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Demographic Analysis of Active Transport Mode Users in Urban Context

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Abstract

Active transportation, such as walking, cycling, and micro-mobility modes, has received a lot of attention in recent years due to its potential benefits to urban residents, such as less traffic, better air quality, more opportunities to get exercise, and an overall higher quality of life. In this study, we used Classification and Regression Trees (CART) to compare and contrast three mobility options: shared micro-mobility, private micro-mobility, and walking. We surveyed 219 people living in Budapest, Hungary, to learn more about their travel habits and investigate the demographic elements that influence people's mode choice, such as age, gender, ownership of micro-mobility vehicles, education, job, and income. Results showed that ownership of personal micro-mobility vehicles, and age as important predictors of active travel mode choice. Men seem to consider cost and weather conditions when choosing shared micromobility modes, while women value safety and weather conditions. Our findings can guide policy decisions and urban planning initiatives by identifying the most significant predictors of mode choice and evaluating the possible benefits and drawbacks of each mode.

Keywords

active travel, mode choice, micro-mobility, shared mobility, walking

1 Introduction

Walking, cycling, and the usage of shared or private micro-mobility modes are all examples of what is known as "active travel." Active transportation has received a lot of attention in recent years as a viable, healthful, and inexpensive substitute for driving and taking public transportation (Danielis and Scorrano 2022). Urban residents may benefit from less traffic, better air quality, more opportunities to get some exercise, and an overall higher quality of life if more people are encouraged to take up active forms of transportation (Jaber and Csonka 2023; Saunders et al., 2013; Torok et al., 2018).

There are several reasons why it is crucial to study active transportation. To begin, it can shed light on the aforementioned infrastructure, safety issues, and societal norms that influence people's decisions to engage in active travel. Second, it can help us gauge the success of initiatives like bike-sharing programs and pedestrian-friendly urban planning in encouraging healthy modes of transportation. Finally, it can inform policy makers and foster sustainable development by shedding light on the health, economic, and environmental benefits of active travel.

The primary goal of our study is to use tree methods based on Classification and Regression Trees (CART) to compare and contrast three mobility options: shared micro-mobility, private micro-mobility, and walking. We seek out the several predictors of mode choice and investigate the advantages and disadvantages of each mode by comparing them and using CART technique to study the demographic elements that influence people's mode choice, such as age, gender, ownership of micro-mobility vehicles, education, job, and income. The novelty lies in innovatively employing Classification and Regression Trees (CART) analysis and shedding light on gender-specific preferences in active travel mode choice, offering unique insights into the multifaceted dynamics influencing urban residents' mobility decisions. Our research can help guide policy and city planning initiatives that encourage eco-friendly and physically demanding modes of transportation.

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2 Literature review

The notion of "active travel," encompassing pedestrian activities, cycling, and various micro-mobility modes, has garnered increasing attention in recent years, serving as a pivotal instrument in promoting sustainable transportation alternatives and improving public health outcomes. Consequently, contemporary research endeavors have been dedicated to unraveling the intricate determinants that either incentivize or hinder individuals from embracing active modes of transportation within urban settings. These investigations endeavor to shed light on the multifaceted dynamics that influence the selection of transportation modes and contribute significantly to the ongoing discourse surrounding sustainable urban mobility.

Numerous research using a wide range of analytic approaches have been conducted to determine what factors influence people to choose active travel modes. The correlation between infrastructure and active travel has been studied using regression analysis Clark et al. 2014 and mixed-effect models (Haybatollahi, 2015; Siiba, 2020) to account for the clustering of data within neighborhoods. Decision tree analysis has been utilized in several studies to identify the most relevant predictors of active travel behavior, such as socio-demographic characteristics, safety concerns, and access to active travel infrastructure (Liu et al., 2021; Xu et al., 2023).

