Satisfaction of Istanbul Citizens with Urban Public Transportation

Ozgur Soy, Leyla Tavacioglu

Transportation is one of the most challenging urban subsystems to transform in an environmentally friendly and futuristic way. Many city dwellers use a variety of modes of transportation. An efficient and sustainable urban transportation system must include many modes of transportation for a single trip. Intermodal combinations are essential for urban transportation efficiency. Public transportation and commuting are essential elements of multimodal travel. In urban areas, a mix of bicycles, vehicles, and public transportation is prevalent, while in rural areas, car, and public transportation are more prevalent. By examining the characteristics that lead customers to prefer water transportation over Metrobus and Marmaray, we hope to gain a better understanding of how the Asian and European sides of Istanbul are traversed. The number of participants in the "Maritime Transportation Satisfaction Survey" was 2,343. During this period, a model was built using the survey item "frequency of use" (dependent variable). Numerous survey examines and evaluation methodologies were utilized to determine the effectiveness of this strategy. The study examines the intermodal travel motivations and the evaluation of transportation options by multimodal users. For a successful urban transportation system, urban planning must take into account multimodal travel behavior and user expectations. There are initiatives to improve water transportation in Istanbul. Conventional maritime transportation is inadequate from start to finish. An integrated route optimization method is needed to increase the efficiency of maritime transportation. We believe that by strengthening maritime transportation links will increase water consumption. Before the coronavirus pandemic, 2,343 maritime carriers were evaluated on March 8, 2020. (Different surveys were conducted among the passengers of City Lines, Private Motors, Metrobus, and Marmaray to compare their choices and reasons.) SPSS will be used for data analysis. Multivariate Statistical Analysis relies on Multinomial Logistic Regression and Discriminant Analysis models, both of which use the K-fold and Leave-one-out criteria to decide which attributes are valid in the regression model and which are valid in the discriminant approach. The Hosmer-Lemeshow test criteria yielded a p-value greater than 0.05 for MLR characteristics.

KEY WORDS
~ Public Transportation
~ Maritime
~ Sea Transportation
~ Accessibility
~ Optimization
~ Urban Mobility

Istanbul Technical University, Maritime Faculty, Basic Sciences Department, Istanbul, Turkiye

e-mail: tavaciog@itu.edu.tr

doi: 10.7225/toms.v12.n01.017

Received on: Jul 31, 2022 / Revised: Mar 4, 2023 / Accepted: Apr 6, 2023 / Published: Apr 20, 2023

1. INTRODUCTION

One of the transportation strategies of the Istanbul Metropolitan Municipality is to increase the share of maritime transport. From the starting point of the journey to its end, it is often not possible to travel exclusively by ship. Increasing the use of the sea route is therefore only conceivable through an integrated approach to route optimization. The theory we are exploring is: "Improving sea routes can significantly increase sea route utilization."

Datasets used:

- Travel data for March 8, 2020, were selected due to it being a busy day before the epidemic.
- Marine transport survey with 2,343 respondents (Separate surveys were conducted with the users of City Lines, Private

Motors, Metrobus, and Marmaray to compare their preferences and reasons).

- Information on connection points within 500m and 800m of City Lines and Special Motor Docks.

