Estimating students' preferences in a pedestrian environment via stated choice analysis

Giovanni VELEZ[a], Taleen Der HAROUTIOUNIAN[a,1], and A.K.M. Kausarul ISLAM[b]

[a] School of Urban Planning, McGill University, Montreal, Quebec, H3A 2K6 Canada
[b] Department of Geography, Planning and Environment, Concordia University, Montreal, Quebec, H3G 1M8 Canada

Abstract

The advent of peak oil as well as the environmental and health effects of automobile use has prompted urban planners to search for ways to make alternative modes of travel, particularly walking, more attractive. A number of studies have shown that the attributes of the pedestrian realm does have influence on an individual's walking behaviour. This research aims to contribute to the body of knowledge by examining the attributes of the pedestrian environment that create a favourable walking experience using students as units of analysis. The study identified five attributes of the pedestrian environment and a stated choice survey was administered to a sample of university students at Concordia University in Montreal, Quebec, Canada to examine whether these attributes have any influence on their walking behaviour. Results show that street lanes, sidewalk width, presence of trees and volume of pedestrians have significant influence on increasing the chances that a student will choose to walk along a particular route to reach their destination. Direction of traffic, on the other hand, had no effect on students' walking preference in a pedestrian environment. The analysis suggests that making sidewalks wider, adding more trees, decreasing the number of lanes and minimizing crowding of streets would improve walkability of streets in downtown Montreal, particularly near university campuses. Identifying these street attributes would give urban planners and policymakers information in improving environments favourable for walking in a downtown area.

Keywords: stated choice, pedestrian realm, walking, route choice, street environment

[1] Corresponding author. Email: taleen.derharoutiounian@mail.mcgill.ca

1 INTRODUCTION

Over the years the number of automobiles has continued to rise, making congestion and parking the largest issues in major cities and downtown areas where space is limited. In 2005, 29 urban areas in the U.S. were experiencing congestion averaging 40 hours or more of delay per week for each traveler. According to transportation researchers, these congestion levels will increase significantly: by 2030, 58 urban areas will have severe levels of congestion (Staley & Moore, 2009). The problems related to the automobile's impact on the environment and people's health further add to the urgent need to solve this problem. With these problems continuing to grow, planners are now eagerly searching for the best ways to make other modes of travel – particularly walking – more attractive.

Previous research suggests that the pedestrian realm of the street plays a role in whether a person will choose one route over another to get to a given destination. Several studies have been conducted on the relationship between walking and factors in the built environment, particularly on the 3Ds – density, diversity and design (Cervero & Kockelman, 1997). Studies that focus on the design aspect regard the design of the pedestrian realm as one factor related to levels of walking. This factor includes attributes such as sidewalk width, building setback and landscape features.

Most of this research divides walking into two primary types: utilitarian and recreational. The main difference between the two is whether or not a person has a predetermined destination in mind when walking. Walking is considered recreational if the person has proceeded to walk without any destination in mind, as when someone goes for a walk around a neighbourhood. On the other hand, walking is considered utilitarian if the person has proceeded to walk with a destination in mind, as when someone is walking to work.

Current research contains mixed results concerning the relationship between particular design elements and pedestrian activity. Some have found correlations between the presence of certain attributes and higher levels of walking. Forsyth et al. (2008) found daily walking trips were positively correlated with the presence of sidewalks, street lights and streets with traffic calming elements. Similar results were noted by Rodriguez and Joo (2004), who found the slope of the terrain and the percentage of sidewalks available along the shortest route to a destination were positively associated with an increase in walking. Even the ability to see public spaces and buildings with commercial functions while walking has been shown to increase pedestrian movement (Foltete & Piombini, 2007).

On the other hand, some studies have come to different conclusions. Research conducted by Crane & Crepeau (1998) found that neither land use nor street network design of an area influence travel behaviour. In another study, Seneviratne & Morrall (1985) found factors related to distance and habit were more important than pedestrian realm attributes when choosing a route in a Central Business District (CBD). Further, some studies have differentiated the impact of the built environment by the type of walking, with most finding that design elements have a greater influence on recreational walking than on utilitarian, destination-oriented travel (Handy, 2004).