The positive effects of active travel on people's health, the economy, and the environment have been studied using a variety of methodologies. The health benefits of walking and cycling, such as lower risks of cardiovascular disease and diabetes, have been estimated using regression models (Riiser et al., 2018). Bicycle-sharing programs and pedestrian-friendly roadway design are two examples of active transport interventions that have been the subject of cost-effectiveness studies (Oeschger et al., 2020; Rojas-Rueda et al., 2011). Finally, the environmental benefits of active transport, such as lower carbon dioxide emissions and less air pollution, have been estimated using case scenarios (Rabl and de Nazelle 2012). The difficulties of encouraging active travel in urban context have been investigated using a number of different types of analysis. Researchers have employed qualitative techniques including in-depth interviews and focus groups to learn more about the cultural trends and beliefs that influence people's propensity for active travel (Aldred and Jungnickel 2014; Biehl et al., 2019).

Unlike traditional regression analysis and mixed-effect models used in previous studies, CART offers a distinct advantage in its ability to handle complex interactions among predictor variables and identify non-linear relationships, thus providing a more comprehensive understanding of the determinants influencing active travel mode choice. While previous studies have primarily focused on identifying individual predictors of active travel behavior, our hypothesis posits that employing CART would allow for the identification of intricate decision pathways within the data, revealing nuanced interactions among demographic factors, socio-economic variables, and perceptions of safety and infrastructure. Consequently, we anticipate that the results derived from CART analysis would not only corroborate existing findings but also uncover previously unrecognized patterns and subgroups within the dataset, ultimately enhancing the depth of insights into the dynamics shaping urban residents' mobility decisions.

In conclusion, a growing amount of scholarship has addressed the factors that encourage active travel, as well as the difficulties in promoting these modes in densely populated locations. Our research adds to this body of knowledge by applying CART-based tree approaches to a comparison of these three forms of active transportation. In order to promote sustainable and active transportation modes, our findings can be used to guide policy decisions and urban planning by identifying the most significant predictors of mode choice and evaluating the possible benefits and drawbacks of each mode.

3 Methodology

3.1 Data collection

In our study, we conducted surveys with a sample of 219 residents residing in Budapest, Hungary, spanning the period from February to May 2023. This timing was selected to capture a diverse range of seasonal travel behaviors. During this timeframe, participants experienced transitions between winter, spring, and early summer seasons, each of which can significantly impact transportation preferences and patterns. Through this online survey, participants were presented with a multifaceted questionnaire designed to delve into their travel patterns, demographics, and preferences for various modes of transportation. Our inquiry focused on three distinct categories of short journeys:

1. shared micro-mobility options like bike-sharing or scooter-sharing,
2. personal micro-mobility options including ownership of bicycles or scooters, and
3. traditional walking.

These short journeys were specifically chosen for examination due to their propensity for being undertaken via active and sustainable modes of transportation. By narrowing our focus to short trips, we aimed to gain a deeper understanding of the factors that influence travel choices in urban environments, where accessibility, convenience, and sustainability often intersect to shape mobility decisions. Noting that short trips were defined as journeys lasting 30 minutes or less. This definition aligns with typical durations for active transportation modes like walking, cycling, and micro-mobility, focusing on urban travel patterns (Both et al., 2022).

3.2 Data analysis

We employed a robust analytical approach to compare these three distinct modes of physical transportation: shared micro-mobility, personal micro-mobility, and walking. Our chosen method for this analysis was Classification and Regression Trees (CART), a powerful non-parametric technique widely utilized for modeling complex relationships between independent variables and a dependent variable, which in our case, is the choice of transportation mode. As described by Breiman et al. 1984, CART relies on a recursive partitioning algorithm, iteratively constructing a decision tree that elucidates the intricate interplay between various factors and the ultimate choice of transportation mode.

Whereas the variables are discrete, a classification tree is developed. On the other hand, if they are continuous, the results are explained by a regression tree. This algorithm mechanism is based on two pillars of "Purity" and "Balance". Purity is designated by Gini (Index of equality; its score ranges from 0 to 1, 0 indicates perfect equality and 1 maximum inequality) and balance is indicated by the same population distribution among the two sides of the decision tree. For each set of records, the splitting criterion is induced by Gini as shown in Eq. 1. This measure is calculated as the summation of class proportions for classes existing at the node; the Gini index is equal to zero if all records in a node belong to the same class. After pruning a branch, if the increase in the misclassification cost is sufficiently lower than the decrease.

$$\text{Gini}(X) = \sum_{j \in N} P_{j,X}\left(1 - P_{j,X}\right) = 1 - \sum_{j \in N} P_{j,X}^2, \quad (1)$$

where N is set of classes, X is set of records, $P_{j},_{X}$ is the probability of category X having class j.