2. LITERATURE OVERVIEW

Intermodal transportation has gained importance in recent years, especially in the largest cities in the country. To improve the efficiency of urban transportation, the possibility of combining several modes of transportation on the same route must be explored. Most research on intermodality has focused either on long-distance travel or on specific mode combinations. This paper examines the use of intermodality in daily mobility by analyzing plausible combinations of modes, trip objectives, regional disparities, and the needs of intermodal transportation users. This paper, which focuses on different modes of transportation, presents the results of a 2016 Berlin survey with a total sample of 1,010 people. According to these figures, people often use multiple modes of transportation to make their daily trips. When establishing multimodal travel patterns, getting to work and using public transportation are important elements. In urban areas, people often combine bicycling and public transportation, but in decentralized communities, residents are more likely to combine driving with public transportation. Highly interconnected communities use a range of public transportation modes. The survey found that multimodal transportation users place a high value on time efficiency. This can be seen in the reasons they give for choosing intermodal routes, as well as in their evaluation of transportation options. To increase the number of intermodal combinations that can be used to create an effective urban transportation system, urban planners need to consider intermodal travel behavior and user expectations (Oostendorp and Gebhardt 2018). New cities have sprung up on the outskirts of existing cities to accommodate the growing urban population. However, because infrastructure systems in these new cities take time to mature, public transportation services in these new settlements often lag behind population growth. To make cities more livable for all, local governments rely on bus networks to fill the gaps in connectivity created by the limited public transit service provided by the metro. Using the quantitative network design created for this research could facilitate the connection between the metro and bus networks and increase the efficiency of public transportation. Using the current notion of social network analysis, the developed method investigates and improves network design. It was evaluated in nine simulated real-world environments (Wu et al., 2019). To create effective and efficient large-scale public transportation networks, an agent-based simulation framework was developed. It outperforms previous solutions due to the dynamic responsiveness of demand to network changes and external inputs. The system was tested in Zurich using MATSim, an agent-based simulation. For the first time, this framework is a part of a multimodal transportation simulation tool on an urban scale, in contrast to a vast majority of previous methods for strengthening public transportation networks. The new network is expected to be much smaller and have fewer vehicles and a much higher frequency of service than the current transportation system. Therefore, the approach assumes that public transit ridership will increase even if subsidies are reduced, and do so automatically by identifying routes that could potentially benefit from an increase in current capacity. Ant Colony Optimization (ACO) was used to solve a vehicle routing problem to determine the most time- and cost-efficient route for passenger transportation (VRP). The system was verified in Catania, Italy, where a metro line is being extended from the city center to the outskirts of the city. To accurately represent the expected travel demand, a Geographic Information System (GIS) was used to construct the road network, select all available bus stops, and weight them according to their accessibility. Finally, the ACO technique was designed and implemented for many agents in the NetLogo programming and modeling environment. In this scenario, simulations of complex systems were performed. These routes were designed to maximize potential passenger demand within a given time limit. Customers, operators and passengers of the parallel Hungarian public transport system all contributed significantly to the overall development of the system. The authors' previous work was based on a supply and demand analysis. As a passenger, one can select the mode of transportation that best suits ones needs. With the help of open source statistical databases, data on demographics of Latvian cities and other relevant information were collected and analyzed. Published timetables and structural details for the passenger station and JSC "Riga International Coach Terminal" served as input data for the simulation model (later in the text, "Terminal"). Simulations were performed to confirm that the new procedure gives the desired results. At the "Rail-International Bus" bimodal transportation hub terminal, the proposed concept for developing a multimodal public transportation hub is being considered. The concept refers to the development of public transport nodes. The average time it takes a passenger to change modes of transport on arrival and departure is used to evaluate both the capacity of the waiting area and the quality of services offered to customers (Bolkovska and Petuhova 2016). As urbanization gradually alters natural ecosystems and impacts the long-term survival of the environment, urban spatial planning has the potential to be used to address urban metabolism and achieve sustainable development goals. Increased demand for essential goods and services such as food and electricity in urban areas results in more carbon emissions than would otherwise occur. This environmental impact can be reduced by incorporating spatial functions such as agriculture and renewable energy generation into urban planning. However, supporting planning technologies capable of experimenting with novel land use allocation techniques within an integrated urban-rural ecosystem are needed (Penazzi et al. 2019). Using a framework for agent-based simulations facilitates the design of large-scale, effective public transportation systems. It outperforms previous systems by including dynamic response to changes in the network and external events. In Zurich, the framework was evaluated using an agent-based simulator (MATSim). This paradigm is not based on the conventional approach to improving the efficiency of the public transportation network, but is rather a citywide, multimodal transportation simulation tool. Compared to the current public transportation system, this one requires a network of less densely packed, smaller, and more frequent vehicles. Consequently, more people will use public transportation, reducing taxpayer expenditures. It can also reveal potential ways to increase capacity. Using similar methods, transportation planners can evaluate their current public transportation networks and prepare for a future with autonomous vehicles (Manser et al. 2020). The characteristics of multimodal transportation routes are dynamically calculated using the Witness simulation software. This strategy seeks to minimize multimodal transportation carbon emissions to promote green transportation, a topic that has recently been receiving increasing attention. In conjunction with a multi-criteria framework for evaluating the efficiency of multimodal transportation, an order-relation analysis and an entropy-weighted fuzzy analytic hierarchy process approach are used to evaluate the performance of routes in different multimodal transportation systems. The proposed method was evaluated on the Sino-European railroad lines from Wuhan to Berlin. In developing environmentally friendly multimodal transportation networks, the multi-criteria and multi-scenario based evaluation methods can reduce emissions and energy consumption by 24 %. Their research proposes a concept of multimodal environmentally friendly transportation organization (Wang et al. 2020). According to their study, airports, ports, railroads, subways, and bus terminals should be interconnected and transformed into multimodal passenger platforms. Local, regional and interregional modes of transport intersect at terminals. The main purpose of a transportation terminal is to meet the needs of its customers while ensuring their safety and well-being. The primary objective of intermodal terminals, which have evolved in response to sustainable development goals, should be the reduction of traffic congestion. Bucharest ranks sixth in the world in terms of traffic congestion (according to TomTom Traffic Index). The simultaneous use of many modes of passenger transportation drastically reduces traffic congestion in the city. Multimodal passenger terminals reduce congestion at the expense of time, convenience, comfort, and even travel costs, as each mode has its own pricing rules. To make public transportation more attractive, intermodal terminals must be designed and managed to encourage frequent or infrequent use. This paper proposes a concept for the design of intermodal passenger terminals that enables switching between different modes of transportation. The framework of the concept includes the linking of transport schedules, the placement of stations to avoid transfers, integrating fares, and using a one-way ticket. This study examines a hypothetical multimodal passenger terminal that benefited from the correlation of transit schedules using the linear integer programming paradigm (Rosca et al. 2020). Public transport in the Russian Federation can compete with private car transport due to the excellent quality of its services to passengers and the consistency of its operations. The total time spent on transportation, including transfers, is an important measure of the quality of urban public transport. A detailed evaluation of the efficiency of interchanges in Russia has not been carried out yet. Therefore, the following criteria are recommended to evaluate the effectiveness of interchange station operations: the total time spent on interchanging, including travel time between interchange stations, and the waiting time for interchanging. A ranking system for services was proposed. Using survey data from interchange stations in Irkutsk and Vienna, the distribution quartiles of the interchange time scale were determined (Kopylova et al. 2018). The effective use of parallel public transportation networks in Hungary should be studied from the perspective of consumers, operators, and end users. This study focuses on mode choice rather than supply analysis for long-distance public transportation. Expressed preference, a unique survey approach, was used in this study. It is critical to determine whether the questionnaire approach is fact-based and places respondents in real transportation conditions. Passengers must freely choose their preferred mode of transportation. According to a recent study, user sensitivity to travel duration depends on their motivation and the distance they have to travel. The price and the quality of comfort of various modes of public transportation differ (Lakatos and Mándoki, 2020). Reducing travel time and expanding service to places where there is currently insufficient access to a service facility are two key factors that would encourage more people to use public transportation instead of driving. Fewer vehicles on the roads would reduce traffic congestion and air pollution through reduced exhaust emissions. The Geographic Information System (GIS), Particle Swarm Optimization (PSO), and Genetic Algorithm (GA) were used to determine the ideal travel time and operability of bus stops in Amman, Jordan. For streets with multiple bus stops at irregular intervals, such as Zahran Street, GIS modeling reduced travel time by (23.25 %) during off-peak hours and by (19.74 %) during peak hours, while PSO reduced travel time by (28.95 %) and (39 %), respectively. Georgia Transit also reported a 47.96 percent reduction in travel time in Zahran Street. Travel time increased from 12.25 minutes each way to 50.71 minutes each way due to an increase in the number of stops on Al-Quds