Due to the mix of evidence generated by these studies, the reliability and validity of their conclusions are still open to debate. Inconsistencies in these findings are attributed to a number of reasons. First, most research on the topic address these elements in bulk under a 'pedestrian-friendly' category rather than studying the contribution of each element individually (Crane & Crepeau, 1998). This creates confusion as to which attributes actually play a role in influencing the route a pedestrian would choose if given various options to reach a destination.

Second, even when the elements are individually considered, each attribute may be defined in different ways. This ambiguity leads researchers to use different measurement tools that would produce inconsistent results from one study to another. The challenge of objectively measuring these subjective attributes is a topic that researchers are still struggling with (Ewing & Handy, 2009).

By studying the contribution of each attribute individually, this study provides a better understanding of which attributes have the most influence on encouraging people to walk along one route over another. This is an important knowledge to have especially during recent economic conditions that have limited municipal spending. If streets are to be improved to become more attractive for pedestrians, resources must be carefully spent on improving the most influential attributes of the pedestrian realm to make the spending worthwhile.

This study aims to examine whether the pedestrian realm of available route options influences which route a student will choose to take when heading to a destination, and if so, which of the attributes found in this realm contribute the most in creating a favourable pedestrian environment for walking. This research contributes to the existing literature in two key ways. First, the researchers used a Stated Choice (SC) survey method, which is a measurement tool that has not been used as often in pedestrian research, to allow the survey to be focused on a few key elements of the pedestrian realm. Second, a focus group among students was used to ensure consistency of definitions concerning elements of the design of the public realm. Through this research it is anticipated that this study would provide clearer results that would contribute to the ongoing debates surrounding this topic.

2 METHODOLOGY

2.1 Respondents and Location

Due to time constraints, this study was conducted within the Sir Gorge William campus of Concordia University, which is situated in downtown Montreal, Quebec. More specifically, the study was administered to students in the Henry F. Hall building, which is located along Maisonneuve Boulevard between Bishop and Mackay Streets. This building was chosen as the main site for this study given its role as a central hub for most social science departments, undergraduate disciplines and student association offices, thereby providing a diverse student sample for the study.

During 2009-2010 school year, the university has a total student population of 45,126 (Concordia University, 2010). Undergraduates comprised 77 percent of the total population, 15

percent were graduate students while the remaining were under continuing education. The university has four major faculties with more than 400 programs of study.

The Henry F. Hall building is surrounded by several major streets, and as such it was assumed that students of this campus would have experienced a variety of different types of street environments. There are also several branded chain restaurants (Tim Hortons, McDonalds, KFC, etc.) located on nearby streets that cater to students of Concordia University. Given these conditions, this study focused on which route students would choose to take when heading to a specific place to eat.

2.2 Stated Choice Survey Design and Data Collection

This research used both qualitative and quantitative methods to collect data. First, a preliminary investigation of the existing literature was done to find relevant information regarding elements of the pedestrian realm and their impact on utilitarian walking behaviour. As mentioned in the literature review of this paper, the results found from this research concerning specific design elements are mixed, however attributes were still noted to keep a thorough list of what was found to be significant by other researchers. The characteristics that were found to be significant and were relevant to a student population were noted for use in the questionnaire.

In order to identify and confirm the significant pedestrian realm attributes and their corresponding levels identified in the literature, it was decided that a focus group study would be conducted with a collection of 6 Concordia University students randomly selected from the Henry F. Hall building. Each researcher interviewed 2-3 university students. These miniature focus group sessions were conducted face-to-face, over the telephone and through online forums such as Facebook. University students were selected as participants for the focus groups since university students would be the respondents for the survey. It was assumed that at the very least this match between education level of respondents and participants of the focus groups would produce reliable results.

Each researcher followed the same structure of questioning in the focus groups. First, the important attributes of the pedestrian realm identified by the participant were noted and discussed. Second, the participants were asked how they would categorize levels of their identified attributes into two categories. Attributes the participants considered important include: presence of trees, sidewalk width, street cleanliness, street alignment, street furniture, number of intersections, direction of traffic flow, number of lanes, and volume of pedestrians on the sidewalk.

A final list of important attributes and their corresponding levels was produced by combining the responses from the focus groups and the findings from the literature review. The final list contains 5 attributes with 2 different levels each (**Table 1**).