This approach involves selecting independent variables that consistently yield the most significant divisions or splits in the dependent variable, mode choice (Jaber and Al-Sahili 2023). By employing CART, we aimed to unveil the underlying patterns and dependencies among demographics, trip objectives, and transportation preferences, providing a nuanced understanding of the factors shaping short-distance mobility choices in the urban context of Budapest.

We divided the data at random into an 80% training set and a 20% testing set to see how well the CART model performed. Using the Gini impurity index, which evaluates the level of consistency between nodes in a tree, we determined the CART model's predictive power.

Our CART model incorporated the following variables:

- The age of the respondents as a continuous variable,
- gender,
- monthly net income (high, average, low),
- purpose of trip: a categorical variable (home, work, education, shopping, leisure),
- education level (high school, undergraduate studies, graduate studies), and
- job (full-time worker, part-time worker, student, unemployed).

Finally, we modeled the associations between independent factors and mode choice across three active travel modes using CART analysis. We evaluated the model's goodness-of-fit and predicted the accuracy. Policy decisions to encourage sustainable and active transportation can be informed by our technique, which provides a robust and systematic approach to examining differences between active travel modalities.

4 Results and discussion

4.1 Descriptive statistics

The descriptive statistics (Table 1) were used to summarize the key characteristics of the sample and the variables of interest. The frequency and percentage distributions were computed for categorical variables such as mode choice, ownership of Micromobility vehicles, gender, trip purpose, income, job, and education level.

The descriptive statistics of the user groups in this study provide valuable insights into the characteristics of different types of active travelers. The results indicate that bike or scooter sharing travelers tend to be slightly younger than personal micro-mobility users, with an average age of 28.6 years. This may be because bike or scooter sharing services tend to be more popular among young adults who live in urban areas and are looking for a convenient and affordable way to get around. In terms of gender, bike or scooter sharing users have a relatively equal distribution of men and women, with a ratio of 1:1.3. Their main trip purpose is for work (32%).

On the other hand, personal micro-mobility users tend to be slightly older than bike or scooter sharing users, with an

Table 1 Descriptive statistics of the sample

Category	Attribute	Frequency	Percent
Mode Choice	Bike or Scooter Sharing	37	16.9%
	Personal Bike or Scooter	80	36.5%
	Walking	102	46.6%
Ownership	Both	54	24.7%
	Only Bike	96	43.8%
	Only Scooter	3	1.4%
	None	66	30.1%
Trip Purpose	Education	69	31.5%
	Home	12	5.5%
	Leisure	66	30.1%
	Shopping	18	8.2%
	Work	54	24.7%
Gender	Female	82	37.4%
	Male	137	62.6%
Income	Low	62	28.3%
	Average	103	47.0%
	High	54	24.7%
Job	Full Time Worker	46	21.0%
	Part Time Worker	31	14.2%
	Student	139	63.5%
	Unemployed	3	1.4%
Education Level	High School	26	11.9%
	Undergraduate Studies	102	46.6%
	Graduate Studies	91	41.6%

average age of 29.1 years. Personal micro-mobility modes, such as bikes and scooters, require an initial investment and ongoing maintenance costs, which may explain why this group has a higher average income than bike or scooter sharing users. Furthermore, personal micro-mobility users tend to be more highly educated, with a higher proportion of graduate students (60%) than the other user groups.

In contrast, walkers tend to be the youngest of the three groups, with an average age of 22.7 years. Furthermore, walkers tend to use active travel modes for leisure or education purposes, with 75% of their trips falling into these categories. Finally, walkers tend to have lower incomes and are more likely to be undergraduate students, reflecting the fact that walking may be a more affordable and accessible mode of transportation for young people who are still in universities or schools (82%).

