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RURAL VS. URBAN TRAVEL BEHAVIOR: A COMPARATIVE ANALYSIS OF MOBILITY PATTERNS IN THE IZMIR URBAN RAIL MASS TRANSIT SYSTEM (IZBAN)

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Highlights

- Travel Behavior
- Public Transportation
- Urban rail transit
- Rural-urban disparities
- Transportation equity
- Socio-economic factors
- Sustainable mobility

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ABSTRACT: Understanding travel behavior is critical for designing equitable and sustainable transportation systems, particularly in the context of rapid urbanization and rural-urban disparities. This study examines the differences in travel behavior between rural and urban areas, with a focus on the Izmir Urban Rail Mass Transit System (IZBAN) in Turkey. By analyzing data from 606 face-to-face surveys, the research explores key factors such as mode choice, trip purpose, travel distance, socio-economic influences, and user costs. Descriptive statistics, correlation analysis, chi-square tests, and hypothesis testing were applied using SPSS to identify patterns and significant differences in travel behavior between rural and urban respondents. The study highlights the distinct challenges faced by rural and urban travelers, including limited transportation options in rural areas and issues of congestion, high rents, and inequality in urban centers. The findings reveal that urban travelers benefit from shorter travel times, greater access to public transportation, and proximity to transit hubs, while rural travelers rely more on private vehicles and face longer travel distances. The study also emphasizes the role of socio-economic factors, such as income and household structure, in shaping travel behavior, as well as the environmental and policy implications of these patterns. By providing a comprehensive analysis of rural and urban travel behavior, this research aims to inform transportation policies that promote accessibility, affordability, and sustainability. The study's insights are particularly relevant for addressing the mobility challenges of underserved populations and optimizing public transportation systems in rapidly growing cities. Ultimately, this research contributes to the broader discourse on sustainable urban development and equitable access to transportation, offering valuable lessons for policymakers and urban planners in Izmir and beyond.

Keywords: *Travel Behavior, Public Transportation, Urban Rail Transit, Rural-Urban Disparities, Transportation Equity, Socio-Economic Factors, Sustainable Mobility*

1. INTRODUCTION

Travel behavior is a cornerstone of transportation research, influencing urban planning, environmental sustainability, and the overall quality of life for individuals and communities. As cities expand and rural areas face unique challenges, understanding the nuances of travel behavior in different geographic contexts becomes increasingly important. This study delves into the differences and similarities in travel behavior between rural and urban areas, with a particular focus on the Izmir Urban Rail Mass Transit System (IZBAN), a critical component of public transportation in Izmir, Turkey. By examining how people in these distinct environments choose to travel, this research aims to provide insights that can inform more effective transportation policies and infrastructure development. Unlike previous studies that often focus exclusively on either urban or rural contexts, this research provides a comparative analysis of both within the same transit system, allowing for a direct and contextualized understanding of spatial disparities in travel behavior. The key contribution of this study is the integration of socio-economic and spatial data to highlight how differences in access, affordability, and mobility manifest between rural and urban IZBAN passengers.

The rapid urbanization of the 21st century has led to significant changes in how people move within and between cities. Increasing migration from rural areas to modern cities has resulted in excessive urban growth, which, while fostering economic opportunities, has also introduced challenges such as increased travel distances, higher transportation costs, and social inequalities [1]. Urban areas, characterized by high population density and mixed land-use patterns, offer a wide array of transportation options, including public transit, cycling, walking, and ride-sharing services. These options are often supported by well-developed infrastructure, such as dedicated bike lanes, extensive public transit networks, and pedestrian-friendly streets [2]. However, urban expansion often exacerbates issues such as traffic congestion, air pollution, and energy consumption, while also contributing to social disparities. For instance, high rents in city centers force lower-income households to relocate to suburban or peri-urban areas, where housing is more affordable, but transportation costs and travel times are significantly higher [3]. This dynamic creates a paradox where households seeking to avoid high rents face increased transportation burdens, further perpetuating inequality and discrimination in access to urban amenities and opportunities.

In contrast, rural areas often face challenges such as limited public transportation options, longer travel distances, and a greater reliance on private vehicles. These disparities in transportation infrastructure and accessibility have profound implications for travel behavior, influencing mode choice, trip purpose, travel distance, and socio-economic factors [1]. Rural residents, particularly those with lower incomes or limited access to private vehicles, often face mobility challenges that restrict their access to essential services such as healthcare, education, and employment [4]. Addressing these challenges requires tailored policies that improve rural transportation infrastructure, promote carpooling, and support demand-responsive transit systems [5].

Understanding these differences is crucial for designing transportation systems that are both efficient and equitable. Urban areas, with their dense populations and diverse transportation options, often experience issues such as traffic congestion, air pollution, and high energy consumption. Policies promoting public transportation, active mobility, and compact urban development are commonly implemented to mitigate these challenges [6]. On the other hand, rural areas, with their dispersed populations and limited infrastructure, face different challenges, such as higher per capita emissions due to reliance on private vehicles and limited access to essential services like healthcare and education [4]. Addressing these challenges requires tailored policies that improve rural transportation infrastructure, promote carpooling, and support demand-responsive transit systems [1].

