



Factors Influencing Commuter Travel Mode Choice - A Study of Travel Survey Data in the Puget Sound Region of the Northwestern United States

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Abstract. Urban commuters are the main participants in urban transportation, directly affecting the planning, design, and operation of urban transportation strategies. The study of commuting modes is a current research hotspot, and studying the effects of factors such as age, gender, and employ on travel mode choices has important reference value for improving urban transportation problems. This research focused on commuters in the Puget Sound area of the Pacific Northwest of the United States, delves into various factors influencing travel mode choices, aiming to provide empirical references for urban transportation planning and management. Using chi-square tests, one-way ANOVA, and multinomial logit regression models, the study found that age, gender, education level, employment status, work location, and commuting frequency significantly influence travel modes. Specifically, the age group of 18-64 years prefers non-motorized transportation; most commuters favor non-motorized transportation regardless of the frequency of commuting; the variability in work location affects travel choices, and a higher level of education increases the tendency towards non-motorized transportation. Moreover, part-time employees lean more towards non-motorized transportation, whereas full-time employees are more inclined to use public/shared transportation, and males are more prone to non-motorized commuting compared to females. The findings of this study provide robust strategic references for urban transportation decision-makers, aiming to foster efficient planning and management of urban transportation.

Keywords: Commuting mode, multinomial logit regression, transportation planning, non-motorized travel

1 Introduction

The efficiency and rationality of urban transportation systems are vital for regional, national, and macro-regional economic expansion and urban evolution. However, given the increasing trend of urban population growth and the rapid rise of motor vehicles, the transportation system of many developing cities is under unprecedented pressure^[1]. Data indicates that the transportation demand of most cities worldwide has

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already surpassed the maximum capacity of their transportation networks ^[2]. In light of this, there is an urgent need to construct and implement innovative policies and strategies to accommodate this surging demand and mitigate the negative effects brought about by the transportation system, such as traffic congestion, frequent accidents, air pollution, and noise pollution ^[3].

Against this research backdrop, a deep exploration of the various variables influencing commuters' travel mode choices holds significant academic and practical implications. This is because these decision variables may have profound effects on the layout of urban transportation infrastructure and the overall urban traffic management strategies. Only when we fully understand these decision-making factors can we formulate more refined and rational strategies, thus enhancing the benefits and convenience of the urban transportation system ^[4]. Research by R.A.M. et al. revealed that income, vehicle ownership, age, perceived safety, and comfort are the primary variables determining the choice between public and private transportation ^[5]. Ko et al. further pointed out that high-income commuters tend to favor commuting modes dominated by private cars ^[6]. Conversely, the travel choices of middle-income commuters may be influenced by a variety of factors, including gender, years of residence, bus stop density, and neighborhood parking conditions. Nkeki and Asikhia's analysis indicates that commuters with lower incomes and lower educational levels are more likely to choose public and non-motorized modes of travel ^[7]. Meanwhile, research by Tembe et al. suggests that, compared to opting for taxis or other public transportation methods, women are more likely to view motorcycles as their preferred mode of transport ^[8].

This study aims to delve deeply into the relationship between commuters' travel mode choices and their personal characteristics, with a particular emphasis on the influence of variables such as age, gender, educational background, employment status, and commuting frequency on travel decision-making. For this purpose, we utilized traffic travel survey data from the Puget Sound area in the Pacific Northwest of the United States, conducted in 2017 and 2019, as the basis for our research. Methodologically, we applied the chi-square test, one-way analysis of variance (ANOVA), and multinomial logit models to identify and quantify the key factors influencing commuters' mode choices. The structure of this research is as follows: The second section provides a detailed description of the data sources and their respective descriptive statistical features; the third section first clarifies the definitions and properties of each variable in the dataset, then evaluates the association of categorical and quantitative variables with travel modes through the chi-square test and one-way ANOVA, culminating in the presentation of the multinomial logit regression statistical results; the fourth section summarizes the research findings, offers conclusions, and engages in an in-depth discussion on related topics.

2 Data sources and statistics

This study utilized travel survey data from the Puget Sound area for the years 2017 and 2019. This area, located in the coastal region of the Pacific Northwest of Washington

State, encompasses 82 towns, approximately 4 million inhabitants, and 1.5 million households. The Puget Sound Regional Council (PSRC) collected individual travel behavior information during April to June in both 2017 and 2019 for transportation demand management and long-term trend analysis. The design of the variables, categories, coding, and data statistics used in this study are presented in Table 1, with "Travel modes" as the dependent variable and the remaining variables as independent variables.