Street from six to twenty-five, compared to the previous six. This reduced the distance to a bus stop from about 2,000 feet to less than 400 feet. In addition, the demand for accessible bus stops far exceeds the current capacity. On Al-Quds Street, the average demand per stop was 10,456, even though capacity was only 1,465. When the models were tested on routes not included in the study, the results were similar, further supporting the reliability of the models. The proven PSO and GA algorithms are readily applicable to any current network or planned urban expansion (Shatnawi et al. 2020). Critical urban subsystems, such as the urban transportation system, pose a major challenge to the development of sustainable and future-oriented urban infrastructure. To mitigate economic, environmental, demographic, and institutional constraints, urban transportation networks must be modified to avoid dead ends and route dependency. According to the authors, the socio-technical system of multimodal transport has the potential to solve some of today's urban mobility problems. Multimodal mobility maximizes the benefits of each system by combining private and public modes of transportation. Recognizing that mobility systems are not monolithic and that transitions require a multilevel analysis, we used a multilevel view that integrated sector-specific actors. Their paper aims to help cities in Germany develop a long-term vision for urban transportation systems using transition theory. Strategic implications for businesses, government organizations, and consumers are derived from empirical information gathered from three concurrent Delphi studies and several focus group workshops, which form our overall framework for strategic problem management. Read more... Among other things, stakeholder strategic goals must coordinate efforts to capitalize on system strengths, build smart transportation networks, diversify public and private funding, change business models, and foster a renaissance of citizen participation (Spickermann et al. 2014). When discounts are granted, individuals are more likely to use public transportation, resulting in higher revenues for transportation providers. In this study, the agent-based simulation model MATSim was used to develop a trip assignment model that accounts for actual travel time, congestion, and fare pricing. Then, a simulation-based optimization problem is devised to maximize the profit by reducing the exchange discount. A metamodeling approach is presented as an alternative to the costly simulation method to improve the computational efficiency. In a scenario involving Hong Kong Island, transfer hubs are built and bus-bus interchange savings are maximized. The ideal interchange discount increased by the proposed metamodel-based strategy increases the profit of bus operators by 12 percent, as shown in the optimization results (Lee et al. 2020). Accessibility to public services, including education, health care, public safety, and justice, is one of the most important considerations when developing regional plans for a city or town. Regional transportation networks are often categorized and reorganized by planners to better serve the region's population centers (with a class of amenities associated with each level of the hierarchy). Transportation network design and urban hierarchy have long been separated in academic literature. Using an optimization model, their research shows how to identify the metropolitan regions and network links which should be elevated to a higher level of the hierarchy so that all amenities are easily accessible. A case study from the Portuguese Centro region illustrates how the concept can be applied to the actual design of an integrated urban hierarchy and transportation network (Bigotte et al. 2010). Traffic congestion and air pollution are becoming a growing problem in urban areas. City governments can proactively address these problems by allowing their residents to use a variety of modes of transportation to get to work. There is a lack of knowledge about 1) the variables that hinder intermodal travel and 2) the aspects that can promote intermodal travel. Their study presents and evaluates research proposals to change passenger behavior toward multimodal travel in metropolitan areas. Following a detailed review of literature and data from governmental and industrial sources, as well as eight in-depth expert interviews and twelve interviews with city visitors, we formulated policy and implementation suggestions based on our primary qualitative data. Particular attention was given to the usefulness of the information in overcoming resistance to change and as a potential behavioral incentive for multimodal travel. One of the benefits was collaboration with other mobility service providers aiming to reduce perceived barriers to mobility and provide better information. To encourage multimodal travel, agencies need to use attractive incentives rather than punitive measures. Tailoring policies and communications to different urban populations is key to effective policy implementation. The multimodal integrated online information platform is widely accepted, according to research findings (Dacko and Spalteholz 2014). This paper provides a unique agent-based strategy for feeder bus route planning capable of bridging the gap between public transportation supply and demand in low-demand regions. Ant Colony Optimization (ACO) was applied to identify the most cost-effective road network routes to improve feeder bus route planning as a vehicle routing problem. In Catania (Italy), where the metro line is being extended from the city center to the outskirts, the above methods were applied. As a proxy for projected travel demand, a GIS technique was used to create the road network, select all possible bus stops, and weight them based on accessibility considerations. The best set of feeder bus routes to a given metro station was determined by using the ACO method implemented in NetLog, a multi-agent programming and modeling environment for simulating complex systems. Each of these routes was designed to maximize passenger demand within a given time frame. Numerous scenarios were analyzed by evaluating a number of key performance criteria based on service coverage and ridership. (Calabr et al., 2020) The results of the first part of the study show that the approach can be used effectively to find suitable routes that connect traditional public transport to urban locations with low demand. In both the United Kingdom and the European Union, rail freight is an important component of the current transportation plan. In late 2005, the British government defined an 80 percent growth target for the 2000-2010 period. This research of the adequacy of measurement types used for rail freight operations, suggests that the realization of defined growth targets or predictions does not necessarily indicate that policies supporting the switch from road to rail would be effective. Due to the fundamental importance of policy implementation and evaluation, alternative or additional techniques for monitoring rail freight activities are recommended (Woodburn 2007). In the last couple of years, there has been a gap between the increase in the number of automotive kilometers traveled and the economic development of some European countries. Road freight transportation has not seen a comparable dissociation (ton-kilometers). The Divisia index decomposition approach is employed to get to the bottom of the factors behind the historically substantial growth in road freight traffic and transportation volumes at the national level in Denmark. The increase in the total volume of road freight traffic was shown to be a consequence of growing impacts on its underlying components, which are often going in the opposite direction. Mostly due to bigger trucks, increased average loads, and a decline in the frequency of empty journeys, the growth of road freight traffic is becoming increasingly dissociated from economic development. There is a direct correlation between the increase in output and the increase in freight moved by road. The handling factor or the number of tons lifted per ton of product produced, decreases, whereas the number of ton-kilometers lifted per ton of product lifted increases (Kveiborg and Fosgerau 2007). Since there is substantial demand for the ownership and use of private vehicles, many industrialized countries and emerging economies face a formidable obstacle when attempting to increase the number of people who use public transportation. Even while the share of public transportation in the transportation market is declining in some countries, others are prepared for a similar trend since wealthy nations are making vehicles more accessible and, therefore, more appealing. However, infrastructural investments in the development of bus rapid transit (BRT) systems have dramatically reversed the loss in the market share of buses in some countries. BRT may be able to provide service levels that are sufficiently competitive with automobiles to attract and retain a client base by making public transportation more visible and distinct from other modes of transportation. BRT, unlike other kinds of public transportation, is gaining popularity globally, particularly in South America, Europe, and Asia (such as light and heavy rail). Its popularity may be attributed to a variety of features, including its value for money, service capacity, affordability, relative flexibility, and network coverage. The operation of the system and its viability as a paradigm for ecologically beneficial forms of transportation are analyzed in detail (Hensher 2007). The availability of information on public transportation is crucial to determine its quality. Integrated information on many modes of transportation can affect consumers' mode selections (IMTI). The goal of this study is to establish what sort of IMTI service people want when they use public transportation. User preferences for IMTI quality during pre-trip, roadside, and aboard encounters may change. The capacity to save both time and effort is the single most important factor in determining the success of a new product or service (physical, cognitive, and affective effort). The ideal time to gather IMTI when planning multimodal travel is during the pre-trip phase, according to a sample of Dutch tourists comprised mostly of young people. During this phase, desired IMTI types are collected and used to design the section of the trip that is completed by public transportation. When a tourist can use roadside IMTI to select a suitable vehicle to continue his journey, it is at its most useful. It is of utmost importance that passengers arrive at interchanges with enough time to catch their connecting mode of transportation. When calculating the amount of money that can be saved when traveling, time is the most essential variable. Apart from that, the amount of time spent searching before departure should be shortened, since physical exertion should take precedence over cerebral duties while traveling (Grotenhuis et al. 2007). The spirit of collaboration that pervades the maritime industry has been commended in the relevant literature for a very long time. This may boost consumer surplus if transportation companies cooperate to minimize the number of drivers, increase profitability, and enhance supply regulation. The liner shipping sector is the only industry in Europe and North America that is mostly immune to antitrust rules. The paper that builds on the EU's recent decision regarding the maritime liner sector and the EU Commission's consultation paper on the review of Regulation 4056/86 tried to determine the manner in which antitrust rules can effectively monitor and control the market in the light of emerging trends in maritime logistics integration. In particular, the paper examines how antitrust laws might effectively monitor and regulate the market in view of the growing marine logistics integration trends (Benacchio et al. 2007). Light rail was an important part of attempts by the UK government to increase accessibility and mobility in urban areas. In 2000, the government's Integrated Transport Policy and Ten-Year Transport Plan featured these initiatives. In 2004, the government decided to withdraw its partial support to light rail projects in Leeds, Liverpool, Manchester, and Portsmouth due to greatly increased capital costs. This decision was adopted after the bankruptcy of Railtrack and the loss of confidence in the private sector. Two years after the introduction of the Ten-Year Transport Plan 2000, the goal of tripling the number of people using light rail and facilitating the installation of 25 new light rail lines was abandoned. The paper also discusses the ways to reduce the capital costs of light rail, identify new funding sources, and manage the environmental impact of the system (Knowles 2007).

3. METHOD

This study identifies the factors that influence whether passengers select water over other modes of transportation, such as Metrobus and Marmaray, while traveling between the Asian and European sides of Istanbul. Marmaray and Metrobus are two examples of these vehicles. During this period, a model was developed based on the dependent variable "frequency of use" obtained from the preliminary results of the "Sea Transportation Satisfaction Survey" conducted on a sample of 2,343 respondents. In addition, other survey questions were used as input, and the model was evaluated using a variety of methods. The study emphasizes the value of time efficiency for the users of intermodal transportation, as seen from the reasons multimodal passengers state for choosing such routes and their ratings of interchanges. Urban planners must take into consideration the travel patterns and expectations of multimodal users if they are to design a successful urban transportation system. The potential advantages of intermodal combinations must be optimized. The Istanbul Metropolitan Municipality has stated that one of its transportation objectives is an increase in the percentage of trips conducted using water transportation. It is often difficult to complete a trip from start to finish using only water transportation. As a result, an all-encompassing approach to route optimization is required to accommodate the growing volume of maritime traffic. While the frequency of usage was recognized as the "dependent variable," the remaining 20 factors were viewed as "independent variables" or "features," and models were developed using two distinct methods:

Based on the responses of 2,343 survey respondents, two distinct methods were employed to extract the features that produced meaningful findings in multivariate statistical analysis. In the initial approach, "discriminant analysis" was attempted. The second strategy was modeling using multinomial logistic regression. This methodology, which takes the human brain as an example, was used to explore the substantial association between characteristics and the dependent variable.