A stated choice survey was designed using the information gained from the literature review and focus group sessions. There were two parts in the survey. The first section captured socio-demographic information about the respondent through 5 close-ended questions and 1 open-ended question. The close-ended questions asked about the respondent's age, sex, level of

study, student registration status and ethnic affiliation. The open-ended question asked about the respondent's program of study. Since Concordia has more than 300 programs of study, 5 broad program categories were created to use for coding after the results were obtained. These 5 categories were arts, social sciences, natural sciences, business and engineering.

The second part of the survey contained the main stated choice questions. This section began with a general question asking students to imagine a hypothetical situation where they must choose one route over another to reach their favourite restaurant from the Henry F. Hall building. A set of ten sub-questions followed, each containing a pair of routes that differentiated by different levels of the 5 attributes identified in the final list made from the focus group session. Students were asked to choose one route from the pair. Since the route choices had to differentiate solely by the chosen attributes used to describe the pedestrian realms, the general question also notified students that distance, time and all other design elements were constant.

The survey was developed using a full factorial experimental design using 5 attributes and 2 levels. Sawtooth software was used to aid in the design of the survey. Three blocks (i.e. three versions of surveys) were designed, with each containing 10 sets of alternative choice questions.

2.3 Sampling Method

A simple random sampling was employed to administer the survey. Researchers were either stationed on the ground floor of the Henry F. Hall building, or on one of the many floors of the building, depending on the day of the week and the time of day. To keep the sample random, researchers approached every third person they saw on the floor they were stationed with the intention of administering all 60 surveys.

3 RESULTS AND DISCUSSION

The survey was administered to a total of 60 students. With 10 stated choice questions in each version of the survey, a total of 600 (60 responses x 10 questions) observations were collected and used as the data set for the analysis. A respondent profile based on the survey results is presented, followed by an analysis of the data on attributes of the pedestrian realm based on a multinomial logit model that influence utilitarian walking among Concordia University students.

3.1 Respondents Profile

Approximately 52 percent of the respondents in the survey were male and 48 percent female. About 50 percent of the respondents were 22-25 years, 35 percent were 18-21 years, 12 percent were 26-29 and 3 percent were more than 30 years of age.

Concerning program and level of study, the majority of the respondents were undergraduate students, with only 9 graduate students surveyed. Approximately, 33 percent of

the students surveyed were in the arts program, 28 percent in social sciences, 15 percent in engineering and the rest of the students were under natural sciences and business programs (**Figure 1**).

For the students' registration status, approximately 67 percent of the students surveyed were Quebec residents, 25 percent were Canadian (other than Quebec) residents, and 7 percent were international students. Only one respondent did not indicate his/her registration status.

Regarding ethnic affiliation, approximately 55 percent of the students were white, 23 percent were Asian, 12 percent were Afro-American/Canadian, 5 percent had a mixed ethnic background and 3 percent were Latino.

3.2 Stated Choice Analysis

A stated choice model was used to define the choice of a pedestrian environment on a particular route (Y) as a function of the attributes of the pedestrian environment. Individual attributes of the pedestrian environment model were specified in the following linear form and were estimated using the multinomial logit regression:

$$Y = \beta_{lanes} + \beta_{sidewalk} + \beta_{street} + \beta_{trees} + \beta_{volume}$$

Louviere, Hensher & Swait (2000) mentioned several advantages of using the multinomial logit regression particularly in understanding stated choice information. Given that most of the variables included in the survey are discrete, using the logit model is a good method to understand the relationship between the pedestrian realm attributes and route choice among students. To estimate the model using Biogeme software, 80 percent of the data (480 observations) was used and the remaining 20 percent (120 observations) was used for validation.

Table 2 contains the estimation results for the basic model based from 480 observations. The multinomial logit model has a log-likelihood difference of -51.84 and an adjusted rho-square of 0.141, obtained from the five main pedestrian realm attributes. All coefficients of the variables are right-sided as they coincide with the results from the histogram analysis. This study found that three of the attributes – trees, lanes and volume of pedestrians - were statistically significant at the 95 percent confidence level. Trees and volume of pedestrians show positive coefficients indicating that if routes have trees or a low volume of pedestrians then the odds of choosing those routes increase by 174.6 percent and 95.6 percent respectively. The finding related to presence of trees is supported by Forsyth et al. (2008) which found trees on sidewalks often produces calming effects to pedestrians. The negative coefficient on number of lanes indicates that the greater the number of lanes, the odds of choosing that route decreases by 19.1 percent.