Table 1. Variable categories and statistics

Variable	Category-Code	Frequency (Percentage)
Gender	Female-1/Male-2	3136(48)/3441(52)
Age	65 years-1/18-64 years-2	6311(96)/266(4)
Employ	Self-employed-1/ full time job-2/part time job-3	5454(83)/772(12)/351(5)
Education	Associates degree-1/Bachelor degree-2/Graduate degree-3/High school graduate-4/Less than high school-5/Some college-6/Vocational training-7	351(5)/2872(44)/2234(34)/298(5)/52(1)/614(9)/156(2)
Workplace	Usually the same location-1/Workplace regularly varies-2	5638(86)/ 939(14)
Commuting days	1 day a week-1/2 days a week-2/3 days a week-3/4 days a week-4/5 days a week-5/6-7 days a week-6/A few times per month-7/Less than monthly-8	70(1)/198(3) /463(7) /799(12) /4480(68)/419(6)/83(1)/65(1)
Travel modes	Non-motorized travel-1/Non-public transport-2/Public or shared transportation-3	979(15)/3247(49)/2351(36)
Numtrips	Number of trips (quantitative variable)	

Note: shared transportation refers to carpooling, ride-sharing, bike sharing and other means of transport shared with others in addition to public transportation.

3 Methodology

3.1 Based on the chi-square test and one-way analysis of variance (ANOVA) for difference testing.

This study used chi-square tests to analyze the differences in "mode of travel" associated with six variables: age, gender, employment, education, place of work, and days of commuting. As can be seen in Table 2 below, the different "mode of travel" samples differed significantly in all variables.

Table 2. chi-square test value

Index	Age	Gender	Employ	Education	Workplace	Commuting days
p	0.000**	0.000**	0.000**	0.000**	0.000**	0.000**

* p<0.05 ** p<0.01

Meanwhile, ANOVA test was used to verify that there was a significant difference (p<0.05) between different "modes of travel" and "number of trips", and the results are shown in Table 3 below.

Table 3. ANOVA test value

Numtr ips	Travel modes			p
	Non-motorized travel(n=979)	Non-public transport(n=3247)	Public or shared transportation(n=2351)	
	13.49±15.65	11.62±15.21	12.37±14.80	0.002**

* p<0.05 ** p<0.01

3.2 Multinomial logit regression

The multinomial Logit regression is a statistical method often used to study the influence of X on Y, where X can be used for categorical data, and Y is multi-category categorical data. In this research, all categorical variables have been dummy variable. The multinomial Logit model is a type of generalized linear model that establishes the relationship between explanatory variables and a response variable with multiple categories [9]. During the multinomial Logit regression, the independent variable coded as 1 and "Non-motorized travel" are set as the reference categories. The established multinomial logit model is presented in Table 4.

Table 4. Multinomial Logit Regression Results

	Regres- sion coeffi- cient	OR	p		Regres- sion coeffi- cient	OR	p
Commuting days:							
Less than monthly	-2.722	0.066	0	Public or shared transportation	-3.178	0.042	0
A few times per month	-1.027	0.358	0.101		-1.403	0.246	0.031
6-7 days a week	-1.348	0.2614	0.014		-1.703	0.182	0.002
5 days a week	-0.982	0.375	0.068		-1.252	0.286	0.021

4 days a week	-0.872	0.41 8	0.1 08	-1.163	0.3 13	0.0 35
3 days a week	-0.448	0.63 9	0.4 2	-0.586	0.5 56	0.2 97
2 days a week	-0.233	0.79 2	0.6 92	-0.796	0.4 51	0.1 85
Workplace regularly varies	0.879	2.40 9	0	0.295	1.3 43	0.0 37
Education: Vocational/technical	-0.435	0.64 7	0.1 72	-0.654	0.5 2	0.0 65
Some college	-0.22	0.80 2	0.3 61	-0.145	0.8 65	0.5 74
Less than high school	0.591	1.80 5	0.3 61	1.088	2.9 68	0.0 99
High school graduate	0.144	1.15 4	0.6 24	-0.049	0.9 52	0.8 77
Graduate/post-graduate degree	-1.101	0.33 2	0	-0.582	0.5 59	0.0 08
Bachelor degree	-1.024	0.35 9	0	-0.457	0.6 33	0.0 37
Employ: part time job	-0.422	0.65 6	0.0 35	0.092	1.0 96	0.6 86
full time job	0.308	1.36 89	0.0	0.863	2.3 7	0
Gender: Male	-0.498	0.60 8	0	-0.526	0.5 91	0
Intercept	3.729	41.6 33	0	2.289	9.8 66	0