This model was evaluated using supervised learning. The makeup of questionnaire participants was as follows:

Table 1.
Age questionnaire participants.

Ages	N	%
18-25	865	36,9
25-30	441	18,8
30-45	551	23,5
45-60	338	14,4
60 and older	148	6,3

Based on the information provided in Table 1, age of questionnaire participants can be described as follows:

Participants were divided into five age categories: 18-25, 25-30, 30-45, 45-60, and 60 and older.

- The total number of participants was 2,343.
- The largest age category was 18-25, representing 36.9 % of the total sample (865 participants).
- The second largest age category was 30-45, accounting for 23.5 % of the total sample (551 participants).
- The smallest age category was 60 and older, representing only 6.3 % of the total sample (148 participants).
- The remaining categories, 25-30 and 45-60 account for 18.8 % (441 participants) and 14.4 % (338 participants) of the total sample, respectively.

Overall, the age distribution of the participants in the questionnaires is skewed towards younger ages, with the majority falling into the 18-25 age range.

Table 2.
Gender of questionnaire participants.

Gender	N	%
Male	1666	71,1
Female	677	28,9

Based on the information provided in Table 2, Gender of questionnaire participants can be described as follows:

- The total number of participants was 2,343.
- The majority of the participants, i.e. 1,666 participants, or 71.1 % of the total sample identified as male.
- The remaining 677 participants, of 28.9 % of the total sample identified as female.

Overall, the gender distribution of questionnaire participants was skewed towards male participants, with males representing a larger proportion of the sample than females.

Table 3.
Beginning and end of the journey of questionnaire participants.

The district where the trip started	Final destination				
	N	%		N	%
Adalar	44	1,9	Adalar	209	8,9
Arnavutköy	12	0,5	Arnavutköy	9	0,4
Ataşehir	53	2,3	Ataşehir	19	0,8
Avcılar	17	0,7	Avcılar	8	0,3
Bağcılar	41	1,7	Bağcılar	12	0,5
Bahçelievler	28	1,2	Bahçelievler	9	0,4
Bakırköy	28	1,2	Bakırköy	10	0,4
Başakşehir	17	0,7	Beşiktaş	138	5,9
Bayrampaşa	29	1,2	Beykoz	141	6,0
Beşiktaş	127	5,4	Beylikdüzü	8	0,3
Beykoz	185	7,9	Beyoğlu	120	5,1
Beylikdüzü	17	0,7	Çekmeköy	12	0,5
Beyoğlu	124	5,3	Other	49	2,1
Çekmeköy	44	1,9	Esenler	7	0,3
Other	32	1,4	Eyüp	22	0,9
Esenler	27	1,2	Fatih	423	18,1
Esenyurt	13	0,6	Kadıköy	523	22,3
Eyüp	56	2,4	Kağıthane	8	0,3
Fatih	169	7,2	Kartal	10	0,4
Gaziosmanpaşa	27	1,2	Küçükçekmece	12	0,5
Gebze	14	0,6	Maltepe	23	1,0
Güngören	9	0,4	Pendik	15	0,6
Kadıköy	275	11,7	Sancaktepe	10	0,4
Kağıthane	38	1,6	Sarıyer	122	5,2
Kartal	44	1,9	Şişli	62	2,6
Küçükçekmece	39	1,7	Ümraniye	39	1,7
Maltepe	60	2,6	Üsküdar	309	13,2
Pendik	49	2,1	Zeytinburnu	14	0,6
Sancaktepe	34	1,5			
Sarıyer	112	4,8			
Sultanbeyli	16	0,7			
Sultangazi	28	1,2			
Şişli	68	2,9			
Tuzla	12	0,5			
Ümraniye	103	4,4			
Üsküdar	323	13,8			
Zeytinburnu	29	1,2			

Table 3 provides information on the "District where the trip started" and the "Final destination" for questionnaire participants.

The table gives the number and percentage of participants who reported starting their trip in a particular district, and the number and percentage of participants who reported their final destination as a particular district.

Kadıköy and Esenler districts were reported as the starting point of the journey for the lowest number of participants (7 and 8 respectively), while the Fatih district was reported as the starting point for the majority of participants (423).

The most commonly reported final destination was Kadıköy, with 523 participants (22.3 %), followed by Üsküdar with 309 participants (13.2 %) and Fatih with 423 participants (18.1 %).

It is also important to note that there were 49 participants (2.1 %) who reported their final destination as "Other," while no participants reported their starting point as "Other."

Overall, the data in Table 3 provides insight into the starting and ending points of the journeys taken by questionnaire participants.

Table 4.
Vehicle or vehicles used prior to filling out the questionnaire.

Vehicle/vehicle uses	N	%
Bus	676	28,85
Metro	480	20,49
Shared taxi	133	5,68
Taxi	69	2,94
Walking	502	21,43
Tram	150	6,40
Metrobus	150	6,40
Ferry	275	11,74
Bike	7	0,30
Marmaray	243	10,37
Individual vehicle	131	5,59
Funicular	6	0,26
Mini bus	19	0,81
Scoter	4	0,17
Train	5	0,21

Table 4 shows the different types of vehicles used by participants prior to filling out the questionnaire and the frequencies and percentages of their use. The most commonly used mode of transportation was the bus, which was used by 28.85 % of participants, followed by the metro at 20.49 %. Walking was also a popular mode of transportation, used by 21.43 % of participants. Other commonly used modes of transportation included the tram (6.40 %), Metrobus (6.40 %), ferry (11.74 %), and Marmaray (10.37 %). Only a small percentage of participants reported using individual vehicles such as cars or motorcycles (5.59 %), and other modes of transportation such as shared taxis, taxis, bikes, funiculars, mini busses, scooters, and trains were used by less than 1 % of participants.

Table 5.
Vehicles used by participants after disembarking from the ferry.

By…	N	%
Bus	580	24,75
Metro	326	13,91
Shared taxi	141	6,02
Taxi	74	3,16
Walking	1051	44,86
Tram	142	6,06
Metrobus	26	1,11
Ferry	40	1,71
Bike	11	0,47
Marmaray	78	3,33
Individual vehicle	58	2,48
Funicular	5	0,21
Minibus	11	0,47
Scoter	8	0,34
Train	1	0,04
Service	2	0,09

Table 5 shows the modes of transportation used by respondents after disembarking from the ferry. The table includes the number of respondents (N) and the percentage (%) of respondents who indicated each mode of transportation. The modes of transportation include buses, metros, shared taxis, taxis, walking, trams, metro buses, ferries, bikes, Marmaray, individual vehicles, funiculars, mini busses, scooters, trains, and services. The majority of respondents (44.86 %) reported walking after getting off the ferry, followed by buses (24.75 %), metros (13.91 %), and shared taxis (6.02 %).

Table 6.
Duration of the walk prior to getting on the ferry.

Minutes	N	%
0-4	544	23,2
5-9	729	31,1
10-14	531	22,7
15-19	312	13,3
More than 20	227	9,7

Table 6 shows minutes walked by respondents before getting on the ferry. The table has five categories: 0-4 minutes, 5-9 minutes, 10-14 minutes, 15-19 minutes, and more than 20 minutes. The table also shows the number of respondents and the percentage of respondents in each category. For example, 544 respondents (23.2 % of the total respondents) reported walking 0-4 minutes before getting on the ferry, while 227 respondents (9.7 % of the total respondents) reported walking more than 20 minutes before getting on the ferry.

