DETERMINATION OF SUPPRESSED & DIVERTED TRAVEL DEMANDS: İZMİR CASE STUDY

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ABSTRACT

DETERMINATION OF SUPPRESSED & DIVERTED TRAVEL DEMANDS: İZMİR CASE STUDY

City planners, transportation engineers, and policymakers rely on data from the public to design effective transportation systems, create policies, and develop investment strategies. Gathering this vital information is achieved through methods such as household surveys that capture travel demand data. A crucial aspect of analyzing this data is understanding the difference between apparent demands and latent demands, with a focus on examining suppressed and diverted travel demands. These demands are key to developing more effective transportation policies and planning strategies.

The primary objective of this thesis is to identify and analyze travel demands in Izmir, comparing them with actual travel behaviors to explore the differences between suppressed and diverted demands. This research draws on data from an online survey conducted with approximately 913 participants representing Izmir. The survey assessed current travel behaviors as well as suppressed and diverted demands, using both stated and revealed preference techniques.

Initial analyses using the chi-square test revealed significant differences between diverted and suppressed demands compared to current travel behaviors. Further categorical data analysis showed that all demand types had a significant relationship with current travel preferences. Notably, suppressed and diverted demands were most prevalent in modal choice, with a strong preference for rail systems. The study found that 43% of the demand is diverted by mode, while 80% of the demand is suppressed. Additionally, 25% of participants cited traffic congestion as the most influential factor in determining their travel demand.

Keywords: Travel Demand, Travel Demand Factors, Suppressed Travel Demand, Diverted Travel Demand, Transportation Planning

ÖZET

BASTIRILMIŞ VE YÖNLENDİRİLMİŞ SEYAHAT TALEPLERİNİN BELİRLENMESİ: İZMİR ÖRNEĞİ

Şehir plancıları, ulaşım mühendisleri ve politika yapıcılar etkili ulaşım sistemleri tasarlamak, politikalar oluşturmak ve yatırım stratejileri geliştirmek için halktan gelen verilere güvenirler. Bu hayati bilgilerin toplanması, seyahat talebi verilerini yakalayan hane halkı anketleri gibi yöntemlerle gerçekleştirilir. Bu verileri analiz etmenin önemli bir yönü, bastırılmış ve yönlendirilmiş seyahat taleplerini incelemeye odaklanarak, görünür talepler ile gizli talepler arasındaki farkı anlamaktır. Bu talepler, daha etkili ulaşım politikaları ve planlama stratejileri geliştirmek için anahtardır.

Bu tezin temel amacı, bastırılmış ve yönlendirilmiş talepler arasındaki farkları keşfetmek için İzmir'deki seyahat taleplerini belirlemek ve analiz etmek, bunları gerçek seyahat davranışlarıyla karşılaştırmaktır. Bu araştırma, İzmir'i temsil eden yaklaşık 913 katılımcıyla yürütülen bir çevrimiçi anketten elde edilen verilerden yararlanmaktadır. Anket, hem belirtilen hem de açıklana tercih tekniklerini kullanarak mevcut seyahat davranışlarının yanı sıra bastırılmış ve yönlendirilmiş talepleri değerlendirdi.

Ki-kare testi kullanılarak yapılan ilk analizler, yönlendirilmiş ve bastırılmış talepler arasında mevcut seyahat davranışlarına kıyasla önemli farklılıklar olduğunu ortaya koydu. Daha ileri kategorik veri analizi, tüm talep türlerinin mevcut seyahat tercihleriyle önemli bir ilişkiye sahip olduğunu gösterdi. Özellikle, bastırılmış ve yönlendirilmiş talepler, raylı sistemlere yönelik güçlü bir tercihle, mod seçiminde en yaygın olanıydı. Çalışma, talebin %43'ünün mod tarafından yönlendirildiğini, talebin %80'inin ise bastırıldığını buldu. Ek olarak, katılımcıların %25'i, seyahat taleplerini belirlemede en etkili faktör olarak trafik sıkışıklığını gösterdi.

Anahtar Kelimeler: Seyahat Talebi, Seyahat Talebi Faktörleri, Bastırılmış Seyahat Talebi, Yönlendirilmiş Seyahat Talebi, Ulaşım Planlaması

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CHAPTER 1

INTRODUCTION

1.1. Problem Definition

In the complexity of transportation planning and urban mobility, the concepts of suppressed and diverted travel demand emerge as an as an issue to be taken care of, affecting developing cities and metropolises. The recognition that not all travel demands occur in observed patterns proves the complexity of transportation systems. The supply of transport services by local governments, or authorities needs to be met with the local people's real (latent) demands, and expectations. If they cannot participate in the travel activities as they desire, then that means there is a difference between what they really want (real demand) and what they have to do (which they really do not wish to). Because of this situation, in this thesis, we tried to determine the suppressed demands by breaking away from the traditional analysis of mobility in Izmir. As a result of the ever-increasing mobility in a big city like Izmir, it is aimed to explore suppressed and diverted travel demands.

As our cities develop and transportation networks expand, traditional measurements of travel demand fall short of capturing the more realistic behaviors and preferences that shape our mobility. Suppressed and diverted travel demand, representing the unmet need for travel due to various restrictions or redirection of travel patterns, emerge as critical considerations in the pursuit of comprehensive transportation planning.

This study is based on the hypothesis that suppressed and diverted demand types will be significant in Turkish cities. This significance will mean an unmet demand problem in our cities. When literature research is conducted, it is very critical that this issue has not been addressed well studied in Turkey, even though there are limited international studies to determine these demands.

1.2. Aim of the Study

The aim of the thesis is to examine the travel preferences of all individuals aged between 18 and 65 living in Izmir, along with the factors influencing these preferences and how travel demands are shaped. The goal is to provide inputs for future transportation planning. In essence, this thesis aims to reveal the disparity between the transportation modes individuals currently use for their daily activities and the modes they actually prefer. Furthermore, the thesis aims to demonstrate how travel behaviors change when individuals' preferences are met. Research questions have been formulated in line with these objectives.

In the thesis, multifaceted research has been conducted, addressing empirical studies, theoretical frameworks, and analyses to unravel the complex effects of infrastructure limitations, economic concerns, social dynamics, and environmental impacts that affect suppressed and diverted travel behaviors. By doing so, this research aims to provide practical insights that transcend traditional models and will benefit policymakers, urban planners, and all stakeholders interested in transportation.

1.3. Hypothesis

The main hypothesis of the thesis is to determine the travel demands in Izmir and to determine the oppression effects on these demands. Outputs determined out of suppressed and diverted travel demands will be an important input when making urban transportation decisions.

There are research questions in this study. All questions focus on determining the diverted and suppressed travel demands in Izmir. The main purpose of the thesis is to reveal the transportation demands in Izmir.

The main hypothesis of the thesis is whether there is a significant difference in apparent (current) demands related to suppressed demand (and diverted demand) in İzmir.

The main research questions linked to this main hypothesis are:

- Is there a significant difference between suppressed demand (and diverted demand) and apparent (current) demands?
- How does the travel demand change and are categorized according to socio-economic, demographic, and preference conditions?

1.4. Methodology

The primary research methodology of this study is the Chi-Square Test, and in cases where the significant condition is met, detailed categorical data analysis is conducted. The Chi-Square Test was used to examine the correlation between participants' current transportation choices and transportation demands. MS Excel and SPSS software were utilized for these methods.

The scope of this study encompasses 913 individuals and is limited to surveys conducted online. Due to methodological limitations in the analyses, the study could not consider all social groups.

1.5. Structure of the Thesis

There are seven chapters in the thesis in total and it starts with the introduction chapter. Then it continues with the literature review and method. The analyses were examined in two chapters. The analyses obtained were discussed in the discussion chapter. Finally, in the conclusion chapter, it was concluded what analysis was done in the thesis in general.

In the first chapter, information is given about the concepts, research questions, method, and scope of the thesis.

In the second part, the theoretical framework of the thesis is examined in 5 chapters. First, travel demand types were examined and the relationship between them was questioned. These are: induced, suppressed, and diverted demand. Afterward, another related topic, the concept of transportation disadvantaged, was examined. After this, the concept of transportation planning was explained and accordingly, research on transportation planning models in the world and in our country was examined. In the last section, information is given about the approaches used in transportation surveys, and the preliminary methods are compared. Then, the literature was summarized and concluded with a critical review.

In the third chapter, the study area, methodology, data, and data collection method of the thesis were examined.

In the fourth section, information about the survey was given, then diverted and suppressed demands were calculated, and their relationship with current travel choices was examined.

In the fifth chapter, detailed categorical distributions of calculated demands were examined and analyzed.

In the sixth chapter, all the analyses were evaluated and interpreted. In the light of the data obtained, suggestions were made for the improvement of urban transportation.

In the last chapter, the results are given, the limitations of the thesis, and spatial and political suggestions are included.

CHAPTER 2

LITERATURE REVIEW

In this section of the thesis, the theoretical framework of the thesis is discussed. In the first subtopic, types of transportation demands and the differences between them are mentioned. In the other heading, types of travel demands and how suppressed travel demand is handled in the literature are discussed. In the last heading, transportation modeling and transportation survey techniques are examined. Then, the literature was summarized and concluded.

2.1. Travel Demand

Travel demand refers to figuring out how people make their travels; daily or hourly travel patterns; numbers, outputs, quantity, and type, taking into account factors such as economy, price, quality, and income among available transportation options.[1] Identifying and analyzing demands is an important input for transportation planning and finally for determining the corresponding transportation supply. As a result of knowing the demand, planners, and decision-makers make improvements in transportation by determining the right policies. Another important point is if the supply or necessary infrastructure and transport services cannot be determined appropriately if the demand configuration is not conducted properly. Therefore, it is important to know the factors that determine demand and determine travel demands based on these.

As seen in Table 2.1, six basic elements affect travel demand according to[1] that are demographics, economics, prices, transport options, service quality, and land use. As can be expected, in addition to economic factors such as income and business activity, demographic factors such as lifestyle and preferences also affect demand.

Table 2.1 Factors That Affect Transport Demand (Litman[1] Adopted by Author)

Demographics	**Economics**	**Prices**	**Transport Options**	**Service Quality**	**Land Use**
Number of people (resident, employees and visitors)	Number of jobs	Fuel prices and taxes	Walking	Relative speed and delay	Density
Income	Incomes	Vehicle taxes & fees	Cycling	Reliability	Mix
Age/lifecycle	Business activity	Road tolls	Public transit	Comfort	Walkability
Preferences	Freight transport	Parking fees	Ridesharing	Safety and security	Connectivity
	Tourist activity	Vehicle insurance	Automobile	Waiting conditions	Transit service proximity
		Public transport fares	Taxi services	Parking conditions	Roadway design
			Telework	User information	
			Delivery services	Social status	

The demand-supply relationship in transportation represents a critical economic phenomenon that significantly influences and regulates the utilization of transportation services within an urban framework. Transportation systems are marked by intricate interactions between supply and demand dynamics. Supply encompasses the infrastructure, vehicles, and management systems necessary to facilitate movement, while demand emerges from travel needs, driven by individual decision-making processes. Transport supply is defined by the capacity of a geographically delineated transportation system over a specified temporal period, encompassing both infrastructure and modal capabilities. In contrast, transport demand is articulated by the degree to which these needs are either fully met, partially addressed, or remain entirely unmet.[2]

Transportation services have traditionally focused on supply-side solutions, emphasizing efforts to increase the capacity of transportation infrastructure and resources. This approach typically involves expanding and enhancing the physical and operational capabilities of the transport system to accommodate growing demand.[3] However, studies have shown that supply-side solutions, such as capacity increases, often become insufficient over time and can lead to the emergence of various types of travel demand. For example, instead of increasing the supply of parking spaces, it has been observed that

more effectively utilizing existing spaces better addresses demand. This shift highlights the limitations of merely expanding capacity and underscores the importance of optimizing current resources to meet evolving transportation needs.[4]

2.1.1. Travel Demand Types

People make various travels throughout their lives and prefer different types of travel. In their daily lives, even going to work and picking up their children from school are examples of travel. They may need to use different travel modes for these travels. From a broader perspective, the diversity in travel fashions varies from city to city and country to country. Individuals choose to use the transportation modes offered to them where they live. In addition, people may make requests other than their current travel modes to reduce transportation costs, increase their comfort, or reduce travel times. At this point, concepts such as induced, suppressed, and diverted demand have emerged in the literature. In this part of the thesis, we will examine how demand types are discussed in the literature.

2.1.1.1. Actual Demand

The concept of actual demand in travel is crucial for the effective management and planning of transportation services. While predictive models typically rely on assumptions to estimate demand, actual demand is examined through the analysis of real-world data using various techniques. McNally[5] highlights the significant impact of demographic variables on transportation demand, such as population density, income levels, or age. For instance, in areas with higher income levels, the preference for private vehicles tends to be greater, making actual demand an important input for transportation planning and decision-making in those regions.

Litman[6] emphasizes that transportation infrastructure directly influences actual transportation demand. He observes that in regions with high-quality public transportation services, demand for public transit increases, whereas in areas with lower-quality infrastructure, private vehicle use is more prevalent. This underscores the direct relationship between actual demand and the quality and accessibility of services.

Moreover, actual demand can fluctuate in response to significant events at the local, city, or even global level. Beck and Hensher[7] examined how the COVID-19 pandemic altered travel behaviors and demands. During the pandemic, the widespread adoption of remote work led to a substantial decline in transportation demand, and concerns over hygiene prompted a shift toward private vehicle use. This variability demonstrates that actual demand is dynamic and must be accurately predicted to ensure that transportation planning meets the true needs of the population.

The need for accurate demand forecasting is evident, as only by correctly identifying actual demand can transportation planning be effectively carried out and responsive to needs. Ben-Akiva and Bierlaire[8] stress the importance of the accuracy of methods used to forecast transportation demand and the need for their continuous improvement.

Identifying actual demand is a critical criterion for enhancing the effectiveness of transportation plans and systems. The literature suggests that accurately determining actual demand also contributes to more successful outcomes in policy development processes.

2.1.1.2. Induced Travel Demand

It is an accepted opinion among transportation researchers that increasing road capacity increases vehicle usage. The increase in vehicle usage is explained by induced demand. While in the economy, it is explained by the tendency of individuals to consume more goods as the price of the goods decreases, induced demand in transportation is explained by the additional vehicle density that occurs (a) as a result of the decrease in time costs (b) as a result of the increase in traffic (c) as a result of the construction of wider roads.[9]

According to Litman[6], induced demand explains the increase in vehicle mileage as a result of the increased distance and frequency of travel after road improvements. This increase causes demand to increase further and causes more travel, which results in a further increase in the total travel volume.

For example, when deciding whether to expand a road, transportation planners prioritize the improvement and development of highways in areas where there is extreme traffic congestion and where economic growth is expected. The initially widened road

begins to attract drivers from other routes and modes. Over time, with the increase in traffic, vehicle speeds decrease, and traffic congestion begins to occur on the road, which again encourages capacity to be increased.[9]

Although highway works have come to the fore in the literature, other induced travel demands within the city have also been examined. Using overpasses as a case study, Rahman et al.[10] evaluated the induced travel demand with transportation infrastructure construction in their study. The effects of the transportation infrastructure using overpasses on travel demand in Dhaka, Bangladesh, were examined. Research findings suggested that transportation infrastructure improvements such as overpasses produced 0.350 triggered travels due to saving one minute in travel time and emphasized that developing countries need to determine transportation policies well to anticipate traffic growth when providing new transportation infrastructure.

Loop et al.[11] define the traffic volume increase that occurs after the opening of new roads as induced demand, and in their study, analyzes conducted in the Netherlands between 2000 and 2012 found that the amount of induced demand was low and that there was a greater traffic volume during peak hours on roads that were mostly congested before adding lanes. It was concluded that there was an increase. Additionally, Loop[11] says that concepts such as induced travel, induced traffic, and latent demand are also used to explain the expression of induced demand.

The US federal government defines induced travel as "an observed increase in traffic volume immediately after a new highway is opened or a previously congested highway is widened".[12] It is said that the main reason for the increase in traffic is the current travel and that the increase in highway capacity is a secondary effect.

Hills[13] provides an overview of all possible behaviors of travelers in terms of possible journeys after the road is widened. As can be seen in table 2.2, after the road is widened, we see that some users continue on the same road, while the behavior of others diversifies. This variety of journeys results in different combinations.

Table 2.2. Theoretically Possible Reactions to Road Expansion

(Hills[13] adopted by author)

	Same destination						Other destination
	Same route, timing, vehicle-occupancy, mode and frequency	Other route	Other timing	Other mode	Lower vehicle-occupancy	Increased in frequency	
Same origin		+		+	+	+	+
Other origin	+	+	+	+	+	+	+

Özuysal and Tanyel[14] highlighted that induced demand is a critical phenomenon for developing countries. In their study, they found that travel per vehicle (TPV) is the most distinguishing criterion for induced travel demand in Turkey, with a 2.0 times increase for private vehicles and a 3.5 times increase for commercial vehicles.

In conclusion, when looking at the literature, induced demand or induced traffic describes the increase in daily vehicle use resulting from the addition of new roads and lanes. For this reason, factors affecting vehicle growth, such as population growth and economic growth, have not been focused on much. As a result of the studies, it can be concluded that a significant part of the induced demand arises as a result of the suppressed transportation demand. At this point, it is important to examine how suppressed demanding occurs and its causes.

2.1.1.3. Suppressed Demand

Suppressed Demand and Induced Demand are two popular demand concepts used in academia today to determine travel demands in cities. There are still different opinions about the definitions of these demand types due to measurability and integration problems in modeling and determining demand.

Suppressed demand is considered in economics as the inability to meet the desire to consume a product or service. In simple language, suppressed demand is the unmet

demand.[15] Obstacles to these unmet demands may be problems such as low income, poor infrastructure, lack of technology, and security.

When examined within the context of transportation, suppressed demand holds significance for the formulation of transportation strategy, as well as for the measurement and forecasting of traffic. Dependent on suppressed demand, travel demand necessitates dynamic planning. Suppressed demand can be elucidated as the desire for travel and the associated transportation need required to fulfill this desire.

Goodwin[16] sought to highlight the issue of suppressed demand in the context of road congestion within the academic sphere. He emphasized that a significant number of individuals avoid traveling during peak hours, leading to a potential surge in traffic if these individuals eventually take to the roads. This phenomenon, coupled with the lack of improvement in traffic conditions, could result in a rise in unmet demand.

Bellemans et al.[17] examine suppressed travel through two factors. Firstly, the non-occurrence of travel due to the suppression of activities corresponding to planned travels. Such suppression of activities may occur due to time pressure induced by other activities in an individual's schedule. Consequently, individuals may opt to save time by skipping activities. Secondly, travel can be suppressed through the displacement of activities. In this scenario, planned travel occurs in a less optimized manner with fewer modes of transportation.

As another point of view, if an individual wants to go to work by bike, but the necessary infrastructure for cycling is not available and therefore he/she goes or has to go by motor vehicle, this shows that his/her preference in terms of cycling is suppressed.[18] Therefore, it can be deduced that the suppressed demand is basically based on the facility availability required to meet the latent demand.

Studies conducted in cities worldwide indicate that the proportion of journeys made using public transportation in Jeddah, Saudi Arabia, decreased from 19% in 1970 to 2.3% in 2007. Following an analysis of the deficiencies in the existing public transportation systems, it was found that nearly 50% of the city's population has almost no access to these systems due to inadequate and poorly maintained infrastructure. This indicates that 50% of the population represents suppressed demand for public transportation.[19]

From a different perspective, some academics consider the concepts of latent and suppressed demand together. Latent demand originates from the economic theories of supply and demand, emerging when the cost of travel exceeds the benefit for the

traveler.[20] This demand, remaining hidden, can also be termed suppressed demand. In this view, latent demand can be defined as the desired demand that remains unrealized due to constraints.

The Bus Rapid Transit (BRT) system implemented in Bogotá, Colombia, was utilized by 40% more passengers than initially projected. This figure indicates that a portion of the city's residents had previously avoided using public transportation due to poor quality and long travel times. Consequently, this 40% excess usage reflects a latent or suppressed demand for public transportation.[21]

In conclusion, there exists a substantial body of literature concerning suppressed demand. Through all these definitions, suppressed demand can be described as the situation in which an individual desires to fulfill a certain activity but is unable to do so within the constraints of existing factors, consequently resorting to utilizing available modes.

2.1.1.4. Diverted Demand

In many studies, increasing capacity on congested roads due to capacity constraints has been found to not alleviate traffic but rather increase traffic volume, while also leading to the emergence of new traffic demands. One of these demands is acknowledged in the literature as "diverted demand," and to comprehend diverted demand, it is necessary to first examine the definitions of diverted travel in the literature.

Diverted demand is shifting or diverting demand from one service to another mod, or different rote. These shifts may involve transitions from modes such as planes or cars to services like trains or metros. Diverted demand can be influenced by various factors, including station locations, the number of stations, ticket prices, service frequency, mode diversity, and others.[22]

In their study, Khattak et al.[23] suggest that drivers' decisions to divert their travels arise not necessarily from continuous traffic congestion but rather from specific incidents. As a result of their research, it was observed that individuals tend to divert their travels more frequently when undertaking long journeys.

Mohammed and Jovanis[24] conducted GIS-based research to understand transportation behavior in their study, and supporting the study of Khattak et al., it was

observed that the shortest route was not the only reason for route selection and that factors such as travel time or traffic safety also caused individuals to take diverted travels.

Öncü[25] defines diverted demand as the demand that shifts from other transportation modes to automobiles and from another time usage to peak hours after a capacity increase. According to him, diverted demand is not a demand due to capacity increase, but a result of the existing traffic volume.

Based on this, it can be deduced that diverted demand is not actually related to capacity increase and that in the current situation, individuals' transportation preferences are the result of a change in their preferences due to certain factors. In this study, individuals' preferences will be examined based on different factors such as ticket prices, service frequency, and mode diversity in order to learn the diverted demand in Izmir.

2.2. Transportation Disadvantaged

Access to personal or public transportation is important for individuals to participate in society and engage in social, political, economic, environmental, and recreational activities. However, some individuals may face challenges in providing their own transportation or accessing public transportation. These individuals are described in studies using the concept of transportation disadvantage. There is no general definition for disadvantaged individuals in the literature on transportation. This indicates that the concept is approached differently by various researchers and that it is multidimensional.

While DA groups are defined as people with limited travel options.[26] [27] Raje[28] found in his study that the 'transportation disadvantaged' group consists of people who do not have or have limited access to transportation, disability, age, or income level. He elaborates on the definition by saying that it occurs.

In situations where transportation disadvantage primarily stems from low income, inadequate access exacerbates exclusion. Economic challenges may lead to the abandonment of travel or a reduction in the number of journeys to only essential ones, thus giving rise to latent travel demand. This decrease in travel also directly impacts access to employment, healthcare, or social participation, affecting the sustainability of these endeavors.[29]

In cases where transportation disadvantage is mainly due to low income, lack of access brings about exclusion. Economic problems cause travel to be abandoned or the number of travels to be minimized and only essential travels to be made, creating a latent

demand for travel.[29] The decrease in travel directly affects the ability to access employment, health, or social life.

Failure to participate in social life, which is one of the consequences of transportation disadvantage, directly causes social exclusion. Therefore, social exclusion and transport disadvantage are interrelated.

Since the 1960s, the relationship between transportation disadvantage and social exclusion and its impact on social life began to be examined by researchers.[30–33] The Social Exclusion Unit[34] in the United Kingdom was the first government to draw attention to the relationship between transportation and social exclusion and explain transportation disadvantages through events such as inability to access transportation due to social exclusion, air pollution or accidents, and inadequate transportation conditions. This report is important in the literature because it draws attention to the social effects of transportation disadvantage and says that social exclusion should be included in studies on transportation disadvantage, but it is insufficient because the scope of social exclusion is limited. Based on this, Hine and Grieco[35] state that exclusion increases when mobility, accessibility, and socialization are insufficient and coexist.

On the other hand, Duvarcı and Mizokami[18] say that socially excluded represents socio-economic well-being, while transportation disadvantaged is defined only in terms of disadvantaged transportation or accessibility, and they support that the two terms are very closely linked.

Studies have observed that access to public transportation is problematic and that there are more disadvantaged groups in urban fringes or rural areas. The lack of transportation options, especially in rural areas, and the problematic access to existing transportation options put individuals at a direct transportation disadvantage.[36]

In conclusion, the concept of transportation disadvantage has been debated and researched in the literature for many years. Individuals facing transportation disadvantage encounter challenges in participating in the economy and social life, which can lead to social exclusion. There can be various reasons for an individual to be transportation disadvantaged, including transportation infrastructure, access to public transportation, geographic location, income status, disability, or age. This thesis aims to provide insight into whether individuals are transportation disadvantaged because of their transportation preferences.

2.3. Transportation Planning and the Issue of Travel Demands

Transportation is one of the most important facilities that individuals must have to live in a city. Transportation planning is a branch of science that covers all of the designs, policies, and regulations to be made for transportation systems and transportation infrastructure prepared to transport individuals and products from one point to another.

Möller[37] defines transportation planning as the process of making decisions about transportation preferences and values. Transportation planning, especially in urban areas, is a multifaceted design that considers the relationship between various land use types such as employment areas, residential areas, and socio-cultural spaces. Urban transportation plans and spatial plans are therefore interconnected and should be considered together as they complement each other.[38] Effective planning should respond to the needs and preferences of individuals living in the city as well as the public policies defined for the city and its transport structure. The basis of good planning is that short-term plans support longer-term plans.[1]

While living in cities, individuals are obliged to use the services provided to them. However, they unconsciously analyze and choose the most suitable transportation modes among the existing ones, without realizing it. At this point, analyzing individuals' transportation preferences and needs becomes crucial input for the development of short and long-term public policies. Factors such as ticket prices, user data, infrastructure information, land use, existing transportation plans, and fuel costs form the basis of public policies.[39] Since all these factors can vary from city to city, it would not be wrong to infer that transportation options and behaviors vary among different populations. For example, vehicle usage in America is twice that of other wealthy countries. Consequently, different policies are being formulated in America, and more emphasis is being placed on transportation and land modeling to evaluate these policies.[1]

In recent years, with the increasing importance of sustainability, social and environmental concerns have been added to existing policies such as road design and vehicle density. Nowadays, issues such as energy conservation, equity, or livability have also begun to be discussed and included in transportation planning policies. As a result, it is important for cities to develop comprehensive transportation plans that address all of these concerns and to formulate policies that support these plans for the future of cities.

2.4. The Use of Travel Demand Types in Transportation Planning Modelling

Transportation planning is a process that emerges through collaboration among public and private enterprises and various stakeholders. The primary objective should be to establish short-term decisions that support long-term goals. Planners, engineers, and policymakers working on transportation aim to design alternative and efficient transportation systems. In this process, multi-modal and comprehensive approaches are preferred for analysis. Transportation modeling refers to the use of mathematical and computational methods to simulate, analyze, and optimize transportation systems.

Mathematical models are used for different purposes such as analyzing data and observing user behavior.[40] Therefore, transportation models are one of the mathematical methods used to simulate and analyze transportation systems. However, what is important at this point is that the model is chosen correctly because success in the analysis can be achieved with the correctly selected model. If there is a match between the models, data sets, and model-based simulation results, the study will achieve its purpose.[37]

The purpose of many models used in transportation planning has been developed to analyze the number of trips and demands of individuals. In these models, data on transportation services, tickets, and different transportation modes are collected and analyzed, and predictions are made on issues such as traffic congestion, traffic volume, and transportation demands.

Clement[41] states that the purpose of transportation planning modeling is to predict the number of trips, considering factors such as the chosen mode of travel, the region of travel, and the time of day as inputs.

The main purpose of the Urban Transportation Modeling System (UTMS) is to compare the current supply with future demands and, as a result, to make infrastructure arrangements according to new demands. Based on this, a 4-stage approach is used where people decide which mode and route they will prefer for their journeys, product distribution, etc.

- Trip Generation: In this step, the production and attraction of travels in the study area are determined. This involves estimating the number of trips originating from and attracted to a specific area. Factors such as land use, population, household size, number of school-age children, and employment data are used to predict the number of

trips in the study area. Understanding trip origins and destinations aids in the comprehension of travel demand patterns.

- Trip Distribution: As a result of planned trips, spatial distribution is made to determine the probable destinations for each trip. In this step, different regions are analyzed, and the selection of my destination is facilitated. Trip distribution can be for reasons such as home to work, home to shopping or home to school. The distance of these purposes to potential destinations is affected by factors such as the duration of the trip and the cost of the trip. Mathematical models are created based on factors such as the distance or attraction of the destination, or the probabilities of trips between the start and end points are estimated by considering different factors.

- Mode Choice: In this step, individuals' transportation mode preferences for their trips should be determined. This step provides information about transportation mode preferences, and certain factors should be considered to predict the distribution of trips. These factors can be traveling time, transportation cost, or the person's own preferences.

- Trip Assignment: Trip assignment analyzes routes and roads to assign trips. This step is important for evaluating existing public transportation lines and infrastructure systems. The models that are created suggest routes for passengers based on factors such as travel time, distance, and infrastructure capacity.

These models use travel surveys and census data to determine transportation demands, establish baseline conditions, and identify future trends. The journeys used as the basis for these models are generally work, shopping, etc. are estimated separately by destination and then aggregated into total trips in the relevant network. This modeling approach allows estimating traffic congestion problems because they focus primarily on measurements of peak period motor vehicle trips on major roads. However, these models are criticized by Stopher and Greaves[42] for not providing sufficient insight into non-motorized transport improvements, as they tend to ignore or undercount non-motorized travel.

Integrated Transportation and Land Use Models are designed to predict how transportation improvements will affect land use patterns, for example, the location and type of development that would occur if a highway or public transportation service were improved and integrated with traffic models. These are important tools for evaluating policies and programs. In addition to mobility, they also provide insight into accessibility. However, since the development process of the model is costly and complex, it is

generally not preferred in small-scale studies.[37,43] The differences and shortcomings in current models always indicate the need for more accurate and comprehensive modeling. As models evolve, they will provide more optimal transportation planning. Nevertheless, the evaluation of the demand types obtained through modeling provides guidance for transportation networks to be designed in the future or for new policies.

In conclusion, identifying and modeling transportation demands is crucial for the effective planning and optimization of urban transportation systems. This thesis's examination of transportation demands in Izmir can provide valuable inputs for future modeling efforts. Accurately modeling these demands offers a critical foundation for decision-making processes, efficient resource allocation, and cost-benefit analysis.

2.5. Summary

Table 2.3. Summary of Literature Review

Concepts	Findings/Inferences	Author(s), Year
Actual Demand	Demographic factors like population density, income, and age greatly impact transportation demand, with higher-income areas favoring private vehicles, making demand key in planning decisions.	McNally[5]
	Transportation infrastructure directly affects demand, with high-quality public transit increasing ridership, while lower-quality infrastructure leads to higher private vehicle use, highlighting the link between demand and service quality.	Litman[4]
	The COVID-19 pandemic changed travel behaviors, with remote work reducing transportation demand and hygiene concerns driving more private vehicle use, showing the need for dynamic and accurate demand forecasting in transportation planning.	Beck and Hensher[7]
	Accurate methods for forecasting transportation demand are crucial, as they guide effective planning and decision-making, emphasizing the need for continuous improvement to adapt to changing trends and behaviors.	Ben-Akiva and Lerman[8]
Induced Demand	In his study, he saw that after the road was widened, users continued to use the road, and some of their behaviors diversified and created different travel combinations.	Hills[13]
	Every 10% of infrastructure improvements causes 9% of traffic, and the most important reason for this traffic is the elimination of the existing suppressed demand.	Cervero[44]
	Induced demand results in increased distance and trip frequency through road improvements and increased total travel volume.	Litman[6]
	Induced demand is a result of the traffic volume that occurs after a new road is opened or a congested road is widened.	FHWA[12]

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Table 2.3. (cont.)