4 Results and discussion

(1) Age:

In the multinomial logit regression analysis examining how age affects mode choice, the group aged 65 and above was selected as the reference category. Compared to the group aged 65 and above, the odds ratio for the 18-64 age group choosing non-motorized travel relative to non-public transport significantly decreased by 0.766 (P=0.001). This suggests that individuals aged 18-64 are more likely to opt for non-motorized travel modes compared to those aged 65 and above.

(2) Commuting days:

In the Logit regression, using those who commute once a week as the baseline, the preference for non-motorized transportation was significant across all commuting frequency groups. Specifically, the coefficients for those who commute less than once a month and a few times a month were -1.403 (P<0.001) and -2.722 (P=0.031), respec-

tively, indicating a strong preference for non-motorized transportation. The preference coefficients for those who commute 6-7 days, 5 days, and 4 days per week were -1.348/-1.703 ($P=0.014/0.002$), -0.982/-1.252 ($P=0.068/0.021$), and -0.872/-1.163 ($P=0.108/0.035$), respectively. The above results indicate that there is no significant correlation between commuting frequency and travel modes, most commuters have a significant preference for non-motorized transportation methods.

(3) Workplace:

Based on the Logit regression analysis, the group with frequently changing workplaces has a log odds ratio of 2.41 ($P<0.001$) for choosing non-public transportation over non-motorized travel methods when compared to those with a fixed workplace location. Moreover, when selecting public or shared transportation modes instead of non-motorized travel methods, the log odds ratio is 1.34 ($P=0.037$). This indicates that compared to individuals with a fixed workplace location, those with frequently changing workplaces significantly lean towards non-public transportation and public or shared transportation options in their travel choices.

(4) Education:

In the multinomial Logit regression analysis exploring the relationship between educational background and travel mode choice, individuals with an associate degree were taken as the reference group. The results indicate that, compared to the reference group, individuals with a graduate/postdoctoral degree have log odds ratios decreased by 1.101 and 0.582 for choosing non-public transportation and public/shared transportation modes, respectively, both reaching statistical significance ($P<0.01$). Similarly, for individuals holding a bachelor's degree, the log odds ratios were respectively reduced by 1.024 and 0.457 ($P<0.05$). This suggests that individuals with higher educational attainments are more inclined towards non-motorized modes of travel than those with an associate degree.

(5) Employ:

In the multinomial Logit regression analysis examining the impact of employment status on travel mode choice, self-employed individuals were used as the reference group. The results indicate that, compared to self-employed individuals, part-time employees have a significantly reduced log odds ratio of 0.422 ($P<0.05$) for choosing non-public transportation over non-motorized travel, with no significant difference in their choice for public/shared transportation ($P=0.686$). In contrast, full-time employees have a significantly increased log odds ratio of 0.863 ($P<0.01$) for choosing public/shared transportation, but the difference in their choice for non-public transportation is not significant ($P=0.089$). This suggests that part-time employees are more inclined towards non-motorized travel, while full-time employees tend to prefer public/shared transportation.

(6) Gender:

In the multinomial Logit regression analysis, females were used as the reference group to investigate how gender influences travel mode choices. The results demonstrate that, compared to females, males have significantly reduced log odds ratios of 0.498 and 0.526 for choosing non-public transportation and public/shared transportation, respectively, over non-motorized travel (both $P<0.01$). This suggests that, compared to females, males are more inclined towards non-motorized travel modes.

5 Conclusion

This paper analyzed the relationship between travel mode choices of commuters in the Puget Sound region of the Pacific Northwest of the United States and their individual characteristics, including age, gender, education level, employment status, workplace location, and commuting frequency. Employing the chi-square test, one-way ANOVA, and multinomial logit regression models based on transportation survey data from 2017 and 2019, this research identified and quantified the key determinants affecting travel mode choices. The findings indicate that age, gender, education level, employment status, workplace location, and commuting frequency all have significant impacts on travel modes. This study offers robust strategic insights for urban transportation decision-makers, aiming to facilitate effective urban transportation planning and management. However, the data used in the research are static and do not capture changes over time. Future research could consider broadening its scope, utilizing panel data to capture dynamic changes, thereby offering a more comprehensive perspective.

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