Sidewalk width just missed being statistically significant at the 95 percent confidence level by having a t-statistic value of 1.93. However, it has a p-value of 0.05, which sits right on the boundary for considering whether a variable is statistically significant. A variable is considered statistically significant if it has a p-value lower than 0.05, which indicates that the chances of the null hypothesis being true (ie. that the variable has no influence) is small. After considering its preference in the histogram analysis, it was judged for the purpose of this report

to consider sidewalk width as statistically significant at the 90 percent confidence level. This indicate that the wider the sidewalk, the greater the chances that students will choose that route.

Street direction, on the other hand, was not significant in this model with a t-statistic value of -0.31 and a p-value of 0.75. This coincides with the histogram analysis results, which indicated no difference in preference between one-way or two-way streets.

While the results present a good model to explain factors influencing walking behaviour of students at Concordia University, the researchers were interested to know whether the respondents' socio-demographic characteristics could also have an effect in choosing a particular route. Likewise, there was also a desire to improve the model by improving the overall goodness-of-fit indicators (likelihood ratio test and adjusted rho-square). As a result, a second model was created by combining socio-demographic characteristics with the main attributes of the pedestrian environment.

Using the same number of observations in the data set, **Table 3** contains the estimated model with the socio-demographic characteristics of respondents and the main attributes of the pedestrian realm. The multinomial logit model has a log-likelihood difference of -60.04 and an adjusted rho-square of 0.156, which is better than the previous model. While the pedestrian realm attributes were still used to run model, three new variables were included:

$$Y = \beta_{lanes} + \beta_{sidewalk} + \beta_{street} + \beta_{trees} + \beta_{volume} + \beta_{engtrees} + \beta_{manual} + \beta_{socival}$$

The estimates show that five variables are statistically significant at the 95 percent confidence level and all coefficients are right-sided. Similar to the previous model's results, trees and volume of pedestrians still maintained positive coefficients indicating that if routes contain trees or have a low volume of pedestrians then the chance of choosing that route increases by 165.1 percent and 103.4 percent respectively.

This model adds to this result by showing that students in certain programs of study will be more likely to choose routes with these attributes over others. For trees, students in engineering programs have high explanatory influence to presence of trees given the results of its t-statistics and p-value. This means that all other things being equal, students who are into engineering programs are more likely to choose a route with trees over students in other programs. For volume of pedestrians, students in social science programs have low preference in choosing routes with low volume of pedestrians. The coefficient shows that the odds of these students choosing a route with low volume of pedestrians decreases by 54.8 percent compared to students in other programs. Thus, students in social science programs will be less likely to choose a route with this characteristic over students in other programs.

Again, as with the previous model's results, the negative coefficient for number of lanes indicates that the greater the number of lanes, the odds of choosing that route decreases by 20.1 percent. Meanwhile, men and volume of pedestrians and sidewalk width were statistically significant at 90 percent confidence level. The coefficients would mean that male students at Concordia University are inclined to choose routes with lower volume of pedestrians and that more students, in general, prefer to walk on wider streets. Street direction, on the other hand, was still not significant in this model.

It is important to note that during the estimation stage other socio-demographic characteristics such as age, registration status and ethnic affiliation were tested in the model, however, no significant results were obtained in relation to the pedestrian realm attributes.

The remaining 20 percent of the data set (120 observations) was used to validate the final model. **Figure 3** shows the comparison between the actual and predicted choices between two alternative routes. The validated data shows no large difference between the actual choices and the predicted ones. This also implies that the model does a good job predicting the frequency of choosing the routes preferred by students to walk.

Looking further at the frequency of the predicted probability of actual choices (**Figure 4**), the histogram shows a strong positive relationship based on the attributes of the pedestrian realm and the preferred route chosen by the students. Given this study had two alternative route options, values from 0.5 and beyond in the histogram shows that the model predicted 76 percent out of the 120 observations in the validation sample. Thus the model does a relatively good job in assigning high probabilities in choosing routes with better attributes in the pedestrian realm.

