How Far to Live and with Whom? The Role of Modal Accessibility on Student's Choice of Living Arrangements and the Distance they are Willing to Live from University in Toronto

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Abstract

This study investigates the factors influencing university student's living arrangement choices and the distance they are willing to live from their university. Particular attention is given to the effects on these choices by student's typical commuting mode choice to and from campus. The dataset used for the study was collected by a travel survey on postsecondary students across four universities in Toronto. An econometric model is developed to jointly model three choices: student's typical commuting mode choice, their discrete living arrangement choice, and the distance they are willing to live from their campus. The model reveals that the students who are likely to leave the family home for university, also have the tendency to live close to the university. Modal accessibility was found to plays a crucial role in the trade-off between students' choices of leaving their family home and the distance they are willing to live from the university. Choice of staying in their family home is positively affected by larger household sizes and the presence of senior members (age 75+). Walk and cycling accessibility appear to be the most influential factor in the distance students are willingness to live away from their university. Cost of housing, neighborhood environment, proximity to transit, and proximity to friends/family also have significant effects on the influence of modal accessibility in defining student's residence distance from their university. These suggest that affordable housing choices by the university campuses can significantly increase the number of active mode users among the student population in Toronto.

1. Introduction

Understanding living arrangement and resident location choices are key interests of urban planners and policy makers as these have significant impacts on various urban dynamics. However, predicting these can be challenging as there are many complex interdependencies. For example, employment opportunities and accessibility to the transportation alternatives can motivate individual's resident location and living arrangement choices. In turn, residential demand in an area can also influence the surrounding area's employment and transportation structure. Resident location choice also involves various behavioural processes and decisions such as when to move, where to move, and who to live with. Studies have shown that location choice behaviour and relocation probability changes over an individual's life span (Beige and Axhausen 2008; Kim et al 2005; Schirmer et al 2014). These changes are often induced by major milestone events such as getting married, a change in place of employment, the start of a postsecondary education, etc. However, the literature on postsecondary student's travel behaviour and resident location choice have been small in number. This is largely credited to the lack of data available on this niche cohort. In fact, they are often under represented in regional travel studies (Hasnine et al. 2017). For example, in a large scale (5% household sample) travel survey in southern Ontario, postsecondary students constituted only 2.5% of the sample but in reality, they contribute 23% of the area's population (Habib et al. 2017).

One data collection initiative that attempted to better understand postsecondary students' travel behaviour was a multi-university student travel survey in Toronto, the StudentMoveTO (2015). This was a joint effort of four universities with seven campuses in Toronto Area to better understand their students' travel behaviour through a one day travel diary survey conducted in the fall of 2015. This paper makes use of this survey data set to investigate factors influencing university students' living arrangement choice and the distance they are willing to live from the university in relation to the perceived accessibility of various commuting mode choice alternatives. An econometric model is developed to jointly estimate these three choices. Four exclusive living arrangement choices are modelled: living with parents/family, living with a partner, living alone, and living with roommates. For the subset of students who leave their parental home, a resident location choice model is developed to estimate the distance students are willing to live from campus. A travel mode choice model for a typical fall-day is used to compute modal accessibility perceptions which was used as inputs in the living arrangement and residence distance location models.

The remainder of the paper is organized as follows. The first section is a summary of the relevant literature on postsecondary student's mode choice, residence distance location choice, and living arrangement. The paper then discusses the data set used for empirical

investigation and proceeds to explain the formulation of the econometric model. Next, the results of the model are presented along with its policy relevancies. Finally, the paper concludes with a summary and recommendations for future research.

2. Literature Review

Studies show that universities can significantly affect the demographic, economic and housing characteristics of its surrounding neighbourhoods (Cortes 2004; Cisneros 1996; Macintyre 2003). Residential location choice models typically ignore these effects and often cluster the students' residence choice behaviour with the general population (Schirmer et al 2014). However, researchers found that this niche population can exhibit considerably different behaviour from that of the general population (Simons et al. 2017; Zheng et al. 2009). The neglect of this demographic cohort is largely attributed to the frequent under representation of postsecondary student in regional travel surveys (Hasnine et al. 2017). Urban planners and researchers recognize this shortcoming and thus the interest in studying postsecondary student travel behaviour has been gaining some traction in recent years.