Table 7.
Duration of the walk after getting off the ferry.

Minutes	N	%
0-4	490	20,9
5-9	661	28,2
10-14	558	23,8
15-19	342	14,6
More than 20	292	12,5

Table 7 shows minutes walked by respondents after getting off the ferry. The table includes the following information:

- Minutes: The range of minutes (in increments of 5) that respondents reported walking after getting off the ferry.
- N: The number of respondents who reported walking for the specified number of minutes.
- %: The percentage of respondents who reported walking for the specified number of minutes.

The table shows that the majority of respondents (about 51 %) reported walking 9-14 minutes after getting off the ferry. About 20.9 % of respondents reported walking 0-4 minutes, while about 12.5 % reported walking more than 20 minutes.

Table 8.
How many times a week do the respondents use the ferry/engine? (Dependent variable).

Times to use	N	%
More than 10 times	310	13,2
5-9 times	220	9,4
1-4 times	647	27,6
Rarely	1166	49,8

Table 8 shows the frequency of the respondents' use of the ferry or engine, which is the dependent variable in this study. The table shows the number of respondents and the percentage for each category of use. The categories are "more than 10 times," "5-9 times," "1-4 times," and "rarely." The majority of respondents, 49.8 %, reported using the ferry or engine rarely, followed by 27.6 % who reported using them 1-4 times a week. A smaller percentage reported using it 5-9 times a week (9.4 %) or more than 10 times a week (13.2 %).

Table 9.
Purpose of using the ferry.

	N	%
Transportation between home and work	790	33,7
Transportation between home and school	80	3,4
Visiting	152	6,5
Entertainment	1231	52,5
Other	90	3,8

Table 9 shows ferry use purposes as reported by survey respondents. The table indicates the number of respondents and the percentage of each purpose. The purposes of using the ferry include transportation between home and work, transportation between home and school, visiting, entertainment, and others. The majority of respondents (52.5 %) reported using the ferry for entertainment purposes, followed by transportation between home and work (33.7 %). Only a small percentage of respondents reported using the ferry for transportation between home and school (3.4 %).

Table 10.
Vehicles used as an alternative to the ferry.

	N	%
Metrobus	439	18,74
Marmaray	686	29,28
Bus	696	29,71
Metro	638	27,23
Taxi	90	3,84
Minibus	64	2,73
Shared taxi	85	3,63
Tram	123	5,25
Individual vehicle	191	8,15
Walking	10	0,43
There is no alternative, I do not use	125	5,34

Table 10 shows the number and percentage of respondents who use different transportation alternatives to the ferry. The alternatives listed in the table include Metrobus, Marmaray, bus, metro, taxi, minibus, shared taxi, tram, individual vehicle, walking, and not using any alternative.

The table indicates that the most common alternatives used by respondents are Metrobus, Marmaray, and bus, with 18.74 %, 29.28 %, and 29.71 % of respondents using them, respectively. Walking is the least common alternative, with only 0.43 % of respondents using it. Additionally, 5.34 % of respondents reported that they do not use any alternative because there is no other option available.

We are testing the concept that "the improvement of marine transport networks may greatly boost seaway space utilization." This study uses several statistical and machine learning (ML) approaches to identify the impacting variables (ferry/motor vehicle usage frequency)(Table 11). These processes are described in more detail in further text. Multivariate statistical analysis combines discriminant analysis and multinomial logistic regression models to assess the responses of 2,343 individuals. In contrast to traditional statistical techniques, machine learning (ML) approaches are used to estimate non-linear models that have the potential to be employed to analyze things such as the frequency of ferry and vehicle traffic. ML is defined as an algorithm that can learn from its own experiences. ML makes use of methods like supervised learning, unsupervised learning, and reinforcement learning. This study incorporates methods of supervised learning. This kind of training requires a prior understanding of the consequences of the topic studied. This experiment makes use of artificial neural networks (ANNs). First, ANN models were trained to determine the most important independent variables and their relevance to the ferry and motor vehicle use frequency. Cross-validation methods included the k-fold and leave-one-out procedures. The study used artificial neural networks (ANNs), which are modeled after the human brain. The brain's structure is composed of many neurons. Synapses allow neurons to communicate with one another. Perceptrons are used to simulate the inputs and outputs of neuron-based artificial neural networks (ANNs). In its most basic form, the output of synaptic weighting equals the sum of all weighted inputs. A perceptron may be used to implement an activation or transfer function, much as one would use a linear, sigmoid, or hyperbolic tangent function. In an artificial neural network (ANN), a hidden layer provides a direct connection between input and output layers. Backpropagation is the most essential component of network training. Gradient-based approaches such as Scaled Conjugant Gradient (SCG), Gradient Descent with Momentum (GDwM), and Levenberg Marquardt (LM) may be applied to train ANNs with stopping criteria such as MSE or cross-entropy.

Table 11 depicts dependent and independent variables used in the survey. The independent variables include gender/age, distance to beginning, walking distance before and after getting on/off the ferry, comparison of Marmaray and Metrobus in terms of speed, access, connection, waiting time, comfort, hygiene, and pleasure, preference for traveling by ferry or motor vehicle, and factors that could influence the choice of transportation mode such as shorter walk, shorter travelling time, and using only one vehicle. The dependent variable is the frequency of ferry/motor vehicle use categorized as 10 or more times, 5-9 times, 1-4 times, and rarely.

Table 11.
Dependent and independent variables.

Independent variables	
Gender/age	Distance to beginning
Walking first	Destination arrival distance
Followed by walking	
Marmaray comparison: speed	Metrobus comparison: speed
Access	Access
Connection	Connection
Waiting	Waiting
Comfort	Comfort
Hygiene	Hygiene
Pleasure	Pleasure
Which would you prefer to use, ferry or motor vehicle?	If I could get information from other sources, I would. If I walked less before/after getting off. If only I could get there more quickly. If only I could get to the ferry/engine with only one vehicle, that would be great.
Dependent variable	
ferry/motor vehicle frequency of use	(10 or more times, 5-9 times, 1-4 times, rarely)

3.1. Model Estimation

Estimating the frequency of ferry and vehicle use necessitates the application of a variety of multivariate statistical methods and machine learning techniques. These techniques are used to predict models with high classification accuracy and a low false positive or negative rate. Each strategy is trained using k-fold cross-validation with a leave-one-out component during model estimation. MATLAB 2015a was used to create learning algorithms. The following table displays the results of all multivariate statistical and machine-learning techniques.

3.1.1. Multinomial logistic regressıon and dıscrımınant analysıs

This part of the research reveals, through the application of Multinomial Logistic Regression and Discriminant Analysis, that the categorization of the frequency of use of ferry and motor vehicles is influenced by mutually independent parameters. Assessing the predictive accuracy of models used to generate forecasts, Table 12 displays the findings of the Multinomial Logistic Regression and Discriminant Analysis.

Table 12 provides information on the performance and selected features of Multinomial Logistic and Discriminant Models in predicting the dependent variable (frequency of use of ferry/motor vehicle).

Model 1 is a Multinomial Logistic Regression model that has eight independent variables, including: age, gender, then walking, and four variables related to comparing Marmaray and Metrobus (waiting time, speed, pleasure, and hygiene). The model does not specify the number of folds or leave-one-out, which could have an impact on its performance. Model 2 and Model 3 are Discriminant models, with K-fold and leave-one-out methods, respectively. Both models have four selected independent variables, including age, then walking, Marmaray comparison speed, and Metrobus comparison access. Model performance is determined based on the number of selected features (NSF). Model 1 has the highest NSF with eight selected features, while Model 2 and Model 3 have four selected features. Overall, determining which model is superior is difficult without additional information on performance metrics (e.g., accuracy, sensitivity, specificity). However, the consistency of the number of selected features in Model 2 and Model 3 could be indicative of a more robust model.