4 CONCLUSION

The results demonstrate that the design of the pedestrian environment does influence route choice among students when heading to a particular destination. Concordia University's location in downtown Montreal offered a prime location to study this relationship. Here, students have many opportunities to walk to various places of interest by taking various different routes. Whether a student chooses one route to reach a location over another would depend on the characteristics of the routes and how users perceived them.

Two findings from this study stood out as particularly relevant for future planning and policy efforts. First, the stated choice survey showed that the attributes of the pedestrian environment did have considerable influence over route choices among students. Second, certain attributes used in this survey did stand out as having more influence over others, and thus could be used as a reference to improve streets to promote walking in downtown Montreal.

While this study did not identify any specific routes surrounding Concordia University's Henry F. Hall building to serve as a reference point for improvement, it is important to note that the pedestrian realm attributes identified as important were based on perceived responses from students. As such, urban planners and policy makers should consider the results from this research and consider the following improvements to make routes along university campuses more 'student-friendly' where possible:

- Making sidewalks wider
- Decreasing the number of street lanes
- Adding more trees
- Designing sidewalks to have low pedestrian volume

The results of this study further suggest that urban planners could utilize these attributes as references to improve the design of the pedestrian realm along streets in general. This study supports the principle that thoughtful design can influence the likelihood that someone will choose to walk along certain streets over others. By paying attention to how certain pedestrian realm attributes can increase walking, streets can be designed to encourage active modes of transportation, strengthen aesthetic features of the street and improve public health.

Although this study had a number of limitations due to time and resource constraints, it demonstrated how the stated choice survey method can be applied to explore the relationship between route choice and characteristics of the pedestrian realm. Further research on this topic should consider improving the scales and definitions for measuring the attributes to ensure everyone understands the attributes in the same way. Although the focus groups conducted in this study helped clarify some ambiguous terms, further fine tuning of definitions could improve the reliability and validity of the research. Using a larger focus group could also generate other important attributes that could be included in the model. Further, another way to expand on this research would be to test this method with other groups of pedestrians aside from students to determine whether the attributes considered in this study would also hold true for other users.

REFERENCES

Cervero, R. & Kockelman, K. (1997). Travel demand and the 3Ds: Density, diversity and design. *Transportation Research D, 2*(3), 199-219.

Concordia University. (2010). Fast Facts. http://www.concordia.ca/about-concordia/who-we-are/fast-facts/. Accessed on 05 December 2010.

Crane, R. & Crepeau, R. (1998). Does neighbourhood design influence travel?: A behavioural analysis of travel diary and GIS data. *Transportation Research D, 3*, 225-238.

Foltete, J.C. & Piombini, A. (2007). Urban layout, landscape features and pedestrian usage. *Landscape and Urban Planning, 81*, 225-234.

Forsyth, A., Hearst, M., Oakes, J.M., & Schmitz, K.H. (2008). Design and destinations: Factors influencing walking and total physical activity. *Urban Studies, 45*(9), 1973-1996.

Handy, S. (2004). *Critical assessment of the literature on the relationships among transportation, land use, and physical activity*. Department of Environmental Science and Policy, University of California, Davis. Prepared for the Committee on Physical Activity, Health, Transportation, and Land Use, July.

Louviere, J.J., Hensher, D.A., & Swait, J.D. (2000). *Stated choice methods: Analysis and application*. Cambridge University Press: New York.

Rodriguez, D.A. & Joo, J. (2004). The relationship between non-motorized mode choice and the local physical environment. *Transportation Research Part D, 9*, 151-173.

Seneviratne, P.N. & Morrall, J.F. (1985). Analysis of factors affecting the choice of route of pedestrians. *Transportation Planning and Technology, 10*, 147-159.

Staley, S.R. & Moore, A.T. (2009). *Mobility first: A new vision for transportation in a globally competitive twenty-first century*. New York: Rowman & Littlefield Publishers.

TABLES

Attributes	Level 1	Level 2
Trees	With	None
Sidewalk	Narrow (5')	Wide (8')
Lanes	2	4
Direction	Two-way	One-way
Volume	Low	High

Table 1: The final list produced by combining the responses from the focus groups and the findings from the literature review.