This study aims to explore these differences by examining the travel behavior of IZBAN passengers in both rural and urban contexts. By analyzing data collected through a comprehensive survey, the research seeks to identify patterns and trends that can inform transportation policies and infrastructure development. The study also considers the impact of socio-economic factors, environmental sustainability, and emerging technologies on travel behavior, providing a holistic view of the challenges and opportunities in rural and urban transportation systems. For instance, socio-economic factors such as income, age, and household structure play a significant role in shaping travel behavior. In urban areas, lower-income groups are more likely to rely on public transportation, while higher-income groups may prefer private vehicles or ride-sharing services [3]. In rural areas, socio-economic factors similarly influence travel behavior, but the lack of transportation alternatives often limits choices, particularly for older adults and low-income households [4].

The significance of this research lies in its potential to contribute to the development of more equitable and sustainable transportation systems. By understanding the distinct travel behavior patterns in rural and urban areas, policymakers and urban planners can design targeted interventions that address the unique needs of each context. For instance, improving public transportation options in rural areas could reduce reliance on private vehicles, thereby lowering greenhouse gas emissions and enhancing mobility for underserved populations. Similarly,

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optimizing urban transportation systems could alleviate traffic congestion, improve air quality, and enhance the overall quality of life for city dwellers.

In summary, this research seeks to bridge the gap in understanding travel behavior differences between rural and urban areas, with a focus on the IZBAN system. By doing so, it aims to provide valuable insights that can inform transportation policies, enhance sustainability, and improve the quality of life for both rural and urban residents. The findings of this study have the potential to influence not only Izmir but also other cities facing similar transportation challenges, contributing to the broader discourse on sustainable urban development and equitable access to transportation. As cities continue to grow and evolve, understanding the complexities of travel behavior will be essential for creating transportation systems that are not only efficient but also inclusive and sustainable.

2. LITERATURE REVIEW

Travel behavior is a critical area of study in transportation research, as it directly influences infrastructure development, environmental sustainability, and quality of life. Understanding the differences and similarities in travel behavior between rural and urban areas is essential for designing effective transportation policies and systems. This review synthesizes existing research on travel behavior in rural and urban contexts, focusing on mode choice, trip purpose, travel distance, socio-economic influences, environmental and policy implications, and emerging trends.

Mode choice is shaped by the availability of transportation options, infrastructure, and socio-economic factors. In urban areas, residents have access to a wide range of transportation modes, including public transit, walking, cycling, and ride-sharing services. High population density and mixed land-use patterns in cities encourage the use of non-motorized and public transportation [2]. The proliferation of bike-sharing programs and app-based ride-hailing services has further diversified urban mobility options [7]. However, private car use remains prevalent in many cities, often leading to traffic congestion and environmental challenges [8]. In rural areas, public transportation options are limited, and there is a greater reliance on private vehicles. The dispersed nature of rural settlements and longer travel distances make car ownership a necessity for most residents [1]. Walking and cycling are less common due to inadequate infrastructure and safety concerns [4]. Carpooling and demand-responsive transit systems have been explored as alternatives, but their adoption remains limited [5].

Trip purpose varies significantly between rural and urban areas, reflecting differences in land use, accessibility, and lifestyle. Urban trips are often shorter and more frequent, with common purposes including commuting, shopping, and leisure activities [9]. The proximity of residential, commercial, and recreational areas in cities facilitates multi-purpose trips, reducing the need for long-distance travel [6]. Rural trips, on the other hand, are typically longer and less frequent, with a focus on essential activities such as work, education, and healthcare [10]. Limited access to services and amenities in rural areas often necessitates longer travel distances, making trip chaining less feasible [11].

Travel distance and time are key determinants of travel behavior, influenced by geographic and infrastructural factors. In urban areas, residents generally experience shorter travel distances due to the compact nature of cities. However, traffic congestion can lead to longer travel times despite shorter distances [12]. Efficient public transportation systems and active mobility options help mitigate these challenges in well-planned urban areas. In rural areas, residents face longer travel distances due to the dispersed nature of settlements and limited infrastructure. While congestion is less of an issue, the lack of efficient transportation options often results in significant travel times [1].

Socio-economic factors such as income, age, and household structure play a significant role in shaping travel behavior. In urban areas, income levels and employment type strongly influence mode choice. Lower-income groups are more likely to rely on public transportation, while higher-

income groups may prefer private vehicles or ride-sharing services [3]. Age and household structure also affect travel patterns, with younger adults and smaller households more likely to use active transportation modes [13]. In rural areas, socio-economic factors similarly influence travel behavior, but the lack of transportation alternatives often limits choices. Older adults and low-income households in rural areas are particularly vulnerable to mobility challenges, as they may lack access to private vehicles or affordable transportation options [4].