It is important to note that while our study primarily focuses on students in Budapest, Hungary, we recognize the need to consider the broader representativeness of the sample. Despite the emphasis on students, the sample does encompass a diverse range of socio-economic backgrounds, with the distribution of income levels reflective of the population in Budapest. This suggests that our findings are representative based on average income levels within the city. However, it is crucial to acknowledge potential limitations in generalizing findings beyond urban settings or to demographic groups not adequately represented in the sample. Moving forward, efforts to diversify the sample and employ more rigorous sampling techniques could enhance the representativeness of future research.

Overall, these descriptive statistics highlight the diversity of active travelers and the importance of understanding the specific characteristics of different user groups in order to design effective interventions and policies to promote sustainable and active transportation.

4.2 CART analysis

Mode choice was employed as the dependent variable, and the CART analysis was performed to model the connections between the independent variables. The resulting decision tree graphically represented the major data splits, with nodes representing the factors that most strongly influenced the choice of each mode. The resulted tree consisted of five nodes with a depth of two as shown in Fig. 1. The data were also divided into training and testing sets, with 80% of the data being utilized for training and 20% for testing. The optimum tree size was determined by cross-validation, and the final model was tested on validation data to ensure its accuracy. The correct percentage for training, and testing sets were 73.5%, and 70.2%, respectively.

The results indicated the following:

- Shared Micromobility options are chosen basically if the travelers do not own any personal Micromobility vehicles such as bikes or scooters.

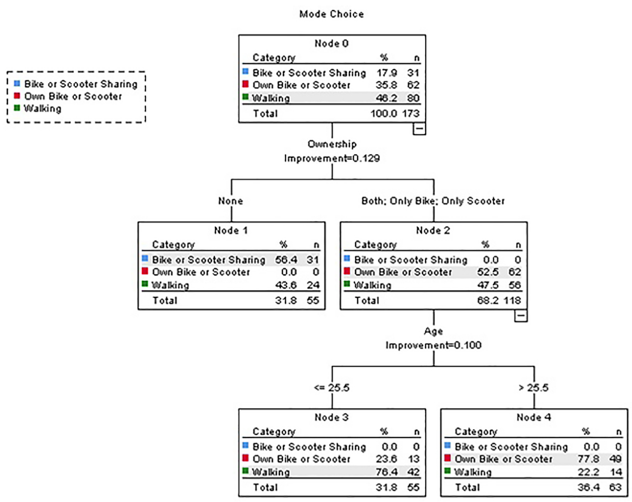

Fig. 1 CART Analysis

- Personal Micromobility modes are chosen if the travelers are older than 25.5 years and own at least one Micromobility vehicle.
- Walking is chosen if the travelers are younger than 25.5 years and own at least one Micromobility vehicle, which is similar to the results Jaber et al. research (Jaber et al., 2023).

Table 2, "Importance of Independent Variables," underscores the significant role that various factors play in influencing mode choice for transportation. Notably, the analysis reveals that ownership and age are the most influential among the factors considered. Ownership, likely related to personal vehicle possession, emerges as the foremost determinant, while age also plays a substantial role in shaping transportation preferences. Interestingly, gender, while an important aspect of the analysis, ranks lower in importance compared to ownership and age, suggesting that other factors, such as socio-demographic considerations like education level, trip purpose, job, and income, contribute to but are less dominant in influencing mode choice.

The use of CART analysis in this study provides a clear and concise method for understanding the relationships between mode choice and various independent variables. The resulting decision tree offers insights into the key factors that influence mode choice and how they interact with each other. The findings of this study are consistent with previous research on active travel behavior that has identified factors such as ownership of personal micro-mobility vehicles, and age as important predictors of mode choice. For example, a study by Cao et al. 2009 found that bike ownership was a significant predictor of cycling mode choice, while age was found to be a significant predictor of walking mode choice. Similarly, a study by Smart 2015 found that the availability of different transport modes in the neighborhood was an important determinant of mode choice.

Our study adds to this literature by demonstrating the importance of ownership of personal micro-mobility vehicles and age in determining mode choice, and by highlighting the key differences between the three modes of shared micro-mobility, personal micro-mobility, and walking. The findings of this study have important implications for policymakers seeking to promote sustainable and active transportation, as they suggest that improving access to personal micro-mobility modes and creating safe and convenient walking environments may be effective strategies for encouraging active travel.