Table 12.
The performances of Multinomial Logistic Regression and Discriminant Models (NSF = number of selected features).

Method	Models	NSF	Selected features
Multinomial logistic	Model 1	8	Age (18-25), Gender (Male) then walking, Marmaray comparison waiting, Metrobus comparison speed, Marmaray comparison speed, Marmaray comparison pleasure, Marmaray comparison hygiene
Discriminant	Model 2 (K-fold)	4	Age, then walking, Marmaray comparison speed, Metrobus comparison access
	Model 3 (Leave-one-out)	4	Age, then walking, Marmaray comparison speed, Metrobus comparison access

The chosen variables in all three models are statistically significant (p 0.05), and the Hosmer-Lemeshow test data support the interpretations of the Multinomial Logistic Regression model (p > 0.05). The findings indicate that the assumption of the equality of variance-covariance matrices is supported (Box-M, p 0.001) and that chosen variables are significant (Wilks' Lambda, p 0.001) for discriminant analysis. Then, a one-unit increase in walking time (for instance, how many minutes do you walk after leaving a boat or motorcycle?). Compared to occasional use, this reduces the frequency of ferry motor use by a factor of 1.034 (1/0.967). The comparison of ferry/motor vehicle trips with Marmaray trips shows that an increase by one unit in standby (compare ferry/motor vehicle trips with Marmaray trips?) boosts the frequency of ferry/motor vehicle use by a factor of 1.178 compared to occasional use. Persons aged 18-25 use the ferryboat motor vehicle 10 or more times less, i.e. less by a factor of 1,961 (1/0.510), than persons over 60. Regardless of gender, the use of the ferryboat motor vehicle more than 10 times increases by a ratio of 2.615 % compared to infrequent use. If we compare ferry or motor vehicle travel to Metrobus travel, a one-unit increase in speed (how fast is Metrobus?) is equivalent to an increase of one unit. It would increase the frequency of ferry motor use by somewhere between five and nine times (1,220), compared to infrequent use. User gender multiplies the probability that they will use the ferryboat motor 5–9 times more often than they otherwise would by a factor of 2,394. A one-unit increase in walking first (how many minutes do you walk before boarding the ferry or motorcycle?) increases the frequency of ferry motor use by 1.013 % compared to occasional use. How long do you walk before you reach the ferry or motorcycle? In comparison to Marmaray, a one-unit increase in speed (how fast is Marmaray travel compared to a ferry or motor voyage?) increases the frequency of ferry or motor vehicle use from 5 to 9 times (factor of 1.141), compared to infrequent use. A one-point increase in sanitation compared to Marmara (how does the ferry/motor route compare to the Marmaray voyage?) increases the frequency of motorized ferry use by a factor of 1,155, from rare to 1 to 4 times. Each increase by one unit of pleasure (would you rather take a ferry/motor ride or a Marmaray voyage?) increases the frequency of ferry/motor use between 1-4 times (by a factor of 1,230) compared to infrequent use. Depending on the gender of the users, the frequency of ferryboat motor use increases between 1–4 times (by a factor of 1.268) compared to infrequent use. Table 13 displays the odds ratios and p-values obtained from the Logistic Regression model that includes all relevant components.

The table shows the odds ratios for independent variables for each category of the dependent variable (ferry/motor frequency of use) as obtained using a Multinomial Logistic Regression with backward elimination. The p-value indicates the statistical significance of the relationship between the independent variable and the dependent variable category. The odds ratio (OR) represents the ratio of the odds of the dependent variable category occurring for a one-unit increase in the independent variable compared to no increase in the independent variable. The 95 % confidence intervals (CI) provide a range within which the true odds ratio is expected to drop with 95 % probability.

For example, in the dependent variable category "10 or more times", the following independent variables are statistically significant ($p<0.05$) and have odds ratios greater than 1: walking after (OR=0.967), Marmaray waiting (OR=1.178), being in the age range 18-25 (OR=0.510), and being male (OR=2.615). This means that for a one-unit increase in Marmaray waiting, the odds of using the ferry/motor 10 or more times increase by a factor of 1.178, if all other variables remain the same. Similarly, being male is associated with 2.615 times higher odds of using the ferry/motor 10 or more times compared to being female, if all other variables remain the same.

Table 13.
Independent variable odds ratios (Multinomial Logistic Regression-backward).

Ferry/motor frequency of use	Independent variables	p	OR	95 % CI (LL)	95 % CI (UL)
10 or more times	Walking after	0,001	0,967	0,949	0,986
	Marmaray waiting	0,049	1,178	1,000	1,387
	[Age=18-25]	0,018	0,510	0,292	0,889
	[Gender=male]	<0,001	2,615	1,832	3,732
5-9 times	Metrobus speed	0,015	1,220	1,039	1,433
	[Gender=male]	<0,001	2,394	1,623	3,531
	Walk first	0,038	1,013	1,001	1,026
	Marmaray speed	0,024	1,141	1,018	1,279
1-4 times	Marmaray hygiene	0,034	1,155	1,011	1,321
	Marmaray pleasure	0,046	1,230	1,004	1,506
	[Gender=male]	0,034	1,268	1,018	1,579

Table 14.
Classification table (discriminant analysis).

Classification results

Discriminant		How many times	Predicted group membership				Total
			1	2	3	4	
Leave-one-out	N	1	148	36	26	100	310
		2	75	35	24	86	220
		3	180	84	103	280	647
		4	325	120	159	562	1166
K-fold	N	1	151	33	26	100	310
		2	71	41	23	85	220
		3	180	84	103	280	647
		4	325	120	159	562	1166

The classification table shows the predicted group membership based on independent variables for the dependent variable "how many times" (referring to the frequency of ferry/motor vehicle use). The table is divided into four groups (1-4 times) and the total number of cases for each group is shown in the "Total" column.

Two classification tables have been provided, one for leave-one-out cross-validation and one for k-fold cross-validation. Both tables show the same information and have the same layout.

For example, in the leave-one-out table, there were 310 cases overall. Of those, 148 cases in group 1 were classified correctly, 36 cases were misclassified as group 2, 26 cases were misclassified as group 3, and 100 cases were misclassified as group 4.

Overall, the discriminant analysis correctly classified a large percentage of cases, with most groups having the overall classification rate of over 70 %.

4. RESULT

When training ANNs, the variable selection procedure is carried out automatically using a machine-learning based approach. Before commencing the training phase, initial tunings are set. After the training and variable selection phase, the classification accuracies and false positive and false negative ratios across the training, test, and total datasets are used to choose the top-performing models. To assess performance, Table 15 displays the best-estimated models together with their accuracy ratios, false positive and false negative rates, as established by ANNs.

Table 15.
The accuracy of the ANN and SVM models in classifying data.

Methods	Procedure	#Input	AUC	Test Acc.	Test FP	Test FN	Selected variables
ANN (scg, mse)	Full Model	20	0.607	0.581	0.422	0.417	All variables in Table 11
ANN (gd, mse)	Full Model	20	0.596	0.546	0.442	0.470	All variables in Table 11

The ANN model was used with estimated weights to get an insight into the relevance of the independent variables that have an effect on the frequency of ferry use. Figure 1 depicts the normalized importance of independent variables in terms of the best complete model. Figure 1 demonstrates that gender, Marmaray cleanliness, age, and Marmaray speed are the top four variables with a normalized significance of above fifty percent. These variables help model Multinomial Logistic Regression and Discriminant Analysis.

