CETRA2024 15-17 May 2024, Cavtat, Croatia
8th International Conferenceon Road and Rail Infrastructure

ASSESSING PREFERENCES FOR THE INTRODUCTION OF A NEW TRAM LINE ON UNIVERSITY OF ZAGREB CAMPUS USING STATED PREFERENCES EXPERIMENT

Nikola Kožul, Luka Novačko, Karlo Babojelić
University of Zagreb, Faculty of Transport and Traffic Sciences, Croatia

Abstract

The development and introduction of sustainable urban transportation systems is crucial in addressing increasing traffic congestion and environmental concerns in the cities. This article aims to assess the potential acceptance and demand for a proposed new tram line in the area of University of Zagreb Campus Borongaj. Using a stated preference survey, a sample of commuters within the area were surveyed to understand their preferences and willingness to use the planned tram line. The survey included questions about travel behavior, transportation modes currently used, and their stated preference for the new tram line in terms of proposed travel time, price, comfort, and access time. The collected data were analyzed using multinomial logit model to estimate relative importance of different factors that affects individuals' choice and acceptance of the new tram line. Additionally, socio-demographic variables were analyzed to identify variations in preferences among different demographic groups. Results of the experiment will provide valuable insights to urban planners, policy makers, and transportation authorities in their decision-making processes. Understanding the preferences and needs of users of the proposed tram line will assist in designing an efficient and user-friendly transportation system, improving overall accessibility and mobility within the area.

Keywords: stated preference, public transport, sustainable transport, utility function

1 Introduction

Public transport plays a pivotal role in the development of sustainable urban development by offering efficient and environmentally friendly mobility solutions with its ability to transfer high number of people with producing low emissions and taking up less space than private vehicles. With integration of public transport planning to urban development, it is possible to improve quality of life by reducing pollution and promoting equitable transport system by providing affordable basic mobility for non-drivers, resource-efficient travel on busy corridors and opportunity for more efficient urban development [1].
The University of Zagreb campus Borongaj is located on the brink of residential and industrial zone on eastern part of Zagreb. Considering the low level of tram infrastructure development, access to the campus is possible only via bus in the form of public transport. Due to the organization of lines, regarding routes and timetables, users are mostly compelled to make multiple transfers between vehicles to successfully reach the campus. Given the situation, a certain part of campus users prefers other transport modes, mostly private cars, that enables them to arrive to campus much easier and faster.

The campus development is still ongoing, and recently there has been frequent mention of introducing a tram line as planned through spatial plans of the City of Zagreb. All things considered, this paper deals with the development of stated preference (SP) surveys to gain insights into campus users' preferences. The stated preference survey is method of finding out about the attitudes of a transport system users in case where users are presented with the new alternative that is not available in the given moment [2].

2 The theory of stated preference

Stated preference techniques are frequently used to gather information about products and services that are not yet available on the market [3]. SP experiments are a family of techniques that use individual respondent statements about their preference in a set of options to estimate utility functions. In an SP experiment, hypothetical choice situations are presented to individuals in a questionnaire format [4]. Individuals have to select one of the offered alternatives only varying the attribute levels that define them, thus enabling analyst to interpret how attribute level variations affect alternative choice selection [5, 6].
Consumer preferences in transport can be represented by a utility function. Ben Akiva borrowed the concept of utility function in economics and applied it to transport mode choice behavior [7]. Utility measures a person's satisfaction with a good or service or benefit from consuming a good or service, but as it is a subjective concept, different people may have different preferences and values and therefore derive different levels of utility from the same good or service [8]. Utility maximization approach assumes that individuals possess adequate information about available transport systems, enabling them to make rational decision regarding their mode of travel [9]. Utility can be defined as the result of individual n choosing alternative j in choice situation t as U_{jnt}, where in a random utility concept utility is composed of deterministic component V_{jnt} and a random component ε_{jnt}. Deterministic component is defined as $V_{jnt} = g(\beta, x_{jnt}, z_n)$, where β is a vector of estimated parameters, x_{jnt} are attributes describing alternative j in the given situation and z_n are characteristics of individual n. Random part of utility measures deviation from modelled utility for alternative j and respondent n [10].