Travel behavior has significant implications for environmental sustainability and transportation policy. In urban areas, travel behavior contributes to air pollution, greenhouse gas emissions, and energy consumption. Policies promoting public transportation, active mobility, and compact urban development are commonly implemented to reduce these impacts [6]. Smart city initiatives and digital technologies are increasingly being used to optimize urban transportation systems [7]. In rural areas, the reliance on private vehicles results in higher per capita emissions and energy use. Addressing these challenges requires policies that improve rural transportation infrastructure, promote carpooling, and support demand-responsive transit systems [1].

Recent developments in technology and societal changes are reshaping travel behavior in both rural and urban areas. In urban areas, the rise of smart cities and digital technologies has transformed urban travel behavior, with increased use of apps for trip planning and real-time information [7]. The COVID-19 pandemic has also led to significant shifts, including increased remote work and reduced public transportation use [14]. These innovations have the potential to improve accessibility and reduce reliance on private vehicles.

In conclusion, travel behavior in rural and urban areas is influenced by distinct geographical, socio-economic, and infrastructural factors. While urban areas benefit from greater transportation options and shorter travel distances, rural areas face challenges related to limited infrastructure and longer travel needs. Addressing these disparities requires tailored policies and innovative solutions to promote sustainable and equitable mobility for all. Future research should focus on the impacts of emerging technologies and societal changes on travel behavior, particularly in rural contexts.

3. METHODOLOGY

This study aims to observe the differences in travel behavior between rural and urban areas. To this end, a comprehensive survey research methodology was employed, incorporating data set. The data set was collected through face-to-face questionnaires administered to 606 participants. This survey examines travel behavior through metrics such as travel frequency, journey days, travel time, travel distance, public transportation modes, access types to IZBAN, travel costs, and times of departure and arrival. Additionally, user cost aspects including access time, in-vehicle time, and waiting times were assessed, alongside demographic characteristics of the respondents including age, gender, education, occupation, household income, and household size.

SPSS (Statistical Package for the Social Sciences) was selected for the statistical analysis in this study on travel behavior differences between rural and urban areas due to its user-friendly interface, extensive statistical capabilities, and widespread use in social sciences research. SPSS is known for its ability to handle large datasets efficiently and perform complex analyses with relative ease [15]. Its wide range of statistical tools, including descriptive statistics, correlation analysis, and hypothesis testing, makes it ideal for exploring patterns and differences in travel behavior between rural and urban contexts [16]. Additionally, SPSS's ability to produce clear and interpretable output, along with its flexibility in data manipulation, ensures that the analysis is both accurate and comprehensible [17]. The software's robustness in handling various data types and its compatibility with multiple data formats made it a suitable choice for analyzing the diverse variables involved in the study of travel behavior across different geographic regions.

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3.1. Izmir Urban Rail Mass Transit System (IZBAN)

The public transportation pricing system in Izmir exhibits considerable variability. A flat fare structure is employed for services such as buses, the metro, and trams. Conversely, a distance-based fare system is applied on certain long-distance bus lines and suburban trains [18]. IZBAN, a prominent component of Izmir's public transit network, has been operational since 2010, linking Aliağa and Selçuk. It represents one of Turkey's largest urban rail mass transit systems connected to the airport [19].

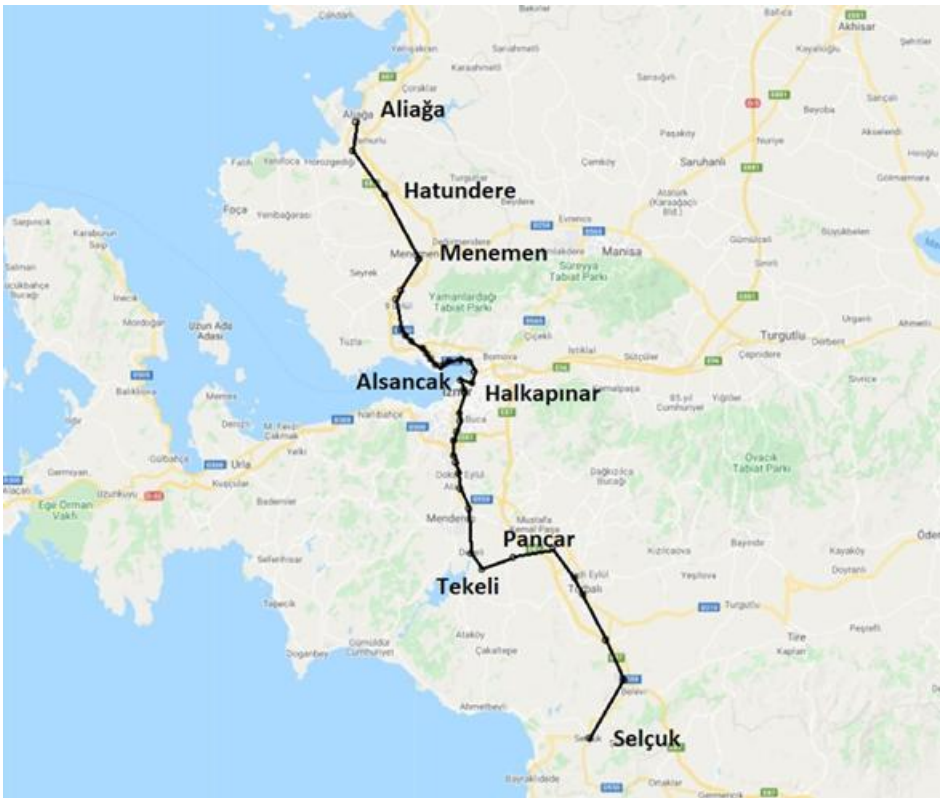

Figure 1. IZBAN stations (Google Maps).