Among the few studies on university students' travel behavior, several investigate the mode choice and general travel patterns of students. Overall, many of the mode choice studies conclude that postsecondary students tend to use more active modes of transport, and make more home-based university trips particularly during off-peak periods (Khattak et al. 2011; Wang et al 2012; Zheng et al. 2009; Simons et al. 2017). A survey of four major universities in Virginia showed students living off campus are more likely to drive (Khattak et al. 2011; Wang et al 2012). A similar survey effort, but in the context of university students in Toronto, supports these findings. Hasnine et al. (2017) developed a series of discrete choice models to capture the commuting mode choice behaviour of Toronto's university students and found students travelling longer distances to their school opted for auto-drive and auto-passenger modes. Transit and walk access mode users particularly lived in close proximity to subway stations and highly transit accessible areas (Hasnine et al. 2017). In terms of walking commutes, a study by Manaugh and El-Geneidy (2013) investigated the impact of walking satisfaction on housing choice of students at McGill University in Montreal, Quebec. Their statistical cluster analysis revealed that persons who valued the environment and exercise were likely to choose a home location that requires a longer walk to their destination and were less likely to base their decision on proximity compared to individuals that valued.

It is obvious that the mode choice of students is directly related to the commuting distance between the university and students' residence. However, the body of literature on students' residence location choice is small in number. Some researchers have attempted to investigate postsecondary school choice based on the distance between the schools and

the student's parental homes. Many of these studies reveal that distance from home to school is a key factor in students' university choice (Frenette 2002; Frenette 2003; Pinjari et al. 2011; Card 1993). In Frenette's (2002) econometric analysis of postsecondary participation in Canada, it is found that prospective students living between 40km and 80km from a university are only 69% as likely to attend as students who live closer to the university.

Since commute time is negatively related to residential location choice, Pinjari et al. (2011) showed that individuals generally try to locate within proximity to their work/school. However, their study does realize the tendency to live closer is less pronounced in higher income households compared to lower income households, possibly because higher income households can afford the higher transportation costs (Pinjari et al. 2011). It is evident from many of other studies that income exerts a strong influence on university participation rates. A follow-up study by Frenette (2003) found Canadian students from lower and middle-income families are most negatively affected by living far away from universities. Particularly for students from lower income families, students living beyond commuting distance to a university are less likely to attend university (Frenette 2003; Christofides et al. 2001). Those that live close to postsecondary institutions have relatively higher education and higher income (Card 1993).

In terms of living arrangements, student's decision of continuing to live in their parental home or moving closer to the university has been rarely studied. One of the more relevant studies was done by Sà et al. (2012) which estimated Dutch students' university choice and decision on living arrangements using a nested logit model. It revealed that the two decisions are simultaneously linked and distance deters both students living in their parental home and those choosing to live elsewhere (Sá et al. 2012). Logistic regression models developed by Mulder and Clark (2002) showed that the likelihood of US college students leaving their parental home increases with parental income and is positively affected by the father's education level. Based on the reviewed literature, most studies define living arrangements as binary choices: stay in the parental home, or leave parental home. Many ignore the different possible student living arrangement outside the parental home, such as living alone, with a partner, or with roommates which are investigated in this paper.

As discussed, there have been notable attempts to model university student's mode choice accessibility, residential location, and living arrangements. Though many studies in the reviewed literature allude to the idea that these choices are interconnected in some form, no study has attempted to jointly investigate these three choices. Therefore, this paper contributes to the literature by providing a comprehensive, holistic view of the interactions between the three decisions. The joint models capture the key factors influencing the

important transitional period for university students and their impact on Toronto's urban environment.

3. Data for Empirical Investigation

The data used in this study were retrieved from the StudentMoveTO web-survey, which is a joint data collection effort initiated by four Toronto universities: Ontario College of Art and Design (OCAD) University, Ryerson University, York University, and the University of Toronto. Collectively, the four universities have seven campuses across the city of Toronto with a total enrollment of over 184,000 postsecondary students. In the fall of 2015, survey invitations were sent to the university email address of all current students in the seven campuses. The data collection initiative collected 15,226 survey responses which yield an 8.0% completion rate.

The information collected includes socio-economic, personal and household attributes, as well as a one-day travel diary of their last commuting day to school. In addition, students were asked several questions on their living arrangement, housing characteristics, and commuting patterns. Table 1 provides the summary statistics of select key variables in the sample dataset. Although the mode share values reported are for typical trips in the fall, more than 90% of the students claim to use the same travel modes in the winter. It is evident that majority of students typically use transit to commute between home and school (64%). Active-modes occupy a significant percentage of the mode share, as 19% of respondents walk and 9% cycle. Interestingly, two-thirds of the respondents own a car and possesses a driver's license, though drivers occupy only 6% of the mode share.

