to start work early or finish late" (0.568)
4	Avoid parking by using PT	62.50% (0.849)	"Avoid the need to find parking" (0.817), "potential to save money" (0.601), "cost of parking at UWA" (0.839), "unable to obtain parking permit" (0.531), "available of parking at UWA" (0.833)
5	Enjoyment/health/social benefits of PT	51.41% (0.515)	"Improve of health/fitness" (0.564), "enjoyment" (0.538), "my friends/colleagues use this mode" (0.502)
6	Infrastructure barriers/weather concerns for cycling	53.91% (0.786)	"Lack of secure bicycle parking facilities at UWA" (0.598), "lack of secure lockers" (0.800), "lack of or poor changing/showering facilities at UWA" (0.679), "weather (rain, wind or heat)" (0.518), "necessity of bringing a change of clothes" (0.655)
7	Inconvenience of cycling	46.00% (0.705)	"Need to travel to/from UWA at night" (0.650), "need to run errands before, during or after work/classes" (0.541), "need vehicle for work/study purposes" (0.536), "too much to carry" (0.445), "need to start work early or finish late" (0.672)
8	Lack of road safety/parenting needs	58.27% (0.543)	"Lack of continuous cycle paths to UWA" (0.962), "danger from vehicular traffic" (0.773), "necessity of taking children/to from school/daycare" (0.406)

9	Avoid parking by cycling	56.98% (0.805)	"Avoid the need to find parking" (0.800), "potential to save money" (0.463), "cost of parking at UWA" (0.851), "unable to obtain parking permit" (0.580), "available of parking at UWA" (0.749)
10	Enjoyment/health/social benefits of cycling	49.95% (0.317?)	"Improve of health/fitness" (0.481), "enjoyment" (0.999), "my friends/colleagues use this mode" (0.301)
11	Avoid parking by walking	65.64% (0.821)	"Avoid the need to find parking" (0.989), "potential to save money" (0.653), "cost of parking at UWA" (0.831), "unable to obtain parking permit" (0.410), "available of parking at UWA" (0.909)
12	Infrastructure barriers for walking	72.29% (0.797)	"Lack of or poor changing/showering facilities at UWA" (0.718), "lack of continuous pedestrian paths to UWA" (0.808), "danger from vehicular traffic" (0.768)
13	Infrastructure barriers for active commuting (AC)	74.33% (0.821)	"Lack of or poor changing/showering facilities at UWA" (0.888), "necessity of bringing a change of clothes" (0.628), lack of shower, lockers, or bike parking facilities" (0.844)
14	Lack of road safety	76.67% (0.839)	"Danger from vehicular traffic" (0.570), "lack of continuous cycle paths to UWA" (0.926), "lack of continuous paths leading to and from UWA" (0.936)
15	Impedance for AC	53.96% (0.712)	"Public transport between my home and UWA is too infrequent" (0.666), "time involved" (0.566), "distance to UWA is too far" (0.598), "public transport route has too many connections" (0.654)
16	Inconvenience of AC	47.60% (0.724)	"Need to travel to/from UWA at night" (0.655), "need to run errands before, during or after work/classes" (0.518), "need vehicle for work/study purposes" (0.586), "too much to carry" (0.588), "need to start work early or finish late" (0.588)
17	Avoid parking by AC	58.27% (0.756)	"Avoid the need to find parking" (0.854), "potential to save money" (0.663), "unable to obtain parking permit" (0.412), "available of parking at UWA" (0.717)
18	Enjoyment, health and environmental benefits of AC	62.65% (0.701)	"Improve of health/fitness" (0.814), "enjoyment" (0.600), "personal contributions to reducing air pollution" (0.584)

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