Initially, IZBAN operated with 31 stations. This number increased to 32 with the addition of the Hilal station, and further expanded to 38 following the inauguration of the Torbalı line. The network grew to 40 stations with the opening of Saglık and Selcuk stations in 2019. Notably, the Hilal and Halkapınar stations serve as key interchange points between Izmir Metro and IZBAN [20].

IZBAN serves approximately 650,000 passengers daily, with the current line extending 136 kilometers. Upon completion of the expansion project, the total length of the line will reach 185 kilometers, extending to Bergama [19]. Initially, IZBAN operated on a flat fare system; however, in 2018, it transitioned to a distance-based pricing model. Under this system, passengers are initially charged based on the maximum distance from their departure station. At their arrival station, any fare corresponding to the distance not traveled is subsequently refunded.

All transportation fares and rent cost data referenced in this study correspond to the year 2019, which reflects the period during which the survey was conducted and aligns with the most recent available IZBAN and housing market data. The IZBAN ticket tariff is structured as follows: 2.86 TL for full fare passengers, 1.65 TL for students, 2.20 TL for teachers, and 1 credit for staff when traveling within the flat fare distance limit of 25 kilometers. Despite this, the distance-based pricing system presents several challenges for passengers.

Passengers are required to preload their transportation cards with varying amounts of money depending on their departure station. For instance, a passenger departing from Aliağa must maintain a minimum balance of 10.60 TL on their card, calculated based on the fare to the farthest station, such as Selçuk. This requirement is often perceived as costly by passengers. Additionally, there is the issue of passengers potentially forgetting to claim refunds for unused fare at arrival stations. These factors may deter passengers from using IZBAN, prompting them to seek alternative public transportation options.

3.2. Data Collection

As part of the data collection process, the following information has been gathered from the Izmir Metropolitan Municipality Suburban and Rail System Investments Department:

- IZBAN's station information and line length
- Distance between stations
- Travel time between stations
- Annual passenger numbers for each stop
- Ticket tariffs under the flat rate system (from IZBAN's inception until the transition to the distance-based pricing system)
- Travel prices between each stop under the distance-based pricing system

Based on the data collected, a preliminary survey was conducted to assess the relevance and effectiveness of the questions for a more comprehensive questionnaire. Following this evaluation, a detailed survey was administered to IZBAN passengers.

The interviewer-assisted method is frequently employed by researchers for data collection and is typically categorized into two types: personal interviews and telephone interviews. While telephone interviews can be efficient, they present several drawbacks, including potential misunderstandings of questions, a higher risk of incomplete responses, and constraints related to time. Additionally, given that the target group for this study consists of IZBAN passengers, reaching them via telephone interviews poses significant challenges. Consequently, personal interviews are deemed the most effective approach for this research, ensuring clearer communication and better engagement with participants.

To enhance the statistical efficiency of the survey, the number of surveys conducted at each train station is determined based on ridership data. The formulation used for this calculation is provided as follows [21]:

$$n_i = n\left(\frac{N_i}{\sum_{i=1}^{L} N_i}\right) = n\left(\frac{N_i}{N}\right) \quad (1)$$

where n is the total number of sample units, n_i is the number of sample units to allocate to stratum *i*, L is the number of strata, N_i is the number of sample units within stratum *i*, N is the number of sample units in the population.

3.3. Survey Design

The questionnaire is structured into two distinct sections. The first part focuses on capturing information related to participants' travel behavior, user costs, and demographic characteristics. The

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second part aims to identify passengers' priorities regarding public transportation and assess their perceived importance of rental prices and travel distances. To achieve comprehensive insights, both revealed preference and stated preference methods are utilized within the questionnaire.

The revealed preference section of the questionnaire includes detailed inquiries into demographic information, travel behavior characteristics, and user costs, with responses providing quantitative data. In the pre-questionnaire phase, the rent-distance relationship is evaluated without considering immediate travel behavior conditions. Consequently, the questions are designed to gather information on the following aspects:

Card Type: Type of transportation card used
Travel Frequency: How often the participant travels
Mean Travel Time: Average duration of travel
Travel Days: Days of the week the participant travels
Journey Hours: Time of day for outward and return journeys
Access Type to IZBAN: Method of reaching the IZBAN station
Departure and Arrival Stations: Stations used for the journeys
Travel Purpose: Reasons for travel
Preferred Public Transportation Mode: Most frequently used mode of public transport
The demographic section addresses:
Gender, Age, Education, Occupation, Monthly Household Income,
Closest IZBAN Stop: Nearest station to the participant's location
Car Ownership: Whether the participant owns a car
Rental Status: Housing situation (own or rent)
Rental Price: Cost of current housing
Additionally, the third part of the questionnaire seeks to gather information on:
In-Vehicle Travel Time: Duration spent traveling within the vehicle
Waiting Time: Time spent waiting for the vehicle
Access Time: Time required to access IZBAN, including the journey from home to the station and from the turnstile to the platform.