To better understand these mode choices, attitudinal questions such as what are the key reasons for choosing their typical commute mode were asked in the survey. Over 50% of the transit users chose transit because it is perceived as one of the most convenient and least expensive options. 20% of these transit users also claimed that they would walk or cycle, though they live too far for those to be realistic options. On a similar note, 80% of walkers chose to walk because of their proximity to campus and it is free of cost. Also, 80% of cyclists find cycling to be one of the faster and least expensive means of transportation. On the other hand, students who use driving as a commuting mode find that driving is their fastest option, and they live too far for other means of transportation to be practical. The small percentage of rideshare commuters state that it saves time and parking expenses, and it is convenient since their carpool partner lives near by. Based on these responses, it is apparent that students' mode choices are highly sensitive to travel time/distance and costs. Sensitivity to costs is understandable as it appears the majority of these students live in low-income households. In terms of distance, the distribution of the distance between student's homes to their main campus appears to skew to the left. On average, their

commuting distance is 12.5km but has an upper limit of approximately 70km. The left skew explains the substantial share of active mode users, as well as transit users.

Table 1. Summary statistics of select variables

Discrete Variables			
Variables	*% Share*	*Variables*	*% Share*
Education level		**Household Income Level**	
Undergraduate	70%	Less than $ 30,000	35%
Graduate	28%	$ 30,000 - 59,999	22%
Other	2%	$ 60,000 - 89,999	16%
Student Status		$ 90,000 - 119,999	11%
Full Time	90%	$ 120,000 - 149,999	16%
Part Time	8%	$ 120,000 - 149,999	6%
Other	2%	$ 150,000 - 179,999	4%
Gender		$ 180,000 +	6%
Female	64%	**Building Type**	
Male	36%	Apartment or Condo	43%
Car ownership		Detached house	32%
Own car	68%	Semi-detached house	14%
Do not own car	32%	Row house	7%
Driver License Ownership		On-campus residence	4%
Possess a driver license	63%	**Household Ownership**	
Does not possess a driver license	37%	Owner	47%
Main mode of transportation in the fall		Tenant	53%
Transit	64%	**Living arrangement**	
Walk	19%	Live with family/parents	53%
Bike	9%	Live with roommate	18%
Driving	6%	Live with partner	17%
Rideshare	2%	Live alone	12%

Continuous Variables				
Variables	*Mean*	*St. Dev.*	*Maximum*	*Minimum*
Distance from home to main campus (km)	12.5	11.8	67.3	0.3
Number of vehicles in household	1.0	1.0	9.0	0.0
Number of years living in current home location	5.6	6.6	50.0	0.0
Household Size	3.2	1.6	20.0	1.0
Age of respondent	24.2	6.9	64.0	16.0
Household Average Age	30.9	8.6	68.0	3.5
Number of dependent children in the family	0.3	0.8	8.0	0.0
Number of seniors (75+) in the family	0.0	0.2	3.0	0.0

The student's sensitivity to cost is also reflected in their residence location choices. Approximately 30% of respondents claimed that the cost of housing was the primary factor influencing their choice of residence. This response corresponds to 53% of respondents living at their parental home since it is the least expensive housing option. 16% of the residence choices are supposedly based on the convenience of walking or biking to campus. Interestingly, 17% of respondents stated that their residence location choice was beyond their control.

In this study, the transportation level-of-service variables (travel time, cost, etc.) for residence to the university is generated by using a regional planning model (traffic assignment component), which is calibrated by using the large regional household travel survey data and is used by the City of Toronto for its planning exercises (Data Management Group 2011).

4. Econometric Model

We modelled three choices jointly and these are:

1. Choice of living arrangements: living with parents/family; living apart from the parents/family, but with a partner, living with a roommate(s), and living alone.
2. Regular choice of mode for a home to the University trips: driving a car, car passenger (carpooling), public transit, bicycle and walk.
3. Distance willing to live from the university for those not living with the parents/family.

The dataset does not provide any information on alternative residence location choices and generating such alternatives would require many strict assumptions that may affect the results of the analysis. So, we proceed to consider the distance between the university and the residence as the continuous variable of choice and modelled it by using direct utility maximization approach. Finally, three alternative choices are investigated and these are discrete living arrangement choice, discrete mode choice, and students' willingness to live from the university which is quantified by a continuous distance variable. It is understandable that these three are correlated choices. We propose that the choices of living arrangement and residence distance are correlated directly through modal accessibility (derived from mode choice) and indirectly through correlated random utility components. Figure 1 depicts the simultaneity of the three choice dimensions under investigation.