	Travel demand refers to individuals determining their preferences among transportation options based on factors such as economy, price, quality or income in the cities they live in.	Litman[1]
	In a study conducted in the Netherlands between 2000 and 2012, it was observed that induced demand was low and roads, which were mostly congested before the addition of lanes, had higher traffic volumes during peak hours.	Loop et al.[11]
	The induced demand is explained by the increase in traffic as a result of the expansion of roads and the decrease in time costs, resulting in additional vehicle density.	Hymel[9]
	Induced demand is a crucial issue for developing countries, and in their study, they found that travel per vehicle (TPV) is the key factor in Turkey, showing a 2.0 times increase for private vehicles and a 3.5 times increase for commercial vehicles.	Özuysal and Tanyel[10]
	The research suggests that transportation infrastructure improvements such as overpasses save one minute in travel time, producing 0.350 induced travel.	Rahman[10]
Suppressed Demand	Suppressed demand is the unmet demand.	LDC Environment Centre[15]
	If the term is explained through an example, if the individual wants to ride a bike to work, but the necessary infrastructure for the bike is not available and therefore he/she goes or has to go by motor vehicle, this shows that his/her demand is suppressed.	Duvarcı and Mizokami[18]
	Suppressed demand, in the context of road congestion, refers to individuals avoiding travel during peak hours, potentially leading to a surge in traffic if they later decide to travel, which, combined with stagnant traffic conditions, could increase unmet demand.	Goodwin[16]
	Latent and suppressed demand should be considered together, and this demand relates to the economic supply-demand balance that occurs when the cost of travel exceeds the individual's benefit.	Noland and Lem[20]
	An analysis of existing public transportation deficiencies revealed that nearly 50% of the city's population lacks access due to inadequate and poorly maintained infrastructure, representing suppressed demand for public transit.	Aljoufie et al.[19]
	The two main types of suppressed travel are suppression of activities that result from planned travel and suppression of travel by displacement of activities.	Bellemans et al.[17]
	Bogotá's Bus Rapid Transit (BRT) system exceeded initial projections by 40%, indicating that many residents had previously avoided public transportation due to poor quality and long travel times, revealing a latent or suppressed demand for better transit options.	Hidalgo and Graftieaux[21]
Diverted Demand	Drivers are more inclined to divert their travels in response to specific incidents rather than continuous traffic congestion, particularly noting a higher frequency of diversion during long travels.	Khattak et al[23]
	In their 1997 GIS-based study, they analysis individuals' route selection is influenced by factors beyond simply the shortest route.	Mohammed and Jovanis[24]

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Table 2.3. (cont.)

	Diverted demand is characterized by a shift from other transportation modes to automobiles and from alternative time usage to peak hours following a capacity increase.	Öncü
	Understanding the intricacies of diverted demand within transportation systems necessitates consideration of various factors such as station locations, ticket prices, service frequency, mode diversity, and others	Russo et al.[25]
Transportation Disadvantaged	Transportation disadvantage groups are defined as people with limited travel options.	Transit Cooperative Research Board and Duvarcı and Yiğitcanlar[26,27]
	Transportation disadvantaged are indentifed as individuals who lack or have restricted access to transportation due to factors such as disability, age, and income level. This group faces challenges in accessing transportation services, which can significantly impact their mobility and overall quality of life.	Raje[28]
	Economic hardships can compel individuals to either abandon non-essential travel or reduce the frequency of their journeys, thereby resulting in latent travel demand.	Blumenberg[29]
	Since the 1960s, researchers have delved into the correlation between transportation disadvantage and social exclusion, as well as its ramifications on social life.	Ward and Walsh; Kain; Wachs and Kumagai; Pereira, Schwanen, and Banister[30,32,33]
	The United Kingdom government drew attention to the intricate relationship between transportation and social exclusion, elucidating transportation disadvantages stemming from various factors.	Social Exclusion Unit[34]
	It has been observed that exclusion increases when mobility, accessibility and socialization are insufficient and coexist.	Hine and Grieco[35]
	While social exclusion represents socio-economic well-being, disadvantaged transport is defined solely in terms of disadvantaged transport or accessibility, supporting that these two terms are very closely linked.	Duvarcı and Mizokami[18]
	The scarcity of transportation choices, particularly in rural regions, coupled with challenges in accessing available transportation services, directly places individuals at a distinct transportation disadvantage.	Combs[36]
Transportation Planning	Characterizes transportation planning as the systematic process of deliberating and making decisions concerning transportation preferences and values.	Möller[37]
	Urban transport plans and spatial plans are therefore interconnected and should be considered together to complement each other.	Akbulut[38]
	The basis of good planning is that short-term plans should support long-term plans	Litman[1]
	Various factors such as ticket prices, user data, infrastructure information, land use patterns, existing transportation plans, and fuel costs serve as foundational elements for shaping public policies related to transportation.	Preston[39]

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Table 2.3. (cont.)

Transportation Planning Modelling	Mathematical models play a crucial role in transportation planning and analysis, serving diverse purposes such as data analysis and observing user behavior.	Janssens et al.[40]
	The purpose of a study in transportation planning can be achieved when there is alignment between the models used, the data sets employed, and the simulation results derived from these models.	Möller[37]
	The purpose of transportation planning modeling is to predict the number of trips, taking into account factors such as the selected travel mode, travel region and time of day as inputs.	Clement[41]
	Transportation planning models for their limited focus on non-motorized transport improvements.	Stopher and Greaves[42]
	While planning models provide information on accessibility in addition to mobility, they are not preferred in small-scale studies because they are costly and complex models.	Dong et al., Möller [37,43]
Stated and Revealed Preferences	Researchers began exploring methods to comprehend the significance of observing consumer behavior and how individuals' preferences influence markets in the early 20th century.	Kroes and Sheldon[45]
	It has been suggested that there may be methods to measure the individual's reaction to different combinations of transportation types, and attention has been drawn to the use of these methods.	Louviere[46]
	Stated Preference methods were introduced and it was examined whether preferences changed when additional alternatives were given.	Kroes and Sheldon[45]
	In the Stated Preference method, analyses can be conducted to anticipate potential effects that do not currently exist but might emerge in the future.	Bradley[47]
	There are two categories in the stated preference method in travel behavior studies.	Hensher[48]
	Revealed Preference (RP) method offers valuable insights for determining services and constructing travel demand models, it has limitations due to its lack of diversity and insufficient correlation between variables.	Kroes and Sheldon[45]
	He compared data obtained from the Revealed Preference (RP) method with that from the Stated Preference (SP) method and criticized the SP method, suggesting that it did not accurately reflect real behavior.	Wardman[49]
Traditional Approaches	In unannounced interviews, it was observed that individuals did not remember their past travels, and this caused reliability problems in the data.	İnbarakan[50]
	It has been seen that it is not safe to conduct studies at home, especially in the USA, and it has been suggested that other types of surveys should be used.	Stopher[51]
New Approaches	In 2011, with only 72% of households in Australia having internet access, relying solely on online surveys could diminish representativeness.	İnbarakan[50]
	Statistical Institute (TUIK), approximately 95.5% of households in Turkey had access to the internet from their homes in 2023.	TUIK[52]

CHAPTER 3

MATERIALS AND METHODS

In the literature review, the focus primarily lies on how travel demands are addressed and what types of methods are used for analyzing these demands. The analyses in this thesis, which concentrate on examining travel demands, aim to create an analysis for designing future transportation networks, improving transportation, and formulating new policies.

3.1. Study Area

İzmir province, which covers an area of 11,891 km², consists of 30 districts and is the third largest city in Turkey with a population of 4,479,525.[52] In İzmir 65.82% of the population lives in central districts, while 34.18% lives in peripheral districts. Based on the density in central districts, it is expected that there will be more transportation options and activities in these districts. Looking at the 2030 Transportation Master Plan, it can be said that this prediction is correct. According to the report[53], the regions with the highest number of trips are the north axis, east axis, and central areas, where the highest population growth is predicted. Industrial zones located in the north and east axes are areas with high demand for daily trips. The reason for the density in the central-east axis is thought to be the trips made for work to the Manisa industrial zone. The central region and CBD are also other areas that attract the most trips due to their significant commercial and entertainment activities.

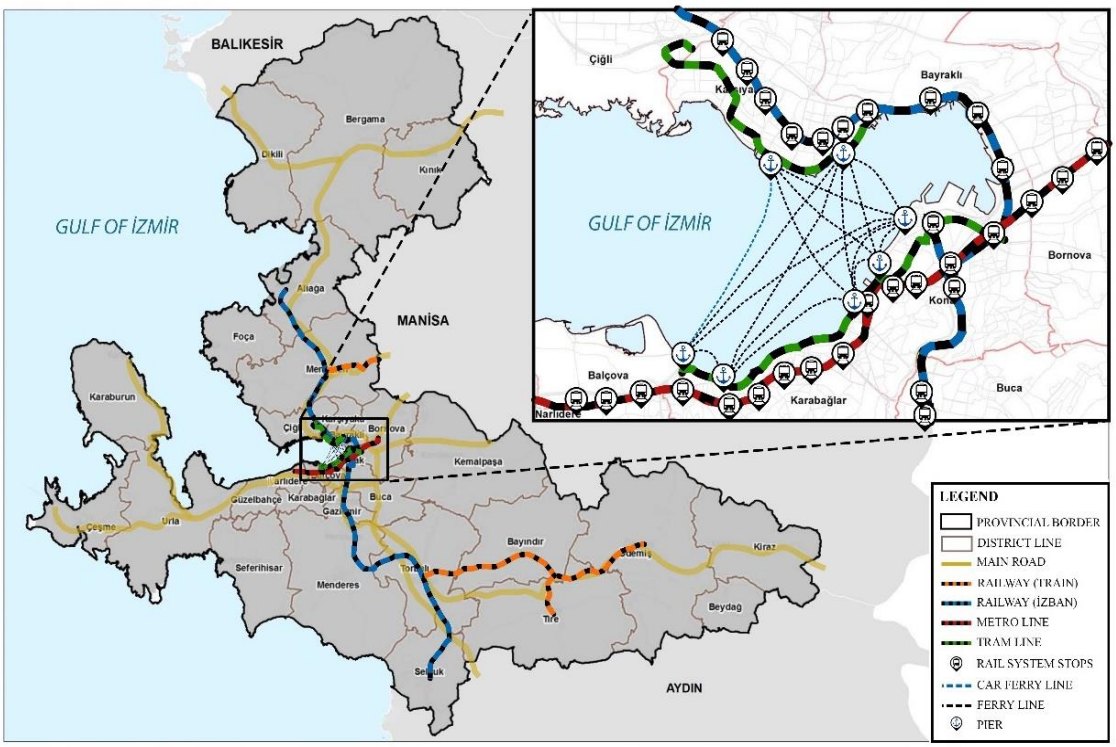

Figure 3.1. İzmir transportation plan

(Produced by Author, Source: İzmir Metropolitan Municipality[59])

In Izmir, public transportation services are provided by the Metropolitan Municipality. The types of public transportation in Izmir include metro, tram, suburban train (İZBAN), ESHOT buses, and ferries. Each mode has a smart card system, and transfer centers are available for transfers between modes. In addition to transportation systems, access to transfer stations is also provided by walking and cycling. Currently, there are 8 transfer centers in the city, and according to the Izmir Transportation Master Plan 2030[53], it is projected that there will be 21 secondary transfer centers and 23 transfer stations by 2030. It can be inferred from this plan that there will be more intermodal transportation in Izmir in the future.

There are different pricing schemes for various passenger categories in İzmir. Students and teachers benefit from discounted public transportation, while individuals aged 60 and over, people with disabilities, national athletes, relatives of martyrs, and veterans travel for free on vehicles. With the smart card system called "İzmirim Kart," there is a 120-minute transfer period after the first boarding for metro, suburban trains, ferries, trams, and buses. Transfer fees are free for students and offered at a discount for other users.[54]

Bus transportation has been provided service in the city since 1943 by the General Directorate of Electricity, Water, Coal, Gas and Public Transportation (ESHOT), which is affiliated with Izmir Metropolitan Municipality. As of 2023, it serves the city with more than 1700 vehicles and 395 lines. İZULAŞ, another organization within the municipality, has 306 buses in its fleet.[55]

The metro line, which is another mode of transportation, started to be built in 1989 under the name of Izmir Metro and was put into service in 2012 with 10 stops. It currently serves with 23 stops between Evka-3 - Kaymakamlık. The line is located on the Northeast-Southwest axis of the city and services are organized every five minutes during peak hours, while the longest flight interval is 10 minutes.[56]

The suburban İZBAN line was put into service in 2010 with the partnership of Izmir Metropolitan Municipality and the Republic of Turkey State Railways (TCDD). The line is located on the north-south axis of the city, and serves with 41 stops between Aliağa and Selçuk. The frequency of departure is 15 minutes.[57]

Although trams have been used in the city since the 1880s, there are currently 3 tram lines. These are T1 (Alaybey - Ataşehir Junction & Mavişehir - Ataşehir) Tram Line, T2 (Fahrettin Altay - Halkapınar) Tram Line and T3 (Ring Road - Kâtip Çelebi University) Tram Line.[58]

When we look at the sea transportation in Izmir, it can be seen that it has been used actively since 1884. Transportation in the bay is provided by the İZDENİZ company, which was established by the municipality after it was taken over by the Izmir metropolitan municipality in 2000. It currently serves with 7 different routes and 200 trips daily. In the summer season, in addition to the existing trips, there are trips to Urla, Mordoğan and Foça Piers.

In addition to public transportation, cycling is also available in the city. There is a bicycle path running along İnciraltı - Sasalı in Izmir. With the shared bicycle system, people can rent and use bicycles with their Izmirim card or credit cards.[59]

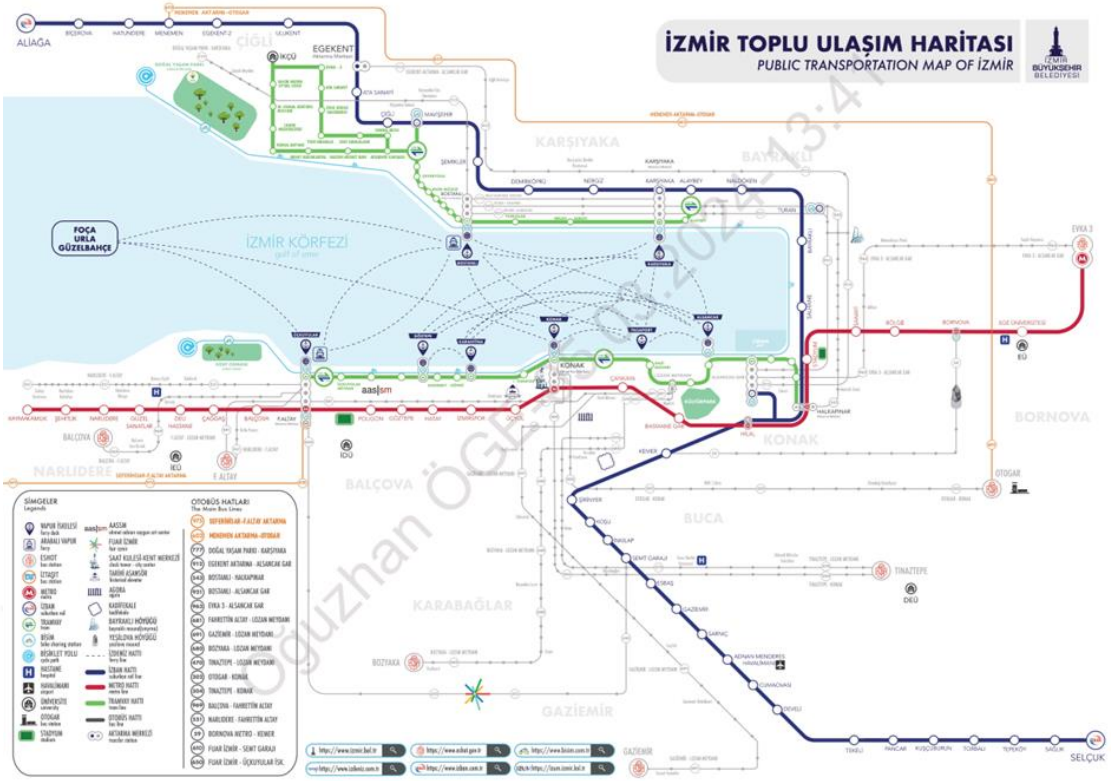

Figure 3.2. İzmir public transportation map
(Source: İzmir Metropolitan Municipality[59])

The number of trips and their purposes form the basis of transportation preferences in cities. In line with this information, information on which transportation modes are requested in that city can be obtained and transportation capacity changes can be made.

Table 3.1. 2015 and 2030 Projection of İzmir City Daily Travel Number And Car Ownership (Source: UPI[53])

	Population and Car Ownership	
	2015	2030
Population	3.920.224	6.208.056
Car Number	642.998	1.444.274
Car Ownership (Car/1000per)	164	233
Total daily travel number	5.883.387	10.242.076

In the Izmir Transportation Plan Report[53] published by the Izmir Metropolitan Municipality, it is estimated that 10.2 million trips will be made in the city in 2030, which

is the target year, and it is said that 26% of these trips will be made by public transportation. This report is important because it provides information about travel routes throughout Izmir and includes projections for 2015 and 2030.

As seen in the table 3.1, it is predicted that the city population will double in 2030 compared to 2015. The number of daily trips is expected to double as the population increases. Additionally, it is said that the number of cars will more than double, and the car ownership rate will increase from 164 to 233.

Table 3.2. 2015 and 2030 Projection of İzmir City Daily Passenger Numbers According To Their Routes (Source: UPI[53])

Travel Type	**Daily Travel Number**	
	2015	2030
Home-based work travel	1.874.142	3.584.658
Home-based school travel	1.228.748	2.037.593
Home-based university travel	163.538	320.284
Home-based others travel	2.332.543	3.894.426
Non-home-based travel	224.416	405.115
Total	5.883.387	10.242.076

Table 3.2 explains the daily travel numbers in Izmir for 2015 and 2030 projections.

The majority of urban travel in the city is home-based, and these trips appear to be mostly for education and business purposes.

Home-based work, home-based school, and home-based university travel accounted for 56% of total daily travel in 2015, collectively. While other home-based travel made up 40%, non-home-based travel accounted for a small percentage of the total daily travel numbers in 2015, with only 4%. In the 2030 projection, the total of home-based work, home-based school, and home-based university trips is expected to increase by 2% from 56% to 58%. On the other hand, other home-based travelers are expected to decrease by 2%. No difference is expected in terms of rate for non-home-based travel.

Table 3.3. İzmir Travel Mobility Coefficients for 2015 And 2030 (Source: UPI[53])

	Population and Travel Numbers	
	2015	2030
Population	3.920.224	6.208.056
Total daily travel number	5.883.387	10.242.075
	Gross Mobility Rate	
Home-based work travel	0,48	0,57
Home-based school	0,33	0,33
Home-based university	0,04	0,05
Home-based others	0,59	0,63
Non-home-based	0,06	0,07
Mobility rate	1,50	1,65

In Table 3.3, gross mobility rates for 2015 and 2030 are explained. The gross mobility rate is calculated by dividing the total number of trips made for a specific purpose, such as home-based work, home-based school, home-based university, home-based other, and non-home-based, by the entire population. It is important data for understanding daily travel purposes in cities. According to the report, the number of daily travels per person in İzmir will rise from 1.50 to 1.65 in 2030. In addition to this, the rate of gross mobility will be expected to increase by 0.10 from 0.85 to 0.95. Following this, the rate of home-based others increases by 0.4, while an increase of only 0.01 is expected in non-home-based.

Figure 3.3. İzmir 2015 and 2030 travel mode preferences projection. (Source: UPI[53])

If no new transportation investments are made until 2030 and it is assumed that the city develops based on existing zoning plans; it is projected that the rate of trips made by private vehicles and public transport will increase by 3.5% and 1.6%, respectively. Following this, it has been calculated that service usage will decrease by 0.5% and pedestrian usage will decrease by 4.6%.

3.2. Date Sources and Data Collection Methods

Online survey method was used as the main data collection method in the thesis. Since the survey data was collected once, each participant answered the questions once. This shows that the study is an Izmir example with a cross-sectional design.

The secondary data collection method was done by analyzing statistical data over the internet. With this method,

- Izmir district population data from TUIK
- Location data and map base from ArcGIS Online, and OpenStreetMap
- Demographic, economic, and travel preferences data obtained from the survey

3.3. Survey Data Collection

The data used in the study was obtained through an online survey method. The reason for choosing an online survey was to conduct a more comprehensive study throughout Izmir. Questions were asked on a person-by-person basis, and people were given options for each question. The simple sampling formula was used to determine the sample size.

Since the target audience of the research is the active population in Izmir, the number of children and the number of elderly populations over the age of 65 in Izmir were not included in the formula when calculating the number of surveys.

Table 3.4. Calculating the Population to be Included in the Formula (Source: TUİK[52])

Children Number	947.680
Number of people over 65 years old	573.856
Total Population	4. 479.525
Population included in the formula	2.957.989

Simple random sampling formula was used to determine the sample size.[60]

$$n = \frac{\mathrm{e}^2 * \mathrm{p} * \mathrm{q} * N}{\mathrm{e}^2 * (N-1) + z^2 * (p * q)}$$

- n = a sample size.
- e = acceptable error (the acceptable maximum error is 0.05, with an associated 95% confidence interval)
- N = the population size, N=2.957.989
- p = sample proportion, p=0,5, q = 1 – p
- z = standard variate at a given confidence level (%95 for confidence level Z = 1.96)

$$n = \frac{(1{,}96)^2 * (0{,}5) * (1-0{,}5) * 2957989}{(0{,}05)^2 * (2957989-1) + (1{,}96)^2 * (1-0{,}5)} = 384{,}06$$

The simple random sampling method is a formula that is widely used in city-based studies. In this study, it was calculated that a minimum of 385 surveys should be conducted using the simple random sampling formula with a margin of error of 5%. In order to obtain stronger data in the study, it was decided that the number of surveys would be 1000 people. When the incorrect and incomplete surveys were removed, a total of 913 surveys were analyzed. The majority of the survey questions were multiple choice questions. All of the data obtained consisted of categorical data. In addition, participants who wanted to express their opinions on the questions were contacted, and the purpose of the survey and the questions were explained.

The online survey was disseminated through social media accounts that share transportation information, traffic incidents, or road conditions specific to İzmir. This approach facilitated random and voluntary participation from individuals residing in İzmir. Additionally, the survey was hosted on Google Forms. Participants were first informed about the purpose of the study and asked for their consent to share their information. To allow for follow-up, participants were requested to provide their email addresses or phone numbers. Depending on their responses, participants were directed to different sets of questions. The primary limitations of this survey are that the participants are limited to individuals with internet access and active social media users. Participants could complete the survey on either a computer or a mobile device by clicking the provided link. Sample survey screenshots are shown below.

Figure 3.4. Sample survey display

3.4. Survey Data and Analysis

The aim of the study was to reach the educated active population in Izmir with an online survey. Therefore, the survey participants were determined as everyone between the ages of 18-65. The survey was prepared under two headings: general information and transportation behaviors. The survey questions were person-based, and general information was asked in the table 3.5. This section consists of questions to determine the participant's age, the district he lives in, whether he/she works or not, and his/her level of education.

Table 3.5. General Information Variables and Categories.

VARIABLES	**CATEGORIES**									
General Information										
Age	18-25	26-35	36-45	46-65						
District	Aliağa	Balçova	Bayındır	Bayraklı	Bergama	Beydağ	Bornova	Buca	Çeşme	Çiğli
	Dikili	Foça	Gaziemir	Güzelbahçe	Karabağlar	Karaburun	Karşıyaka	Kemalpaşa	Kınık	Kiraz
	Konak	Menderes	Menemen	Narlıdere	Ödemiş	Seferihisar	Selçuk	Tire	Torbalı	Urla
Unemployee/ Employee	Unemployee	Employee								
Education Level	Primary	High School	Associate Degree	Undergraduate	Master	Doctorate				

In the next section, questions shown in the table 3.6 were asked to learn about transportation behaviors. The aim here is to learn about individuals' vehicle ownership and their transportation behaviors accordingly. The last question was whether they see themselves as disadvantaged in transportation.

Table 3.6. Travel Behavior Variables and Categories.

VARIABLES	**CATEGORIES**			
Private Car Ownership	Bicycle-Scooter	Motorcycle	Private Car	Not Owned
Frequency of using private vehicle	1-2 times a week	3-4 times a week	5+ times a week	Almost never use
Frequency of using public transport	1-2 times a week	3-4 times a week	5+ times a week	Almost never use
Public transport satisfaction	Satisfied	Not Satisfied		
Feeling transportation disadvantaged	Yes	No		

Subsequently, questions were asked to learn more about the transportation modes individuals use. In addition to their current usage, the questions also aimed to discover their mode preferences under varying conditions such as maintenance works or peak hours. Additionally, questions were asked to understand the latent transportation demand and to determine the reasons why it is not being met. The questions answered by the participants here consist of revealed preference questions.

Table 3.7. Mode of Transportation Variables and Categories.

VARIABLES	**CATEGORIES**									
Current Choice	Bicycle-Scooter	Bus	Ferry	Minibus	Motorcycle	Private vehicle	Rail Systems	Taxi	Walking	
Preferred during peak hours	Using Same Mode	Bicycle-Scooter	Bus	Ferry	Minibus	Motorcycle	Private vehicle	Rail Systems	Taxi	Walking
Preferred during maintenance works	Using Same Mode	Bicycle-Scooter	Bus	Ferry	Minibus	Motorcycle	Private vehicle	Rail Systems	Taxi	Walking
Demanded mode of transportation	Bicycle-Scooter	Bus	Ferry	Minibus	Motorcycle	Private vehicle	Rail Systems	Taxi	Walking	
Reason for not using the desired mode	Lack of pedestrian and bicycle paths	Infrequent public transportation hours	Traffic congestion	Parking problem	Transportation costs	Infrastructure deficiency	Using chosen mode of transportation	Other		

In response to the answers received, questions were prepared for each presented problem to determine whether individuals would prefer the transportation modes they desire if they were improved by 50%. The questions answered by the participants here consist of stated preference questions.

Table 3.8. Transportation Improvement Variables and Categories.

VARIABLES	**CATEGORIES**	
Improvement of pedestrian and bicycle paths by 50%	Used	Not Used
Improvement the number of public transport vehicles by 50%	Used	Not Used
Traffic congestion reduced by 50%	Used	Not Used
Improvement the number of parking lots by %50	Used	Not Used
Transportation costs reduced by %50	Used	Not Used
Improvement the infrastructure problems by %50	Used	Not Used
Improvement on other problems by %50	Used	Not Used

Questions provided in the table 3.9 were directed at individuals to learn about their trip rate and to determine the suppressed demand based on these quantities. The questions answered by the participants here consist of revealed preference questions.

Table 3.9. Trip Rate Variables and Categories.

VARIABLES	**CATEGORIES**			
Current trip rate	0-2	3-5	6-8	9+
Demanded trip rate	0-2	3-5	6--8	9+
Trip rate to be done if the demanded type of transportation is provided	0-2	3-5	6--8	9+

Since transfer transportation is available at many points in Izmir, the questions shown in the table 3.10 were asked to survey participants to learn how much they travel with transfers. The questions answered by the participants here consist of revealed preference questions.

Table 3.10. Transfer Travel Variables and Categories.

VARIABLES	CATEGORIES							
Transferring	Yes	Not						
Reason for transfer	Accessibility	Cost	Travel time	Security	Comfort	Environmental Factors (Landscape, Scenery)		Others
Reason for demanded to travel without transfer	No desire	Accessibility	Cost	Travel time	Security	Comfort	Environmental Factors (Landscape, Scenery)	Others
Preference when transfer fees are removed	Yes	No						

Four different questions were asked to find out the average time the participants spent on transportation during a trip. In the last question, they were asked to indicate the reasons why they could not arrive on time. The questions answered by the participants here consist of revealed preference questions.

Table 3.11. Travel Time Variables and Categories.

VARIABLES	CATEGORIES				
Current average travel time	0-30	30-60	60-90	90+	
Demanded travel time	0-30	30-60	60-90	90+	
Travel time to be done if the demand of transportation is provided	0-30	30-60	60-90	90+	
Arriving place on time	Yes	No, lack of infrastructure	No, traffic jam	No, parking problem	No, lack of public transportation service

In the final part of the survey questions, participants were asked questions to determine their route preferences during daily travel and the changes in these preferences under certain conditions. The questions answered by the participants here consist of revealed preference questions.

Table 3.12. Route Preference Variables and Categories.

VARIABLES	CATEGORIES									
Current route choice and reasons	Same route	Accessibility	Cost	Travel time	Security	Comfort	Environmental Scenery)	Factors	(Landscape,	Others
Preferred route during peak hours	Same route	Accessibility	Cost	Travel time	Security	Comfort	Environmental Scenery)	Factors	(Landscape,	Others
Preferred route during maintenance works	Same route	Accessibility	Cost	Travel time	Security	Comfort	Environmental Scenery)	Factors	(Landscape,	Others
Demanded to use a different route	Same route	Accessibility	Cost	Travel time	Security	Comfort	Environmental Scenery)	Factors	(Landscape,	Others

As detailed above, the research survey consists of 8 sections. The survey, which comprises a total of 36 questions, directed participants based on their responses.

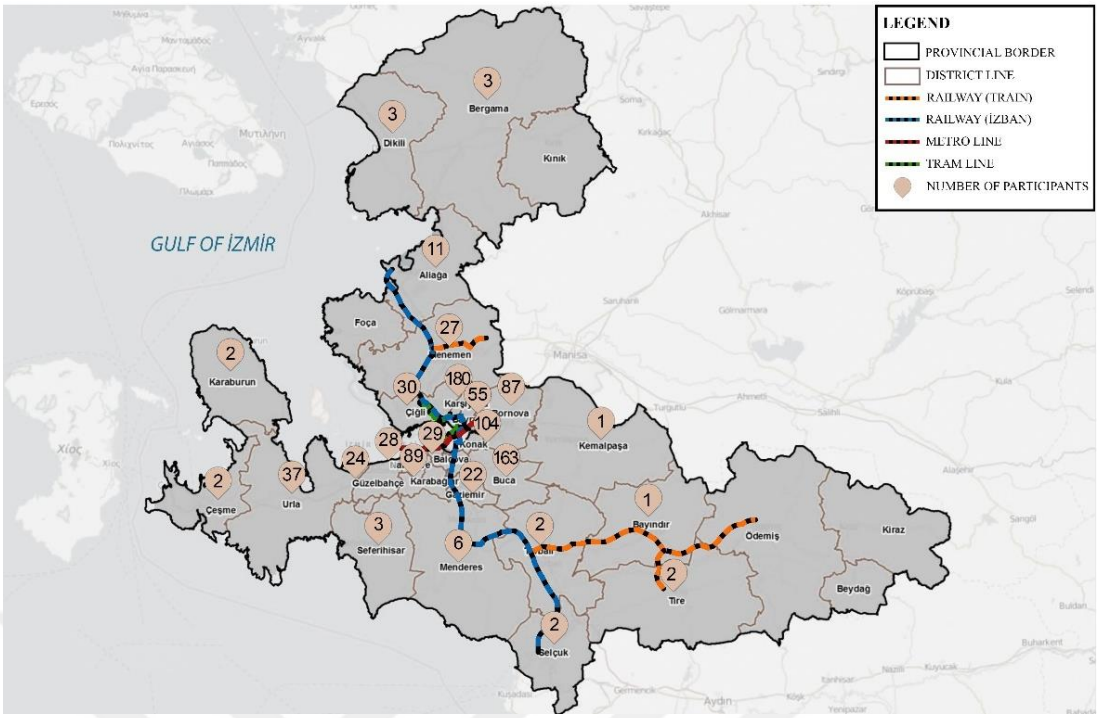

Figure 3.5. Number of participants by district

(Produced by Author)

A total of 1000 people participated in the survey. After removing incomplete and erroneous surveys, data from 913 participants were used in the analyses. The survey questions from which the data were obtained are attached. The distribution of participants by district and the public transportation systems of those districts are as seen in the figure 3.5. The district with the highest participation was Karşıyaka with 180 people, followed by Buca with 163 people and Konak with 104 people.

3.4.1. Demographic Information

In this part of the thesis, the statistical distributions of demographic data are examined. All information was collected through an online survey, and this section includes four fundamental questions to understand the importance of these demographic data on the transportation demand questions answered by individuals in the survey.