In the stated preference method applied to the section addressing passenger expectations from public transportation, the following factors are evaluated: Ticket Price, Travel Time, Waiting Time and Comfort.

Each factor is compared against the others to assess its relative importance to users. This approach is designed to gauge how passengers prioritize these aspects of public transportation and to understand their preferences in terms of value and service quality. The insights gained from this analysis will help in identifying which factors are most critical to passengers and how they influence their overall satisfaction with public transportation.

Based on the 2018 IZBAN data, which reports a total of 84,450,567 passengers annually and a daily ridership of 231,371, the sample size for the survey is determined using Yamane [22]'s formula. For a 95% confidence level and assuming a proportion P=0.5, the required sample size is calculated as follows:

$$n = \frac{N}{1 + N(e^2)} \tag{2}$$

where n is the sample size, N is the population size, e is the level of precision.

A total of 606 questionnaires were administered, with the distribution of participants across stations based on annual ridership data. The number of participants for each station is calculated by applying the percentage distribution of annual ridership to the total number of surveys. For example:

Şirinyer Station: With an annual ridership of 7,848,161, the station has 72 participants.

Ciğli Station: With an annual ridership of 3,478,991, the station has 32 participants.

The survey does have certain limitations:

Passengers Under Age 18: This group is excluded from the survey because they may lack the financial independence required to answer questions about rent and other economic factors, as they often rely on family support.

University Students in Dormitories: These individuals are also excluded from the survey due to the relevance of rent prices to the study. University students residing in dormitories are not typically responsible for rental expenses, which makes their input less applicable to the research focus on rent prices and related financial considerations.

4. ANALYSIS AND RESULTS

4.1. Analysis of Travel Behavior Patterns

The results of the IZBAN passenger survey align with several findings in the literature regarding public transportation usage patterns and factors affecting commuter behavior. Table 1 represents descriptive statistics of the survey.

Ticket Types and Usage Patterns: The predominance of full fare cards (67%) and the substantial use of student cards (24.8%). This reflects a broader trend where standard fare systems dominate public transportation usage, particularly in environments with substantial student populations.

Journey Frequency and Peak Hours: The finding that 27.90% of passengers use IZBAN five days a week mirrors trends observed in other urban transit systems where daily commuters frequently utilize public transport during peak hours [23]. The peak travel period between 06:00 and 10:00, and the low usage between 20:00 and 24:00, correspond with findings that peak hours are characterized by higher ridership due to work-related travel [24].

Travel Time Perceptions: The perception of journey time as short by 34.70% of passengers and very long by 0.70%. Short journey times are often perceived positively, while long journey times can significantly impact passenger satisfaction.

Return Trip Patterns: The predominance of return trips between 16:00 and 20:00 (47.40%) reflects a common pattern in commuter behavior, where significant travel activity occurs during the late afternoon and early evening due to work-related returns. The low return trip frequency between 06:00 and 10:00 highlights the difference in travel behavior patterns compared to outward journeys.

Travel Purposes: The high proportion of trips for school and work (48.10%) and visiting (41.30%). The minimal use for emergencies (1.20%) corroborates findings that emergency trips are less frequent compared to regular commuting and social activities.

Access Modes: The finding that 49.80% of passengers walk to IZBAN stations and 45.20% use other public transportation modes is supported by studies on multimodal access to transit systems, where walking and transfers from other public modes are common [25]. The low usage of cars (3.60%) aligns with the preference for non-motorized access to reduce parking and congestion issues around transit hubs.

Mode Preferences: The high utilization rate of IZBAN (44.20%) compared to other public transportation modes, particularly ferries (1.80%), highlights the importance of proximity to major transit routes.

These results reflect broader trends observed in the field of urban transportation and provide valuable insights into the usage patterns and preferences of IZBAN passengers.

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Table 1. Descriptive statistics of the survey

Questions		Frequency	Percent (%)
Rental Status	*Yes*	237	39.1
	No	369	60.9
Card Type	*full fare*	406	67.0
	student	150	24.8
	teacher	8	1.3
	60 years	19	3.1
	staff card	14	2.3
	Over 65 free card	9	1.5
Journey Frequency	*5 or more times a week*	169	27.9
	3-4 times in a week	103	17.0
	1-2 times in a week	154	25.4
	1-3 times in a month	118	19.5
	Less than once a month	62	10.2
Mean Travel Time	*very short*	79	13.0
	short	210	34.7
	short middle	132	21.8
	middle	94	15.5
	long middle	68	11.2
	long	19	3.1
	very long	4	.7
Journey Days	*In-week*	261	43.1
	Weekend	174	28.7
	Both	171	28.2
Outward Journey Time	*06:00-10:00*	236	38.9
	10:00-13:00	134	22.1
	13:00-16:00	142	23.4
	16:00-20:00	83	13.7
	20:00-24:00	11	1.8
Return Journey Time	*06:00-10:00*	4	.7
	10:00-13:00	8	1.3
	13:00-16:00	51	8.4
	16:00-20:00	287	47.4
	20:00-24:00	256	42.2
Access to IZBAN	*foot*	302	49.8
	other pt modes	274	45.2
	taxi	6	1.0
	own car	22	3.6
	bicycle	2	.3
Journey Purpose	*work*	201	33.2
	school	90	14.9
	visiting	250	41.3
	shopping,bank and other	58	9.6
	hospital	7	1.2
Public Transportation Type	*bus*	212	35.0
	railway	268	44.2
	ferry	11	1.8
	tramway	37	6.1
	metro	14	2.3
	dolmuş	64	10.6