$$U_{jn} = V_{jn} + \varepsilon_{jn} \tag{1}$$

With all utility parts combined, the probability of individual n choosing alternative i (out of $j = 1, \ldots, J$) in choice task t is given by:

$$P_{int} = P\left(V_{int} + \varepsilon_{int} > V_{jnt} + \varepsilon_{jnt}, \qquad \forall j \neq i\right) \tag{2}$$

In the logit model, which is most used in the disaggregated approach, the random variable behaves in accordance with Gumble's distribution. In the logit model there are two possible outcomes where 1 means that the individual has chosen an alternative and 0 means that the individual did not choose an alternative [11]. Given probability for choosing a specific alternative can be presented as:

$$P_{in} = \frac{e^{\mu V_{in}}}{\sum_{j=1}^{J} e^{\mu V_{jn}}} \tag{3}$$

The utility function can be constructed by several variables with its own coefficients that can be calculated using logistic regression. In order to gain a logistic regression function it is necessary to obtain several individual observations that represent how alternatives have been chosen.

3 Case study

3.1 Current situation

The University of Zagreb campus Borongaj is located in the eastern part of the city situated in between residential and industrial area with shopping attractions in the near vicinity. The campus is located on the site of a former military barracks that have been repurposed for academic activities. It was opened in 2007 upon the completion of the first phase of development, which involved the renovation of buildings utilized by Faculty of Croatian Studies, Faculty of Education and Rehabilitation Sciences and Faculty of Transport and Traffic Sciences. At the same time, a student restaurant was established along with implementation of needed IT infrastructure and a new campus exclusive bus line operated by the City of Zagreb public transport operator ZET. Currently, around 5.000 students and 300 faculty members are located on the Borongaj campus.
The University of Zagreb has plans for development of campus. There are several new Faculties that are planning to relocate to campus area such as Faculty of Chemical Engineering and Technology and Faculty of Political Science. Except for academic activities, plans include construction of sport facilities, student dormitories and adequate spaces for many institutes and agencies. Upon completion of all planned projects, the University of Zagreb expects campus to be used by 35.000 students in an area of 92,8 ha area.
Given the location and plans for development of the campus, and taking urbanization of the city into consideration, implementation of tram line on the property of campus should be considered. It is important to mention that the City of Zagreb spatial plans already include a tram line within the area of the Borongaj campus, although the planned route may not be fully optimized it provide valuable insights in the potential and possibilities that the tram line can offer on given area.