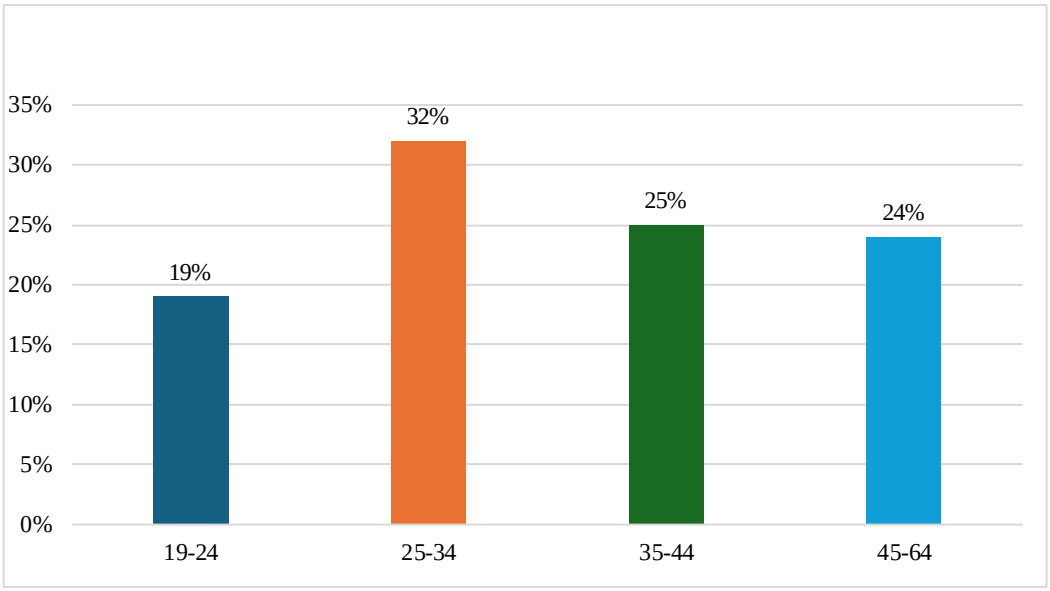

Figure 3.6. Age group distribution of the study

Age data were analyzed in four categories, based on the most actively traveling age range of 19-64 years. These ranges were considered as 19-24, 25-34, 35-44, and 45-64. As seen in Figure 3.6. 32% of the participants fall within the 25-34 age range. The age group with the least participation is the 19-24 age group, which constitutes 19% of the total participants. The 35-44 and 45-64 age ranges have nearly the same number of participants, with percentages of 25% and 24%, respectively. Overall, it can be said that the age distribution of the participants is balanced.

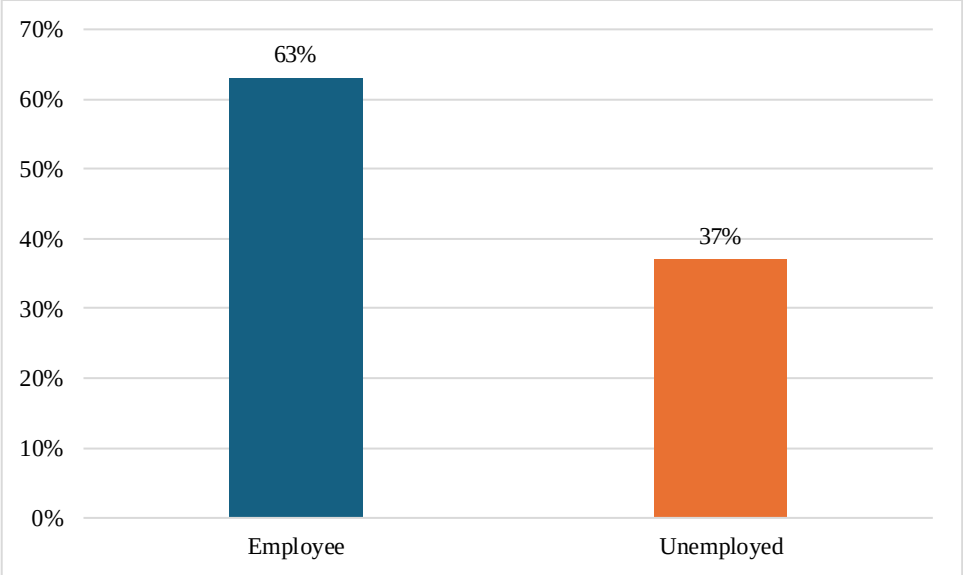

Figure 3.7. Employed/Unemployed distribution of the study

When considering employment status, 63% of the participants are employed, while 37% are not employed. Among the 37%, students are also included among the participants.

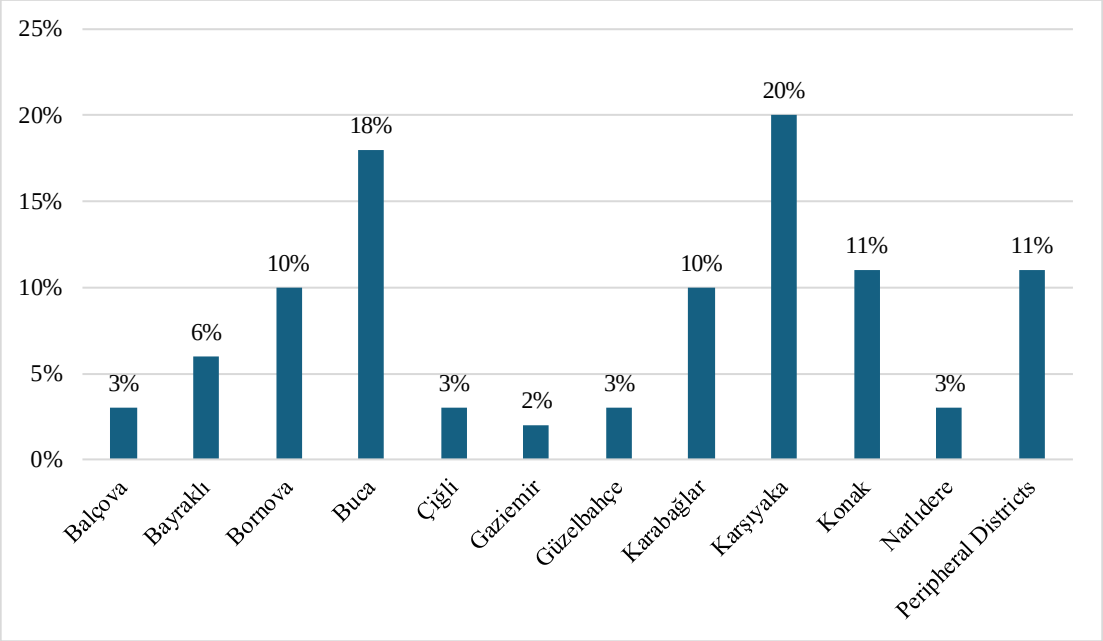

Figure 3.8. District distribution of the study

When looking at the districts where participants reside, the highest participation rate, at 20%, is in Karşıyaka. This is followed by Buca at 18%, Konak at 11%, and Karabağlar at 10%. Peripheral districts, when considered separately, show very low percentages individually, totaling an 11% participation rate when combined.

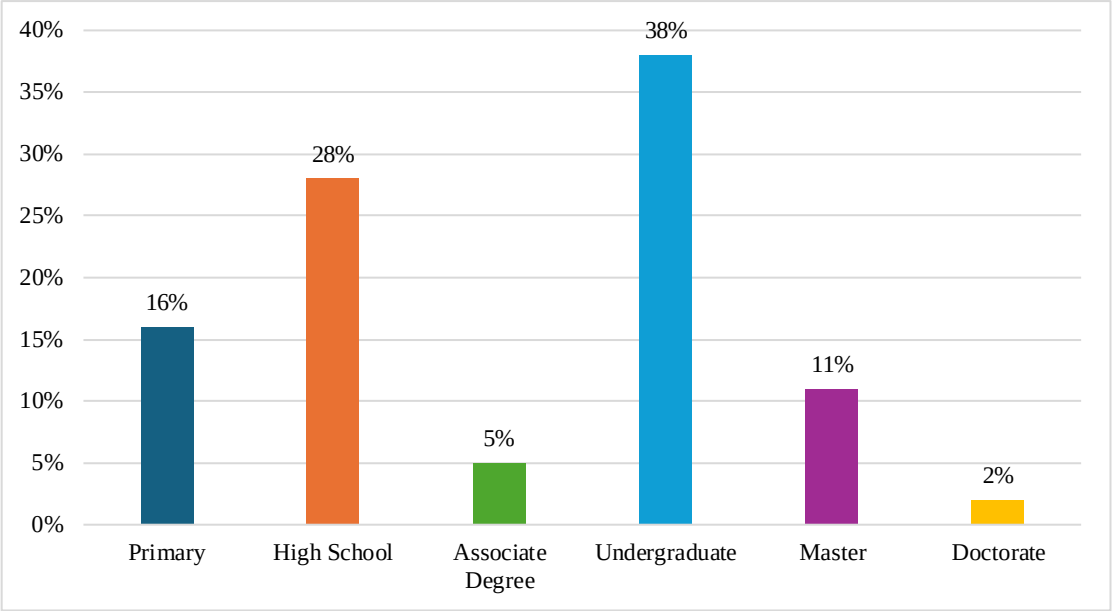

Figure 3.9. Education distribution of the study

To determine participants' educational levels, six categories were identified: primary, high school, associate degree, undergraduate, master's, and doctorate. 38% of the participants are undergraduate degree holders, followed by 28% who are high school graduates. The lowest percentage, at 2%, consists of doctoral degree holders.

3.4.2. Travel Behavior

In this section of the analysis, the statistical distributions of participants' travel behaviors have been examined. The following questions were asked:

- Do you own a vehicle? If yes, what type?
- How often do you use your vehicle for journeys?
- Do you use public transportation? If yes, how frequently?
- Are you satisfied with the current public transportation systems?
- Do you consider yourself a "transportation disadvantaged" in terms of benefiting from transportation systems?

To determine individual vehicle ownership, participants were asked whether they owned a private car, bicycle-scooter, or motorcycle. According to survey responses, 49% of participants do not own any vehicle. In contrast, 45% own a car. The ownership rates for bicycle-scooters and motorcycles are the same at 3%.

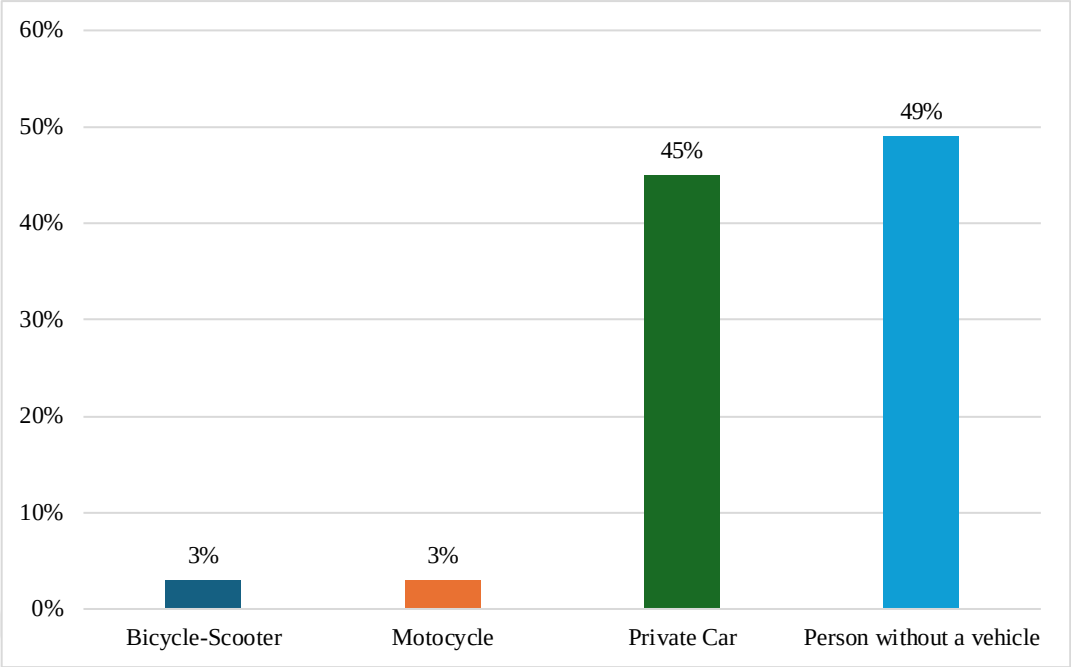

Figure 3.10. Transportation vehicle ownership

According to survey responses, 49% of participants do not own any vehicle. In contrast, 45% own a car. The ownership rates for bicycle-scooters and motorcycles are the same at 3%.

There are a total of 465 participants who own a vehicle. These individuals were asked about the type of vehicle they use and how often they use it per week, based on their usage in the last 15 days.

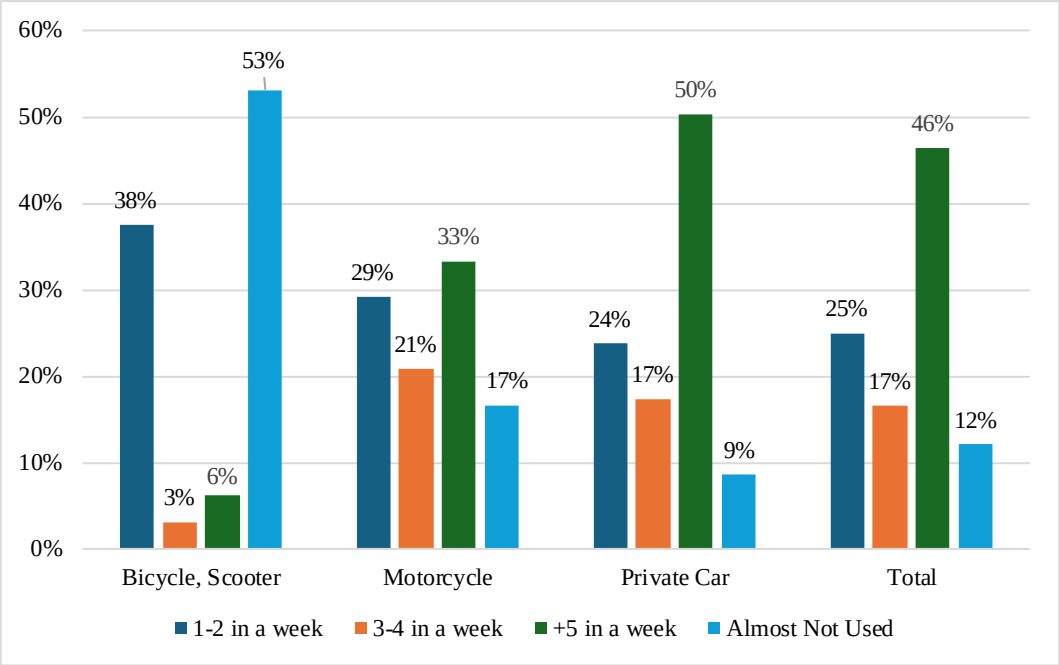

Figure 3.11. Vehicle usage frequency by ownership

Responses indicate distribution as described in figure 3.11. When asked participants who own vehicles, 50% of those with private cars use their vehicles more than 5 times a week. 24% use them 1-2 times a week, while 17% use them 3-4 times a week. Only 9% of participants state they use their vehicles almost never.

When the same question was asked to bicycle-scooter owners, 53% indicated they use their vehicles rarely. Following this, 38% use them 1-2 times a week. Users who use their vehicles more than 5 times a week account for 6%, while those who use them 3-4 times a week are only 3%. These figures suggest that bicycle and scooter usage is not actively preferred in traffic across Izmir.

Regarding motorcycle ownership, a more balanced distribution is observed compared to other vehicles. Users who use their motorcycles more than 5 times a week represent the largest segment at 33%. They are followed by users who use them 3-4 times a week at 21%. 17% of participants stated they rarely use their motorcycles. 29% use their motorcycles 1-2 times a week.

Subsequently, all participants were asked whether they use public transportation and how frequently they use it.

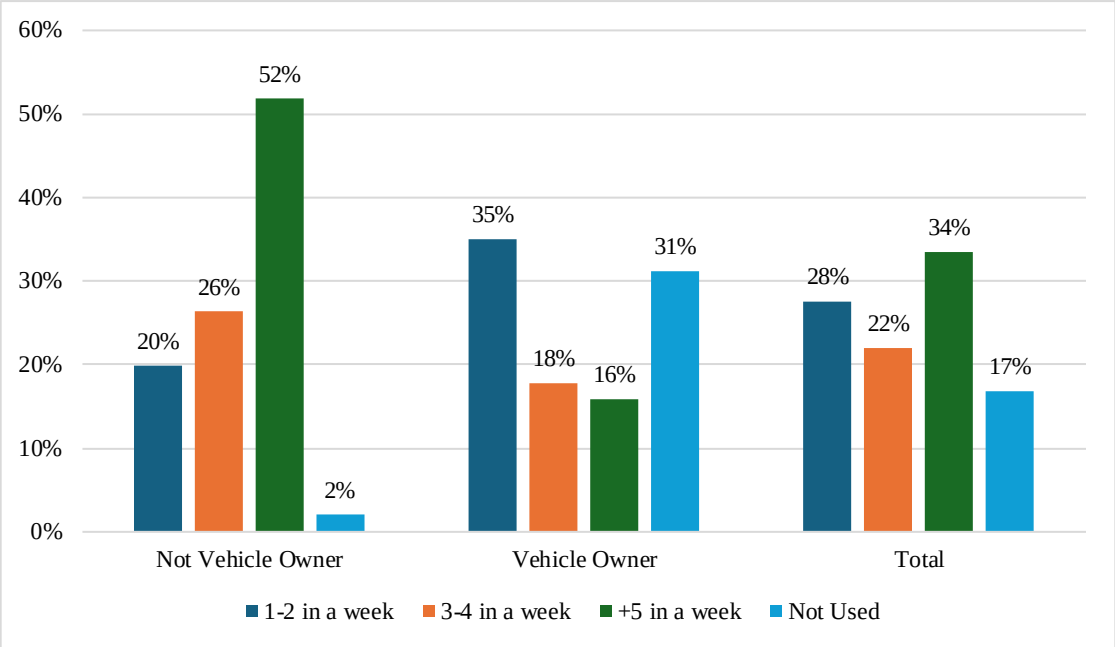

Figure 3.12. Frequency of public transportation usage by vehicle ownership

The percentage of vehicle owners who do not use public transportation is 31%. In contrast, 35% stated they use it 1-2 times a week, 18% use it 3-4 times a week, and 16% use it more than 5 times a week. Consequently, vehicle owners who use public transportation constitute 61%.

When the same question was posed to participants who do not own vehicles, it was observed that more than 50% use public transportation more than 5 times a week. 26% use it 3-4 times a week, and 20% use it 1-2 times a week. Only 2% of non-vehicle owners do not use public transportation.

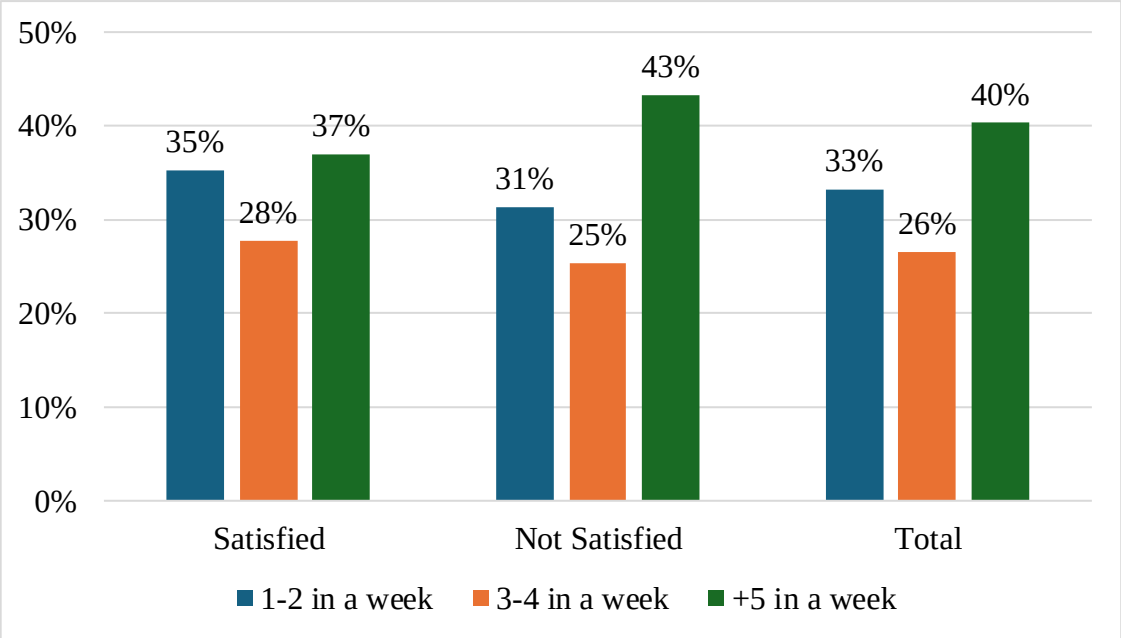

Figure 3.13. Frequency of public transport usage by satisfaction level

35% of individuals who use public transportation and are satisfied with it use it 1-2 times a week. Additionally, 28% use it 3-4 times a week, and 38% use it more than 5 times a week.

Among those who use public transportation but are not satisfied, 43% use it more than 5 times a week. 25% use it 3-4 times a week while expressing dissatisfaction, and 31% use it 1-2 times a week but are not satisfied with the public transportation systems. From this, it can be seen that satisfaction with public transportation decreases as usage frequency increases.

Overall, when examining the relationship between public transportation usage and satisfaction, 47% of the 759 individuals who use public transportation are satisfied, while 53% are not satisfied. Among these, 41% use public transportation more than 5 times a week. The percentage of individuals who use public transportation 3-4 times a week is 26%, while those who use it 1-2 times a week make up 34%.

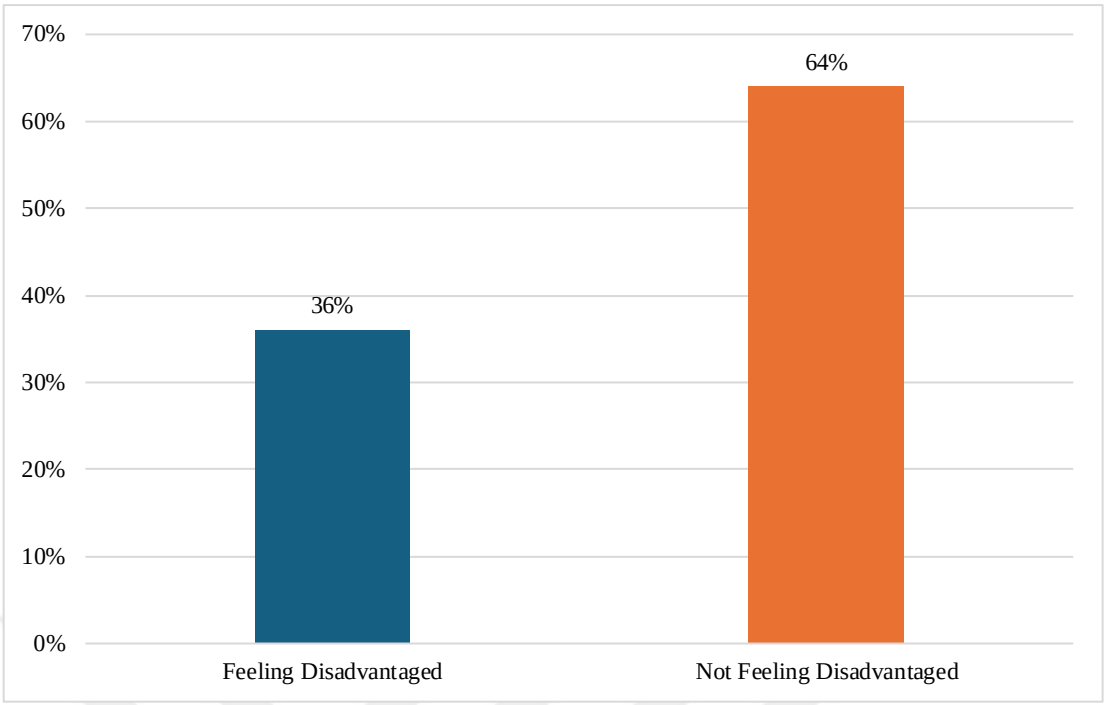

Figure 3.14. Disadvantages in public transportation

The last question asked in this section is to find out whether the individual feels disadvantaged. While 64% of the participants do not see themselves as disadvantaged, 36% think they are.

3.5. Research and Statistical Analysis Methods

3.5.1. Stated and Revealed Preferences for Travel Survey Techniques to Measure the Type of Demands

It is crucial for transportation plans in cities to be forward-looking, to meet future demands, and to address current problems. In this context, preference methods are used to determine future transportation methods and understand transportation demands. Deciding which preference methods to use and what information to collect about individuals' preferences and opinions is the first step in data collection. In this regard, this section of the thesis explains and compares stated preference and revealed preference methods. Subsequently, a general overview of survey types used in transportation is provided, discussing their history, advantages, and disadvantages.

Revealed and Stated preference methods are approaches used in economics to reveal individuals' preferences by looking at their behavior across different statements of conditions. Looking at the historical onset of the methods, it can be observed that in the early 20th century, they began to emerge in the context of market research and determining consumer behavior. Researchers started seeking methods to understand the importance of observing consumer behavior and the impact of individuals' preferences on markets.[45]

In Louviere's[46] studies on transportation, he suggested that there might be methods to measure the individual's response to different combinations of transportation modes and drew attention to the use of methods. Thereupon, the SP method was introduced by Kroes and Sheldon [45] and the question of whether their preferences would change if they had additional alternatives to which they chose among the given options was also examined.

In other words, in the SP method, analyses can be made for effects that do not exist in the present but may arise later.[47] Individuals are offered options for collecting data, and different combinations are obtained from the results obtained. In other words, it is a method of obtaining information through hypothetical assumptions that do not exist. Surveys suitable for SP methods should be consistent with the subject to be researched and survey questions should be prepared in detail. Having clear differences between the questions makes it easier for individuals to choose between the answers, and thus the data obtained is meaningful.

There are basically two categories in the stated preference method in travel behavior studies. In the first one, individuals are asked to rank their preferences among different options describing services and modes. Since the ranking or rating is made, you have data about all the options. In the second category, the person is asked to choose among combinations of features, and information is obtained only by going through the selected ones. This is called the first-preferences choice task.[48] For example, students may be presented with different options and asked to choose the modes of transportation they prefer when going to school, taking into account impacts such as cost and travel time. These preferences are analyzed statistically by researchers one by one for each effect, and data is collected about how students will make choices.

The stated preference method is important for evaluating scenarios that do not exist in reality. For example, residents can be asked questions about a bike path in a neighborhood, but there is no bike path in that neighborhood. However, these scenarios

are valuable for providing data input about services to be provided in the future and new methods to be proposed.

On the other hand, the RP method analyzes the choices individuals actually make, not through hypothetical scenarios. Although the RP method provides important analyzes for determining services and creating travel demand models, it is insufficient on its own because it does not provide sufficient diversity and there is not enough correlation between variables.[45]

On the other hand, it is necessary to carefully determine the number of individuals in surveys about transportation. Although it depends on the subject, there are differences between SP and RP methods in determining the factors, as seen in table 3.13. Based on these differences, more realistic data can be obtained when the methods are used together.

Table 3.13. Revealed Versus Stated Preference Data

REVEALED PREFERENCE DATA	STATED PREFERENCE DATA
It is based on real behavior.	It is based on theoretical scenarios.
Impact measurement contains errors.	Determination of effects contains errors.
It has limited effect change.	It has a wide range of effects.
Invisible effects are not taken into account.	Invisible effects are taken into account.
It is more consistent with real behavior.	It may not match actual behavior.
Preference is an indicative choice.	The preference indicator can be degree, ratio, or choice.

Wardman[49] compared RP and SP data in his studies and criticized the SP method, saying that they did not reflect real behavior. He pointed out that SP data was obtained using methods such as repeated "repeat questioning" and "holdout" approaches, and that preferences may have changed when the method was used again after a certain time. Therefore, he thought that the data could be misleading. At the end of his study, he compared the SP and RP values and compared the hypothetical He saw that the preferences provided accurate information about real preferences and said that the two methods worked harmoniously.

Kroes and Sheldon[45] state that the RP method provides limited information about primary service variables such as travel time and cost, and that it is insufficient to evaluate the effect of secondary variables such as seat design and station facilities. At this point, SP methods are needed.

In conclusion, SP and RP methods, which have been used for many years in transportation research, provide important data for planners, policy makers and engineers to obtain important data about public preferences and choices. While the PR method is used to determine actual travel behavior, the SP method enables analysis by presenting options based on assumptions. By determining the needs of individuals, both methods can create important inputs for transportation systems to be designed in the future and can also be used in determining new transportation policies. For this reason, the RP method is used in the thesis to directly obtain real travel demands, and the SP method is also included to see how transportation preferences will evolve if the current situation changes through hypothetical assumptions.

3.5.2. Travel Survey Techniques

When the history of travel surveys is researched, it is seen that they have been conducted since the 1950s. The purpose of the surveys is to determine the travel behavior of the population in the place where the research will be conducted and to use this data as a basis for planning decisions. In the 1950s and 1960s, travel research was generally conducted in major American cities.[50] These surveys were conducted as home interviews in which interviewers collected information by visiting homes.

Over the years, in addition to face-to-face interviews, various types of surveys have emerged, such as sending surveys by mail or conducting surveys over the phone. In recent years, a combination of surveys conducted via mail, telephone, and the Internet has also been utilized. However, nowadays, the most popular survey format is online surveys conducted over the Internet.

Over the years, changes in survey methods can be attributed to several factors, including uncertainties regarding response rates, coding, and data accuracy. Additionally, increases in survey administration costs have played a role. Specifically, in face-to-face interviews conducted without prior notice, respondents may not accurately recall their travels, leading to reliability issues in the data.[50]

In this section, survey approaches are examined in more detail under two subheadings: traditional and new approaches.

3.5.2.1. Traditional Approaches

Traditional approaches are called face-to-face and self-administered surveys. Travel surveys first began to be conducted face-to-face at home by visiting households. These types of surveys allow for direct interaction between the interviewer and the participant, allowing them to explain the questions, ensure correct understanding of the answers, and verify the answers immediately. The biggest disadvantage of this research is that it takes a lot of time, requires a lot of personnel, and therefore causes high costs. Another problem is security. For example, Stopher [51] stated in his study that it is not safe for surveyors and researchers to work in some regions, especially in America, and that other types of surveys should be used instead of home interviews.

Self-administered surveys are usually surveys that are asked to be completed for a trip on a specific date. In these surveys, the questions are given directly to the people who will answer them, and they are expected to fill them out themselves. The advantage of this type of survey is that the cost is low and the person who answers the survey can determine the time to answer it. The disadvantage is the possibility of collecting incorrect data if the questions are not understood.

Another approach, telephone surveys, was previously a logical option for collecting data in cities with high levels of home telephone ownership. However, over the years, it has been observed that there has been a rapid decline in the response rate to surveys conducted over the phone. The biggest reason for this is the decrease in the use of home phones and the increase in the use of mobile phones.

The downside of taking samples from published phone records is that listed numbers are excluded from the sample.[61] Although people can be contacted via their mobile phones, it is difficult to find information about where they live. This creates a problem in the sample geographically.

As a result, traditional approaches have long yielded important data for transportation surveys. However, new approaches have emerged due to developing technology and changing environmental and social factors.

3.5.2.2. New Approaches

In the early stages of internet proliferation, there were debates about conducting surveys solely online due to the ability to reach only a specific segment of the population. Inbakaran[50] mentions in his article that in 2011, with 72% of households in Australia having internet access, conducting surveys solely online would reduce representativeness. However, looking at Turkey, according to TUIK[52] data, as shown in the graph, it is observed that in 2023, 95.5% of households had access to the internet from home. The percentage of individuals using the internet was 87.1%. Looking at figure 3.15, it would not be incorrect to infer that access rates will continue to increase each year. The most important point here, besides access, is whether the individuals participating in the survey understand the questions correctly. Therefore, it is essential for the survey to be prepared with clear and detailed questions. Otherwise, it is important to share contact information for individuals to reach out to the surveyor if they have any questions.