Considering random utility-based modelling of choice makings, the utility functions (U) of the three choices are:

$$U_m = (\sum \beta y)_m + \varepsilon_m; \quad \text{m=1, 2, 3, 4 and 5} \qquad (1)$$

$$U_R = (\sum \alpha x)_R + \varepsilon_R \; ; \; \text{R=1, 2, 3, and 4} \quad (2)$$

$$U_l = (\sum \gamma z)_l + \varepsilon_l; \quad l = 1, 2 \text{ and } 3 \quad (3)$$

Here, m indicates mode choice, R indicates living arrangement choice, and l indicates distance willing to love from the university.
Alternative values of m, R and l are indicated in Figure 1.
ε indicates the random components of the utility functions
y indicates the systematic attributes that explain the choices of alternative modes with β as corresponding coefficients
x indicates the systematic variables explaining the choices of living arrangement choice with α as corresponding coefficients
z indicates the systematic variables explaining the choice of resident location defining the distance between residence and the university with γ as corresponding coefficients

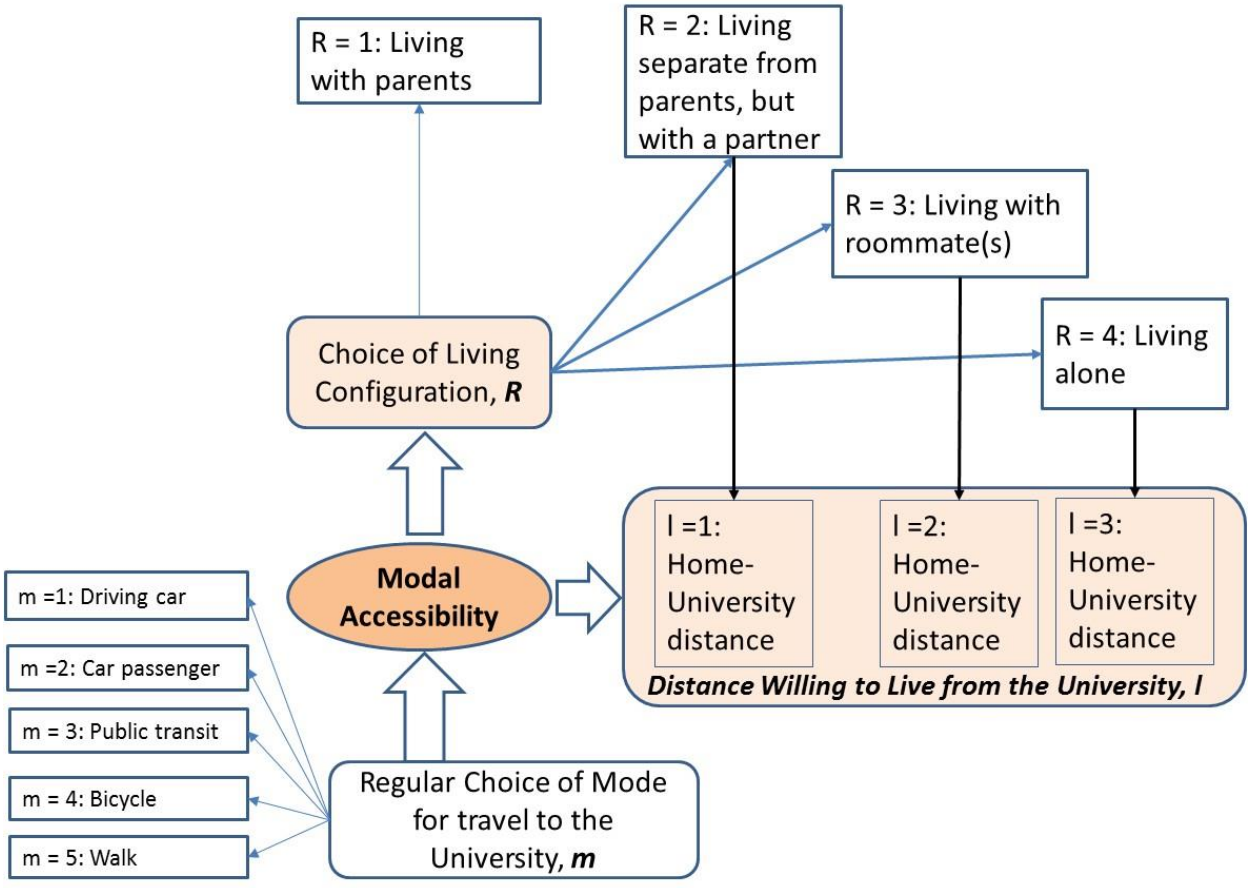

Figure 1: Modelling the influence of modal accessibility on choices of living arrangement and the location of the residence