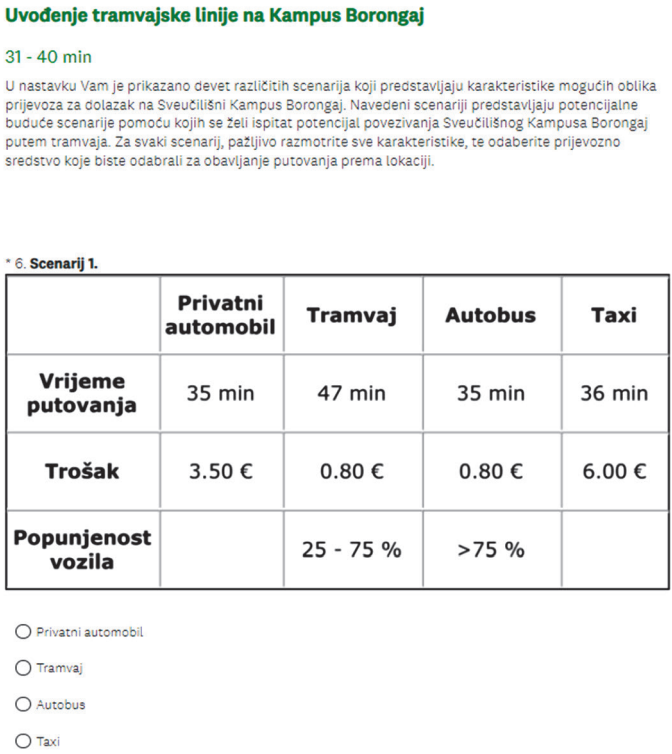
3.2 Survey design

Considering that the primary objective of the research was to determine the acceptance of introducing tram transport to the campus area, the target population identified for the study was the campus users such as students and faculty members. Users' mode decisions are mostly defined on their socio-economic characteristics and travel attributes, a survey was developed to obtain desired information. The survey was organized into three sections where each section was created with the aim of gathering detailed information. First section of the survey aimed to gather information about respondents' current travel habits, such as their primary mode of transportation, frequency of visits to the campus, arrival, and departure times as well as their typical travel times from their home to the campus. The second section of the survey was constructed of nine scenarios where respondents had to choose between presented alternatives with given attributes. The third section of the survey was dedicated to collecting socio-demographic data about respondents participating in the survey.
The SP experiment, the second part of the survey, was created via Ngene software [12]. Ngene software was used to generate a D-efficient design for the MNL model. SP scenarios were created with four different alternatives including private car, tram, bus, and taxi. The four have been selected due to specifics of campus location. Since there is no railway station located in the vicinity of campus, the train as mode of transport was not included. Also, as there are no developed bicycle lanes in the wider campus area, bicycles and e-scooters are not provided as possible alternatives. Private car and taxi alternatives had two attributes describing them (travel time and cost), while tram and bus had three attributes describing them (travel time, cost, and occupancy of vehicle) where each attribute was divided into three attribute levels.

Also, one important design element was determined in the starting stage of development, and that is to have labelled alternatives, so respondents know between what alternatives they are choosing.
One of the main challenges encountered during the survey development was the issue of presenting various travel times to respondents, considering that not all the individuals have the same origin point. Ultimately, an approach adopted was where the user's response in the first section of the survey, where they define their average travel time, was considered. Based on this response, the user was directed to the section of the survey presenting the scenarios within their average travel time. Consequently, this resulted in the development of seven distinct SP experiments, each containing nine different scenarios based on the respondents' average travel time.

3.3 Data collection

The data collection took place during January 2024 and the survey was conducted through SurveyMonkey web-based application called SurveyMonkey (www.surveymonkey.com). As target population were campus users, survey link was given to faculties that are located on campus area which later distributed survey link to their students and faculty members. It is important to state that the sample is representative for the campus only and not for the whole possible route of the tram line.



Uvođenje tramvajske linije na Kampus Borongaj

31 - 40 min

U nastavku Vam je prikazano devet različitih scenarija koji predstavljaju karakteristike mogućih oblika prijevoza za dolazak na Sveučilišni Kampus Borongaj. Navedeni scenariji predstavljaju potencijalne buduće scenarije pomoću kojih se želi ispitat potencijal povezivanja Sveučilišnog Kampusa Borongaj putem tramvaja. Za svaki scenarij, pažljivo razmotrite sve karakteristike, te odaberite prijevozno sredstvo koje biste odabrali za obavljanje putovanja prema lokaciji.

* 6. **Scenarij 1.**

	Privatni automobil	Tramvaj	Autobus	Taxi
Vrijeme putovanja	35 min	47 min	35 min	36 min
Trošak	3.50 €	0.80 €	0.80 €	6.00 €
Popunjenost vozila		25 - 75 %	>75 %	

- ○ Privatni automobil
- ○ Tramvaj
- ○ Autobus
- ○ Taxi

Figure 1 Example of an SP survey

The survey collected 643 responses, and the valid amount of collected surveys was 534, which is 83,05%, where incomplete surveys were excluded from further analysis. The main dropout point was the third section with socio-demographic elements of the respondent. Also, a certain number of respondents have dropped out during the second section of the survey, SP experiment, which gives indication for further development of the survey.
Out of valid respondents, 78,65% were female, while 21,35% were male respondents. Out of all the respondents, 72,85% of them were in the age group between 18 and 23, which is expected due to structure of the sample on the campus area. 66,48% of the respondents are residing in the City of Zagreb, while the 33,52% of the respondents are traveling from the city suburb or even further. Since the sample mostly consisted of the students, 59,74% of the respondents' average monthly income is between 0 and 400 euros.