Ridership Patterns and Station Characteristics: The highest ridership is observed at the Şirinyer stop, located in Buca, a district with significant population density and proximity to major commercial and residential avenues. Şirinyer benefits from its location in Izmir's most populous county, which has a population of 507,773 [26]. This high population density contributes to elevated ridership levels at this station. Table 2. shows descriptive statistics for departure and arrival stations.

The Halkapınar stop, an important transfer hub connecting the metro, bus, and tram networks, also experiences substantial ridership. Its strategic location near densely populated districts such as Bornova and Konak, where many metro passengers transfer from, further enhances its usage. This

finding aligns with literature indicating that transfer stations, especially those integrating multiple modes of transport, tend to attract higher passenger volumes due to increased connectivity [27].

Table 2. Descriptive statistics for departure and arrival stations.

	Station	Departure		Arrival	
		Frequency	Percent (%)	Frequency	Percent (%)
North Axix	Aliağa	16	2.6	25	4.1
	Biçerova	3	.5	1	.2
	Hatundere	5	.8	1	.2
	Menemen	27	4.5	26	4.3
	Egekent 2	17	2.8	12	2.0
	Ulukent	8	1.3	3	.5
	Egekent	21	3.5	15	2.5
	Ata Sanayi	17	2.8	3	.5
	Çiğli	39	6.4	26	4.3
	Mavişehir	18	3.0	14	2.3
	Şemikler	18	3.0	8	1.3
	Demirköprü	9	1.5	8	1.3
	Nergiz	13	2.1	14	2.3
	Karşıyaka	23	3.8	61	10.1
	Alaybey	8	1.3	3	.5
	Naldöken	4	.7		
	Turan	2	.3	9	1.5
Central Axis	Bayraklı	19	3.1	14	2.3
	Salhane	3	.5	11	1.8
	Halkapınar	62	10.2	55	9.1
	Alsancak	20	3.3	103	17.0
	Hilal	34	5.6	39	6.4
	Kemer	9	1.5	7	1.2
	Şirinyer	97	16.0	30	5.0
	Koşu	33	5.4	2	.3
	Inkılap	15	2.5	2	.3
	Semt Garajı	17	2.8	14	2.3
	Esbaş	9	1.5	45	7.4
	Gaziemir	10	1.7	19	3.1
	Samıç	9	1.5	9	1.5
	Havalimanı			15	2.5
	Cumaovası	5	.8	2	.3
	Develi				
	Tekeli			2	.3
	Pancar	1	.2		
	Kuşçuburun	1	.2		
South Axis	Torbalı	9	1.5	5	.8
	Tepeköy	5	.8	1	.2
	Sağlık				
	Belevi				
	Selçuk			2	.3

Similarly, the Hilal stop, which is connected solely to the metro, exhibits high ridership. This is consistent with the observation that stations with metro connections, particularly in areas with significant commuter traffic, generally have higher patronage.

In contrast, the Kuşçuburun, Hatundere, and Biçerova stops exhibit lower ridership levels. These stations are situated in rural areas, distant from the city center, which typically results in reduced usage [24]. The low ridership at these stops corroborates findings that stations located in less urbanized areas or farther from central commercial zones attract fewer passengers [28].

Furthermore, Develi, Tekeli, Sağlık, and Belevi stations also report minimal usage, likely due to their remote locations and lack of significant residential or commercial development. The Havalanı

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station, built primarily to serve the airport, and the recently constructed Selçuk station, along with Sağlık and Belevi stations in 2019, currently show no departures, reflecting their recent addition to the network and limited time for passenger establishment.

Arrival Station Ridership Patterns: The distribution of ridership across arrival stations exhibits notable patterns influenced by geographic and investment factors. Alsancak, a highly attractive area in Izmir known for its appeal to businesses, students, and tourists, shows the highest ridership. This aligns with findings that stations located in vibrant commercial and cultural hubs tend to attract more passengers [24].

Similarly, Karşıyaka, situated in the northern part of the city near popular bazaars, avenues, and the coast, also experiences high ridership. The station's proximity to these amenities contributes to its attractiveness and high passenger volume.

In contrast, Esbaş station, while also experiencing significant passenger traffic, shows a considerable disparity between arrival and departure ridership. Located near a major industrial free zone and Izmir's largest shopping mall, Esbaş serves primarily employees and shoppers, highlighting how commercial investments can influence station usage patterns [28].