Equation 1 and 2 are of discrete choices and so the corresponding utility functions are of indirect utility functions, but equation 3 is of continuous distance from the university to the resident location and of a direct utility function. Assumptions of an Independent and Identically Distributed (IID) Type I extreme distribution with unit scale assumptions for ε_m lead to standard multinomial logit models. Thus resulting to the following mode choice model:

$$\Pr(m) = \frac{\exp((\sum \beta y)_m)}{\sum_{m'=1}^{5} \exp((\sum \beta y)_{m'})} \quad (4)$$

As per the properties of RUM and the distributional assumption of ε_m, the expected maximum utility of mode choice is (EMU):

$$EMU = ln\left(\sum_{m'=1}^{5} (\sum \beta y)_{m'}\right) \quad (5)$$

This is also known as modal accessibility (Akbari and Habib 2015). Modal accessibility is a measure of ease of getting access to a particular destination by available modes. The value of such modal accessibility increases with increasing number of alternative feasible modes and decreases with increasing travel time to get to the destination. So, the EMU is a measure of the performances of the available modes and so we consider that this has systematic effects on both choices of resident configuration choice and residence distance location choice. Considering this assumption and an IID Type I Extreme Value distribution with unit scale for ε_R the choice probability of resident choice becomes:

$$\Pr(R) = \frac{\exp((\sum \alpha x + EMU)_R)}{\sum_{R'=1}^{4} \exp((\sum \alpha x + EMU)_{R'}} \quad (4)$$

For the continuous variable, l, considering a log-normal[1] distribution with σ^2 variance for ε_l and a Cobb-Douglas direct utility maximization formulation, the probability of a chosen distance from the university becomes:

$$\Pr(l) = \frac{1}{\sigma} \phi \left(\frac{\ln(l) - ((\sum \gamma z)_l + EMU)}{\sigma} \right) \quad (5)$$

It is also understandable resident configuration and the location choices can be correlated. In the above formulations of resident configuration and location choices, modal accessibility plays a common moderating role linking the systematic utility components of both choices. Such link connects observed systematic components of the two choices, but there could be unobserved correlated factors that influence both choices too. A further

[1] Lognormal distribution assumption helps maintain the fact that the distance must be non-negative.

assumption on correlated observed factors influencing discrete resident configure choice and the continuous distance between the university and the resident choice can be induced by following Lee's transformation technique (Lee 1983; Habib and Hasnine 2017), which is also known as Gaussian Copula approach. Under this approach, the discrete marginal probabilities of resident configuration choice as specified in equation 4 is transformed into an equivalent standard normal random variable. This transformed normal variable is assumed to be jointly distributed with the normal random error ε_l as per a bivariate normal distribution form. The resulting joint probability of resident configuration choice and the residence distance location choice from the university becomes:

$$P(R\&l) = \frac{1}{\sigma}\phi\left(\frac{\ln(l)-((\sum \gamma z)_l+EMU)}{\sigma}\right)\Phi_2\left(\Phi^{-1}\left(\frac{\exp((\sum \alpha x+EMU)_R)}{\sum_{R=1}^{4}\exp((\sum \alpha x+EMU)_{R'}}\right)-\rho\left(\frac{\frac{\ln(l)-((\sum \gamma z)_l+EMU)}{\sigma}}{1-\rho^2}\right)\right) \quad (6)$$

Here, $\phi(.)$ is the probability density function of a univariate standard normal distribution
$\Phi^{-1}(.)$ is the inverse of the cumulative density function of a univariate standard normal distribution
$\Phi_2(.)$ is the cumulative density function of a bivariate standard normal distribution
ρ is the correlation coefficient between the unobserved factors influencing the choices of R and l, which varies between -1 and +1

Under this formulation, the likelihood function (L) of an observation (observed travel mode m; resident configuration type R and distance l) becomes:

$$L = \prod_{R=1}^{4}\prod_{m=1}^{5}\left(\frac{1}{\sigma}\phi\left(\frac{\ln(l)-((\sum \gamma z)_l+EMU)}{\sigma}\right)\Phi_2\left(\Phi^{-1}\left(\frac{\exp((\sum \alpha x+EMU)_R)}{\sum_{R=1}^{4}\exp((\sum \alpha x+EMU)_{R'}}\right)-\rho\left(\frac{\frac{\ln(l)-((\sum \gamma z)_l+EMU)}{\sigma}}{1-\rho^2}\right)\right)\right)^{\delta_R}\left(\frac{\exp((\sum \beta y)_m)}{\sum_{m'=1}^{5}\exp((\sum \beta y)_{m'})}\right)^{\delta_m} \quad (7)$$

Here,
δ_R is an indicator variable for resident type choice R taking the value 1 for type R and 0 otherwise
δ_m is an indicator variable for mode choice m taking the value 1 for type m and 0 otherwise

Equation (7) presents a closed form likelihood function that can be estimated by using the classical maximum likelihood estimation approach. In this paper, we programmed the likelihood function in GAUSS and used its MAXLIK estimation routine for the maximum likelihood estimation approach (Aptech 2017).