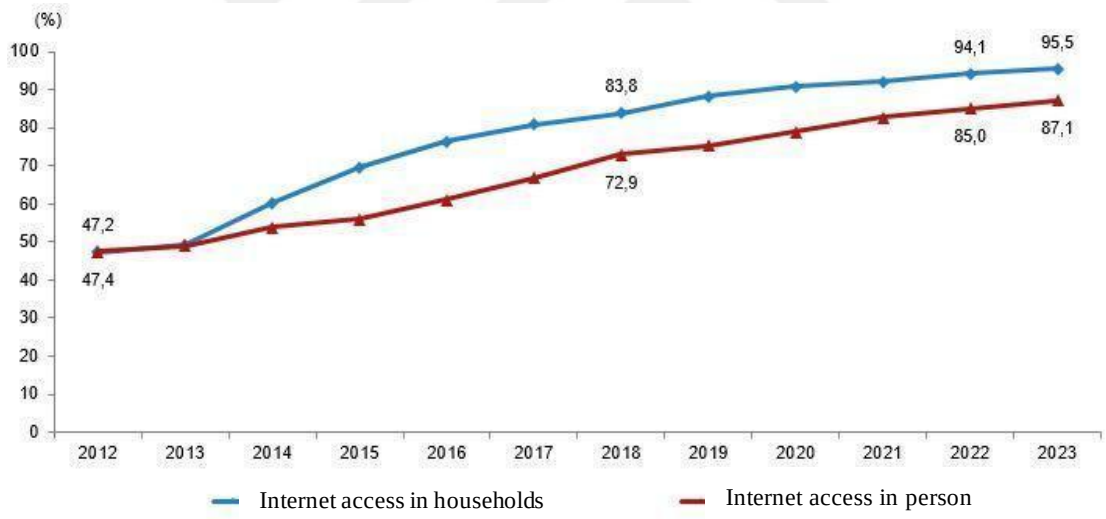

Figure 3.15. Internet access availability in households and internet use by individuals in Turkey, 2012-2023 (TUİK[52])

With the introduction of mobile technologies such as cell phones and GPS devices into our lives, new options have emerged for conducting travel-related research.

3.5.3. Chi Square Test

The Chi-square test is a significance test developed by statisticians. It is a statistical measure used in sample analysis to compare a variance with a theoretical variance.[62]

This test is utilized to determine whether categorical data are dependent or whether two classifications are independent.

For the application of the Chi-square test, the data must take nominal values. Additionally, the groups must be independent of each other, and each subject should be in only one cell.

The test can be calculated manually or using statistical software such as SPSS.

$$x^2 = \sum \frac{(O_{ij} - E_{ij})^2}{E_{ij}}$$

x^2= Chi-square value of the cell

O_{ij} = observed frequency of the cell in ith row and jth column.

E_{ij} = expected frequency of the cell in ith row and jth column.

When calculated in SPSS, for the results to be interpretable, less than 20% of the cells should have an expected count less than 5, and the expected count value should be above 5. Following this, the value in the Asymptotic Significance (2-sided) column corresponding to the Pearson Chi-Square row is examined. This value is the Chi-square value, and if it is below 0.05, it is interpreted that the correlation between the variables is significant.

3.5.4. Categorical Data Analysis

Categorical data analysis is a type of statistical analysis in which data are analyzed based on classified variables. Categorical variables are defined by specific classes rather than numerical values and can be nominal or ordinal.

Nominal scale is the scale of qualitative variables that cannot be ordered. Examples include residential district, gender, and age. Ordinal scale, on the other hand, is the scale of qualitative variables that can be ordered. Examples include education level

and employment status. For instance, education level can be coded as follows: primary school (1), middle school (2), high school (3), undergraduate (4), postgraduate (5).

In this measurement level, analyses such as frequency, mode, median, and range can be performed.[63] However, arithmetic mean cannot be calculated. To examine the relationship between two or more categorical variables, a contingency table is used.

Categorical data analysis in transportation research is used to examine the relationships between variables such as individuals' transportation mode choices and travel behaviors. Analyzing these relationships and determining their distribution according to demographic factors provides important guidance for decision-makers in transportation policy and planning.

Ben-Akiva and Lerman[8] emphasize the significance of categorical data analysis in transportation demand modeling. Techniques such as multinomial logistic regression have been employed to collect categorical data to understand how individuals make choices between different transportation modes.

Train[64] highlights the use of categorical data analysis in understanding decision-making processes in transportation research. He notes that categorical data analysis is crucial in evaluating the alternatives individuals face when choosing transportation modes and identifying the factors that influence these choices.

In conclusion, categorical data analysis is a vital tool in transportation studies. Research in the literature indicates that this analytical method provides valuable insights for transportation planning and policymakers. In this study, all survey questions were presented to respondents in a categorical format. The data collected were organized into tables. Contingency tables were utilized and interpreted to examine the changes in proportions between the current situation and demands. These tables were instrumental in determining and analyzing the demand for different transportation modes, travel times, and journey quantities. IBM SPSS software was employed to prepare the tables.

CHAPTER 4

SIGNIFICANCE OF DIVERTED AND SUPPERESED DEMAND

4.1. Significance of Travel Demand by Mode

This section examines whether actual demand affect diverted and suppressed demands over transportation modes. While actual demand refers to the travel mode participants currently use or prefer, diverted demand describes the transportation modes they choose in alternative situations such as peak hours and long-term maintenance works. First, participants' travel demands were examined over 4 transportation modes via a cross table, then the significance of diverted and suppressed demand with actual demand was examined in a chi-square table.

Table 4.1. Crosstab of Diverted Demand on Peak Hours

			Diverted Demand on Peak Hours		Total
			Same Mode Demand	Different Mode Demand	
Actual Demand by mode	Bicycle, Scooter	Count	9	2	11
		% within Mode	81,8%	18,2%	100,0%
	Private Vehicle	Count	89	131	220
		% within Mode	40,5%	59,5%	100,0%
	Public Transportation	Count	379	229	608
		% within Mode	62,3%	37,7%	100,0%
	Walking	Count	29	45	74
		% within Mode	39,2%	60,8%	100,0%
Total		Count	506	407	913
		% within Mode	55,4%	44,6%	100,0%

It was determined that 44.6% of the participants had diverted demand during peak hours. 81.8% of those whose actual demand is bicycle, or scooter preferred the same mode during peak hours. This means that diverted demand is 18.2%. It is observed that 59.5% of individuals who drive have diverted demand, while the remaining participants continue to travel by their own vehicles during peak hours. Among public transportation users, 62.3% do not change their mode of travel during peak hours, while 37.7% shift to

alternative modes. Lastly, it is understood that 60.8% of those who walk also exhibit diverted demand during peak hours.

Table 4.2. Chi-Square of Diverted Demand on Peak Hours

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	42,706[a]	3	,000
Likelihood Ratio	43,008	3	,000
Linear-by-Linear Association	3,005	1	,083
N of Valid Cases	913		

a. 1 cells (12,5%) have expected count less than 5. The minimum expected count is 4,90.

When the Chi-square Test result is examined, the significance value is found to be 0.000. This means that there is a significant relationship between the actual demand and diverted demands during peak hours.

Table 4.3. Crosstab of Diverted Demand on Maintenance Works

			Diverted Demand on Maintenance Works		Total
			Same Mode Demand	Different Mode Demand	
Actual Demand by mode	Bicycle, Scooter	Count	7	4	11
		% within Mode	63,6%	36,4%	100,0%
	Private Vehicle	Count	132	88	220
		% within Mode	60,0%	40,0%	100,0%
	Public Transportation	Count	360	248	608
		% within Mode	59,2%	40,8%	100,0%
	Walking	Count	24	50	74
		% within Mode	32,4%	67,6%	100,0%
Total		Count	523	390	913
		% within Mode	57,3%	42,7%	100,0%

It is observed that 42.7% of participants switch to alternative transportation modes during maintenance work, indicating the presence of diverted demand. Among bicycle or scooter users, 63.6% continue to use the same modes during infrastructure work. For private vehicle users, 60% persist in using their cars during such periods, while 40% shift to other modes, indicating diverted demand. This proportion is 40.8% among public transportation users and 67.6% among pedestrians.

Table 4.4. Chi-Square of Diverted Demand on Maintenance Works

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	20,444[a]	3	,000
Likelihood Ratio	20,327	3	,000
Linear-by-Linear Association	8,824	1	,003
N of Valid Cases	913		

a. 1 cells (12,5%) have expected count less than 5. The minimum expected count is 4,70.

When the Chi-square Test result is examined, the significance value is found to be 0.000. This means that there is a significant relationship between the actual demand and diverted demands during maintenance works.

Table 4.5. Crosstab of Suppressed Demand

			Suppressed Demand		Total
			Same Mode Demand	Different Mode Demand	
Actual Demand by mod	Bicycle, Scooter	Count	2	9	11
		% within Mode	18,2%	81,8%	100,0%
	Private Vehicle	Count	58	162	220
		% within Mode	26,4%	73,6%	100,0%
	Public Transportation	Count	109	488	608
		% within Mode	17,9%	82,1%	100,0%
	Walking	Count	10	64	74
		% within Mode	13,5%	86,5%	100,0%
Total		Count	179	734	913
		% within Mode	19,6%	80,4%	100,0%

When looking at the participants, it is observed that 80.4% actually want to use a different transportation mode, in other word it is noticing that 80.4% of participants have suppressed demand. Among bicycle and scooter users, 18.2% stated they would prefer to continue using the same modes, while 81.8% expressed a desire not to use these modes, demonstrating suppressed demand. For private vehicle users, the suppressed demand rate is 73.6%, while for public transportation users, it is 82.1%.

Table 4.6. Chi-Square of Suppressed Demand

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	9,217[a]	3	,027
Likelihood Ratio	8,939	3	,030
Linear-by-Linear Association	4,499	1	,006
N of Valid Cases	913		

a. 1 cells (12,5%) have expected count less than 5. The minimum expected count is 2,16.

When the Chi-square Test result is examined, the significance value is found to be 0.027. This means that there is significant relationship between the actual demand and suppressed demands.

4.2. Travel Demand by Trip Rate

This section examines whether current trip rates affect suppressed demands e. First, the suppressed demands of the participants were examined over the current trip rate in four categories through a cross table, and then the significance of current trip rate with suppressed demand was examined in the chi-square table.

Table 4.7. Crosstab of Suppressed Demand

			Trip Rate Demand		Total
			Same Trip Rate Demand	Different Trip Rate Demand	
Current Trip Rate	0-2	Count	546	56	602
		% within Trip Rate	90,7%	9,3%	100,0%
	3-5	Count	144	125	269
		% within Trip Rate	53,5%	46,5%	100,0%
	6-8	Count	8	19	27
		% within Trip Rate	29,6%	70,4%	100,0%
	9+	Count	9	6	15
		% within Trip Rate	60,0%	40,0%	100,0%
Total		Count	707	206	913
		% within Trip Rate	77,4%	22,6%	100,0%

Total suppressed demand based on trip rate is 22.6%. 90.7% of those making 0-2 trips per day still demand the same number of trips, while their suppressed demand is

9.3%. Those making 3-5 trips per day have suppressed demand of 60.7%. Those making 6-8 trips per day have suppressed demand, which is the highest compared to other trip rates, at 70.4%. Those making 9 or more trips per day have suppressed demand, which is expected to be higher, at 40%.

Table 4.8. Chi-Square of Suppressed Demand

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	186,500[a]	3	,000
Likelihood Ratio	177,791	3	,000
Linear-by-Linear Association	150,883	1	,000
N of Valid Cases	913		

a. 1 cells (12,5%) have expected count less than 5. The minimum expected count is 3,38.

When the Chi-square Test result is examined, the significance value is found to be 0.000. This means that there is a significant relationship between the current trip rate and suppressed demands.

4.3. Travel Demand by Travel Time

This section examines whether current travel times affect suppressed demands over travel time. First, the suppressed demands of the participants were examined over the four categories of current travel time through a cross table, and then the significance of travel demands with current travel time was examined in the chi-square table.

Table 4.9. Crosstab of Suppressed Demand

			Travel Time Demand		Total
			Same Travel Time Demand	Different Travel Time Demand	
Current Travel Time	0-30 min	Count	180	8	188
		% within Current	95,7%	4,3%	100,0%
	30-60 min	Count	20	514	534
		% within Current	3,7%	96,3%	100,0%
	60-90 min	Count	2	144	146
		% within Current	1,4%	98,6%	100,0%
	+90 min	Count	00	45	45
		% within Current	0,0%	100,0%	100,0%
Total		Count	379	534	913
		% within Current	22,1%	77,9%	100,0%

It is seen that 77,9% of the participants have suppressed demand by travel time. 4,3% of those whose current travel time is 0-30 minutes have suppressed demand. Of those with a current travel time between 0-30 minutes, 95.7% have the same duration demand, while 4.3% have pent-up demand. The suppressed demand of those whose current travel time is between 60-90 minutes is 98,6%. When the travel time is over 90 minutes, suppressed demand has reached the maximum level compared to the others and is 100%. It can be generalized that as the current travel time increases, the suppressed demand of the participants also increases.

Table 4.10. Chi-Square of Suppressed Demand

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	745,365[a]	3	,000
Likelihood Ratio	707,082	3	,000
Linear-by-Linear Association	403,268	1	,000
N of Valid Cases	913		

a. 0 cells (0,0%) have expected count less than 5. The minimum expected count is 9,96.

When the Chi-square Test result is examined, the significance value is found to be 0.000. This means that there is a significant relationship between current travel time and suppressed demands.

4.4. Travel Demand by Route

This section examines whether current route choice affect demands. First, participants' travel demands were examined through a cross table with whether they preferred different routes, and then the significance of travel demands with current route choice was examined in a chi-square table.

Table 4.11. Crosstab of Diverted Demand on Peak Hours

			Route Demand on Peak Hours		Total
			Same Route Demand	Different Route Demand	
Current Route Choice	Same	Count	261	379	640
		% within current	40,8%	59,2%	100,0%
	Different	Count	228	45	273
		% within current	83,5%	16,5%	100,0%
Total		Count	489	424	913
		% within current	53,6%	46,4%	100,0%

The rate of diverted demands of the participants on the routes during peak hours is 46.4%. In other words, 46.4% of the participants tend to use other routes during peak hours. While 59.2% of those who did not change their current route preferences have diverted demands, this rate is 16.5% for those with different current route preferences. From this, it can be inferred that 83.5% of those who use different routes are satisfied with the current different routes.

Table 4.12. Chi-Square Test Diverted Demand on Peak Hours

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	140,511[a]	1	,000		
Continuity Correction[b]	138,798	1	,000		
Likelihood Ratio	151,318	1	,000		
Fisher's Exact Test				,000	,000
Linear-by-Linear Association	140,357	1	,000		
N of Valid Cases	913				

a. 0 cells (0,0%) have expected count less than 5. The minimum expected count is 126,78.

b. Computed only for a 2x2 table

When the Chi-square Test result is examined, the significance value is found to be 0.000. This means that there is a significant relationship between the current route choice and diverted demands in peak hours.

Table 4.13. Crosstab of Diverted Demand on Maintenance Works

			Route Demand in Maintenance Works		Total
			Same Route Demand	Different Route Demand	
Current Route Choice	Same	Count	345	295	640
		% within current	53,9%	46,1%	100,0%
	Different	Count	225	48	273
		% within current	82,4%	17,6%	100,0%
Total		Count	570	343	913
		% within current	62,4%	37,6%	100,0%

The rate of diverted demands of the participants on the routes during the maintenance works is 37.6%. While 46.1% of those who did not change their current route preferences have diverted demands, 53.9% say they did not prefer a different route despite the works. Diverted demands of those with different current route preferences are 17.6%. From this, it can be concluded that 82.4% of those who use different routes are satisfied with the current different routes.

Table 4.14. Chi-Square Test of Diverted Demand on Maintenance Works

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	66,325[a]	1	,000		
Continuity Correction[b]	65,115	1	,000		
Likelihood Ratio	71,442	1	,000		
Fisher's Exact Test				,000	,000
Linear-by-Linear Association	66,253	1	,000		
N of Valid Cases	913				

a. 0 cells (0,0%) have expected count less than 5. The minimum expected count is 102,56.

b. Computed only for a 2x2 table

When the Chi-square Test result is examined, the significance value is found to be 0.000. This means that there is a significant relationship between the current route choice and diverted demand.

Table 4.15. Crosstab of Suppressed Demand

			Route Demand		Total
			Same Route Demand	Different Route Demand	
Current Route Choice	Same	Count	354	286	640
		% within current	55,3%	44,7%	100,0%
	Different	Count	221	52	273
		% within current	81,0%	19,0%	100,0%
Total		Count	575	338	913
		% within current	63,0%	37,0%	100,0%

It is seen that the suppressed demands of the participants on the route are 37%. On the other hand, there is no change in the route choice of 63% of the participants. While 44.7% of those who did not change their current route choice have suppressed demands, this rate is 19% for those with different current route choice. From this, it can be concluded that 81% of the people who use different routes are satisfied with the routes.

Table 4.16. Chi-Square of Suppressed Demand

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	53,959[a]	1	,000		
Continuity Correction[b]	52,865	1	,000		
Likelihood Ratio	57,611	1	,000		
Fisher's Exact Test				,000	,000
Linear-by-Linear Association	53,900	1	,000		
N of Valid Cases	913				

a. 0 cells (0,0%) have expected count less than 5. The minimum expected count is 101,07.

b. Computed only for a 2x2 table

When the Chi-square Test result is examined, the significance value is found to be 0.000. This means that there is a significant relationship between the current route

choice and diverted demands during peak hours.

CHAPTER 5

CATEGORY ANALYSIS

5.1. Travel Mode Choice

In this section of the analysis, individuals' preferences for transportation modes they use currently and how these preferences change under varying conditions such as maintenance works (road works, metro construction) or peak hours have been examined. The study also investigated how preferences would change if the demand for the preferred mode of transport was improved by 50%. These differences and changes provide insights into suppressed and diverted travel demands through transportation modes.

The following questions were asked in this section:

- What is the most frequently used transportation mode currently?
- During peak hours (e.g., after work, after school), do you prefer a different transportation mode than what you currently use? If yes, which one?
- Due to long-term infrastructure projects (such as road construction, metro construction, etc.) causing traffic problems, do you prefer a different transportation mode? If yes, which one?
- If you had the choice, what transportation mode would you prefer to use the most?
- What is the reason you cannot use the transportation mode you chose?

Based on the stated reason, individuals were asked only one of the following questions:

- If pedestrian and bicycle lanes were increased by 50%, would you travel by walking or biking?
- If the number of public transportation vehicles increased by 50%, would you use your preferred transportation mode?
- If traffic congestion in Izmir decreased by 50%, would you prefer your chosen transportation mode?
- If parking spaces increased by 50%, would you prefer to travel with your preferred transportation mode?

- If transportation costs decreased by 50%, would you prefer your chosen transportation mode?
- If infrastructure problems were improved by 50%, would you prefer your chosen transportation mode?
- If improvements were made to the problem you described by 50%, would you prefer your chosen transportation mode?

Firstly, the most used transportation modes of the participants were analyzed.

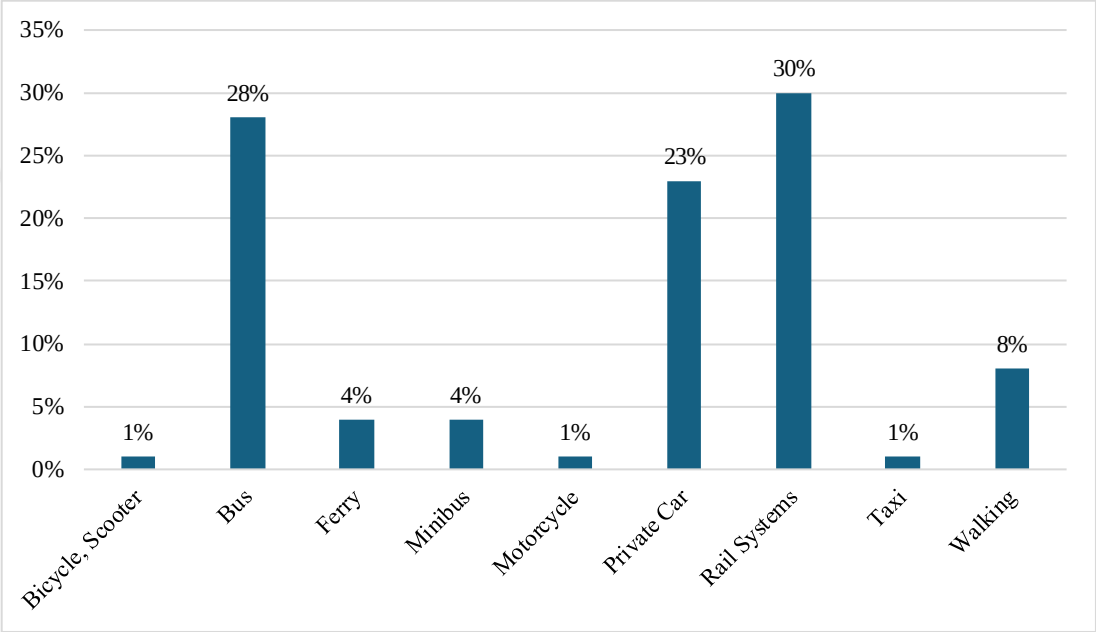

Figure 5.1. Most used transportation modes

When asked about the transportation mode currently used by the participants, the most used transportation mode was rail systems with 30%. It is followed by buses with 28% and private vehicles with 23%, respectively. Ferry preference is 4%. While the rate of walking is 8%, minibus use is 4%. Motorcycles, bicycle-scooters, and taxis have a value of only 1%.

Considering their vehicle ownership, the most used transportation modes of the participants are examined in the analysis (Figure 5.2.).

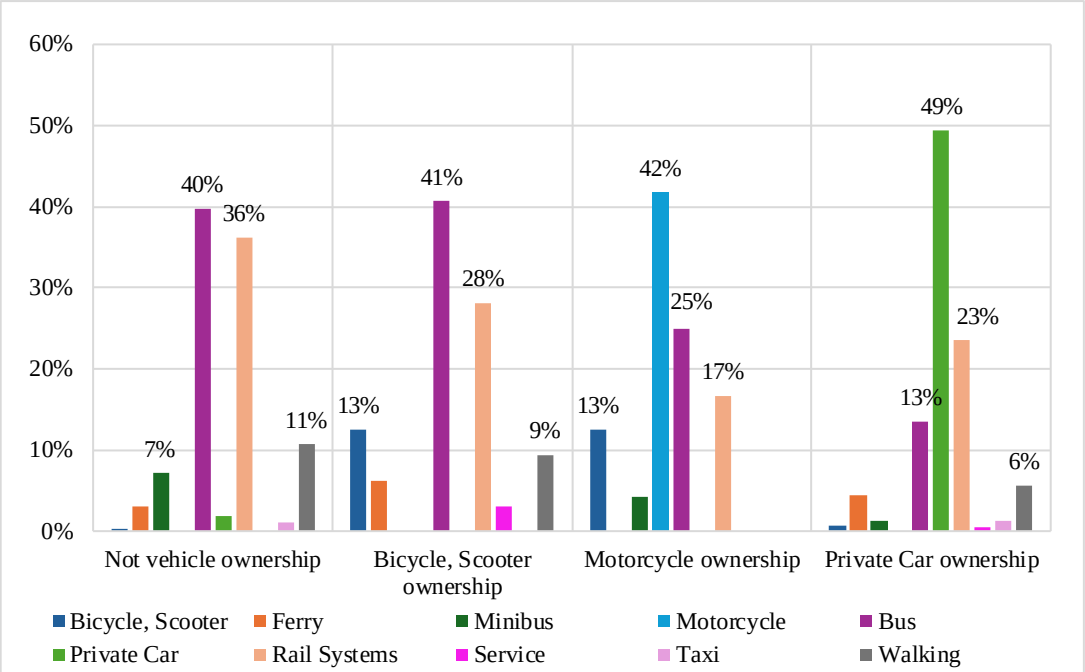

Figure 5.2. Mode used by vehicle ownership

The most used mode by those who do not have a vehicle is a bus with 40%, followed by rail systems with 36%. The most used mode by 13% of people who own a bike-scooter is again bicycle-scooter. The most used choice of the remaining people was the bus with 41%. The most used transportation mode of 87% of people who own bicycles and scooters is different. Among motorcycle owners, 42% identify the motorcycle as their most frequently used mode, while the remaining group relies heavily on buses and rail systems. A broader analysis reveals that 58% of motorcycle owners do not use their motorcycles as their primary mode of transportation. When we look at car owners, approximately half of the people who own a vehicle said that their most used mode of transportation is their private vehicle. Regarding car ownership, approximately half of car owners report that their private vehicle is their most used mode, while 23% of the remaining car owners indicate rail systems as their preferred mode of transport. In general, although 51% of the participants own a vehicle, the modes of transportation they use most are different.

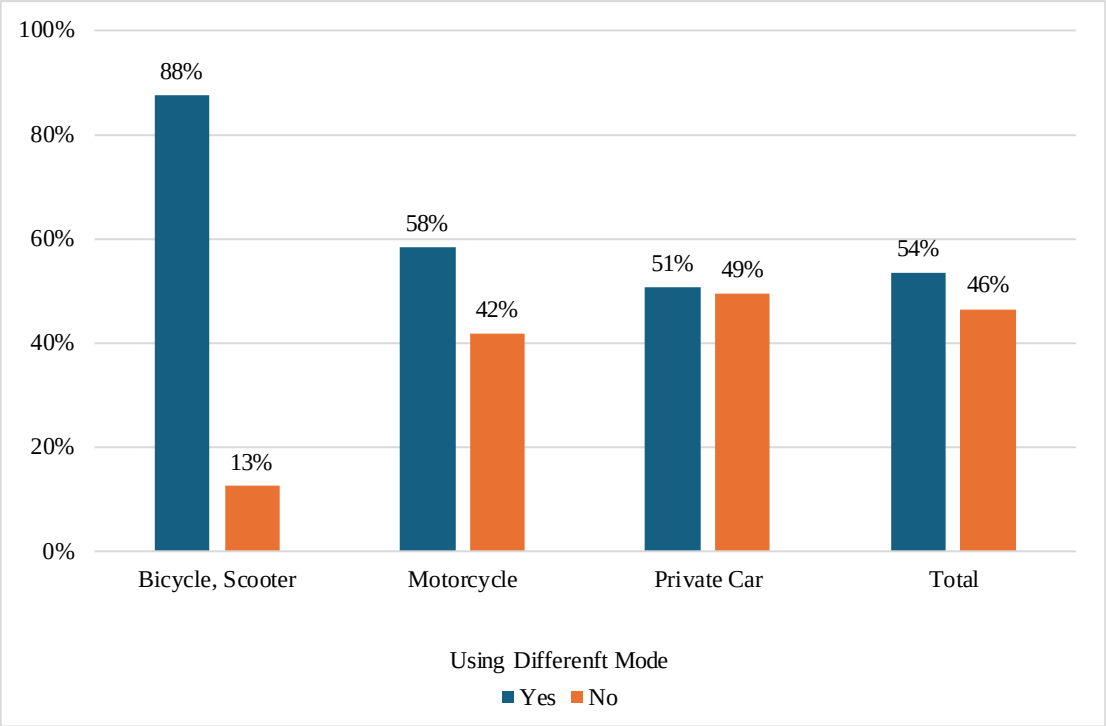

Figure 5.3. Using different modes by vehicle ownership

As a result, the percentage of people who own a vehicle but have a different preference for the mode they use the most is 54%. The remaining 46% prefer the vehicle they own as their primary mode of transportation. From here, it can be interpreted that more than half of the people who own a vehicle have different modes of transportation as their primary mode of transportation and that public transportation is very important and widely used.

In order to examine the changes in the travel, diverted demand by modes analysis in peak hours (Figure 5.4.)

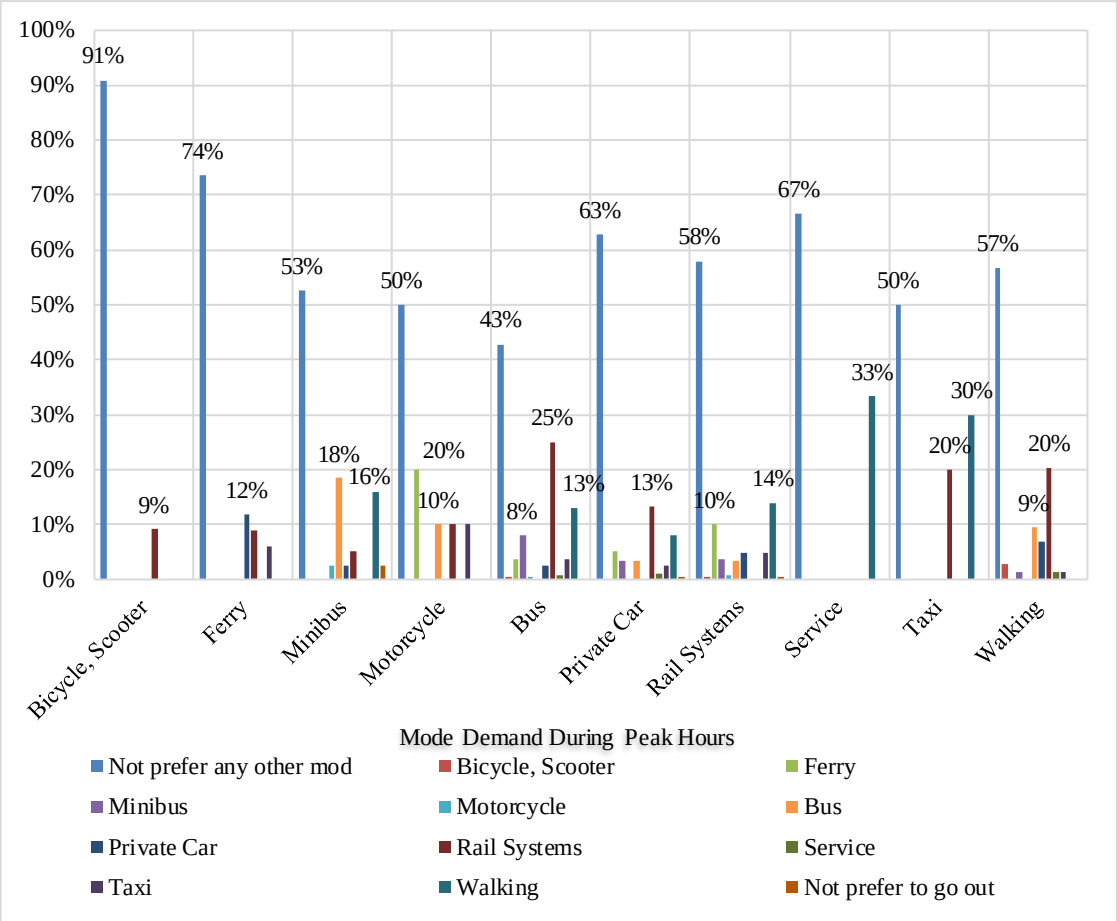

Figure 5.4. Mode demand during peak hours

While 74% of those who use ferry continue to use ferry during peak hours, 12% have diverted demand by private vehicles and 9% have diverted demand by the rail system.

Minibus users of the 53% are continuing to use minibuses. The rest demand to use the bus the most and then walk.

When looking at motorcycle users, 50% say they use another mode of transportation at different peak hours. While 20% have diverted demand by ferry and 10% by bus, rail system and walking.

A majority of private vehicle users (63%) reported continuing to use their own vehicles during peak hours. The rest have directed demands, while the most demand is for rail as a mode. Walking and ferry follow them with 8% and 5% respectively.

During peak hours, 58% of rail system users continue to rely on rail systems, while the most common alternatives are walking (14%) and ferries (10%).

Half of taxi users continue to use taxis during peak hours, while 30% have diverted demand by walking and 20% by rail systems. Similarly, 57% of those who typically walk

maintain this mode during peak times, with 20% have demand to rail systems and 4% choosing minibuses.