Conversely, Hatundere and Biçerova are among the least preferred stations for arrival, reflecting their location in more rural and less accessible areas. The lack of ridership at these stations confirms previous research indicating that stations situated in less urbanized areas or with limited amenities attract fewer passengers [24].

Additionally, stations such as Naldöken, Develi, Pancar, Kuşçuburun, Sağlık, and Belevi are not selected as arrival stations, suggesting limited appeal or accessibility. The new Selçuk station, despite its status as a tourist destination, shows low ridership, which may be attributed to its novelty and the relatively low frequency of visits.

User Cost Components in the Passenger Survey:

The second part of the survey focuses on estimating various user cost components, including access time, platform access time, waiting time, and in-vehicle time. Table 3. indicates descriptive statistics of user cost components.

Access Time: A significant majority of passengers, 48.34%, reported an access time to IZBAN of 10 minutes or less, indicating efficient proximity for most users. In contrast, 3.30% of passengers experience an access time exceeding 30 minutes. The mean access time from home to the IZBAN station is 14.1980 minutes. These findings suggest that while most passengers have relatively short access times, a small segment experiences notably longer commutes, reflecting the variability in access times across different residential areas.

Platform Access Time: Regarding the time required to access the platform from the turnstile, 49.83% of passengers reported it takes 1 minute or less, which suggests efficient station design and minimal congestion. Conversely, 0.82% reported a platform access time exceeding 5 minutes. The average platform access time is 1.7163 minutes. These results indicate that most passengers face minimal delays when transitioning from the turnstile to the platform.

Waiting Time: The survey results show that 63.86% of passengers wait between 5 and 10 minutes at stations. A smaller percentage, 4.29%, report waiting times exceeding 15 minutes. The mean waiting time is 9.2855 minutes. These findings highlight that while most passengers experience moderate waiting times, a minority faces longer waits, potentially affecting overall travel satisfaction.

In-Vehicle Time: In-vehicle time, defined as the duration from entering to exiting the train, shows that 36.96% of passengers spend between 10 and 20 minutes on the train. However, 1.98% of passengers report an in-vehicle time exceeding 60 minutes. The average in-vehicle time is 25.9620 minutes. This data reflects a diverse range of journey lengths, with a substantial portion of passengers experiencing relatively short trips, while a small segment endures longer travel durations.

These components provide a comprehensive view of the typical travel experience for IZBAN passengers and underscore areas for potential improvement in service efficiency and user satisfaction.

Table 3. Descriptive statistics of user cost components.

Variable	Minimum	Maximum	Mean	Std. Deviation	Variance
Access time (home to IZBAN)	2.00	100.00	14.1980	10.61523	112.683
Access (to platform)	.16	12.50	1.7163	1.25045	1.564
Waiting time	1.00	30.00	9.2855	3.80683	14.492
In-vehicle time	3.00	105.00	25.9620	16.65601	277.423

Travel Distance and Pricing Patterns:

Most passengers, specifically 82.84%, travel 26 kilometers or less and thus are not subject to the distance-based pricing system. In contrast, only 0.17% of passengers travel distances exceeding 75 kilometers. For those traveling beyond 26 kilometers, the travel price is determined based on the distance traveled. Table 4. explains descriptive statistics of travel distance and travel price.

Regarding ticket tariffs, 55.94% of participants pay the standard fare of 2.86 TL, while 20.13% benefit from the discounted student tariff of 1.65 TL. Additionally, 16.34% of passengers are subject to the distance-based pricing rules. The mean travel distance reported is 15.8231 kilometers, and the average travel price is 2.5852 TL.

Table 4. Descriptive statistics of travel distance and travel price.

Variable	Minimum	Maximum	Mean	Std. Deviation	Variance
Travel distance	1.00	75.47	15.8231	13.65743	186.525
Travel price	0.00	6.39	2.5852	0.92979	0.865

These results are influenced by the availability of free or discounted tickets, such as those provided to individuals aged 65 and over, teachers, and staff. The presence of these discount schemes affects the overall distribution of travel costs among passengers, highlighting the impact of ticket tariff structures on travel expenditure.

Stated Preference Analysis:

In the stated preference section of the survey, passenger expectations for IZBAN were evaluated. The results indicate that passengers prioritize factors in the following order: travel time, travel price, waiting time, and travel comfort. Table 5. summarizes comparisons between travel time, price, comfort and waiting time.

This prioritization suggests that while comfort is a less critical factor for shorter trips, it becomes more significant for longer journeys.

The emphasis on travel time and price reflects the broader trend where efficiency and cost are primary determinants of travel behavior. The lower emphasis on comfort for short trips aligns with the expectation that shorter journeys are less likely to impact overall passenger satisfaction compared to longer trips.

Table 5. Comparisons between travel time, price, comfort and waiting time.