5. Empirical Investigation and Policy Relevance

The empirical model is presented in Table 2. The joint model estimates student's typical commuting mode choice to and from university, their living arrangement choice and the distance they are willing to live from the university. We considered a 95 percent confidence limit with expected signs to determine the variables in the model. The final model has a total of 57 parameters. We retained some parameters with lower than 95 percent confidence as those provide behavioural insights. The model fitness is compared against a null model that considered all discrete choices as equally likely and only constants for the continuous distance model component. The adjusted Rho-squared value of the final model is 0.23, which is a reasonably good fit considering the complexity and multiple choices modelled jointly.

The correlation between unobserved factors affecting the choice of living configuration and distance willing to live from the university campus is significant and negative. This indicates that the unobserved variable that influence the choice of not staying in family/parental house also recued the willingness to live far from the university campus. This is intuitive and thus an implicit validation of the captured relationship of the three choices investigated in this empirical model. It refers to the fact that students who leave their family home to attend the university will obviously tend to live close the university campus. However, the fact of the matter is that there are many systematic variables/factors that defy this inherent and implicit choice by allowing students to choose one of the three living configuration choices (except staying in family/parental home) and corresponding residence location that may not be optimal in terms of proximity to campus. In this context, the effects of the investigated systematic variable captured in the model give us clear understandings on the choice constraints of postsecondary student living in big cities, such as Toronto.

The joint model used a simplified mode choice model to make the modal accessibility variable endogenous to the living arrangement and distance choice model as it is an input of these model components. The mode choice model has alternative-specific-constants, travel time and travel cost. This gives a subjective value of travel time savings of approximately $4 per hour, which is a conservative estimate given that this is of regular fall travels. This value can vary for day-to-day trips and with seasons. Since living arrangement and location choices are of longer-term choices than day-to-day trip choices, the mode

choice model representing general fall university trips are considered as opposed to specific school trip mode choice.

The resulting model reveals that the expected maximum utility of mode choice to be statistically significant, thus confirming our speculation that the choice of living arrangement and distance students are willing to live from the university are directly correlated with modal accessibility. The group that appears to be most sensitive to modal accessibility is the students living with roommates. Those living with roommates tend to have a full-time student status and are relatively younger in age. Though individuals in this group are rather likely to own a driving license, they are unlikely to have personal vehicles at their residences. This discrepancy between vehicle ownership and license ownership is explained by the group's low-income level. The living arrangement model shows that those living with roommates tend to have an annual household income less than $30,000, therefore making many of these students financially unfit to own a vehicle. Notably, the residence distance location model suggests that younger individuals choosing to live with roommates are more inclined to live closer to campus.

On the other hand, students choosing to live alone appear to be relatively older than those living with roommates. The age variable is highly significant in their living arrangement and residence distance location models. The distance willing to live from the university model suggests that the older these student are, the more likely they will live further from campus. Notably, income of these students is also low. The low household income level could be attributed to the fact that these are only one-person households comprised of students.

Similar to the students who live with roommates, students who live alone are likely to own a driving license but are unlikely to have personal vehicles. Interestingly, the results suggest that if they own a vehicle they are more inclined to live closer to campus. Initially this statement may seem counterintuitive, however, it could hold some truth. For example, ownership of a vehicle can serve as a proxy for a student's financial status. Provided this is true, it could be hypothesized that those who own a vehicle are of a higher income status and thus can afford to live alone and live closer to campus. Neighborhoods in the vicinity of universities, particularly urban universities, have shown to have higher housing prices (Cortes 2004) and Toronto is no exception.

In terms of students choosing to stay in their parental/family home, their decision is largely influenced by the number of years they have lived in that location and their family's ownership of the home. It could be postulated that families of those who own the home and have lived there for a long time have high family and/or home attachment.