3.4 Data analysis

The model was estimated using Apollo Choice Modelling package available via R software. Apollo is a free package that combines R functions to provide estimation of simplest Multinomial Logit models or complex structures using random coefficients [13]. Since the alternatives and their attributes were developed in the survey design process, utility functions of the alternatives were introduced to the Apollo as follows:

$$V_{car} = asc_{car} + \beta_{tt} \cdot tt_{car} + \beta_{cost} + cost_{car} \tag{4}$$

$$V_{tram} = asc_{tram} + \beta_{tt} \cdot tt_{tram} + \beta_{cost} + cost_{tram} + \beta_{25} \cdot occ_{tram} + \beta_{25\_75} \cdot occ_{tram} + \beta_{75} \cdot occ_{tram} \tag{5}$$

$$V_{bus} = asc_{bus} + \beta_{tt} \cdot tt_{bus} + \beta_{cost} + cost_{bus} + \beta_{25} \cdot occ_{bus} + \beta_{25\_75} \cdot occ_{bus} + \beta_{75} \cdot occ_{bus} \tag{6}$$

$$V_{taxi} = asc_{taxi} + \beta_{tt} \cdot tt_{taxi} + \beta_{cost} + cost_{taxi} \tag{7}$$

Where:
Asc – is constant of the alternative (car's constant is set to 0),
tt – is value of travel time of alternative in scenario,
cost – is price of alternative in scenario,
occ – is occupancy of the vehicle of the alternative in the scenario,
β_{tt}, β_{cost}, β_{25}, $\beta_{25\_75,}$ β_{75} – are vectors of respondents' preferences.

Table 1. shows the results of the estimated Multinomial logit model. The direction of the coefficient (Beta values) is determined by its estimated sign, which can be positive or negative. If the sign for the coefficient is negative, it means it creates disutility, while positive sign means that with the increase of the value utility is going to be higher.
As seen by the results, the constant estimated for the tram is the only one that has positive sign, indicating that according to the model, the majority of the respondents exhibit a high level of preference for the tram as transport mode to the campus. Given that the constant for the private car is fixed at 0, based on the estimated constants, it is apparent that respondents find both the bus and taxi unattractive, as both alternatives have a negative sign preceding their constants.
Based on survey results, it was possible to determine the mode choice based on SP experiment. Respondents have chosen the tram 55% of the time, with the bus as the next choice with 29%. Respondents chose private car 14% of the time while taxis had the lowest choice with only 2%. Comparing the data of existing state with those gathered through the SP experiment, there is decrease in private car users by 5%, while the overall share of public transport (including tram and bus) has increased by 10%. However, it is important to note that not all possible modes of travel were offered withing the scope of the SP experiment.

Table 1 Modal share by SP experiment

	Private car	Tram	Bus	Taxi	**Total**
Times chosen	684	2.629	1.412	81	**4.806**
% chosen	14,23%	54,70%	29,38%	1,69%	**100,00%**

Through the analysis of the collected data, in line with the estimated values, it is evident that users traveling to the Borongaj campus are significantly more sensitive to changes in price compared to the travel time. This suggests that users place greater importance on lower transportation costs than on minimizing travel time to reach the campus. Furthermore, consistent with expectations, respondents are considerably more accepting of traveling in vehicles with lower occupancy than those that are nearly full.

Table 2 MNL estimation results

	Coefficient
asc_{car}	0.000
asc_{tram}	0.608
asc_{bus}	-0.125
asc_{taxi}	-1.163
β_{tt}	-0.089
β_{cost}	-0.519
β_{25}	0.000
β_{25_75}	-0.086
β_{75}	-0.502
Number of observations	534
LL (start)	-6662.53
LL (final)	-4643.39

4 Conclusion

The main objective of this study was to present the design of stated preference experiment with aim to find out the acceptance of introducing tram transport to the Borongaj campus area. The analysis of the data has revealed several key findings, such as strong preference among respondents for tram transport, as evidenced by the positive constant associated with this mode of transport. Conversely, alternatives such as the bus and taxi were seen as less attractive, as indicated by negative constants.