Variable	Coefficient	Exp(b)	Std error	t-test	p-value
lanes	-0.212	0.809	0.0636	-3.33	0.00
sidewalk*	0.0974	1.102	0.0505	1.93	0.05
street	-0.0451	0.956	0.144	-0.31	0.75
trees	1.01	2.746	0.135	7.49	0.00
volume	0.671	1.956	0.124	5.42	0.00
Number of observations	480	Rho-square		0.156	
Null log-likelihood	-332.711	Adjusted rho-square		0.141	
Final log-likelihood	-280.871	Final gradient norm		+1.326e-003	
Likelihood ratio test	103.680				

Note: * - significant at 90% confidence level

Table 2: Model estimation results for pedestrian realm attributes and route choice.

Variable	Coefficient	Exp(b)	Std error	t-test	p-value
BETA_engtrees	1.02	2.773	0.421	2.41	0.02
BETA_lanes	-0.224	0.799	0.0646	-3.47	0.00
BETA_manvol *	0.440	1.553	0.244	1.80	0.07
BETA_sidewalk*	0.0975	1.102	0.0519	1.88	0.06
BETA_soscivol	-0.793	0.452	0.268	-2.96	0.00
BETA_street	-0.0418	0.959	0.147	-0.28	0.78
BETA_trees	0.975	2.651	0.146	6.66	0.00
BETA_volume	0.710	2.034	0.190	3.73	0.00
Number of observations	480	Rho-square		0.180	
Null log-likelihood	-332.711	Adjusted rho-square		0.156	
Final log-likelihood	-272.670	Final gradient norm		+8.248e-004	
Likelihood ratio test	120.082				

Note: * - significant at 90% confidence level
engtrees – students in engineering program and presence of trees
manvol - men and volume of pedestrians
soscivol - students in social science program and volume of pedestrians

Table 3: Model estimation results for pedestrian realm attributes and route choice with sociodemographic characteristics considered.

FIGURES

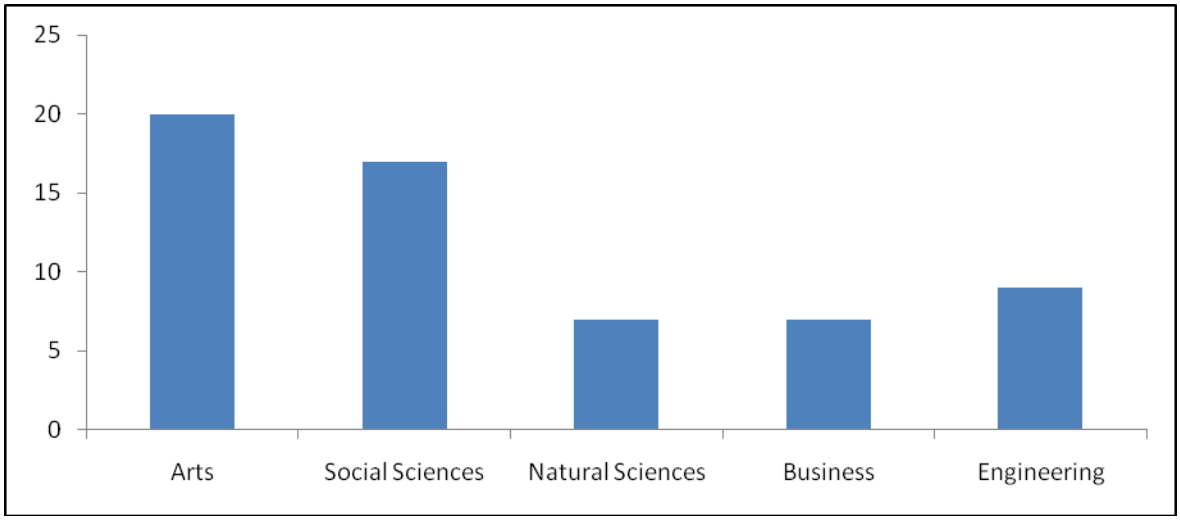

Figure 1: Percentage of respondents by program of study.