Table2: Empirical Model

Dwelling Configuration Choice Model

	Living with parents		*Living with a partner*		*Living alone*		*living with roommate(s)*	
Variable	*Para*	*t-stat*	*Para*	*t-stat*	*Para*	*t-stat*	*Para*	*t-stat*
Alternative Specific Constant								
	0.000	---	-14.399	-17.34	-12.286	-12.29	-7.016	-6.93
Number of years living in current location (log transformed)								
	1.026	17.71						
Family owning the home								
	0.843	9.03						
Household income less than $30,000 per year								
	0.000	---	0.000	---	0.506	4.70	0.382	4.18
Number of members in the household								
	1.065	17.60	0.648	10.20	0.000	---	0.886	15.40
Numer of dependent children in the household								
	-0.060	-0.68	-0.305	-3.10	0.000	---	-0.650	-5.42
Number of seniors (75+) in the household								
			0.562	4.04				
Number of cars per adult household members								
	0.000	---	-0.073	-0.48	-0.246	-1.59	-0.334	-2.17
Gender: Female								
			0.233	2.35				
Age in years (log transformed)								
	0.000	---	4.874	19.67	4.536	15.17	2.299	7.29
Student: Graduate/Professional								
			0.335	4.33				
Status: not full time								
							-0.318	-2.14
Having a driving lincese								
	0.000	---	0.417	3.64	0.273	2.16	0.338	2.87
Expected Maximum Utility of mode choice								
	0.000	---	0.520	8.93	0.636	8.06	0.957	12.40

Logarithm of the Distance Willing to Love from the University

	Living with parents		*Living with a partner*		*Living alone*		*living with roommate(s)*	
	Para	*t-stat*	*Para*	*t-stat*	*Para*	*t-stat*	*Para*	*t-stat*
Constant			-1.369	-2.58	-0.991	-1.59	3.267	4.47
Gender: Female			0.103	1.42				
Age in years (log transformed)			0.883	5.61	0.804	4.32	-0.593	-2.57
Owning a car			0.105	1.49	-0.130	-2.05	0.000	---
Expected Maximum Utility of mode choice for considering the following factor as the 'Primary factor'in choosing residence								
-Proximity fo public transit			-0.578	-8.63	-0.654	-11.46	-0.447	-4.38
-Ability to walk or bike to campus			-0.789	-15.42	-0.802	-14.58	-0.621	-12.57
-Cost of housing			-0.615	-15.01	-0.653	-11.17	-0.491	-10.09
-Neighbourhood and proximity of family/friends			-0.595	-13.68	-0.697	-13.06	-0.529	-9.69

Mode Choice Model of Regular Trips from Home to the University

	Driving car		*Car passenger/pool*		*Public transit*		*Bicycle*		*Walk*	
	Para	*t-stat*	*Para*	*t-stat*	*Para*	*t-stat*	*Para*	*t-stat*	*Para*	*t-stat*
Constant	2.373	36.07	0.000	---	1.533	26.44	-0.120	-1.79	-2.282	-22.12
Time	-0.022	-21.31	-0.022	-21.31	-0.022	-21.31	-0.022	-21.31	-0.022	-21.31
Cost/fare	-0.330	-18.87	-0.330	-18.87	-0.330	-18.87				

Loglikelihood of full model	-10219
Loglikelihood of null model	-7839.5
Number of parameters in full model	57
Number of parameters in null model	4
Adjusted Rho-Squared value	0.23

Corelation between unobserved factors affecting resident configuraion and location

	Para	*t-stat*
Correlation coefficient	-0.93	-141.27

The household size and the number of seniors over the age to 75 in the parental/family home have considerable positive effects on a student's decision to stay home. Intuitively, this makes sense. Larger families could impose greater responsibilities and chores on the student. Also, the student may need to assist and care for the senior family members. Interestingly, this finding substantiates the statistic mentioned earlier in the paper that 17% of survey respondents said their residence location choice was beyond their control. The number of dependent children in the household has a negative influence on a student's probability of living with parents/family. One plausible rationale could be that students are more inclined to leave their family home because the presence of children makes a loud, distractive environment, not ideal for studying.

Students deciding to live with a partner typically comprise of older students and students with a graduate or professional student status. Similar to students who live alone, the group's willingness to live further from campus increases with age. The distance willing to live from the university model also reveals that those in the group who own a car are willing to live even further from campus. However, the number of cars per adult household member variable exerts a negative, though small influence on the student's probability of living with a partner. Furthermore, driving license ownership exhibits a positive effect on the living with a partner choice option. This could suggest vehicles are likely shared among partners. Interestingly, the group's probability of living further from campus also increases if the student is a female. Moreover, the living arrangement choice model shows a statistically significant positive correlation between female students and the choice of living with a partner. The number of members in the household appears to have a strong explanatory power in the living with a partner configuration model. However, the number of dependent children in the household is negatively correlated with the probability of a student living with a partner. It is possible that those living with their partner and attending school are unlikely to have children at that time.