Moreover, the study highlighted the significant sensitivity of users traveling to campus to changes in costs of transport, especially compared to travel time, underscoring importance of affordability in mode choice decisions. Additionally, respondents demonstrated preference for traveling in less crowded vehicles, reflecting a preference for comfort during their commute. These insights prove the desirability of introducing tram transport as a sustainable mobility solution for the campus.

It is important to state that this study represents an initial phase of the research, with the aim of continuing data collection and developing more advanced and complex models to obtain further detailed insights. Given that the planned tram line extends beyond the campus area, it is essential to expand the research to include the boarder urban context.

This necessitates the inclusion of other residents residing along the planned tram route, thereby requiring surveying a more representative sample of respondents.
Furthermore, there is potential to enhance the study by introducing additional alternatives and attributes in SP experiment. Incorporating walking and micromobility modes, such as cycling or e-scooters, as alternatives can significantly influence modal distribution. Additionally, integrating attributes such as parking fees, public transit waiting times, transfers or access times can impact on users' choice. Thus, it is important to stated that this study represents an initial phase of the experiment and serves to determine basic preferences, but further development of SP survey is necessary to fully define preferences.

References

[1] Litman, T.A.: Evaluating Public Transit Benefits and Costs Best Practices Guidebook, 2024, www.vtpi.org

[2] Kores, P.E., Sheldon, J.R.: Stated Preference Methods, Journal of Transport Economics and Policy, 22 (1988), pp. 11–25

[3] Louviere, J.J., Hensher, D.A., Swait, J.D., Adamowicz, W.: Stated Choice Methods, Cambridge University Press, 2000, DOI: 10.1017/cbo9780511753831

[4] Esztergár-Kiss, D., Tordai, D., Lopez Lizarraga, J.C.: Assessment of travel behavior related to e-scooters using a stated preference experiment, Transp Res Part A Policy Pract,166 (2022), pp. 389–405, DOI: 10.1016/j.tra.2022.11.010

[5] Sanko, N.: Guidelines for Stated Preference Experiment Design, Professional Company Project in Association with RAND Europe, School of International Management Ecole Nationale des Ponts et Chaussées, Class 2000/01, 2001.

[6] Hensher, D.A., Rose, J.M., Greene, W.H.: Applied choice analysis: a primer, Cambridge University Press, 2005.

[7] Ben-Akiva, M., De Palma, A., Kanaroglou, P.: Dynamic Model of Peak Period Traffic Congestion with Elastic Arrival Rates, 1986, https://www.jstor.org/stable/25768227

[8] Sipos, T.: Evaluation of Stated Preference Surveys with Statistical Methods, Promet - Traffic and Transportation, 35 (2023) 5, pp. 655–661, DOI: 10.7307/ptt.v35i5.259

[9] Meyer, M., Miller, E.: Urban Transportation Planning, second edition, Boston: McGraw-Hill Science, 2001.

[10] Hess, S., Daly, A., Batley, R.: Revisiting consistency with random utility maximisation: theory and implications for practical work, Theory Decis, 84 (2018) 2, pp. 181–204, DOI: 10.1007/s11238-017-9651-7

[11] Krasić, D.: The use of logit model for modal split estimation: a case study, 5th International Conference on Road and Rail Infrastructure - CETRA 2018, pp. 1241–1246, 17-19 May 2018, DOI: 10.5592/co/cetra.2018.687

[12] ChoiceMetrics, Ngene 1.4 User manual & reference guide, The Cutting Edge in Experimental Design, 2024, www.choice-metrics.com

[13] Hess, S., Palma, D.: Apollo: a flexible, powerful and customisable freeware package for choice model estimation and application, 2019, https://cran.r-project.org/