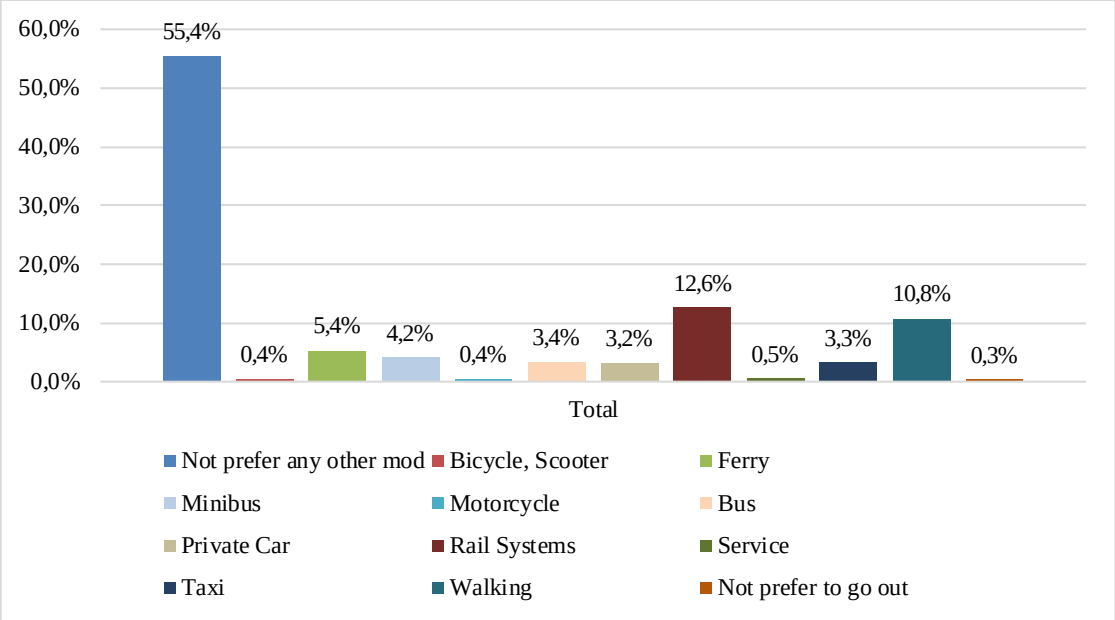

Figure 5.5. Total mode demand during peak hours

As seen in the figure 5.5., 55,4 % of the participants do not use a different type of transportation during peak hours. However, this indicates that 44.6% of the participants have diverted demand during peak hours. Only 0.3% prefer not to travel during these hours.

Then, in order to examine the changes in the travel, diverted demand by modes analysis during maintenance works (Figure 5.6.).

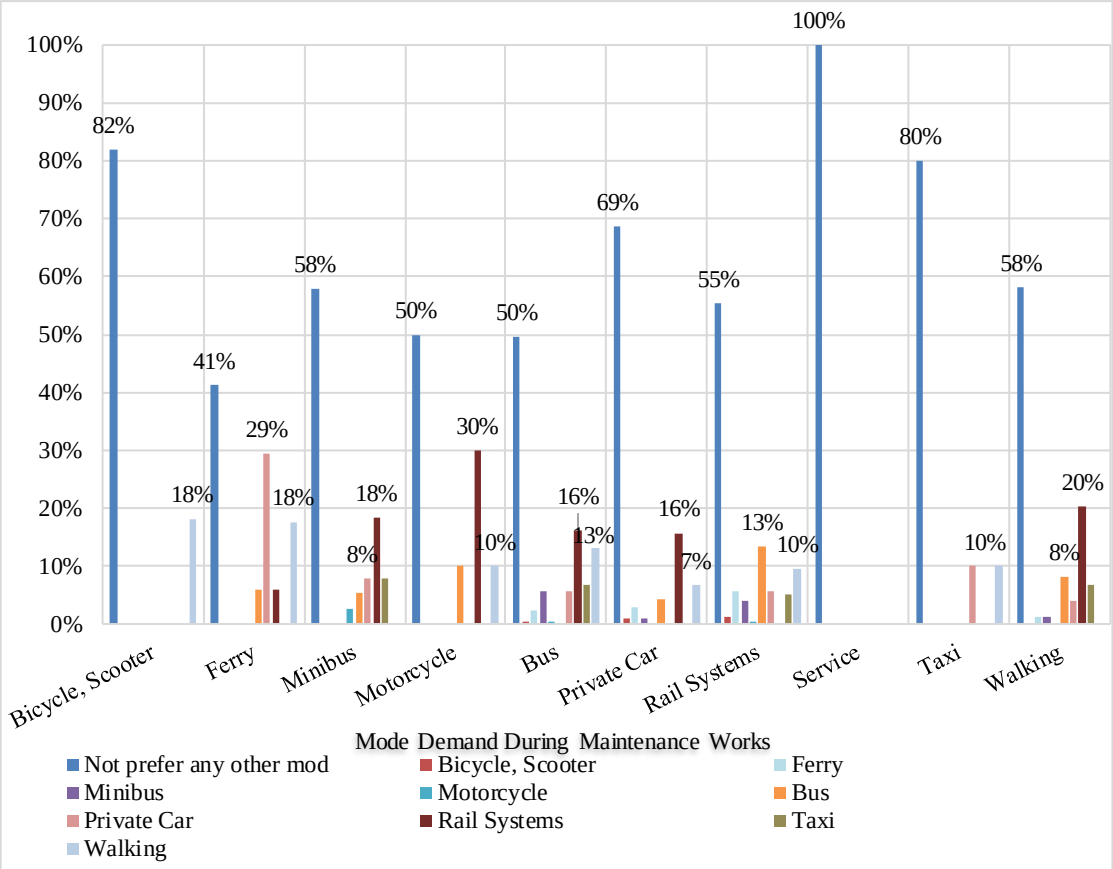

Figure 5.6. Mode demand during maintenance works

During maintenance periods, 82% of individuals who typically use bicycles and scooters continue to do so, while the remaining 18% demand to walking.

While 41% of people using ferry continue to use them, 29% of those who use private vehicles during maintenance works. It is followed by those who demand to walk with a rate of 18%.

A majority of minibus users (58%) preserve their use of minibuses during maintenance periods, with 18% demand to rail systems, and 8% opting for private vehicles or taxis. Notably, no participants chose walking, bicycles and scooters, or ferries as alternatives.

Of those who use buses, 49% do not use another mode of transportation. Of those with a diversified demand, 16% prefer rail transportation and 7% prefer walking.

Of those who use private vehicles, 69% continue to use their vehicles during maintenance work. However, it is seen that 16% of the population has a demand for a rail system.

A majority of rail system users (55%) not have diverted demand in maintenance works. The most demanded mode of transportation by rail system users is a bus with 13%. It is followed by walking with 10%. Ferry and private vehicles received 5% each.

The number of people who say that the service is their most preferred mode is only 3, and these people also prefer the service in maintenance works.

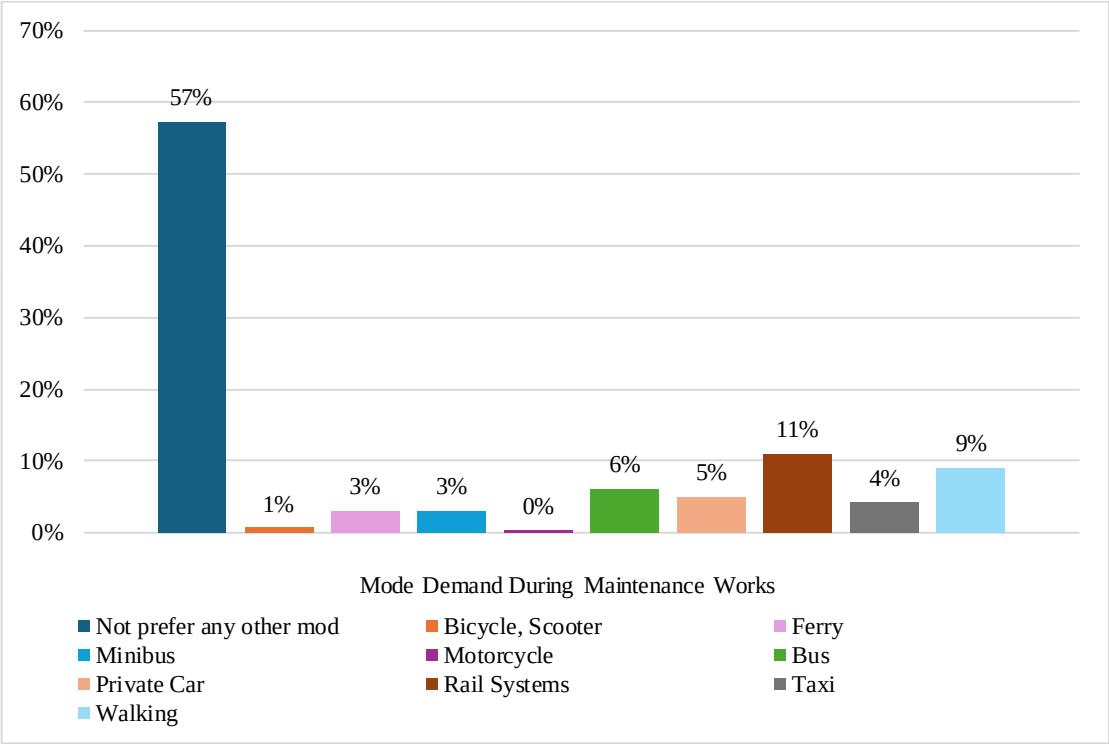

Figure 5.7. Total mode demand during maintenance works

When the changes in individuals' transportation modes during maintenance works are examined, it is seen that there is no change in the mode used of 57% of the participants. The rate of those who turn to different modes is 43. In other words, diverted demand is 43%. The most demanded mode during maintenance works was rail systems with a rate of 11%. It is followed by those who choose to walk with 9%. Motorcycle and bicycle use are the least demand modes.

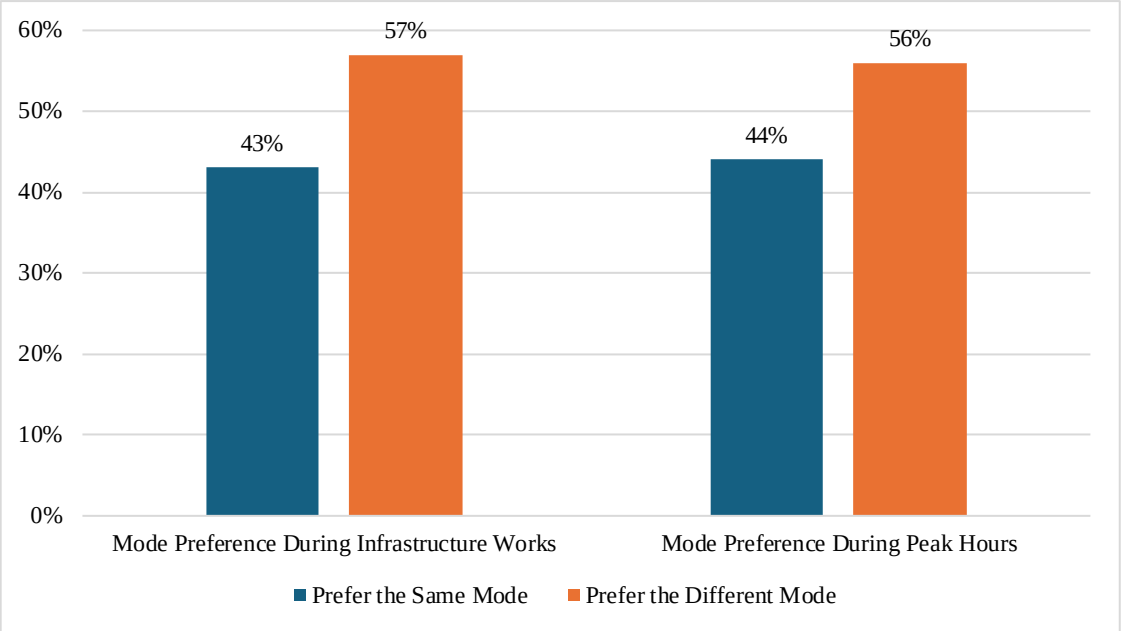

Figure 5.8. Changes of mode preferences in two situations

As a result, the number of individuals using different transportation modes in maintenance works is less than those using different transportation modes during peak hours. Still, an average of 44% of individuals have diverted demand in different situations.

Afterward, suppressed demand had analysis based on the modes of transportation that people use (actual demand) and the modes that they want to use (suppressed demand) were examined (Figure 5.9.)

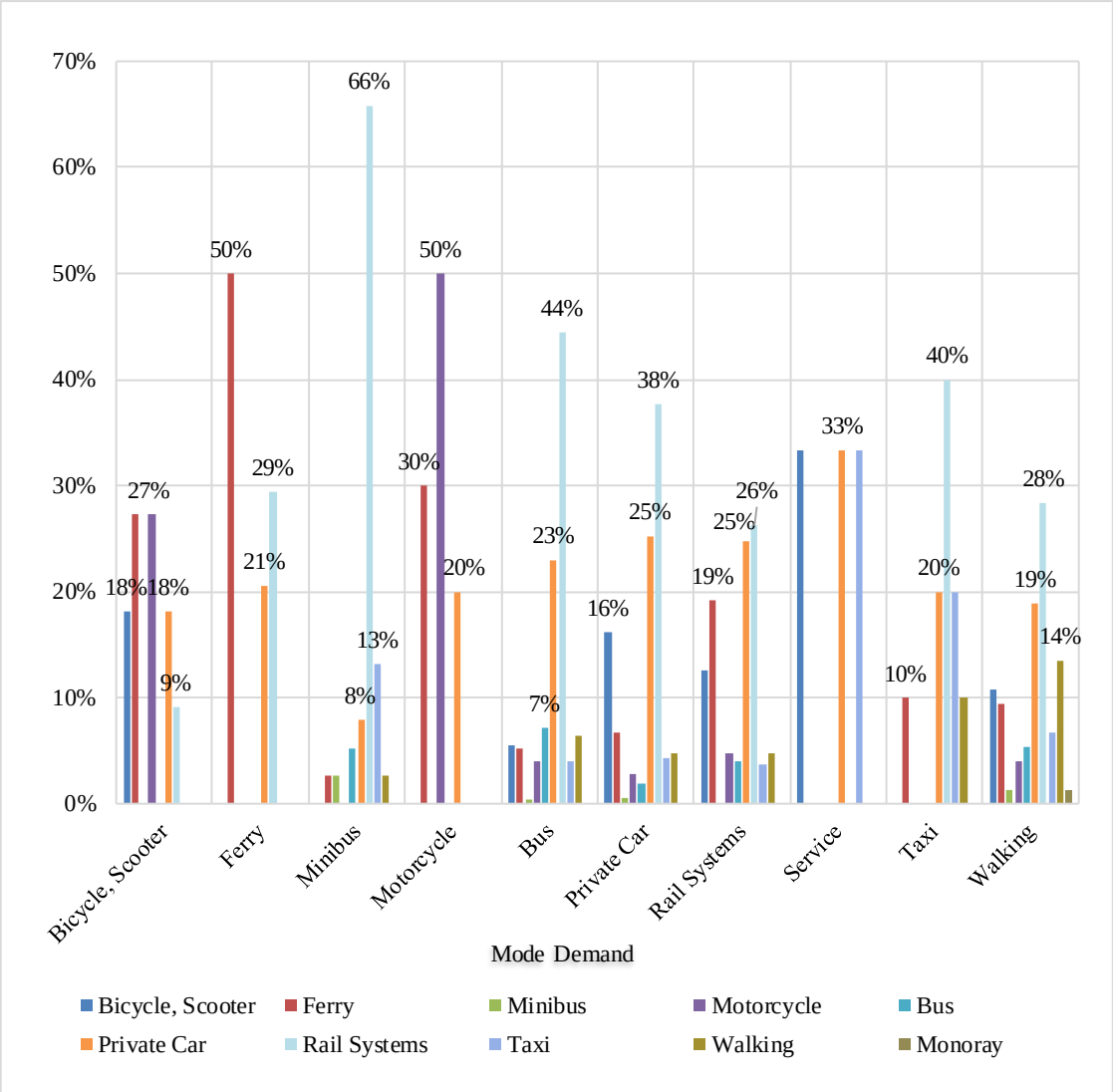

Figure 5.9. Mode demand in general

Suppressed demand from cyclists is for ferries and motorcycles, at 27%.

When we look at the ferry, there is a current usage of 4%. When looking at ferry users, it is seen that 50% of them do not have a demand. In contrast, 29% have suppressed demand for rail systems and 21% have private vehicle demand. When looking at bus users, 66% have suppressed demand for rail systems. At this point, none of the minibus users want to use this mode of transportation.

When motorcycle usage is examined, 50% of people who currently ride motorcycles do not change their transportation mode. Among people with different mode demand, the most suppressed demand ones are ferry with 30% and private vehicles with 20%.

Bus mode is one of the most used modes, as seen from previous analyses. On the other hand, only 7% of bus users did not tend to change mode. Rail systems were the most preferred among people who have suppressed demand with 44%. While those who want to choose a private vehicle are 23%, those who want to walk are 6% and those who want to use a ferry are 5%.

Twenty-five percentage of the participants who say that they mostly use their private vehicles do not change their mode. The rate of those who have suppressed demand by rail systems is 38%. Unlike those who prefer other modes, the rate of private vehicle users who want to use bicycles and scooters is 16%. The least wanted use mode was minibus with 0.5%.

When considering the mode changes of the users who use rail systems the most, 26% do not want to change their preferences. 25% want to choose a private vehicle. It is followed by ferry with 19% and bicycle-scooter with 16%. Motorcycle and walking modes are preferred at the same rate (4.8%).

Nine percentages of those who travel mostly on walking use the same mode. While 28% want to use rail systems, 19% want to choose private vehicles. Among the bicycle users, one person said that the mode of transportation he wanted to choose was the monorail.

As a result, in this analysis, the suppressed demand that occurs over transportation modes when participants change their uses was examined.

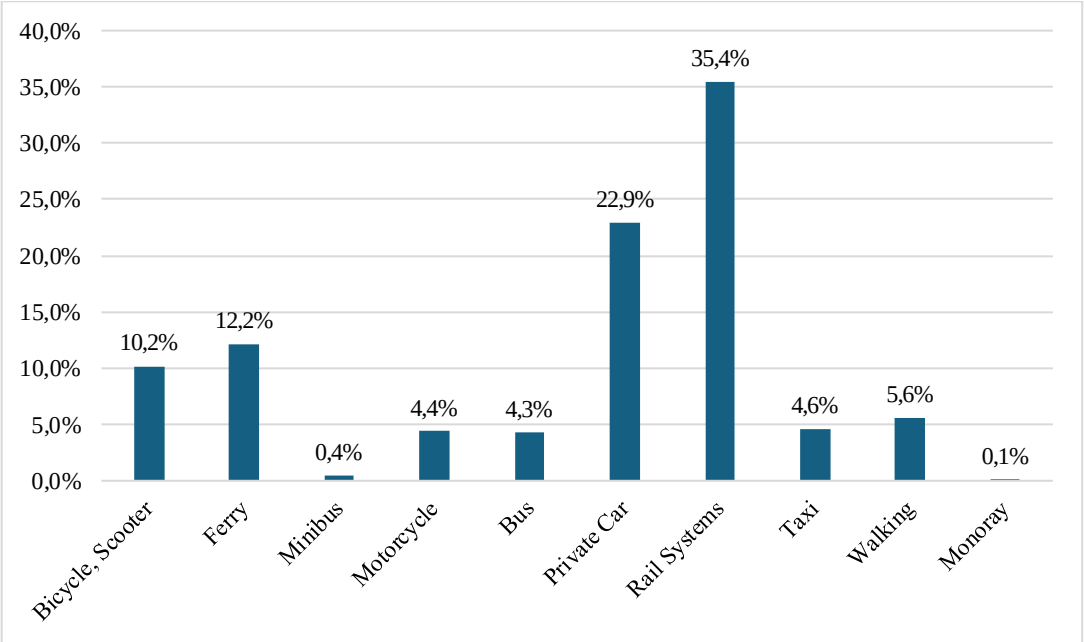

Figure 5.10. Suppressed demand by modes

Among participants, 35% said that they have suppressed demand by rail systems. Those who want to choose a private vehicle follow it with 23%. Although the bus is one of the most used modes, its demand rate is 3%. The least demand ones were monorail with 0.1% and minibus with 0.4%, respectively.

Based on all these data and analyses, a comparison was obtained based on whether the participants wanted to choose the transportation modes they currently use or not. In this figure 5.11, the total suppressed demands of the mode users are explained. If a person demands a mode different from the mode, he/she uses daily, this is an indication that he/she has suppressed demands.

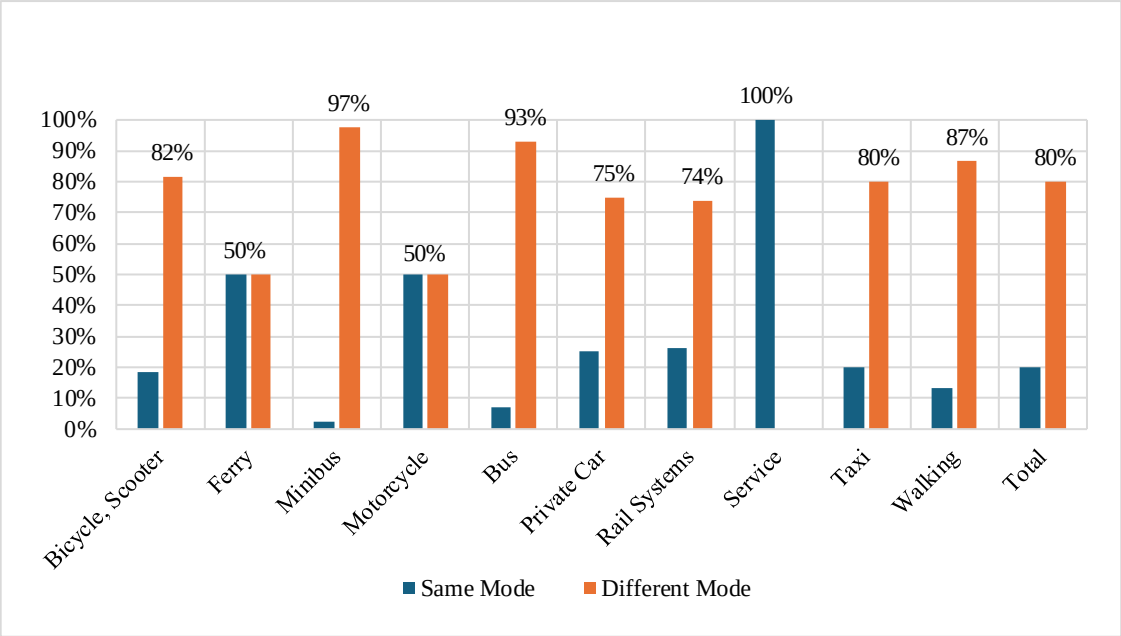

Figure 5.11. Suppressed demands based on most used mode

The study reveals that only 18% of bicycle users want to use this mode of transportation. The remaining 82% express a desire to use a different mode, indicating a suppressed demand of 87% among bicycle users.

For those who use ferry, the distribution is equal, with 50% continuing to use it and the other 50% wanting to switch to another mode. This implies a suppressed transportation demand of 50% for ferry users.

In contrast, only 3% of minibus users continue to use their current mode of transportation, while a substantial 97% would rather use a different mode. This suggests that a large majority are using minibuses out of necessity, indicating a suppressed demand of 97% among minibus users.

For motorcycle users, the distribution is also equal, with 50% satisfied with their mode of transport and 50% wanting to switch, indicating a suppressed demand of 50%.

When examining bus users, only 7% use their current mode of transport, while 93% want to use a different mode. This suggests that a significant proportion of bus users are also using this mode out of necessity, indicating a suppressed demand of 93%. Among private vehicle users, 25% use their current mode of transport, while 75% want to use a different mode, indicating a suppressed demand of 75%.

Rail systems, although the most preferred mode of transportation in previous analyses, show that only 26% of people continue to use this mode. The remaining 74% express a desire to switch to another mode, indicating a suppressed demand of 74%. For taxi users, only 20% prefer their current mode of transport, while 80% would prefer a different mode.

At this point, it is crucial to understand the reasons behind individuals' suppressed travel demand based on mode uses. To investigate this, a figure has been created to analyze participants' suppressed demands and the reasons why these demands cannot be realized (Figure 5.12).

After identifying the demanded modes, participants were asked why they could not use these modes. The reasons provided by participants and their corresponding percentages according to their mode preferences are examined. This data provides insight into which problems need to be addressed.

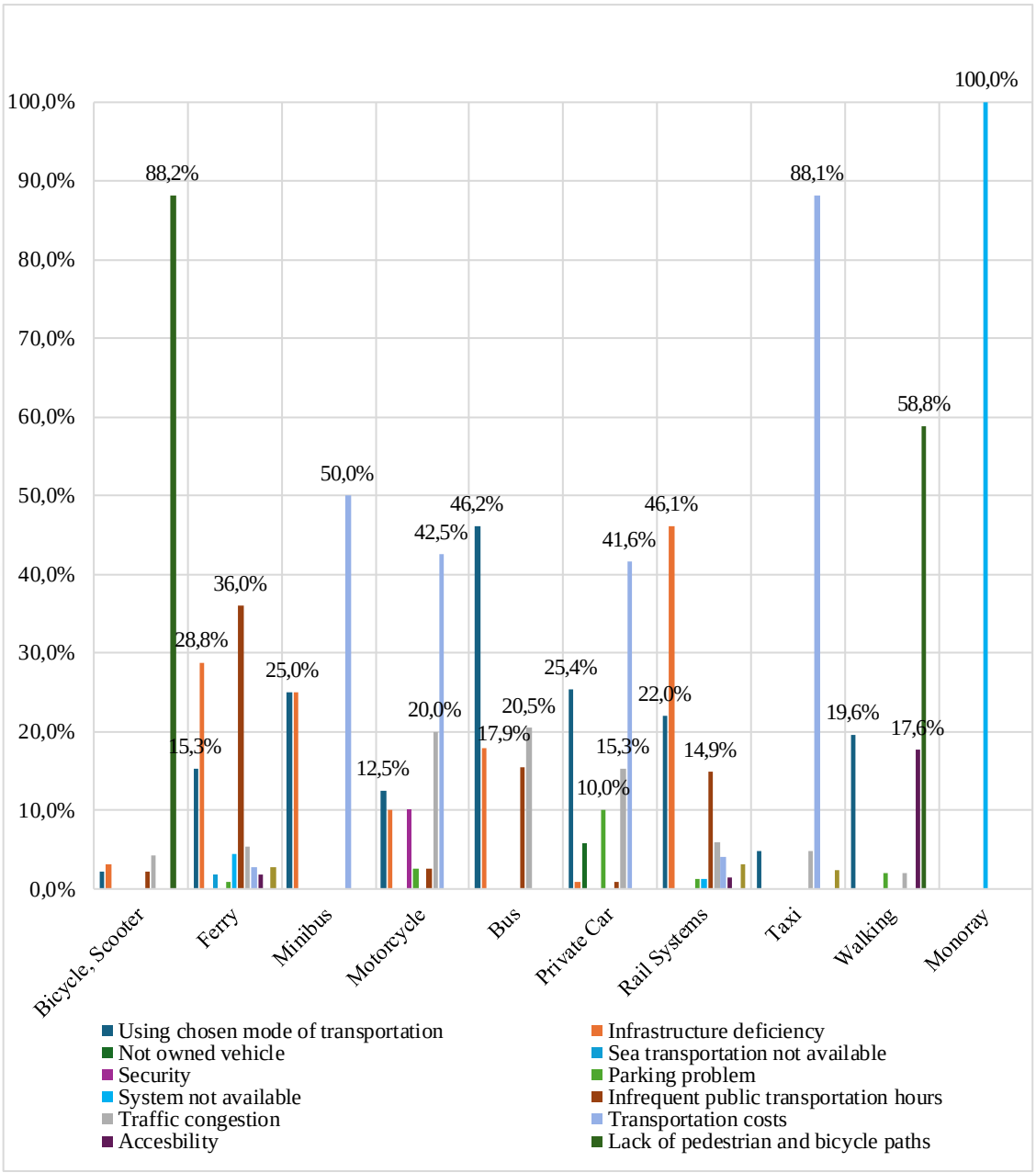

Figure 5.12. Reasons for not using demanded based on modes

Individuals who prefer to use bicycles as their mode of transportation cite the following reasons for not being able to do so: 88% mention the lack of pedestrian and bicycle paths, 4% are negatively impacted by traffic congestion, and 3% attribute it to infrastructure deficiency.

Among those who have suppressed demand to use ferry, 36% indicate that infrequent public transportation schedules are the reason for their preference not being realized, while 29% cite infrastructure deficiency. Additionally, 5% mention the absence of the system as the reason.

Participants who suppressed demand to use motorcycles state that 43% are deterred by high transportation costs. Another significant factor is traffic congestion, which affects 20%. Safety concerns and infrastructure deficiencies each account for 4%.

For those who demanded buses, 21% cite traffic congestion as a reason for not using them, 18% mention infrastructure deficiency, and 15% indicate infrequent service schedules.

Participants who demanded private vehicles report that 42% are discouraged by transportation costs, 15% by traffic congestion, and 10% by parking issues.

Among those who have demand for rail systems, 46% cite inadequate infrastructure as the reason for not using them, with another significant factor being infrequent service schedules, mentioned by 15%.

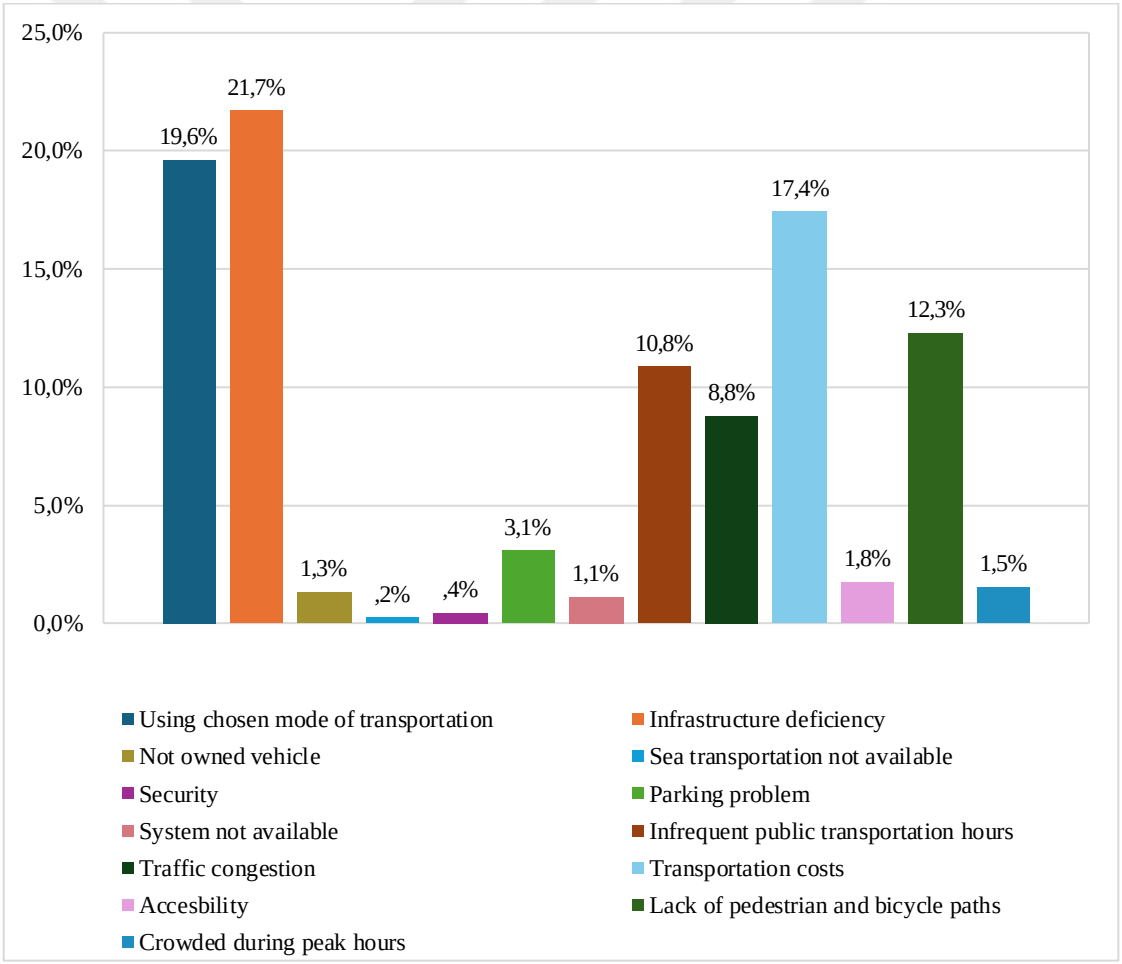

Figure 5.13. Reasons for not using demanded in total

As a result, the most important reason for the participants' suppressed demand is the lack of infrastructure with 22% and transportation costs with 17%. In response, 20% say that they do not have suppressed demand.