Across all living arrangements analyzed in the residence location choice model, it is apparent that student's expected maximum utility of mode choice has a profound negative effect on the distance students are willing to live away from the campus. The walk and cycling accessibility of a location appear to be the most influential factor in student's residence location choices. However, other factors such as the cost of housing, neighborhood environment and proximity to friends/family, and proximity to transit follow closely behind.

In the context of policy relevance, we have achieved a better understanding of the motivations and dynamics at play in student's residence choices. The findings of the study suggest that to promote active mode commutes, policy initiatives should be in place to ensure affordable housing options in the proximity to campuses. One method to achieve affordable housing is to increase the residential density permitted in the area as well as

take advantage of the housing's occupancy standards. It is clear from the results that students, particularly full-time undergraduate students, are willing to compromise living space for convenient commutes to campus. Therefore, there is demands for housing with multiple shared dwelling units around the university areas. As for graduate/professional students who tend to live with their partners or live alone, housing options for single and two-person households should also be provided near the university. However, those living alone or with their partners appear less sensitive to commuting distance compared to those living with roommates, thus there should be provisions to ensure a larger percentage of high density, shared housing options adjacent to the university.

However, the land use of the area should not be entirely dominated by residential housing for students. As shown in the study, the neighbourhood environment is an important factor that students consider when choose their residence location. Thus, mixed use is encouraged and it also improves the walkability of the area. Furthermore, planners should ensure the neighbourhoods around the university are highly pedestrians and cyclists friendly as it appears students are inclined to choose these active modes of transport when they are perceived as feasible options. Transit accessibility is important as well for the majority of university students in Toronto use transit to commute.

The study does show that many students hold a driving license though they do not typically own a vehicle, thus there may be a market for a car-share/car-rental program around university campuses. In terms of the students who do not have a choice but to drive to and from campus, universities could consider implementing carpool programs to reduce the parking demand on campus. When creating these carpool programs, the factors motivating current student carpoolers that are revealed in the study should be considered: save on parking cost and time, and proximity to carpool partner(s).

6. Conclusions and Recommendations for Future Research

This paper investigated the typical commuting mode choice, living arrangement choice, and residence distance location choice of students from four universities in Toronto. An econometric model is proposed that jointly models these three choices. The overall objective of the study is to identify the nature and extent of various systematic and random factors influencing university student's residence choice behaviour in order to provide evidence for the planners and policy makers to act upon. Clearly, the implicit and apparently un-captured (by systematic variables) trend is that students who tend to leave the family home to attend the university would prefer to live close to their campus; however, the urban transportation and land use contexts do not allow them to do so optimally. As a result, the trade-off between choices of living configuration and the distance they are willing to live from the University are influenced by these transportation, land use and socioeconomic factors.

The resulting model revealed modal accessibility significantly influence the living arrangement and the residence distance location models. It was found that students choosing to live alone or with roommates are likely to live in low-income households which often have a lower vehicle to household member ratio. Students living with roommates appear to be highly sensitive to modal accessibility. They are also more likely to be younger and hold a full-time student status. On the contrary, those living alone or with a partner tend to be older students, possibly with a graduate or professional student status. The probability of students choosing to stay at home with their parents/family is positively influenced by the size of the household and the number of seniors (over the age of 75) in the household.

For students who are more probable to leave their parental/family home, a residence distance location choice model was developed to estimate the distance they are willing to live away from campus. It was found that for those living with roommates, the younger they are the more inclined they are to live closer to campus. However, for students living with partners and living alone, their likelihood of living closer to campus decreases with age. Intuitively, owning a car allows those living with a partner to be less sensitive to distance in their location choice.

Across all living arrangements, it was apparent that student's expected maximum utility of mode choice has a profound negative effect on the distance students are willing to live away from campus. The walk and cycling accessibility of a location appear to be the most influential factor. Additional factors such as the cost of housing, neighborhood environment and proximity to friends/family, and proximity to transit also have significant effects. This suggests that affordable housing choices by the university campuses can significantly increase the number of active mode users among the student population in Toronto.

This study contributes to a better understanding of university students' residence choice and commuting behaviour. However, the framework in this paper can be extended to estimate student's discrete residence choices, as opposed to using a continuous distance variable. This could help provide more insight on the spatial distribution of students' housing choices and the impact of housing characteristics, such as rental cost, on these choices.

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