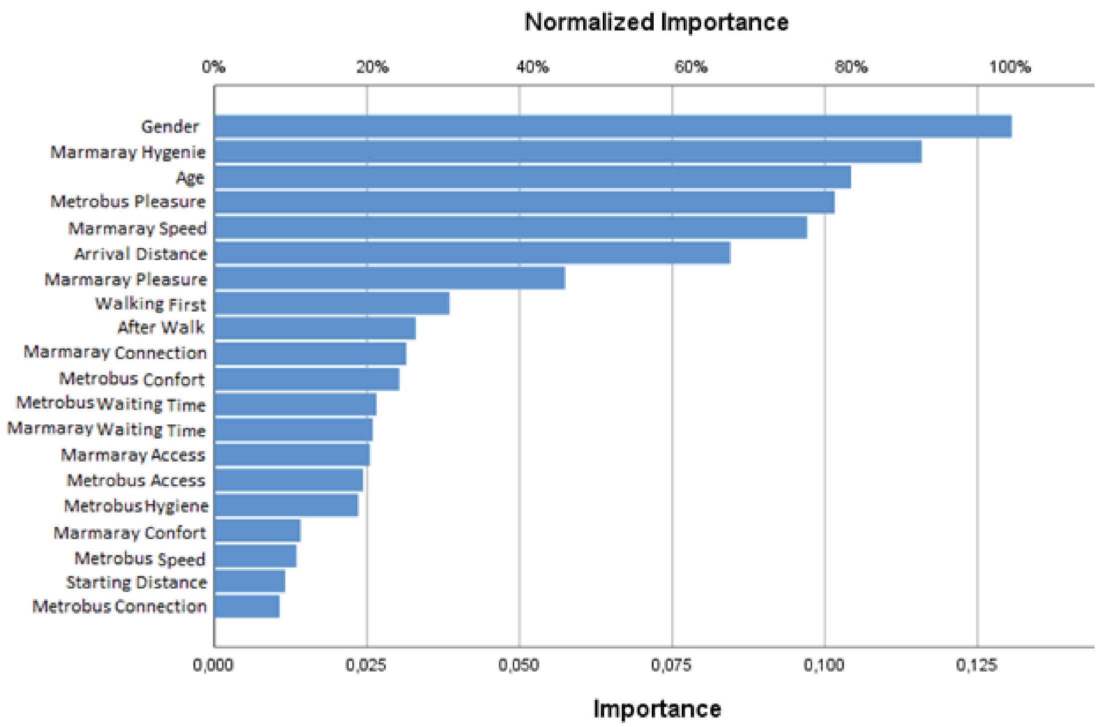

Figure 1.
Normalized importance of independent features.

Table 16.
Percentage share of sea transportation in total transportation.

Deniz	Adalar		Beşiktaş		Beykoz		Beyoğlu		Fatih		Kadiköy		Sarryer		Şişli		Ümraniye		Üsküdar		Grand Total	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Beşiktaş	957	100	3201	4.3	349	8.8	140	1.3	228	1.0	3932	84.5	223	0.9	163	0.9	277	15.0	21438	96.4	31792	14.6
Beykoz	108	100	228	6.7	363	0.6	19	12.1	155	58.9	54	1.5	1884	85.4	12	0.8	9	0.2	154	1.2	3030	2.9
Beyoğlu	186	100	306	2.9	181	47.8	1399	3.1	309	0.7	4492	94.1	358	3.8	39	0.2	104	43.3	6271	94.4	14176	7.7
Fatih	1672	100	468	5.0	320	41.6	222	0.6	3327	1.2	8413	23.0	334	2.2	47	0.2	166	12.3	4453	14.5	20495	3.1
Kadiköy	1149	100	245	6.4	236	6.3	5355	40.5	10512	20.8	12018	8.5	78	0.7	159	1.7	113	0.9	888	3.0	31911	7.7
Sarryer	11	100	196	1.1	2325	85.3	94	1.2	196	1.3	31	13.0	436	0.5	34	0.2	17	11.3	214	59.8	3595	2.2
Üsküdar	3318	100	22346	93.8	311	2.3	3161	72.3	8064	22.6	4195	10.2	881	34.7	855	26.0	309	0.5	8418	6.5	53976	14.1

Multidimensional scaling, or MDS, was used to determine the degree to which seven sites selected for this examination were similar in terms of passenger numbers, the number of stops placed within 500-800 meters from each other, and the existence of minibus stops. Explanatory factor analysis was performed to determine the magnitudes of the variables that influenced the presence of minibus stops, the number of passengers, and the number of stops within 500-800 meters from each other to evaluate the dimensions of the MDS graph. Two dimensions were found to account for 96.3 percent of the total data variance. The following interpretation of the MDS chart accounts for the high weights assigned to the variables of the number of stops and the presence of minibus stops within 500-800m from each other in the first dimension, as well as the weight assigned to the number of passengers variable in the second dimension:

Kadıköy, Beşiktaş and Üsküdar (D1) vary in size compared to other districts due to the enormous volume of people traveling through these areas. In terms of the Üsküdar (D2) dimension, Beşiktaş differs from other districts due to the greater number of stops made in various parts of the country. District marine transportation modules included in the same framework are quite similar to one another.

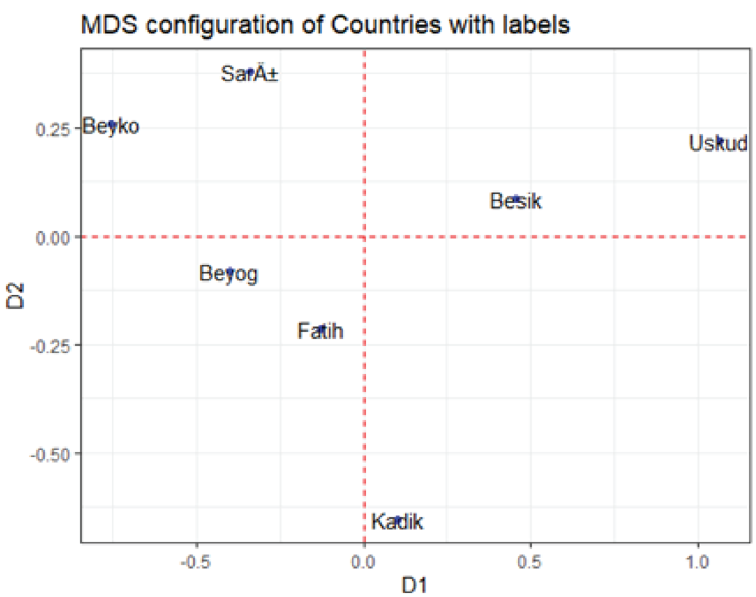

Figure 2.
MDS configuration.

Table 16.
Squared loading extraction sums.

Component	Total	% Variance	Cumulative %
1	3,817	76,330	76,330
2	0,998	19,958	96,288

Table 17.
Component matrix.

	Component	
	1	2
Passengers	0,464	0,879
Station500	0,927	0,244
Station800	0,954	-0,105
Minibus500	0,957	-0,279
Minibus800	0,957	-0,279

The table shows squared loading extraction sums which are used to determine the amount of variance that can be explained by each component or factor. In this case, it seems like there are two components, with the first component explaining 76.33 % of the variance and the second component explaining 19.96 % of the variance. The cumulative percentage indicates the total amount of variance explained by each component up to that point. In this case, the first component explains 76.33 % of the variance on its own, and both components combined explain 96.29 % of the variance.