Based on the reasons provided by 81% of the participants for not using their demanded mode of transportation, they were asked if they would choose this mode if a 50% improvement was made in the identified problem. The analysis at this point gives an idea about which problem to focus on the most.

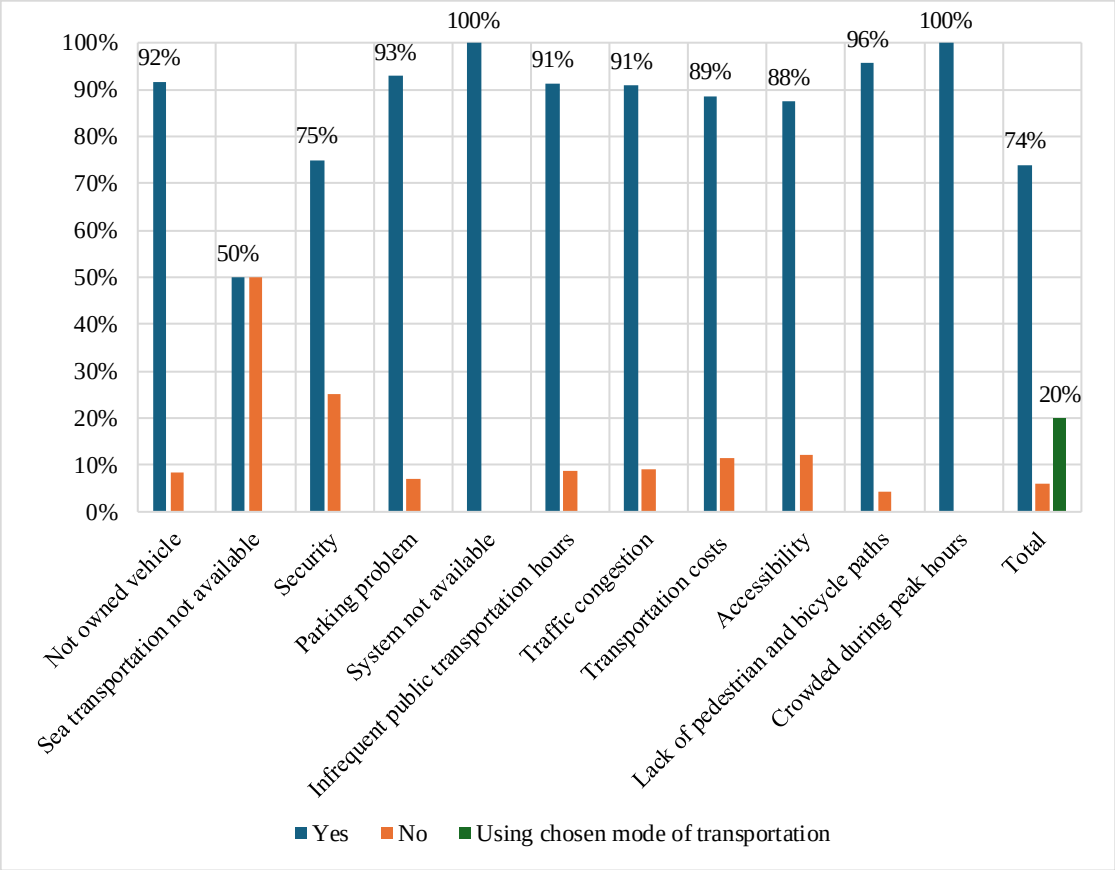

Figure 5.14. Mode change with 50% improvement in demand

Participation of 75% stated that they would use their desired mode of transportation under these improved conditions, whereas only 6% indicated that they would still not be able to use their demanded mode. When participants were informed that transportation costs would be improved by 50%, 89% believed that this would meet their demand, while 11% thought that this improvement would still be insufficient. Furthermore, it was observed that as a result of system improvements during peak hours, all participants would use their preferred mode of transportation.

Later, suppressed demand was examined through socio-economic data. The participants' most used modes and suppressed demands were compared based on categories such as education level, age range, district they live in, and whether they feel disadvantaged.

Table 5.1. Travel Modes by Education Level.

Education Level	**Current Choice**	**Suppressed Demand**
Doctorate	Private Car (39%)	Ferry (22%)
Graduate	Railway System (37%)	Railway System (27%)
Undergraduate	Bus (30%)	Railway System (31%)
Associate degree	Private Car (33%)	Railway System (33%)
High school	Railway System (30%)	Railway System (23%)
Primary school	Railway System (26%)	Railway System (30%)

These data reveal the transportation preferences of graduates based on their educational levels and the corresponding demand for public transportation. Educational level serves as a significant factor in shaping individuals' socioeconomic status and daily routines, which, in turn, influences their transportation choices.

For individuals with primary education, 26% use rail systems, while 30% express a demand for this mode, indicating that rail systems are the suppressed transportation preference for this group. In other words, although primary school graduates rely on alternative modes, their latent demand for rail systems remains high.

High school and master’s degree holders predominantly use rail systems, which are also the most requested mode of transportation for these groups. This suggests that current rail users maintain a consistent preference for this mode, and those relying on other transportation methods also exhibit suppressed demand for rail systems.

For individuals with associate degrees, private vehicles are the most frequently used mode, with 33% utilizing them for daily travel. However, similar to other educational levels, this group also shows a significant latent demand for rail systems.

Lastly, individuals with doctoral degrees are primarily using private vehicles (39%), but they also exhibit a demand for water transportation. This tendency reflects a preference for more comfortable transportation options, potentially indicating that many of these individuals reside in coastal districts. The increasing interest in water transportation highlights the need for its greater accessibility and integration into urban transport planning.

The widespread acceptance of rail systems across educational levels underscores the necessity of further developing and expanding this mode of transportation. Additionally, the rising demand for water transportation indicates the need for enhancements in this area. In urban planning, providing transportation modes that align with individuals' educational levels, job positions, and lifestyles will improve the efficiency of the city's transportation network. Reducing private vehicle use and encouraging the use of public transportation will contribute to the establishment of a more sustainable urban transport system.

Table 5.2. Travel Modes by Education Level.

Age Groups	Current Choice	Suppressed Demand
19-24	Bus (51%)	Private Car (29%)
25-34	Railway System (36%)	Railway System (30%)
35-44	Private Car (29%)	Railway System (25%)
45-64	Private Car (28%)	Private Car (29%)

These data are used to analyze the current transportation preferences of different age groups and the modes they actually wish to use. In the context of transportation and urban planning, demographic characteristics of age groups are essential inputs for the planning process.

For the 19-24 age group, which typically consists of university students or young professionals, it is expected that they would prefer economical and accessible transportation options. Currently, the most used mode is the bus (51%), but their most desired mode is rail systems. Given this, identifying areas with a high concentration of young people and planning rail systems around those locations would be both beneficial and effective.

The 25-34 age group, more active in the workforce, also predominantly uses rail systems (36%), with this mode being the most requested (30%). The advantages of rail systems—such as speed, reliability, and lower transportation costs—clearly meet the needs of this group. This signals the necessity of increasing the capacity of rail systems and improving the existing infrastructure.

Among the 35-44 age group, private vehicle use is the highest (29%). However, their desire to shift towards rail systems can be explained by factors such as traffic congestion, parking issues, and rising fuel costs. In this context, implementing policies and initiatives that facilitate the transition from private vehicles to rail systems is crucial.

The demand for rail systems from the 45-64 age group indicates that this mode is widely regarded as a reliable and comfortable option in the long term.

These findings show that rail systems are increasingly becoming the preferred mode of transportation in urban areas, emphasizing the need for further investments in this sector. Particularly, the growing demand from both the younger population and middle-aged professionals calls for expanding the capacity and geographic reach of rail systems. In conclusion, transportation and urban planning should focus on providing flexible and integrated solutions that address the diverse needs of different age groups, ultimately enhancing the efficiency and sustainability of urban transportation systems.

Table 5.3. Travel Mode Based on Perceived Disadvantage.

	Current Choice	**Suppressed Demand**
Feeling Disadvantaged	Bus (%40)	Railway System (33%)
Not Feeling Disadvantaged	Railway System (42%)	Railway System (24%)

Participants who consider themselves disadvantaged primarily use buses (40%), indicating their reliance on low-cost and widely accessible public transportation options. However, 33% of this group express a demand for rail systems, suggesting a desire for a more reliable and faster mode of transportation.

On the other hand, those who do not perceive themselves as disadvantaged predominantly use rail systems (42%), which is also the most requested mode of transportation within this group.

The fact that both groups identify rail systems as their most desired mode highlights the widespread perception of rail transport as a fast, reliable, and comfortable alternative across the city. This insight emphasizes the need to expand access to rail systems, as it is seen as a preferred option for a significant portion of the population, regardless of their perceived disadvantage.

Table 5.4. Travel Mode by Districts.

	Current Choice	Suppressed Demand
Balçova	Bus (34%)	Railway (62%)
Bayraklı	Railway (36%)	Railway (31%)
Bornova	Bus (30%)	Railway (31%)
Buca	Bus (41%)	Railway (38%)
Çiğli	Railway (33%)	Ferry (23%)
Gaziemir	Bus (41%)	Railway (32%)
Güzelbahçe	Bus (38%)	Railway (63%)
Karabağlar	Railway (48%)	Railway (34%)
Karşıyaka	Private Car (27%)	Ferry (22%)
Konak	Railway (52%)	Private Car (19%)
Menemen	Railway (41%)	Ferry (56%)
Narlıdere	Private Car (39%)	Railway (43%)
Urla	Bus (30%)	Railway (43%)

When examining the districts with the highest participant numbers, it is evident that the most prevalent suppressed demand, as indicated by the mode, is for railway transportation. In coastal districts such as Çiğli and Menemen, maritime transportation emerges as the primary suppressed demand. It is seen that the most demanded mode in Balçova and Güzelbahçe is railway systems. It is estimated that the newly added metro lines will meet this demand to a large extent.

5.2. Trip Rate

In this part of the analysis, the following questions were posed to individuals to understand their daily trip rate and to determine their suppressed demand trip rate:

- How many trips do you currently make on an average day?
- How many trips would you need to make on an average day?
- If your demand mode of transportation were available, how many trips would you make on an average day?

The demands of individuals based on their travel frequency and the resulting changes provide insights into suppressed demands in trip rate.

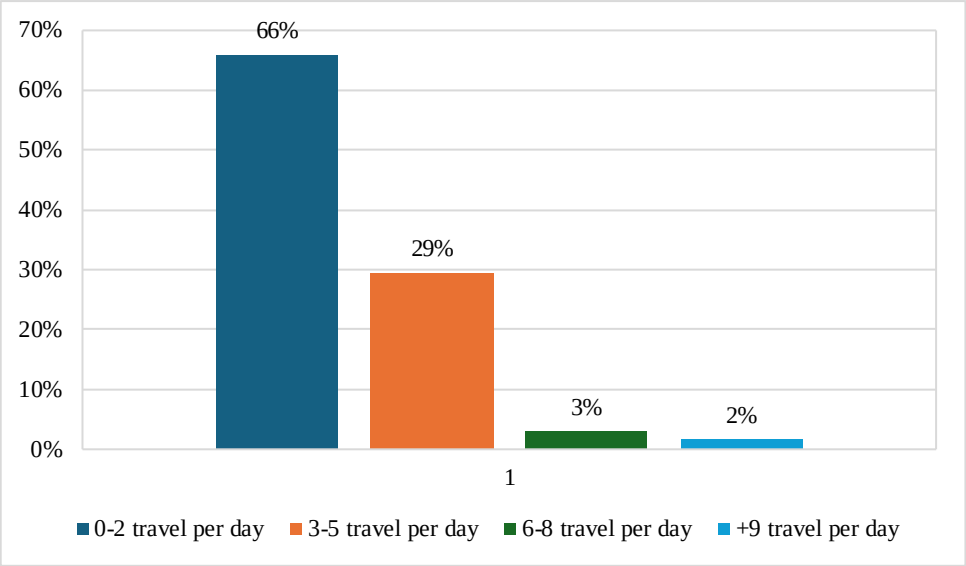

Figure 5.15. Daily trip rate

Participants of 66% make an average of 0-2 trips per day while 29% of them make 3-5 trips per day, and 3% make 6-8 trips per day. Only 2% of the participants reported making 9 or more trips per day.

Afterwards, the distribution of people's demands according to their daily trip rate was examined (Figure 5.16).

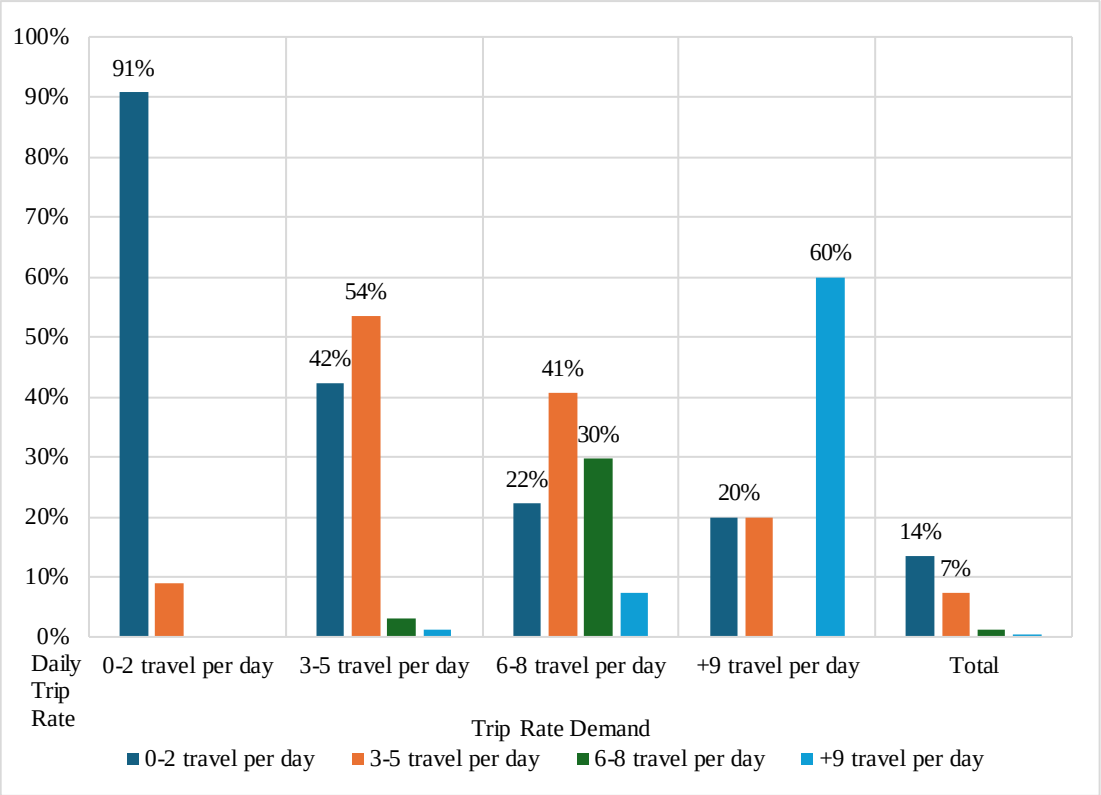

Figure 5.16. Trip rate demand

Of the participants whose daily trip rate is between 0-2, 90% have no demand, while the remaining 9% want to make 3-5 trips per day, and 1% request 6-8 trip rates per day.

Among the participants who travel 3-5 times per day, 42% requested only 0-2 trip rates, while 54% argued that 3-5 trips are necessary.

Among the participants who travel 6-8 times per day, 41% requested 3-5 trip rates, and 22% said that 0-2 trips should be possible.

Among the participants who travel 9 or more times per day, 60% preferred the same trip frequency, while 20% requested 3-5 trips, and the other 20% requested 0-2 trips.

In total, suppressed demand based on the amount of travel is 22.6% and the most demanded trip rate was 0-2 with 13%.

Subsequently, participants were asked about changes in their travel frequency if their desired mode of transportation was provided. The table 5.17 illustrates the relationships between these variables.

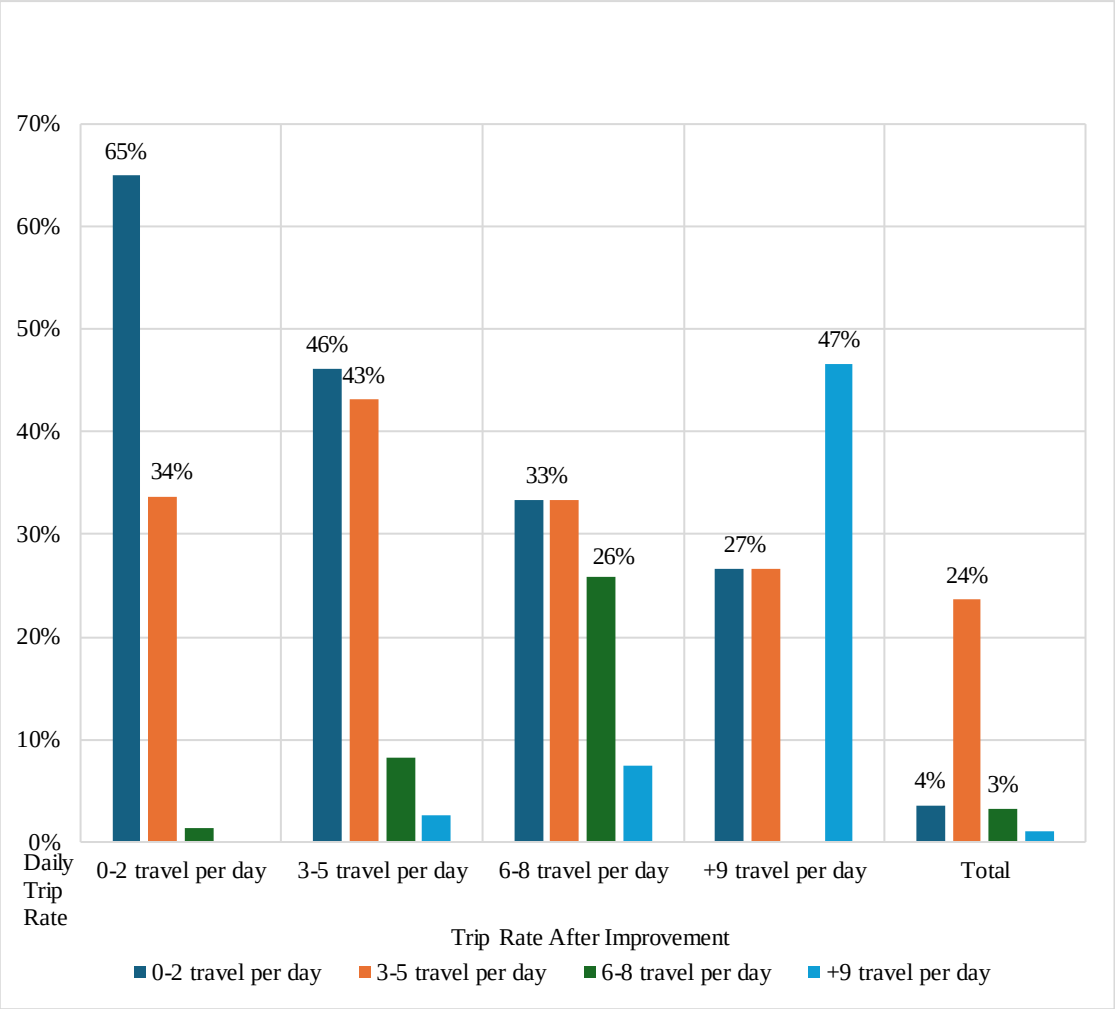

Figure 5.17. Participants' daily trip rate and change with improvements

When their preferred mode of transportation is provided, 33.7% of participants who usually travel 0-2 times per day indicated that they would increase their travel frequency to 3-5 trips per day, while 65% would maintain their current frequency of 0-2 trips per day.

Among those who travel 3-5 times daily, 42.1% stated that their travel frequency would decrease to 0-2 trips per day if their preferred mode of transportation was available. Conversely, 43.1% believed their travel frequency would remain unchanged.

For individuals who currently travel 6-8 times per day, 33.3% indicated that their travel frequency would adjust to 0-2 or 3-5 trips per day with their preferred mode of transportation. Meanwhile, 25% stated that their travel frequency would remain unchanged.

Among those who travel 9 or more times per day, 26.7% suggested that their travel frequency would decrease to 0-2 or 3-5 trips per day if their preferred transportation mode was available. The remaining 46.7% indicated no change in their travel frequency.

As a result, Figure 5.18 shows how individuals change their total trip rate after improvements.

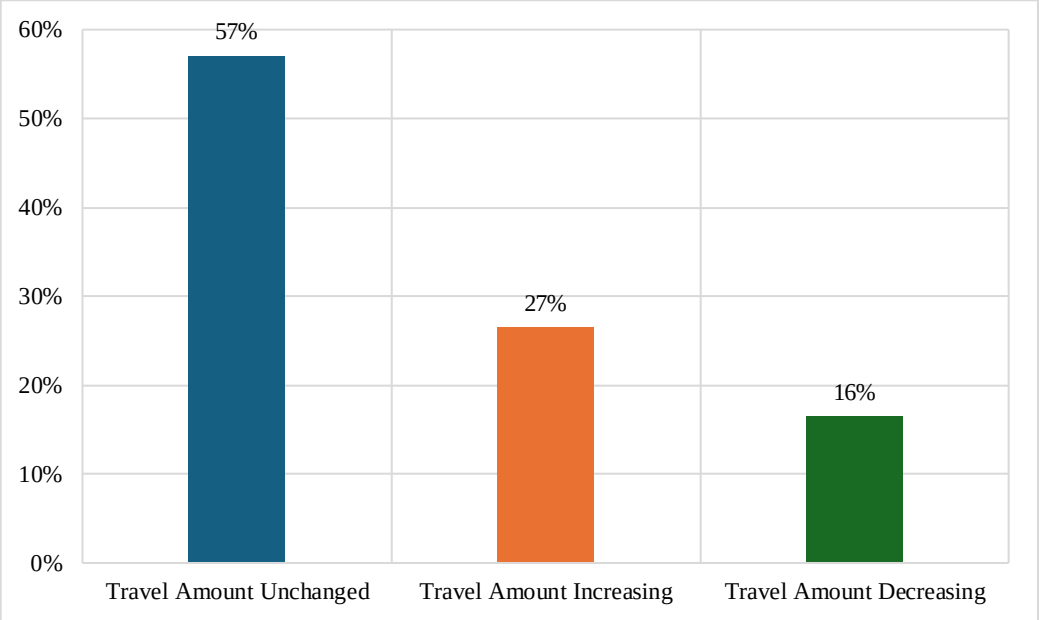

Figure 5.18. Changes in trip rate due to improvements

In conclusion, when participants' preferred modes of transportation are provided, the travel frequency for 57.1% of individuals remains unchanged. Meanwhile, 26.5% of participants experience an increase in their travel frequency, and 16.4% report a decrease in their travel frequency.

5.3. Transfer Travel

In this part of the analysis, the following questions were posed to participants to understand their transfer preferences and reasons while traveling:

- Do you usually make transfers while traveling?
- What is the reason for making transfers?
- Would you demand to travel without making transfers? If so, please specify why.
- If transfer fees were eliminated, would you prefer using transfer-based transportation?

These questions aim to determine the extent to which transfer demands are suppressed and to identify the reasons behind this suppression.

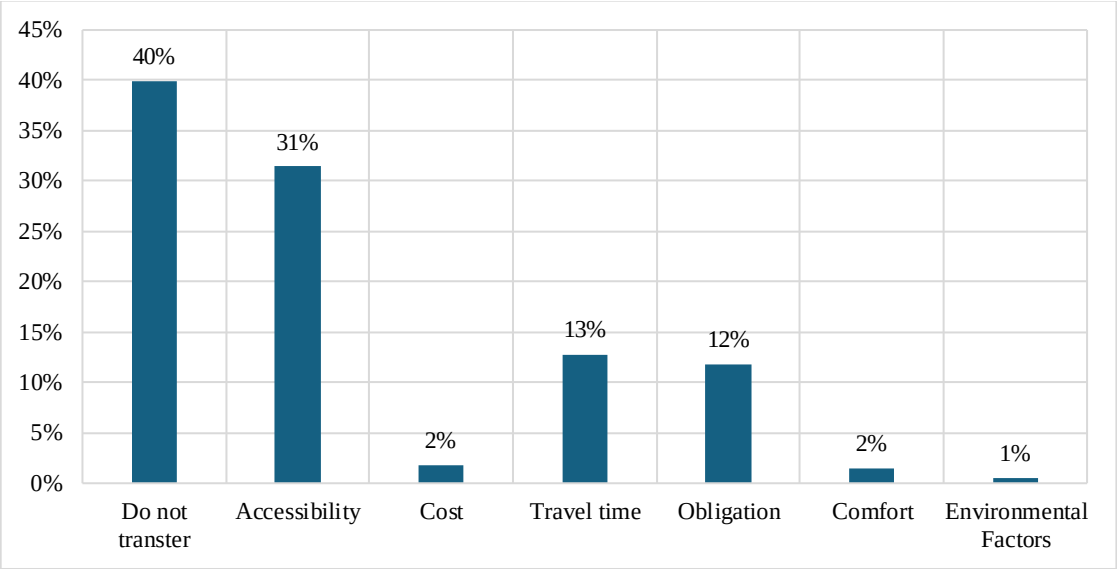

Figure 5.19. Reasons for transferring

60% of the participants reported that they make transfers while traveling, whereas 40% indicated that they do not make transfers. Among those who make transfers, 31% stated that they choice transferring due to the convenience it provides. This was followed by 12% who cited the reduction in travel time as their reason. Additionally, 11% mentioned that they make transfers because they have no other option. The percentages for those who transfer due to cost and comfort considerations were 3% and 2%, respectively. Only 1% of the participants reported making transfers due to environmental reasons.

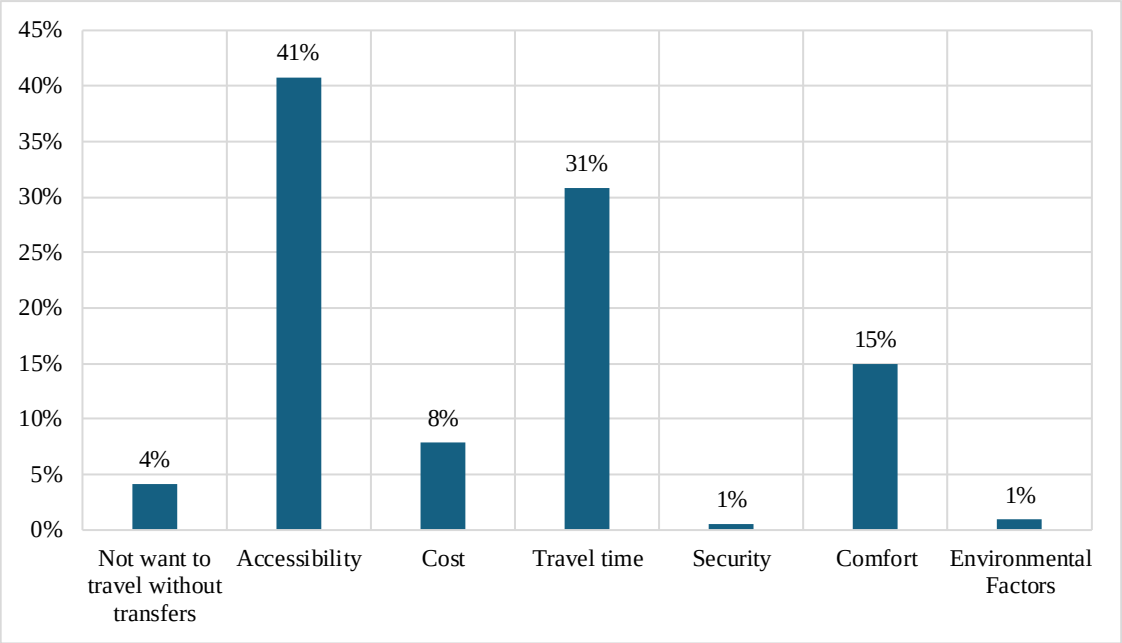

Figure 5.20. Reasons why people do not want to transfer

Participants who make transfers while traveling were asked if they would prefer to travel without making transfers and to specify their reasons if applicable.

Only 4% of the participants expressed a desire to continue making transfers. In contrast, 41% of participants who prefer not to make transfers cited the convenience of direct travel. Another 32% stated that they prefer transfer-free travel because it shortens travel time. Additionally, 15% of participants believe that transfer-free travel would be more comfortable.

From these findings, it can be inferred that while 60% of participants currently make transfers, 37% would prefer not to, indicating a significant level of suppressed demand for transfer-free travel options.

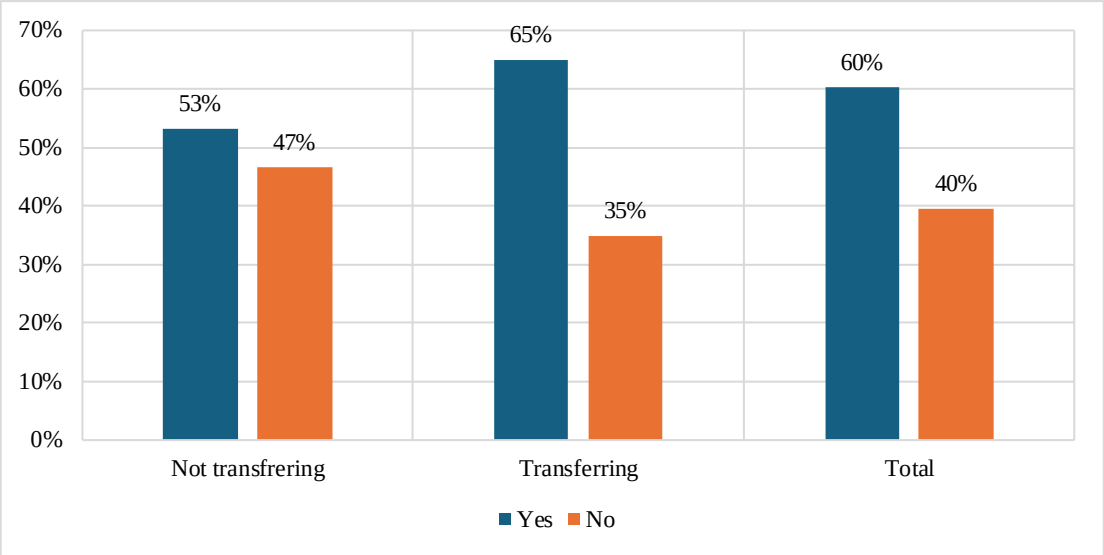

Figure 5.21. Transferring usage if transfer fees are removed

All participants were asked whether they would use transfer-based transportation if transfer fees were eliminated (Figure 5.21). Among those who currently use transfer-based transportation, 65% indicated that they would continue to prefer transfers. Additionally, 53% of those who do not currently prefer transfer-based transportation stated that they would consider using it if the fees were eliminated.

Overall, 60% of participants indicated that they would use transfer-based transportation if transfer fees were removed, while 40% stated that they would not.

This analysis suggests that eliminating transfer fees would significantly impact individuals who do not currently make transfers, potentially encouraging them to use transfer-based transportation.

5.4. Travel Time

To determine participants' travel times, the following questions were asked. The aim was to analyze the average travel times in Izmir and to identify suppressed demand based on travel times. Participants were asked the following questions in sequence:

- What is your average travel time to get to a destination?
- If you had the choice, how long would you like your travel time to be?
- If your demand mode of transportation were available, how your travel time change?

- Do you usually arrive at your destination on time? If not, please specify the reasons.

The responses to these questions are intended to help establish the average travel times in Izmir and identify areas where travel times may be longer than desired, indicating suppressed demand for more efficient transportation options.