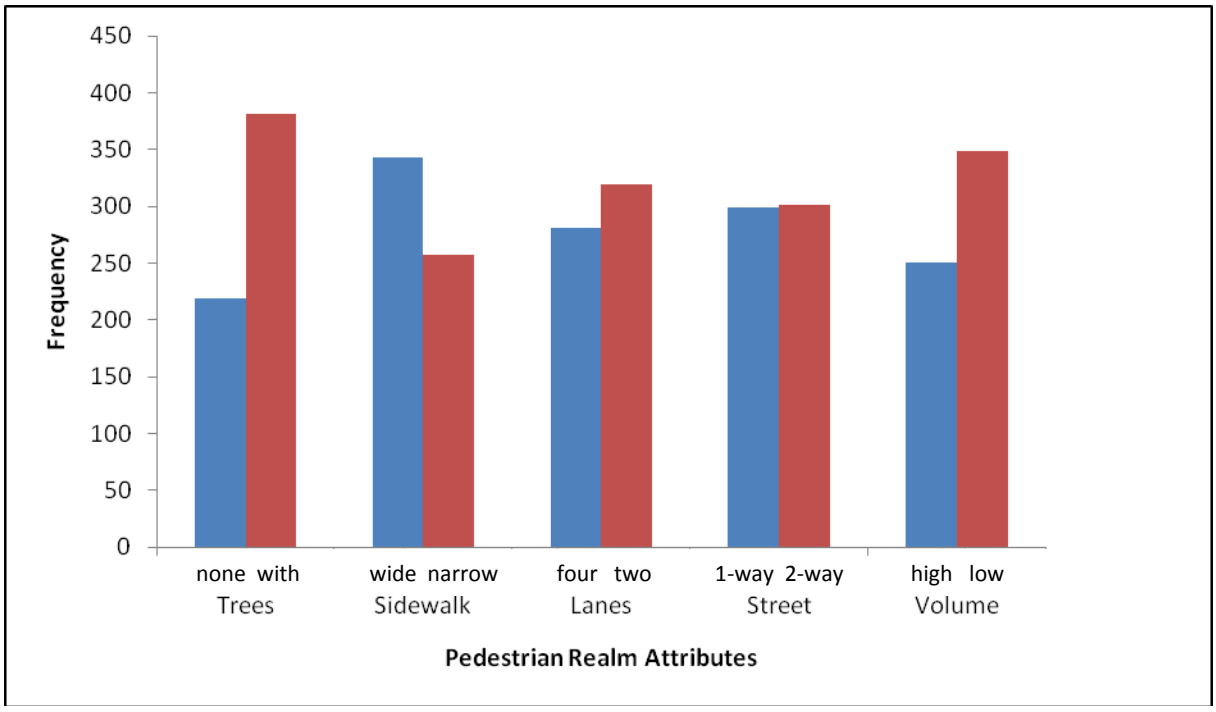

Figure 2: Pedestrian realm attributes and frequency of route chosen based on two levels.