Table 18.
A median for walking after using transportation.

Then walking		Med.+SD	Med. (Min.-Max.)	p
How many times	More than 10 times	8,3+7,1	5 (1-60)	0,004
	5-9 times	10,3+9,3	10 (1-60)	
	1-4 times	10,1+9,3	10 (0-60)	
	Rarely	10,6+9,7	10 (0-60)	

In a component matrix, each row represents a variable and each column represents a component. The values in the table represent the correlation between each variable and each component. In this particular table, there are two components. The first component accounts for 76.33 % of the total variance, while the second component explains 19.96 % of the total variance. The variables in the table seem to be related to transportation stations and modes in some areas. The exact meaning of each variable is not clear without additional context, but based on their names, they might represent the number of passengers, the distance to different transportation stations, and the availability of Minibuses. The values in the table indicate the strength and direction of the correlation between each variable and each component. For example, the first component has high positive correlations with all variables, which suggests that it might represent an overall level of transportation demand or accessibility in the area. The second component, on the other hand, has a negative correlation with Station800 and Minibus800, but a positive correlation with Minibus500, which suggests that it might represent some sort of spatial or directional pattern in transportation demand or accessibility.

The table suggests that passengers who use transportation more than 10 times tend to walk less after reaching their destination, with a median of 5 minutes (minimum 1 and maximum 60 minutes) compared to passengers who use transportation 5-9 times or 1-4 times, with a median of 10 minutes. The difference is statistically significant with a p-value of 0.004.

5. CONCLUSION

Specifically, consumers who have used the service ten or more times have a shorter walking distance after getting off compared to those who have used the service less frequently. This finding highlights the importance of considering the number of stops in transportation planning and design. In future studies, the researchers plan to further examine the relationship between mobile data and consumer behavior by using regression analysis. They also plan to examine the utilization percentages on routes and the number of passengers in regions where maritime transportation is used, to gain insights into the factors that influence transportation use patterns. By gaining a better understanding of these factors, transportation planners can make better informed decisions when designing and implementing transportation services.

CONFLICT OF INTEREST

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

REFERENCES

Benacchio, M. et al., 2007. The liner shipping industry and EU competition rules. Transport Policy 14(1), pp. 1–10. Available at: https://dx.doi.org.10.1016/j.tranpol.2006.05.010.

Bigotte, J.F. et al., 2010. Integrated modeling of urban hierarchy and transportation network planning. Transportation Research Part A: Policy and Practice 44(7), pp. 506–522. Available at: https://dx.doi.org/10.1016/j.tra.2010.03.020.

Bolkovska, A. and Petuhova, J., 2016. Simulation-based Public Transport Multi-modal Hub Analysis and Planning. In: Procedia Computer Science. Elsevier B.V., pp. 530–538. Available at: https://dx.doi.org/10.1016/j.procs.2017.01.169.

Calabrò, G. et al., 2020. Bridging the gap between weak-demand areas and public transport using an ant-colony simulation-based optimization. In: Transportation Research Procedia. Elsevier B.V., pp. 234–241. Available at: https://dx.doi.org/10.1016/j.trpro.2020.03.012.

Dacko, S.G. and Spalteholz, C., 2014. Upgrading the city: Enabling intermodal travel behavior. Technological Forecasting and Social Change 89, pp. 222–235. Available at: https://dx.doi.org/10.1016/j.techfore.2013.08.039.

Grotenhuis, J.W. et al., 2007. The desired quality of integrated multimodal travel information in public transport: Customer needs for time and effort savings. Transport Policy 14(1), pp. 27–38. Available at: https://dx.doi.org/10.1016/j.tranpol.2006.07.001.

Hensher, D.A., 2007. Sustainable public transport systems: Moving towards a value for money and network-based approach and away from blind commitment. Transport Policy 14(1), pp. 98–102. Available at: https://dx.doi.org/10.1016/j.tranpol.2006.10.004.

Knowles, R.D., 2007. What future for light rail in the UK after Ten Year Transport Plan targets are scrapped? Transport Policy 14(1), pp. 81–93. Available at: https://dx.doi.org/10.1016/j.tranpol.2006.10.001.

Kopylova, T. et al., 2018. A Level-of-Service concept regarding intermodal hubs of urban public passenger transport. In: Transportation Research Procedia. Elsevier B.V., pp. 303–307. Available at: https://dx.doi.org/10.1016/j.trpro.2018.12.087.

Kveiborg, O. and Fosgerau, M., 2007. Decomposing the decoupling of Danish Road freight traffic growth and economic growth. Transport Policy 14(1), pp. 39–48. Available at: https://dx.doi.org/10.1016/j.tranpol.2006.07.002.

Lakatos, A. and Mándoki, P., 2020. Mode-choice Analysis in Long-distance Parallel Public Transport. In: Transportation Research Procedia. Elsevier B.V., pp. 332–341. Available at: https://dx.doi.org/10.1016/j.trpro.2020.02.034.

Lee, E. et al., 2020. Transit interchange discount optimization using an agent-based simulation model. In: Procedia Computer Science. Elsevier B.V., pp. 702–707. Available at: https://dx.doi.org/10.1016/j.procs.2020.03.168.

Manser, P. et al., 2020. Designing a large-scale public transport network using agent-based microsimulation. Transportation Research Part A: Policy and Practice 137, pp. 1–15. Available at: https://dx.doi.org/10.1016/j.tra.2020.04.011.

Oostendorp, R. and Gebhardt, L., 2018. Combining means of transport as a users' strategy to optimize traveling in an urban context: empirical results on intermodal travel behavior from a survey in Berlin. Journal of Transport Geography 71, pp. 72–83. Available at: https://dx.doi.org/10.1016/j.jtrangeo.2018.07.006.

Penazzi, S. et al., 2019. Planning low carbon urban-rural ecosystems: An integrated transport land-use model. Journal of Cleaner Production 235, pp. 96–111. Available at: https://dx.doi.org/10.1016/j.jclepro.2019.06.252.

Rosca, M. et al., 2020. Solutions for improving transit through intermodal passenger terminals. In: Procedia Manufacturing. Elsevier B.V., pp. 225–232. Available at: https://dx.doi.org/10.1016/j.promfg.2020.03.033.

Shatnawi, N. et al., 2020. Optimization of Bus Stops Locations Using GIS Techniques and Artificial Intelligence. In: Procedia Manufacturing. Elsevier B.V., pp. 52–59. Available at: https://dx.doi.org/10.1016/j.promfg.2020.02.204.

Spickermann, A. et al., 2014. Heading towards a multimodal city of the future: Multi-stakeholder scenarios for urban mobility. Technological Forecasting and Social Change 89, pp. 201–221. Available at: https://dx.doi.org/10.1016/j.techfore.2013.08.036.

Wang, Q.Z. et al., 2020. Modelling green multimodal transport route performance with witness simulation software. Journal of Cleaner Production 248. Available at: https://dx.doi.org/10.1016/j.jclepro.2019.119245.

Woodburn, A., 2007. Appropriate indicators of rail freight activity and market share: A review of UK practice and recommendations for change. Transport Policy 14(1), pp. 59–69. Available at: https://dx.doi.org/10.1016/j.tranpol.2006.09.002.

Wu, S. shan et al., 2019. Rethinking bus-to-metro accessibility in new town development: Case studies in Shanghai. Cities 94, pp. 211–224. Available at: https://dx.doi.org/10.1016/j.cities.2019.06.010.