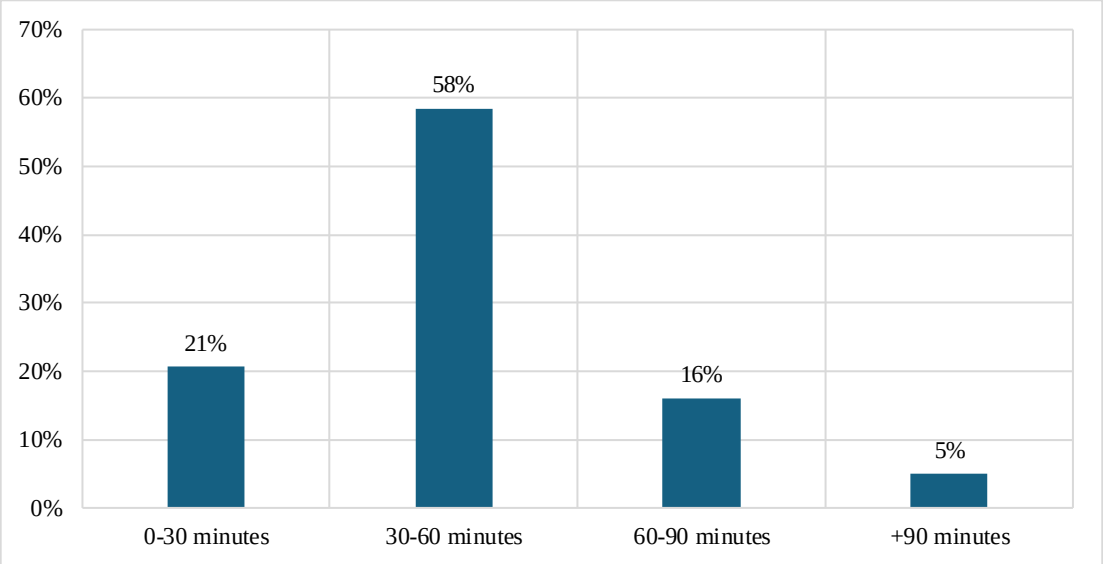

Figure 5.22. Average daily travel times

Approximately 21% of the participants reported that their journeys take less than 30 minutes, while 58% indicated that their trips last between 30 and 60 minutes. 16% of participants stated that their average travel time is between 60 and 90 minutes, and only 5% reported that their journeys exceed 90 minutes.

Afterwards, the participants' demands were examined according to their daily travel times (Figure 5.23). At this point, the travel times that individuals want to represent their suppressed demand based on travel time.

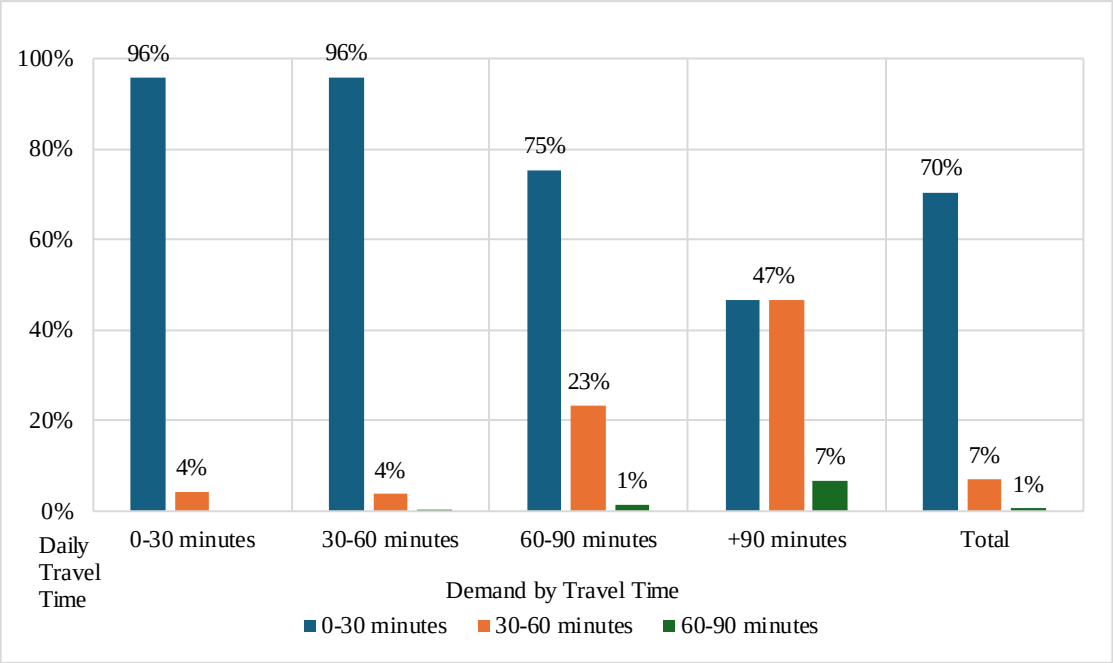

Figure 5.23. Travel time demand

Of participants with a daily travel time of less than 30 minutes, 96% expressed a desire to maintain their travel time under 30 minutes. For those currently traveling 30-60 minutes, 96% demanded to reduce their travel time to less than 30 minutes, while only 4% preferred to keep their travel time the same.

Among participants with a current travel time of 60-90 minutes, 75% wanted to reduce their travel time to less than 30 minutes, and 23% demanded a travel time of 30-60 minutes. For those traveling over 90 minutes, 47% desired a travel time of less than 30 minutes, another 47% demanded a travel time of 30-60 minutes, and only 6% wanted to reduce their travel time to 60-90 minutes.

In conclusion, the vast majority of participants exhibit suppressed demand, aiming to keep their travel times under 30 minutes. This demand for shorter travel times is particularly evident among those with longer current travel times. As expected, very few participants demanded for travel times of 60-90 minutes, indicating a strong demand for shorter travel durations among residents of İzmir.

In total, suppressed demand is 78% and 70% of this is demand for travel times to be less than 30 minutes.

Subsequently, the participants' current travel times have been examined in relation to the travel time demands that would emerge if improvements were made.

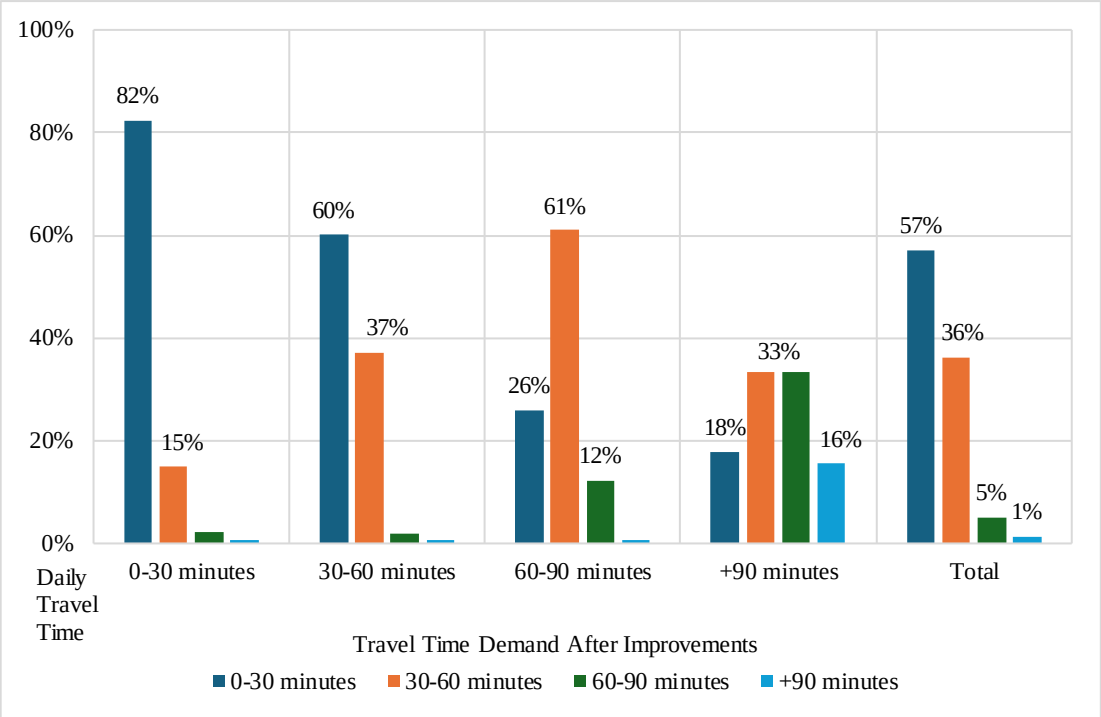

Figure 5.24. Participants' daily travel time and change with improvements

Respondents were asked about daily travel times and travel demands over time. Of those currently traveling less than 30 minutes, 15% said they would like to travel 30-60 minutes and 2% said 60-90 minutes.

Of those currently traveling 30-60 minutes, 60% said they demanded to travel less than 30 minutes, 38% said they would like to travel 30-60 minutes and 2% would like to travel more than 90 minutes.

Of those traveling 60-90 minutes, 61% said they would like to travel 30-60 minutes and 26% said they would not like to travel less than 30 minutes.

Finally, of those traveling more than 90 minutes, 33% demanded to travel 30-60 minutes, 33% thought they should travel 60-90 minutes and 18% thought they should travel less than 30 minutes.

Analysis of demands across four different travel time categories indicates that overall, participants' current travel times exceed what they perceive as necessary. This discrepancy highlights inefficiencies in the transportation system and traffic issues in İzmir. The gap between current time and travel demands suggests a need for improvements in transportation system efficiency. Infrastructure enhancements and better integration of public transportation are essential to optimize travel times.

Subsequently, participants were asked whether they were able to arrive at their destinations on time, and if not, to identify the reasons for the delay (Figure 5.25)

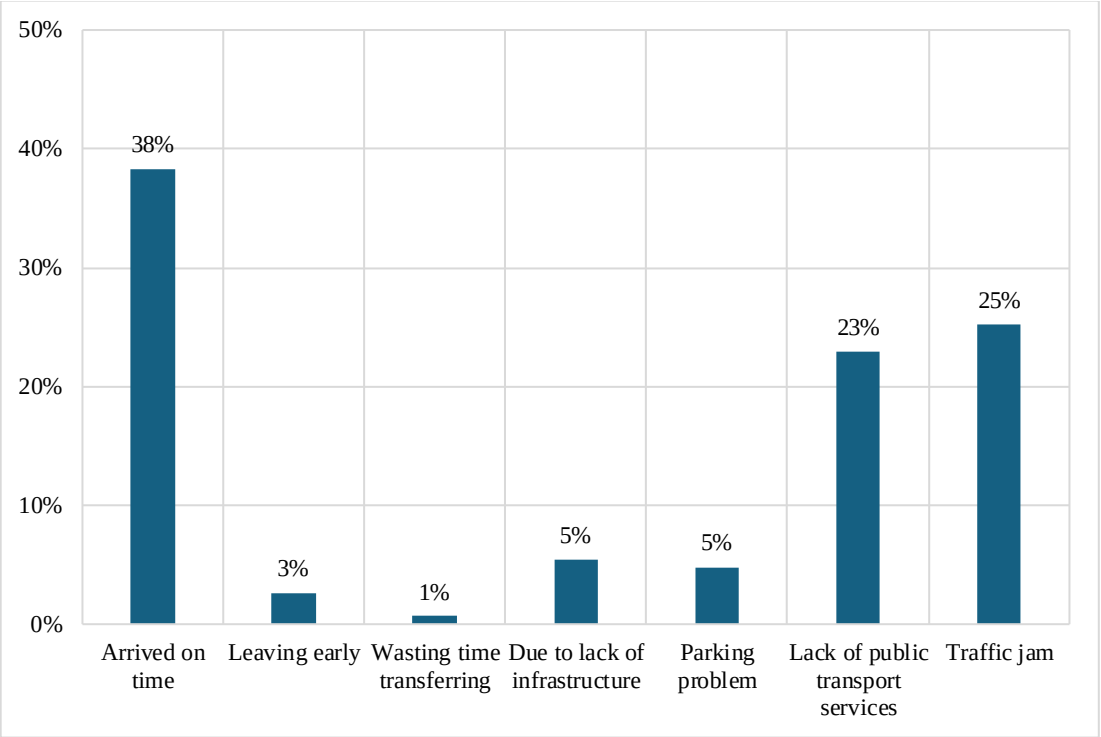

Figure 5.25. Reasons for unfulfilled activities

Participants were also asked if they arrived at their destinations on time. Only 38% reported arriving on time, while an additional 3% stated they arrived on time by leaving early.

A significant 25% of participants cited traffic congestion as the reason for not arriving on time, making it the most common issue that needs to be addressed. The second most frequently mentioned problem was the infrequency of public transportation services, with 23% of participants indicating this as an issue. Reviewing and improving the frequency and scheduling of public transportation services could be beneficial.

Additionally, 5% of participants said they were unable to arrive on time due to insufficient public transportation services, highlighting the need for improvements in the public transportation system. Another 5% cited parking issues as the reason for not arriving on time. This problem is especially prevalent in city centers and densely populated areas where parking spaces are limited or costly.

Only 1% of participants reported that they lost time due to transfer delays, resulting in late arrivals.

In summary, two main issues stand out: traffic congestion and the frequency of public transportation services. Addressing these issues is crucial for ensuring that participants can complete their journeys on time. Implementing solutions to reduce traffic congestion and increasing the frequency of public transportation services are essential steps that need to be taken.

5.5. Route Choice

Route choice is crucial in terms of travel duration, quality, and comfort. Choosing the right route can save time by reducing travel duration. Additionally, route choices are important due to costs associated with fuel consumption and transfer fees. Opting for a shorter and smoother route can lead to fuel savings and lower travel expenses. Another factor influencing route choice can be the desired scenery during the journey. For instance, someone traveling from Fahrettin Altay to Alsancak in İzmir might prefer a scenic coastal route, choosing the tram for public transportation or Mustafa Kemal Coastal Boulevard if driving, prioritizing a more enjoyable journey over a faster one.

To examine and compare route preferences in İzmir, participants were asked the following three questions:

- Do you usually take the same route when traveling? If you take different routes, please specify why.
- Would you like to take different routes when traveling? If so, please specify why.
- Do you prefer different routes during peak hours (e.g., after work)? If so, please specify why.
- Do you choose different routes during traffic congestion caused by maintenance works? If so, please specify why.

These questions aim to understand the factors influencing route choices and preferences among residents in İzmir, shedding light on their travel behaviors and the potential need for improvements in the transportation system.

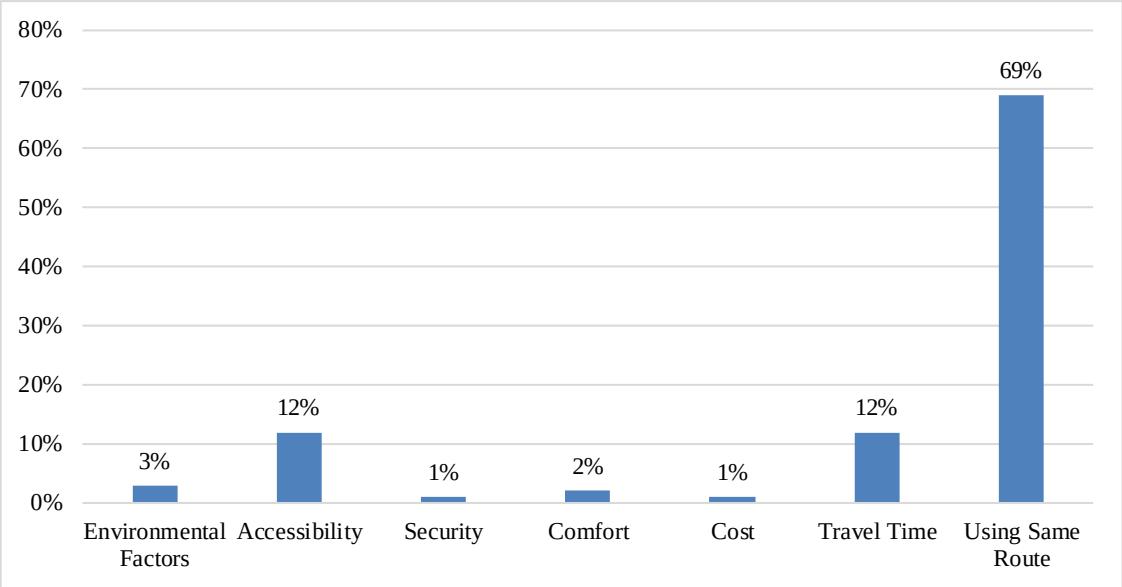

Figure 5.26. Reasons for using different routes

Among the participants, 69% used the same route. A significant 12% indicated that accessibility and travel time are important factors, and these are the primary reasons for choosing different routes.

Environmental factors were important for only 3% of participants when choosing different routes, suggesting that environmental considerations are not a major influence on route selection for most people.

Comfort was cited by 2% of participants as a reason for choosing different routes, implying that either comfort is not a primary concern for most users, or it is not as significant as other factors.

Cost and safety were factors influencing route choice for 1% of participants. This indicates that most users find their current routes safe, and that cost is not a significant concern. It also suggests that users generally do not perceive a substantial cost difference between different routes, leading to the conclusion that cost does not play a crucial role in route selection.

These insights highlight the primary factors influencing route choices among residents in İzmir, providing a basis for understanding their travel behavior and demands.

Following this, the reasons behind participants' decisions to use the same or different routes were analyzed, and the significant reasons that emerged overall were interpreted.

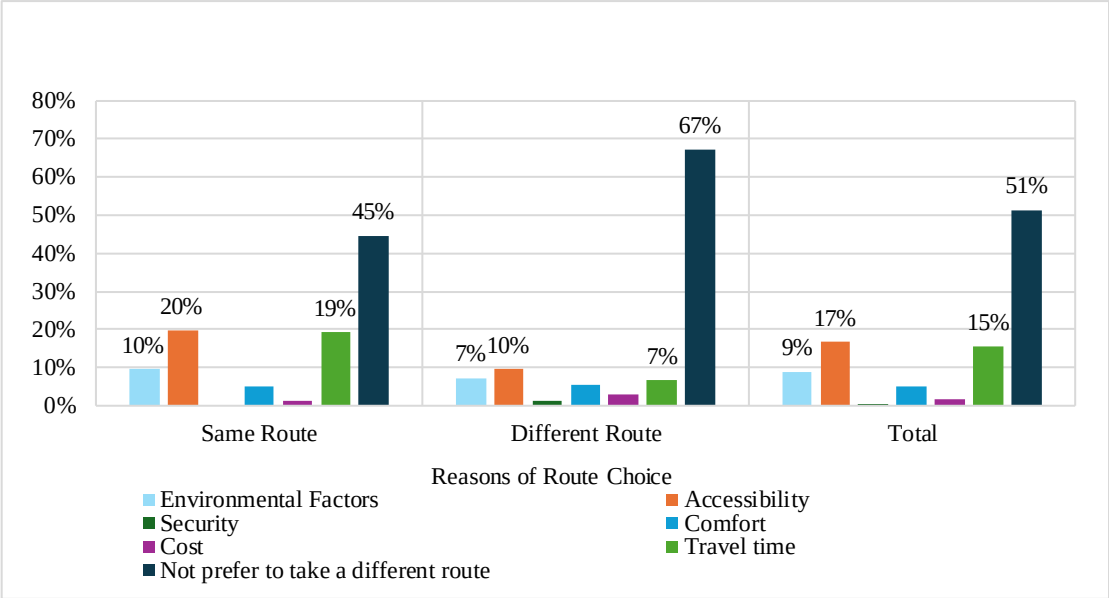

Figure 5.27. Route demanded based on their current choice

Among participants currently using the same route, 45% indicated that they do not wish to choose a different route. This is followed by 20% who demanded different routes for easier access. Additionally, 19% of those using the same route stated that they demanded different routes to reduce travel time. Furthermore, 10% expressed a desire to choose different routes due to environmental factors such as scenery and landscape, even though they do not currently use different routes.

For participants currently using different routes, 67% stated that they prefer routes other than the ones they currently use. Of these, 9% would choose different routes for easier access, and 7% would prefer different routes due to environmental factors like scenery and landscape. Following this, 6% indicated they would choose different routes to reduce travel time.

Overall, 51% of participants indicated that they have no demand for different routes and are satisfied with the current ones. In contrast, 49% expressed a desire for different routes. The most significant reasons for this demand are easier access (9.5%), environmental factors (7.3%), and travel time (6.6%). Comfort (5.5%) moderately influences route preferences, while safety and cost have a low impact on route choice.

These findings highlight the primary reasons behind route preferences and the varying degrees of importance different factors hold for residents in İzmir.

Afterward, considering participants' route preferences, it was investigated whether they opted for different routes during peak hours, and if so, their reasons were

explored. This allowed for an analysis of diverted demand during peak hours based on route choices (Figure 5.28).

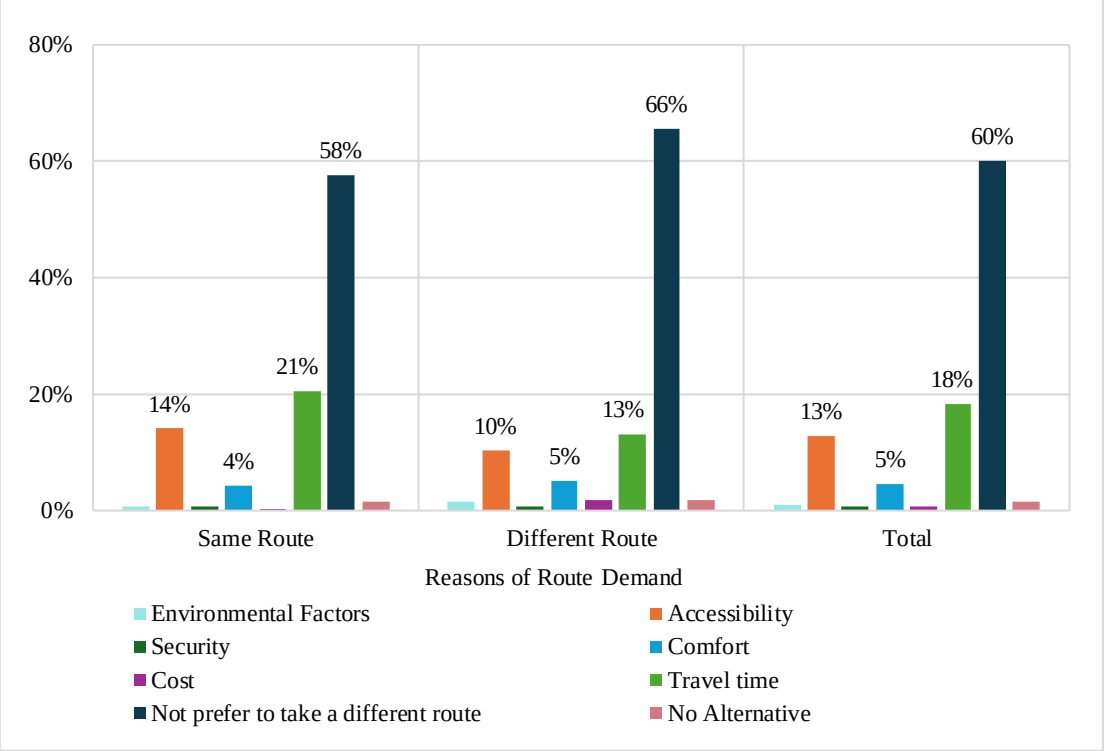

Figure 5.28. Route demanded during peak hours

Currently, 57% of individuals who do not prefer alternative routes state that they continue using the same routes during peak hours. In contrast, 21% report choosing different routes to reduce travel time, while 14% select alternative routes during peak hours for easier access. A small proportion, around 4%, prioritize alternative routes to improve comfort during peak hours. The influence of other factors appears to be minimal.

Among those who currently use different routes, 34% switch during peak hours. The primary reason for this change is to reduce travel time, representing 13%. This is followed by 10% who choose alternative routes for easier access, and 5% who switch to different routes for a more comfortable journey during peak hours.

Overall, 60% of individuals do not change their routes due to peak hour congestion. In contrast, 40% shift to different routes. Thus, it would not be incorrect to assert that there is a 40% diverted demand for different routes during peak hours based on route choice.

The same analysis was conducted for periods of maintenance work. Participants were asked whether their route preferences changed during these times. This provides an examination of the diverted demand that occurs during maintenance work (Figure 5.29)

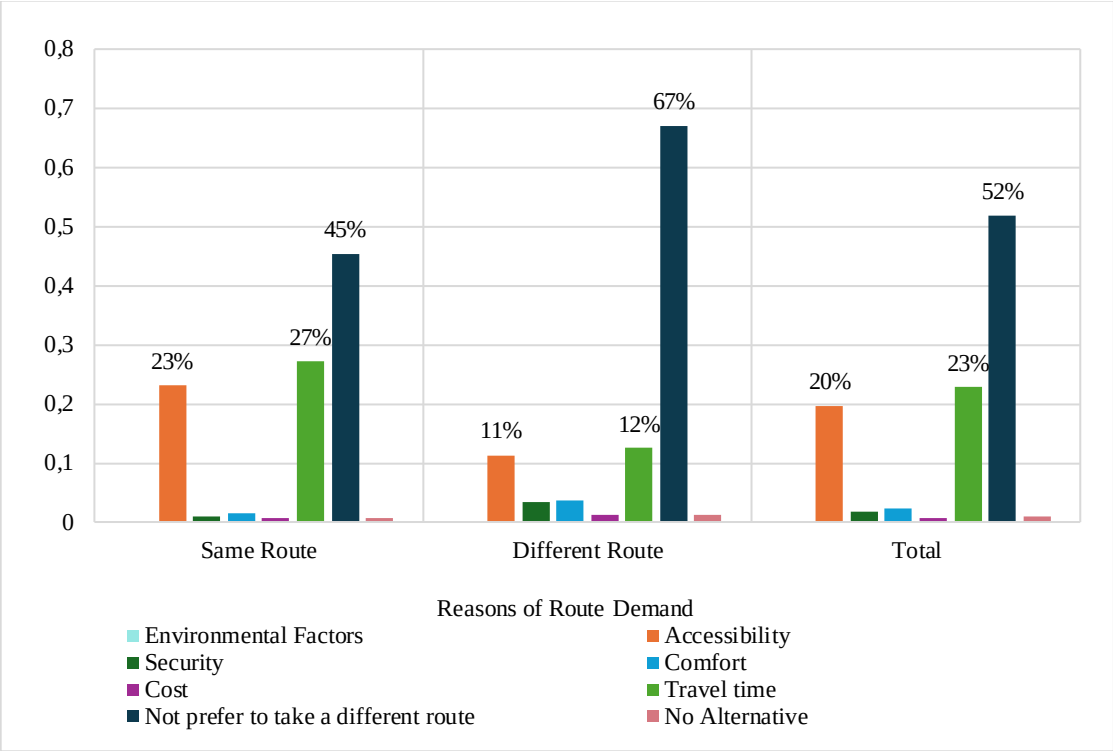

Figure 5.29. Route demanded during maintenance works

At present, 45% of individuals who do not prefer alternative routes report continuing to use the same routes during maintenance works. In comparison, 27% state that they opt for different routes to reduce travel time, while 23% select alternative routes for easier access during these periods. The influence of environmental factors, safety, transportation costs, and comfort is minimal.

Among individuals who currently use alternative routes, 33% switch to different routes during maintenance works. The primary motivation for this switch is to reduce travel time, accounting for 12%. This is followed by 11% who select alternative routes for easier access, and 4% who do so for a more comfortable journey during maintenance works.

Overall, 52% of individuals do not change their routes due to maintenance works. In contrast, 48% shift to different routes. Thus, it would not be incorrect to assert that there is a 48% diverted demand for different routes during maintenance works based on route preferences.

CHAPTER 6

DISCUSSION

The results of this thesis provide a perspective on the diverted and suppressed demands in Izmir and the effects of these demands on the factors. In this section, the analysis results are discussed and interpreted. This study examines the factors affecting the travel demands of 913 people in Izmir and the preferences according to which travel demands are formed and the results of the changes.

In the beginning, it was examined whether the diverted and suppressed demands obtained from cross tables had a significant relationship with current choice and the chi-square test was used for this analysis. As a result of the test, it was observed that there was a significant relationship between current preferences and suppressed (and diverted) demands in all tests.

Table 6.1. Summary Table of Significance Test Between Current Choice And Travel Demands

		Significance Test
Travel Demand by Mod	Diverted Travel Demand due to peak hours	Significant
	Diverted Travel Demand due to Maintenance works	Significant
	Suppressed Travel Demand	Significant
Travel Demand by Trip Rate	Suppressed Travel Demand	Significant
Travel Demand by Travel Time	Suppressed Travel Demand	Significant
Travel Demand by Route	Diverted Travel Demand due to peak hours	Significant
	Diverted Travel Demand due to Maintenance works	Significant
	Suppressed Travel Demand	Significant

After the chi-square tests, categorical data analysis was performed to examine the demand distributions in more detail.

Diverted and suppressed demands were examined through transportation modes. While reviewing the diverted demand, two sub-categories were examined: during maintenance works and during peak-hours.

- It is seen that 45% of the participants have diverted demand during peak hours. Among these demands, the most preferred mode is rail systems with 13%.
- It is seen that 43% of the participants have diverted demand during maintenance works. Among these demands, the most preferred mode is rail systems with 11%.
- It is seen that 80% of the participants have suppressed travel demand. Among these demands, the most preferred mode is rail systems with 35.4%. It is followed by private vehicles with 22.9%.

When looking at travel demands by mode, it is seen that the most demanded transportation mode is the rail system. Among the reasons why people do not use the rail system, the biggest problems are seen as infrequent transportation hours, the system not being available, and inadequate infrastructure. When the existing rail systems in Izmir are considered, the demands can be met by producing solutions such as using these systems more efficiently and increasing the number of stops based on the demands.

Afterward, the suppressed demands of the individuals were examined via trip rate.

- It was observed that 35% of people who make 0-2 trips per day have suppressed demand.
- It was observed that 56.9% of people who make 3-5 trips per day have suppressed demand.
- It was observed that 74.1% of people who make 6-8 trips per day have suppressed demand.
- It was observed that 53.3% of people who make 9 or more trips per day have suppressed demand.

As a result, it was seen that 23% of the participants had a suppressed demand. At the same time, it was seen that when these people provided the transportation modes they wanted, 26.5% of them would increase their trip rate and 16.4% would decrease their trip generation.

Participants were examined with suppressed demand over travel time.

- It was observed that 4% of the participants with travel times of 0-30 minutes had suppressed demand.

- It was observed that 96% of the participants with travel times of 30-60 minutes had suppressed demand.
- It was observed that 98% of the participants with travel times of 60-90 minutes had suppressed demand.
- It was observed that all the participants with travel times of over 90 minutes had suppressed demand.

As a result, it was seen that 78% of the participants had a suppressed demand. In addition, 70% of these consist of people who want to travel less than 30 minutes. In addition, 59% of the participants said that they could not get to their destination on time. The biggest reason for this was traffic congestion (25%), and infrequent public transport services (23%).

It is seen that the suppressed demand of the people increases as the current travel time increases. The most demanded by the participants to reduce the travel time is to reduce traffic congestion and increase the frequency of public transport services, which can be made significant improvements and meet the demands.

Participants diverted and suppressed demands were examined through Route Choice. When examining the diverted demand, it was examined through two sub-categories, namely maintenance works and route preferences that change during peak hours. 69% of the participants say they do not change their routes. Due to accessibility and travel time, 12% prefer different routes.

- It is seen that 46% of the participants have diverted demand during peak hours. The biggest reason for the formation of diverted demand is to reduce travel time by 13%, and to provide ease of access with 10%.
- It is seen that 37% of the participants have diverted demand during maintenance works. The biggest reason for the formation of diverted demand is to reduce travel time by 12%, followed by ease of access by 11%.
- It is seen that 37% of the participants have suppressed travel demand. The biggest reason for the formation of suppressed demand is to provide ease of access with 9%, followed by environmental factors (view, landscape) with 7%.

It has been observed that the biggest reasons for the demands to choose different routes are to reduce travel time and to provide ease of access. At this point, it will be important to find suggestions that will reduce travel time and increase access to meet the demands that occur in mandatory situations.

As we interpreted from the categorical analysis, there are significant differences in the travel demands of the participants. The data shows that especially the suppressed demand has a large rate in Izmir.

When evaluating the improvement of transportation systems in Izmir from a planning perspective, several important suggestions emerge. First of all, the frequency of rail systems in Izmir should be increased, especially during peak hours, and additional stops can be added to priority districts, provided that they are compatible with the existing systems. Making improvements in the integration of existing stations and providing additional services during peak hours will significantly alleviate the current problems.

The capacity of the piers can be expanded, and new piers can be established to make more efficient use of ferry transportation in Izmir Bay. Special attention should be paid to meeting the transportation demand in the Bayraklı.