Table 2 Importance of independent variables

Independent Variable	Importance	Normalized Importance
Ownership	0.138	100.0%
Age	0.133	96.2%
Education Level	0.039	28.4%
Trip Purpose	0.030	21.9%
Job	0.030	21.7%
Income	0.020	14.5%
Gender	0.008	5.7%

4.3 Scoring analysis

Recognizing the multifaceted nature of decision-making, we asked our survey participants to evaluate the significance of six distinct factors in their choice of shared micro-mobility solutions. These factors were meticulously chosen to encompass a wide spectrum of considerations, including proximity to shared micro-mobility stations, cost-effectiveness, safety, traffic congestion, weather conditions, and ease of access via distance to docking lots. Each participant was encouraged to assign a score to these factors, with the least important factor receiving a score of 1, and the most pivotal factor earning a score of 10. This structured approach not only allowed us to gauge the relative importance of these aspects but also facilitated the comparison of preferences among our respondents. The findings, as meticulously detailed in Table 3, provide a deep insight into the nuanced distinctions between male and female travelers concerning their prioritization of these critical factors when making choices within the shared micro-mobility landscape. Such insights hold great potential for urban planners and policymakers as they seek to craft more tailored and gender-responsive strategies to enhance urban mobility.

Table 3 provides valuable insights into gender-based differences in the factors influencing the selection of shared micro-mobility options, shedding light on how individuals make choices when it comes to these modern urban transportation alternatives. One notable finding is the contrast in how men and women prioritize proximity to the nearest station. Men, with a rating of 7.1 and a fourth-place ranking, appear to be less concerned about the distance to the station, possibly indicating a higher willingness to walk or travel a bit further to access these shared services. In contrast, women rate

Table 3 Gender-based differences of affecting factors on mode choice

Factor	Male	Rank	Female	Rank
Distance to nearest station	7.1	4	7.4	3
Cost	7.6	1	6.6	5
Safety	7.2	3	7.8	1
Congestion	7.0	5	6.4	6
Weather Conditions	7.4	2	7.5	2
Distance to Docking Lot	6.8	6	6.7	4

proximity higher, giving it a 7.4 rating and ranking it third, suggesting that convenience and accessibility play a more critical role in their micro-mobility mode choice.

Furthermore, the table highlights the gender-based differences in safety considerations. Safety is of paramount importance to women, ranking first with a rating of 7.8, potentially reflecting their heightened concerns about personal security when using shared micro-mobility options. Men, while still recognizing the importance of safety, rate it lower at 7.2 and rank it third, indicating that safety concerns may not be as pronounced for them when making decisions about micro-mobility choices. This highlights the importance of safety in mode choice preferences, as it presents a significant public health and economic problem to communities and influences people's travel choices (Kiss et al., 2013). These distinctions underscore the need for micro-mobility providers and urban planners to take into account gender-specific preferences and priorities when designing and promoting shared micro-mobility services, ultimately fostering a more inclusive and user-centric urban transportation landscape.

5 Conclusions

This study used Classification and Regression Trees (CART) to compare and contrast three modes of active transportation: shared micro-mobility, private micro-mobility, and walking. The goal of the research was to identify the predictors of mode choice by using demographic elements such as age, gender, ownership of micro-mobility vehicles, education, job, and income. The study found that age and ownership of micro-mobility vehicles were significant predictors of mode choice. People who own a bike or a scooter were more likely to choose private micro-mobility modes, whereas people who do not own any micro-mobility mode were more likely to choose walking or shared micro-mobility modes.

The literature review highlighted the increasing popularity of active travel and the factors influencing people to choose active travel options. This research contributes to the body of knowledge by applying a CART-based tree approach to comparing and contrasting three forms of active transportation. The data collected from 219 people living in Budapest, Hungary, provided valuable insights into the travel habits of urban residents. The study focused on short journeys because people are more likely to take them via active means of transportation. The use of CART allowed for the identification of the most significant predictors of mode choice and the evaluation of the possible benefits and drawbacks of each mode.

Overall, this study provides useful information for policymakers and urban planners who are interested in promoting sustainable and active transportation modes. By identifying the most relevant predictors of mode choice, policymakers can design interventions that better meet the needs of urban residents and foster a more sustainable and healthy urban environment.

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