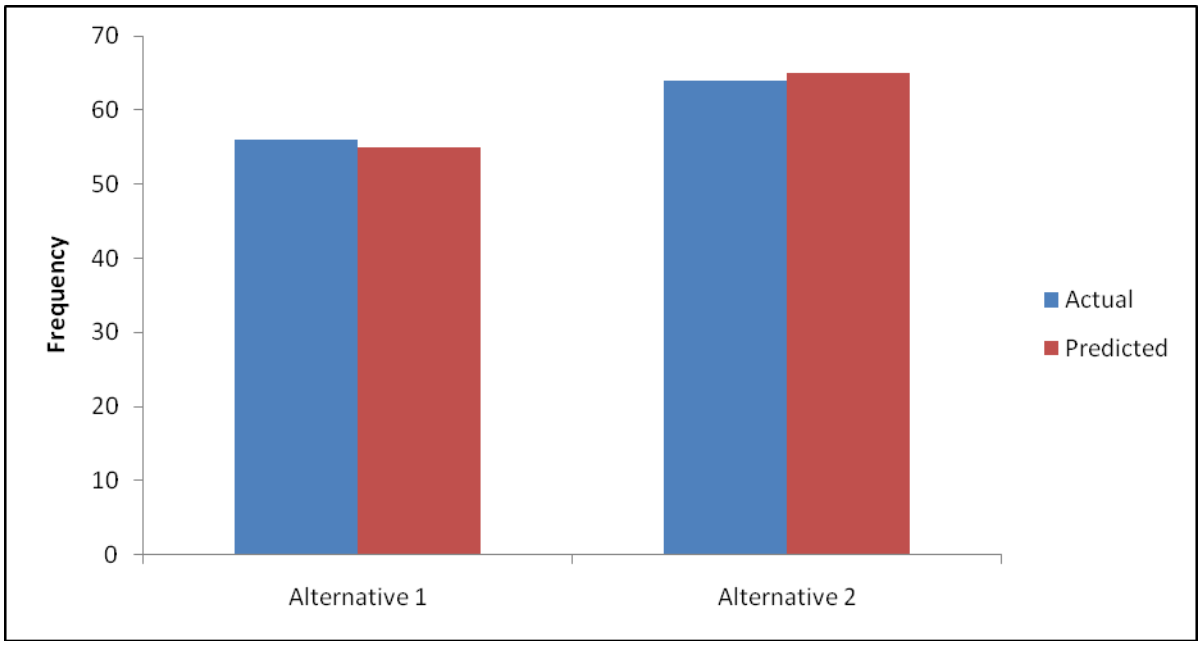

Figure 3: Frequency of observed and predicted data based on chosen route alternative.

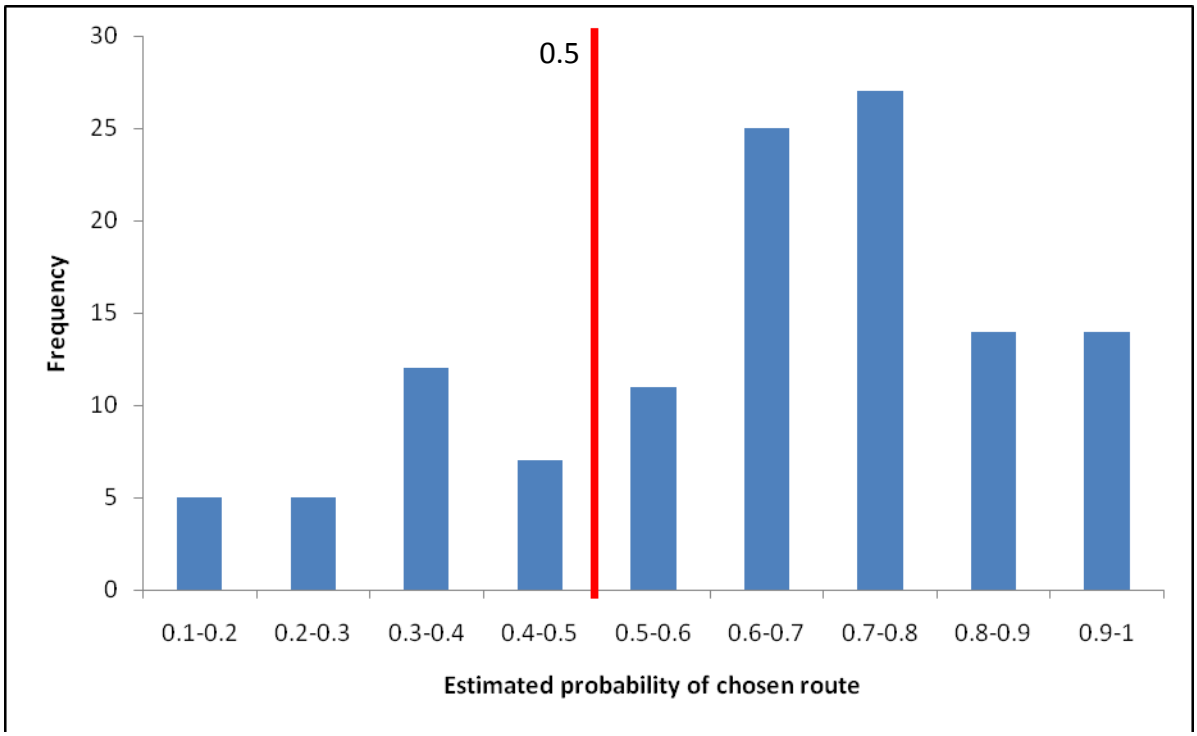

Figure 4: Frequency of predicted (by model) of chosen pedestrian realm attributes.