Bus use is also quite high in Izmir. Detailed studies can be carried out to increase the frequency of service and to create new routes in high-demand areas.

Locals can be encouraged to use alternative transportation modes such as bicycle paths and pedestrian paths by prioritizing the infrastructure of these modes in the city center. This is a critical step towards creating a sustainable transportation infrastructure in Izmir.

Traffic congestion emerges as one of the most important challenges. Measures should be taken to increase road efficiency and alternative routes should be determined.

It is also important to include local communities and stakeholders in all these transportation planning processes. This approach allows for more detailed data to be collected and effective solutions to be developed in line with public demands. A participatory approach will yield more efficient, solution-oriented results. In conclusion, the main hypothesis of the thesis was whether there is a significant difference in apparent (current) demands related to suppressed demand (and diverted demand) in İzmir.

The main research questions linked to this main hypothesis are:

• Is there a significant difference between suppressed demand (and diverted demand) and apparent (current) demands?

• How do the travel demand change and are categorized according to socio-economic, demographic, and preference conditions?

Firstly, it was seen that the diverted demands and suppressed demand formed via mode have a significant difference with apparent (current) preference. It was calculated that the suppressed demands formed in trip rate and travel time have a significant

difference with current preference. Finally, it is seen that the diverted and suppressed demands formed in route preferences have a significant difference with current preference.

Secondly, when examined through transportation modes, it was seen that 80% of the participants had suppressed travel demand. 45% of the participants stated that they had demand diverted during peak hours and 43% of the participants stated that they had demand diverted during maintenance works. When the total of participants is examined, it is seen that the rate of those who have demand suppressed through the trip rate is 23%. As the participants' trip distributions increase, suppressed demands are also seen. When the total is examined, it is seen that the rate of those who have suppressed demand through trip distribution is 78%, When the demands are examined through the change in route preferences, the diverted demand rates in peak hours is 46% and during maintenance works 37%. Suppressed demand is 37%. In all analyses, it is seen that the current behaviors are significantly different from the types of travel demands formed. Although this difference is very clearly seen in some categories, it is seen at lower rates in some categories.

CHAPTER 7

CONCLUSION

This section summarizes the data obtained by evaluating the research questions of the thesis. The study focuses on identifying suppressed and diverted transportation demands in Izmir. In this context, the study addresses two main questions:

1) Is there a significant difference between suppressed demand (and diverted demand) and apparent (current) demands?

2) How do the travel demand change and are categorized according to socio-economic, demographic, and preference conditions?

The study commences with a comprehensive literature review on the types of travel demands, followed by an examination of the relationship between transportation planning and travel demands. Additionally, it discusses the definition of transportation disadvantage from various perspectives in the literature. The final section explores travel survey techniques focusing on stated and revealed preferences and provides insights into both traditional and new approaches.

The target group of the research comprises individuals aged 18-65 actively using transportation systems in Izmir. A survey consisting of 36 questions was prepared, and an online survey was conducted to reach a total of 913 participants. Contact information such as phone numbers and emails were collected to facilitate communication in case of erroneous responses.

Findings indicate that suppressed demand, comprising transportation modes, accounts for 80%, with rail systems being the most preferred mode. It is observed that diverted demand averages 44% during peak hours and maintenance works. Rail systems remain the most demanded mode during these periods as well.

Examining suppressed demand based on trip rate reveals a percentage of 23%. Furthermore, an analysis of changes in trip rate when the demanded mode is provided shows an increase of 26.5% in trip numbers.

When diverted demand is examined based on travel time, it is noted that as current travel time increases, individuals suppressed demands also increase. Suppressed demand is 78%. Of this suppressed demand, 70% want travel times to be less than 30 minutes.

Regarding route preferences, it is observed that 37% of participants experience diverted demands during peak hours and infrastructure maintenance times, while suppressed demand is found to be 46%. The primary reasons for demand creation among participants include reducing travel time and enhancing accessibility.

Based on these findings, recommendations are provided for resolving transportation issues in Izmir and improving existing systems. Rail systems emerge as the most demanded mode, with 23% of participants expressing dissatisfaction with the frequency of public transportation services. Addressing this demand could involve increasing service frequencies and adding new stops, which warrants attention and further detailed investigation by experts.

Twenty-five percent of participants identify traffic congestion as the most significant transportation issue, suggesting the need to incentivize alternative transportation modes and conduct detailed studies on road efficiency. It is believed that addressing these issues will directly reduce travel time and significantly alleviate accessibility problems.

Finally, the data collected is a basis for transportation modeling. More detailed examinations can be done by experts with technical analysis. Due to analytical limitations, all social groups could not be examined. Future research focusing on social groups and districts could deepen the study. As an unexplored topic specific to Izmir, the study provides insights for future research endeavors in Izmir.

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APPENDICIES

APPENDIX A

Table A1. QUESTIONNAIRE

	KİŞİSEL BİLGİLER
1.	**Kaç Yaşındasınız?** A.10-18 B.19-24 C.25-35 D.35-44 E.45-64 F.65+
2.	**Hangi ilçede oturuyorsunuz?** .....
3.	**Çalışıyor musunuz?** A. Evet B. Hayır
4.	**Eğitim durumunuz nedir?** A. Ortaokul B. Lise C. Önlisans D. Lisans E. Yüksek Lisans F. Doktora
5.	**İletişim Bilgisi (Mail/Telefon Numarası)** .....
	ULAŞIM DAVRANIŞLARI
6.	**Aracınız var mı? Var ise ne tür?** A. Aracım yok B. Bisiklet, Scooter C. Motosiklet D. Araba E. Diğer(.....)
7.	**Aracınız varsa ne kadar sıklıkla yolculuklarınızda kullanıyorsunuz?** A. Hiç kullanmıyorum B. Neredeyse hiç kullanmıyorum C. Az kullanıyorum D. Genellikle kullanıyorum E. Hep kullanıyorum
8.	**Toplu Taşıma kullanıyor musunuz? Kullanıyorsanız sıklığı ne kadar?** A. Hayır, kullanmıyorum B. Haftada 1-2 Kez C. Haftada 3-4 Kez D. Haftada 5 veya 5'ten fazla
9.	**Mevcut toplu taşıma sistemlerinden memnun musunuz?** A. Evet, Memnunum B. Hayır, Memnun değilim
10.	**Ulaşım sistemlerinden yararlanma anlamında kendinizi "ulaşım dezavantajlısı" olarak tanımlar mısınız?** (Ulaşımda Dezavantajlılar, erişilebilirlik, hareketlilik, maliyet, kolaylık ve bilgiye erişim gibi konularda yeterli hizmeti alamayan kişilerdir.) A. Tanımlarım B. Tanımlamam

(cont. on the next page)

Table A1. (cont.)

11.	**Mevcutta en çok hangi ulaşım şeklini kullanmak zorunda kalıyorsunuz?** A. Yürüme B. Bisiklet, Scooter C. Motosiklet D. Özel araç E. Otobüs F. Minibüs G. Raylı sistemler (Metro, İzban, Tramvay) H. Deniz Ulaşımı I. Taksi J. Diğer(……)
12.	**Mevcutta en çok kullanmak zorunda kaldığınız ulaşım şeklini seçme sebebiniz nedir?** A. Erişilebilirlik B. Maliyet C. Seyahat Süresi D. Güvenlik E. Konfor F. Çevresel Etkenler (Peyzaj, manzara) G. Diğer(……)
13.	**Zirve saatlerde (iş çıkışı vb.) mevcutta kullanmak zorunda olduğunuz ulaşım türünden farklı bir ulaşım şekli tercih ediyor musunuz? Ediyorsanız hangisidir?** A. Farklı bir ulaşım şekli tercih etmiyorum B. Yürüme C. Bisiklet, Scooter D. Motosiklet E. Özel araç F. Otobüs G. Minibüs H. Raylı sistemler (Metro, İzban, Tramvay) I. Deniz Ulaşımı J. Taksi K. Diğer(……)
14.	**Altyapı çalışmalarından dolayı (yol, metro gibi) oluşan trafik problemlerinde mevcutta kullanmak zorunda olduğunuz ulaşım türünden farklı bir ulaşım şekli tercih ediyor musunuz? Ediyorsanız hangisidir?** A. Farklı bir ulaşım şekli tercih etmiyorum B. Yürüme C. Bisiklet, Scooter D. Motosiklet E. Özel araç F. Otobüs G. Minibüs H. Raylı sistemler (Metro, İzban, Tramvay) I. Deniz Ulaşımı J. Taksi K. Diğer(……)
15.	**Seçebilme şansınız olsaydı gündelik olarak en çok hangi ulaşım şeklini tercih etmek isterdiniz?** A. Yürüme B. Bisiklet, Scooter C. Motosiklet D. Özel araç E. Otobüs F. Minibüs G. Raylı sistemler (Metro, İzban, Tramvay) H. Deniz Ulaşımı I. Taksi J. Diğer(……)

(cont. on the next page)

Table A1. (cont.)

16. **Tercih etmek istediğiniz ulaşım şeklini kullanamama sebebiniz nedir?**

A. Yaya ve Bisiklet yolları eksikliği
B. Toplu taşıma araçlarının yetersiz olması
C. Trafik sıkışıklığı
D. Otopark sıkıntısı
E. Ulaşım maliyetleri
F. Diğer (……..)

17. **17.1 Eğer cevabınız A(Yaya ve Bisiklet yolları eksikliği) ise yaya ve bisiklet yolları iki katına çıkarılsa istediğiniz ulaşım şeklini tercih eder miydiniz?**
A. Evet, ederdim
B. Hayır etmezdim

17.2. Eğer cevabınız B(Toplu taşıma araçlarının yetersiz olması) ise toplu taşıma araç sayısı iki katına çıksa istediğiniz ulaşım şeklini tercih eder miydiniz?
A. Evet, ederdim
B. Hayır etmezdim

17.3. Eğer cevabınız C(Trafik sıkışıklığı) ise trafik sıkışıklığı yarıya düşse istediğiniz ulaşım şeklini tercih eder miydiniz?
A. Evet, ederdim
B. Hayır etmezdim

17.4. Eğer cevabınız D(Otopark sıkıntısı) ise otopark sayısı 2 katına çıkarılsa istediğiniz ulaşım şeklini tercih eder miydiniz?
A. Evet, ederdim
B. Hayır etmezdim

17.5. Eğer cevabınız E(Ulaşım maliyetleri) ulaşım maaliyetleri yarıya düşürülse istediğiniz ulaşım şeklini tercih eder miydiniz?
A. Evet, ederdim
B. Hayır etmezdim

17.6. Eğer cevabınız F diğerleri ise ½ oranında iyileştirme yapıldığında o ulaşım şeklini tercih eder miydiniz?
A. Evet, ederdim
B. Hayır etmezdim

18. **Mevcutta günde ortalama kaç kez yolculuk yapmak zorunda kalıyorsunuz? (Örnek: İşe veya okula gidip gelmek 2 yolculuk olarak sayılmaktadır)**
A. Günde 0-2 yolculuk
B. Günde 3-5 yolculuk
C. Günde 6-8 yolculuk
D. Günde 8+ yolculuk

19. **İstediğiniz ulaşım modu sağlansaydı ortalama kaç kez yolculuk yapardınız? (Örnek: İşe veya okula gidip gelmek 2 yolculuk olarak sayılmaktadır)**
A. Günde 0-2 yolculuk
B. Günde 3-5 yolculuk
C. Günde 6-8 yolculuk
D. Günde 8+ yolculuk

20. **Eğer 15.soruda tercih etmek istediğiniz ulaşım şekli (bisiklet, otobüs, raylı sistem vb.) sağlansaydı günde ortalama kaç yolculuk yapardınız? (Örnek: İşe veya okula gidip gelmek 2 yolculuk olarak sayılmaktadır)**
A. Günde 0-2 yolculuk
B. Günde 3-5 yolculuk
C. Günde 6-8 yolculuk
D. Günde 8+ yolculuk

(cont. on the next page)

Table A1. (cont.)

21.	**Genellikle yolculuk yaparken aktarma yapıyor musunuz?** A. Evet, aktarma yapıyorum B. Hayır, aktarma yapmıyorum (25.soruya geçiniz)
22.	**Aktarma yapma sebebiniz nedir?** A. Erişilebilirlik B. Maliyet C. Seyahat Süresi D. Güvenlik E. Konfor F. Çevresel Etkenler (Peyzaj, manzara) G. Diğer(……..)
23.	**Aktarma yapıyorsanız aktarma yapmadan yolculuk yapmak ister miydiniz?** A. Evet, isterdim B. Hayır istemezdim
24.	**Neden aktarma yapmadan yolculuk yapmak isterdiniz?** A. Erişilebilirlik B. Maliyet C. Seyahat Süresi D. Güvenlik E. Konfor F. Çevresel Etkenler (Peyzaj, manzara) G. Diğer(……..)
25.	**Eğer aktarma ücretleri olmasaydı, aktarmalı ulaşımı tercih eder miydiniz?** A. Evet, tercih ederdim B. Hayır, tercih etmezdim
26.	**Mevcutta bir yere giderken ortalama yolculuk süreniz ne kadar? (90 dakikadan fazla ise neden?)** A. 30dk'dan az B. 30-60 dk C. 60-90 dk D. 90+ dk
27.	**Seçebilme şansınız olsa ne kadar sürede gideceğiniz yere ulaşmak isterdiniz? Nedenini belirtiniz.** A. 30dk'dan az B. 30-60 dk C. 60-90 dk D. 90+ dk
28.	**Genellikle gideceğiniz yere zamanında varıyor musunuz?** A. Evet, varıyorum B. Hayır, varamıyorum (30. Soruya geçiniz)
29.	**Genellikle gideceğiniz yere zamanında varamıyorsanız nedeni nedir?** A. Altyapı eksikliği B. Trafik sıkışıklığı C. Otopark sıkıntısı D. Diğer(……)
30.	**Yolculuk yaparken genellikle aynı güzergâhı mı kullanıyorsunuz? Nedenleri belirtiniz.** A. Evet, aynı güzergahı kullanıyorum çünkü…….. B. Hayır, aynı güzergahı kullanmıyorum çünkü……
31.	**Yolculuk yaparken farklı güzergâh kullanmak ister miydiniz?** A. Evet, isterdim B. Hayır, istemezdim
32.	**Yolculuk yaparken farklı güzergâh kullanmak istiyorsanız sebebi nedir?** A. Erişilebilirlik B. Maliyet C. Seyahat Süresi D. Güvenlik E. Konfor F. Çevresel Etkenler (Peyzaj, manzara) G.Diğer(……)

APPENDIX B

Table B.1. Current Mode Preference – Mode Demand

			Transportation Mode Demand										Total
			Bicycle, Scooter	Ferry	Minibus	Motorcycle	Bus	Private Car	Rail Systems	Taxi	Walking	Monoray	
Currently Mode Preference	Bicycle, Scooter	Count	2	3	0	3	0	2	1	0	0	0	11
		% within current	18,2%	27,3%	0,0%	27,3%	0,0%	18,2%	9,1%	0,0%	0,0%	0,0%	100,0%
	Ferry	Count	0	17	0	0	0	7	10	0	0	0	34
		% within current	0,0%	50,0%	0,0%	0,0%	0,0%	20,6%	29,4%	0,0%	0,0%	0,0%	100,0%
	Minibus	Count	0	1	1	0	2	3	25	5	1	0	38
		% within current	0,0%	2,6%	2,6%	0,0%	5,3%	7,9%	65,8%	13,2%	2,6%	0,0%	100,0%
	Motorcycle	Count	0	3	0	5	0	2	0	0	0	0	10
		% within current	0,0%	30,0%	0,0%	50,0%	0,0%	20,0%	0,0%	0,0%	0,0%	0,0%	100,0%
	Bus	Count	14	13	1	10	18	58	112	10	16	0	252
		% within current	5,6%	5,2%	,4%	4,0%	7,1%	23,0%	44,4%	4,0%	6,3%	0,0%	100,0%
	Private Car	Count	34	14	1	6	4	53	79	9	10	0	210
		% within current	16,2%	6,7%	,5%	2,9%	1,9%	25,2%	37,6%	4,3%	4,8%	0,0%	100,0%
	Rail Systems	Count	34	52	0	13	11	67	71	10	13	0	271
		% within current	12,5%	19,2%	0,0%	4,8%	4,1%	24,7%	26,2%	3,7%	4,8%	0,0%	100,0%
	Service	Count	1	0	0	0	0	1	0	1	0	0	3
		% within current	33,3%	0,0%	0,0%	0,0%	0,0%	33,3%	0,0%	33,3%	0,0%	0,0%	100,0%
	Taxi	Count	0	1	0	0	0	2	4	2	1	0	10
		% within current	0,0%	10,0%	0,0%	0,0%	0,0%	20,0%	40,0%	20,0%	10,0%	0,0%	100,0%
	Walking	Count	8	7	1	3	4	14	21	5	10	1	74
		% within current	10,8%	9,5%	1,4%	4,1%	5,4%	18,9%	28,4%	6,8%	13,5%	1,4%	100,0%
Total		Count	93	111	4	40	39	209	323	42	51	1	913
		% within current	10,2%	12,2%	,4%	4,4%	4,3%	22,9%	35,4%	4,6%	5,6%	,1%	100,0%

APPENDIX C

Table C.1. Current Mode Preference – Mode Demand During Peak Hours

			Mode preferences during peak hours												Total
			Not prefer any other mod	Bicycle, Scooter	Ferry	Minibus	Motorcycle	Bus	Private Car	Rail Systems	Service	Taxi	Walking	Prefer to not go out	
Currently mode preference	Bicycle, Scooter	Count	10	0	0	0	0	0	0	1	0	0	0	0	11
		% within current	2,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	,9%	0,0%	0,0%	0,0%	0,0%	1,2%
	Ferry	Count	25	0	0	0	0	0	4	3	0	2	0	0	34
		% within current	4,9%	0,0%	0,0%	0,0%	0,0%	0,0%	13,8%	2,6%	0,0%	6,7%	0,0%	0,0%	3,7%
	Minibus	Count	20	0	0	0	1	7	1	2	0	0	6	1	38
		% within current	4,0%	0,0%	0,0%	0,0%	25,0%	22,6%	3,4%	1,7%	0,0%	0,0%	6,1%	33,3%	4,2%
	Motorcycle	Count	5	0	2	0	0	1	0	1	0	0	1	0	10
		% within current	1,0%	0,0%	4,1%	0,0%	0,0%	3,2%	0,0%	,9%	0,0%	0,0%	1,0%	0,0%	1,1%
	Bus	Count	108	0	9	20	1	0	6	63	2	9	33	0	251
		% within current	21,3%	0,0%	18,4%	52,6%	25,0%	0,0%	20,7%	54,8%	40,0%	30,0%	33,3%	0,0%	27,5%
	Private Car	Count	132	1	11	7	0	7	0	28	2	5	17	1	211
		% within current	26,1%	25,0%	22,4%	18,4%	0,0%	22,6%	0,0%	24,3%	40,0%	16,7%	17,2%	33,3%	23,1%
	Rail Systems	Count	157	1	27	10	2	9	13	0	0	13	38	1	271
		% within current	31,0%	25,0%	55,1%	26,3%	50,0%	29,0%	44,8%	0,0%	0,0%	43,3%	38,4%	33,3%	29,7%
	Service	Count	2	0	0	0	0	0	0	0	0	0	1	0	3
		% within current	,4%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	1,0%	0,0%	,3%
	Taxi	Count	5	0	0	0	0	0	0	2	0	0	3	0	10
		% within current	1,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	1,7%	0,0%	0,0%	3,0%	0,0%	1,1%
	Walking	Count	42	2	0	1	0	7	5	15	1	1	0	0	74
		% within current	8,3%	50,0%	0,0%	2,7%	0,0%	22,6%	17,3%	13,1%	20,0%	3,3%	0,0%	0,0%	8,1%
Total		Count	506	4	49	38	4	31	29	115	5	30	99	3	913
		% within current	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%

APPENDIX D

Table D.1. Current Mode Preference – Mode Demand During Long-term Maintenance Works

			Mode preferences during long-term maintenance works										
			Not prefer any other	Bicycle, Scooter	Ferry	Minibus	Motorcycle	Bus	Private Car	Rail Systems	Taxi	Walking	Total
Currently mode preference	Bicycle, Scooter	Count	9	0	0	0	0	0	0	0	0	2	11
		% within current	81,8%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	18,2%	100,0%
	Ferry	Count	14	0	0	0	0	2	10	2	0	6	34
		% within current	41,2%	0,0%	0,0%	0,0%	0,0%	5,9%	29,4%	5,9%	0,0%	17,6%	100,0%
	Minibus	Count	22	0	0	0	1	2	3	7	3	0	38
		% within current	57,9%	0,0%	0,0%	0,0%	2,6%	5,3%	7,9%	18,4%	7,9%	0,0%	100,0%
	Motorcycle	Count	5	0	0	0	0	1	0	3	0	1	10
		% within current	50,0%	0,0%	0,0%	0,0%	0,0%	10,0%	0,0%	30,0%	0,0%	10,0%	100,0%
	Bus	Count	125	1	6	14	1	0	14	41	17	33	252
		% within current	49,6%	0,4%	2,4%	5,6%	0,4%	0,0%	5,6%	16,3%	6,7%	13,1%	100,0%
	Private Car	Count	144	2	6	2	0	9	0	33	0	14	210
		% within current	68,6%	1,0%	2,9%	1,0%	0,0%	4,3%	0,0%	15,7%	0,0%	6,7%	100,0%
	Rail System	Count	150	3	15	11	1	36	15	0	14	26	271
		% within current	55,4%	1,1%	5,5%	4,1%	0,4%	13,3%	5,5%	0,0%	5,2%	9,6%	100,0%
	Service	Count	3	0	0	0	0	0	0	0	0	0	3
		% within current	100,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	100,0%
	Taxi	Count	8	0	0	0	0	0	1	0	0	1	10
		% within current	80,0%	0,0%	0,0%	0,0%	0,0%	0,0%	10,0%	0,0%	0,0%	10,0%	100,0%
	Walking	Count	43	0	1	1	0	6	3	15	5	0	74
		% within current	58,1%	0,0%	1,4%	1,4%	0,0%	8,1%	4,1%	20,3%	6,8%	0,0%	100,0%
Total		Count	523	6	28	28	3	56	46	101	39	83	913
		% within current	57,3%	0,7%	3,1%	3,1%	0,3%	6,1%	5,0%	11,1%	4,3%	9,1%	100,0%

APPENDIX E

Table E.1. Current Mode Preference – Mode Demand During Long-term Maintenance Works

			Reason to not use													
			Using chosen mode of transportation	Infrastructure deficiency	Not owned vehicle	Sea transport	Security	Parking problem	System not a	Infrequent public transportation hours	Traffic congestion	Transportation costs	Accesbility	Lack of pedestrian and bicycle paths	Crowded during peak hours	Total
Suppressed Demand	Bicycle, Scooter	Count	3	2	0	0	0	0	0	2	4	0	0	82	0	93
		% within mode	3,2%	2,2%	0,0%	0,0%	0,0%	0,0%	0,0%	2,2%	4,3%	0,0%	0,0%	88,2%	0,0%	100,0%
	Ferry	Count	17	33	0	2	0	1	5	40	6	3	2	0	2	111
		% within mode	15,3%	29,7%	0,0%	1,8%	0,0%	,9%	4,5%	36,0%	5,4%	2,7%	1,8%	0,0%	1,8%	100,0%
	Minibus	Count	1	1	0	0	0	0	0	0	0	2	0	0	0	4
		% within mode	25,0%	25,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	50,0%	0,0%	0,0%	0,0%	100,0%
	Motorcycle	Count	5	4	0	0	4	1	0	1	8	17	0	0	0	40
		% within mode	12,5%	10,0%	0,0%	0,0%	10,0%	2,5%	0,0%	2,5%	20,0%	42,5%	0,0%	0,0%	0,0%	100,0%
	Bus	Count	15	7	0	0	0	0	0	8	8	0	0	0	0	38
		% within mode	39,5%	18,4%	0,0%	0,0%	0,0%	0,0%	0,0%	21,1%	21,1%	0,0%	0,0%	0,0%	0,0%	100,0%
	Private Car	Count	48	3	12	0	0	23	0	2	32	88	0	0	0	208
		% within mode	23,1%	1,4%	5,8%	0,0%	0,0%	11,1%	0,0%	1,0%	15,4%	42,3%	0,0%	0,0%	0,0%	100,0%
	Rail Systems	Count	73	148	0	0	0	4	4	46	19	13	6	0	11	324
		% within mode	22,5%	45,7%	0,0%	0,0%	0,0%	1,2%	1,2%	14,2%	5,9%	4,0%	1,9%	0,0%	3,4%	100,0%
	Service	Count	2	0	0	0	0	0	0	0	2	37	0	0	1	42
		% within mode	4,8%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	4,8%	88,1%	0,0%	0,0%	2,4%	100,0%
	Taxi	Count	11	0	0	0	0	1	0	0	1	0	9	30	0	52
		% within mode	21,2%	0,0%	0,0%	0,0%	0,0%	1,9%	0,0%	0,0%	1,9%	0,0%	17,3%	57,7%	0,0%	100,0%
	Walking	Count	0	0	0	0	0	0	1	0	0	0	0	0	0	1
		% within mode	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	100,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	100,0%
Total		Count	175	198	12	2	4	30	10	99	80	160	17	112	14	913
		% within mode	19,2%	21,7%	1,3%	,2%	,4%	3,3%	1,1%	10,8%	8,8%	17,5%	1,9%	12,3%	1,5%	100,0%

APPENDIX F

Table F.1. Current Travel Time– Travel Time Demand

			Demand Travel Time			Total
			0 -30 min	30-60 min	60-90 min	
Current Travel Time	0-30 min	Count	180	8	0	188
		% within current	95,7%	4,3%	0,0%	100,0%
	30-60 min	Count	512	20	2	534
		% within current	95,9%	3,7%	,4%	100,0%
	60-90 min	Count	110	34	2	146
		% within current	75,3%	23,3%	1,4%	100,0%
	+90 min	Count	21	21	3	45
		% within current	46,7%	46,7%	6,7%	100,0%
Total		Count	823	83	7	913
		% within x	90,1%	9,1%	,8%	100,0%

APPENDIX G

Table G.1. Current Trip Rate – Trip Rate Demand

			Demand Trip Rate				Total
			0-2 travel per day	3-5 travel per day	6-8 travel per day	+9 travel per day	
Current Trip Rate	0-2 travel per day	Count	546	54	2	0	602
		% within current	90,7%	9,0%	,3%	0,0%	100,0%
	3-5 travel per day	Count	114	144	8	3	269
		% within current	42,4%	53,5%	3,0%	1,1%	100,0%
	6-8 travel per day	Count	6	11	8	2	27
		% within current	22,2%	40,7%	29,6%	7,4%	100,0%
	6-8 travel per day	Count	3	3	0	9	15
		% within current	20,0%	20,0%	0,0%	60,0%	100,0%
Total		Count	669	212	18	14	913
		% within current	73,3%	23,2%	2,0%	1,5%	100,0%

APPENDIX H

Table H.1. Current Route Preference – Different Route Preference

			Different Route Demands and Reasons							
			Environmental Factors	Accessibility	Security	Comfort	Cost	Travel time	Not prefer to take a different route	Total
Current Route Preferences and Reasons	Using same route	Count	61	126	3	32	9	123	286	640
		% within x	9,5%	19,7%	,5%	5,0%	1,4%	19,2%	44,7%	100,0%
	Diff. Environmental Factors	Count	14	3	0	3	0	4	4	28
		% within x	50,0%	10,7%	0,0%	10,7%	0,0%	14,3%	14,3%	100,0%
	Diff. Accessibility	Count	8	58	0	5	4	11	23	109
		% within x	7,3%	53,2%	0,0%	4,6%	3,7%	10,1%	21,1%	100,0%
	Diff. Security	Count	0	1	2	0	0	0	1	4
		% within x	0,0%	25,0%	50,0%	0,0%	0,0%	0,0%	25,0%	100,0%
	Diff. Comfort	Count	1	4	0	5	1	2	1	14
		% within x	7,1%	28,6%	0,0%	35,7%	7,1%	14,3%	7,1%	100,0%
	Diff. Cost	Count	1	0	0	1	1	1	0	4
		% within x	25,0%	0,0%	0,0%	25,0%	25,0%	25,0%	0,0%	100,0%
	Diff. Travel time	Count	10	18	3	6	3	51	23	114
		% within x	8,8%	15,8%	2,6%	5,3%	2,6%	44,7%	20,2%	100,0%
Total		Count	95	210	8	52	18	192	338	913
		% within x	10,4%	23,0%	,9%	5,7%	2,0%	21,0%	37,0%	100,0%

APPENDIX I

Table I.1. Current Route Preference – Different Route Preference During Peak Hours

			Different Route Demands and Reasons During Peak Hours								
			Environmental Factors	Accessibility	Security	Comfort	Cost	Travel time	No alternative	Not prefer to take a different route	Total
Current Route and Reasons	Using same route	Count	5	90	5	28	1	132	369	10	640
		% within x	,8%	14,1%	,8%	4,4%	,2%	20,6%	57,7%	1,6%	100,0%
	Diff. Environmental Factors	Count	3	2	2	5	0	10	4	2	28
		% within x	10,7%	7,1%	7,1%	17,9%	0,0%	35,7%	14,3%	7,1%	100,0%
	Diff. Accessibility	Count	3	60	0	5	2	24	13	2	109
		% within x	2,8%	55,0%	0,0%	4,6%	1,8%	22,0%	11,9%	1,8%	100,0%
	Diff. Accessibility	Count	0	2	0	0	0	0	2	0	4
		% within x	0,0%	50,0%	0,0%	0,0%	0,0%	0,0%	50,0%	0,0%	100,0%
	Diff. Comfort	Count	0	3	0	3	0	2	5	1	14
		% within x	0,0%	21,4%	0,0%	21,4%	0,0%	14,3%	35,7%	7,1%	100,0%
	Diff. Cost	Count	0	1	0	0	0	0	3	0	4
		% within x	0,0%	25,0%	0,0%	0,0%	0,0%	0,0%	75,0%	0,0%	100,0%
	Diff. Travel time	Count	1	20	0	4	3	73	13	0	114
		% within x	,9%	17,5%	0,0%	3,5%	2,6%	64,0%	11,4%	0,0%	100,0%
Total		Count	12	178	7	45	6	241	409	15	913
		% within x	1,3%	19,5%	,8%	4,9%	,7%	26,4%	44,8%	1,6%	100,0%

APPENDIX J

Table J.1. Current Route Preference – Different Route Preference During Long-term Maintenance Works

			Different Route Demands and Reasons During Long-term Maintenance Works								
			Environmental Factors	Accessibility	Security	Comfort	Cost	Travel time	Not prefer to take a different route	No alternative	Total
Current Route and Reasons	Using same route	Count	5	90	5	28	1	132	369	10	640
		% within x	,8%	14,1%	,8%	4,4%	,2%	20,6%	57,7%	1,6%	100,0%
	Diff. Environmental Factors	Count	3	2	2	5	0	10	4	2	28
		% within x	10,7%	7,1%	7,1%	17,9%	0,0%	35,7%	14,3%	7,1%	100,0%
	Diff. Accessibility	Count	3	60	0	5	2	24	13	2	109
		% within x	2,8%	55,0%	0,0%	4,6%	1,8%	22,0%	11,9%	1,8%	100,0%
	Diff. Accessibility	Count	0	2	0	0	0	0	2	0	4
		% within x	0,0%	50,0%	0,0%	0,0%	0,0%	0,0%	50,0%	0,0%	100,0%
	Diff. Comfort	Count	0	3	0	3	0	2	5	1	14
		% within x	0,0%	21,4%	0,0%	21,4%	0,0%	14,3%	35,7%	7,1%	100,0%
	Diff. Cost	Count	0	1	0	0	0	0	3	0	4
		% within x	0,0%	25,0%	0,0%	0,0%	0,0%	0,0%	75,0%	0,0%	100,0%
	Diff. Travel time	Count	1	20	0	4	3	73	13	0	114
		% within x	,9%	17,5%	0,0%	3,5%	2,6%	64,0%	11,4%	0,0%	100,0%
Total		Count	12	178	7	45	6	241	409	15	913
		% within x	1,3%	19,5%	,8%	4,9%	,7%	26,4%	44,8%	1,6%	100,0%