Criteria	Frequency	Percent (%)		Frequency	Criteria
Travel time	410	67.7	32.3	196	Price
Comfort	223	36.8	63.2	383	Price
Comfort	148	24.4	75.6	458	Travel time
Waiting time	47	7.8	92.2	559	Travel time
Waiting time	412	68.0	32.0	194	Comfort

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Demographic Information of Survey Participants:

The final section of the survey provides a detailed demographic profile of the respondents. Table 6. shows demographic results of the survey. Of the participants, 62.9% are male, while 37.1% are female. In terms of housing arrangements, 39.1% of respondents pay rent, whereas 60.9% own their homes.

Educational attainment among participants varies, with 48.3% holding a high school diploma, and only 0.8% having completed a doctoral program. This distribution highlights a predominance of secondary education among most respondents.

Employment status reveals that employees constitute the largest group of IZBAN users. Private sector employees lead with a rate of 54.8%, followed by students at 22.1%, and public sector employees at 9.7%. The survey also includes housewives, retirees, and individuals not currently engaged in work, with 1.7% of participants indicating that they do not work.

These demographic insights provide a comprehensive understanding of the IZBAN user base, reflecting a predominantly male, employed population with varying levels of educational attainment.

Table 6. Demographic results of the survey.

Questions		Frequency	Percent (%)
Gender	*female*	225	37.1
	male	381	62.9
Education	*primary school*	71	11.7
	high school	293	48.3
	vocational school	64	10.6
	bachelor	154	25.4
	master	19	3.1
	Ph.D.	5	.8
Occupation	*public sector*	59	9.7
	private sector	332	54.8
	student	134	22.1
	housewife	33	5.4
	retired	38	6.3
	non-worker	10	1.7

Age and Household Composition of Survey Participants:

Participants under the age of 18 were excluded from the study due to their likely dependency on family units, which could affect their financial independence and rental decisions. The majority of survey respondents are employees aged between 27 and 59, comprising 49.83% of the sample. In contrast, only 1.49% of participants are over the age of 65. The mean age of the participants is 32 years. Table 7. Indicates descriptive statistics of age and household size.

Regarding household size, the number of household members among participants ranges from 1 to 12. Notably, 31.7% of the respondents come from households with four members. The average household size is between 3 and 4 individuals. This distribution highlights a predominance of moderately sized households among the survey population.

These demographic details provide valuable context for understanding the socio-economic background of IZBAN users, which may influence their travel behaviors and preferences

Household Income and Rent Preferences:

Household income is a crucial factor in evaluating housing and transportation affordability, as many individuals consider their income when making purchasing decisions [29]. Accordingly, household income data was collected for this study to understand its impact on travel and rental preferences. Table 8. explains distribution of income, rent price and car ownership. Among the survey participants, 16.8% report a household income ranging from 4000 to 5000 TL, representing the highest proportion within all income brackets. The average monthly household income of participants is between 5000 and 6000 TL.

Table 7. Descriptive statistics of age and household size.

Variable	Minimum	Maximum	Mean	Std. Deviation	Variance
Age	18.00	76.00	31.9455	12.18109	148.379
Household size	1.00	12.00	3.4752	1.39606	1.949

Table 8. Distribution of income, rent price and car ownership.

Variable		Frequency	Percent (%)
Household income	*below 2000TL*	25	4.1
	2000-2999TL	79	13.0
	3000-3999 TL	100	16.5
	4000-4999 TL	102	16.8
	5000-5999 TL	82	13.5
	6000-6999 TL	69	11.4
	7000-7999 TL	37	6.1
	8000-8999 TL	26	4.3
	9000-9999 TL	36	5.9
	10.000-10.999	16	2.6
	11.000-11.999	6	1.0
	12.000 TL and	28	4.6
Rent cost	*Below 500 TL*	22	3.6
	500-744 TL	66	10.9
	750-999 TL	162	26.7
	1000-1249 TL	125	20.6
	1250-1499 TL	83	13.7
	1500-1749 TL	54	8.9
	1750-1999 TL	33	5.4
	2000-2249 TL	28	4.6
	2250-2499 TL	11	1.8
	2500-2749 TL	14	2.3
	2750-2999 TL	3	.5
	3000 TL and	5	.8
Car ownership	*yes*	256	42.2
	no	350	57.8

Regarding rental preferences, all participants were asked about their potential rent payments, even those currently living in their own homes. If they did not own a house, 26.7% indicated they would be willing to pay between 750 and 1000 TL for rent, while only 0.5% would pay between 2750 and 3000 TL. The mean rent preference is between 1000 and 1250 TL.

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Car ownership is also a significant factor influencing travel behavior. The survey results show that 42.2% of participants own a car, whereas 57.8% do not. This indicates that a substantial proportion of respondents prefer using IZBAN over personal vehicles, underscoring the role of public transportation in their travel choices.

Distribution of Closest IZBAN Stops:

The distribution of the closest IZBAN stops among participants mirrors the patterns observed for departure stations. Table 9. indicates closest IZBAN stations to participants. The Şirinyer stop, with its high population density, accounts for the largest share of 16.2% of respondents. This is followed by the Halkapınar and Ciğli stops, which also show relatively high representation.

In contrast, stops such as Kuşçuburun, Pancar, and Tekeli have the lowest representation, each comprising only 0.2% of the total. Additionally, certain stops—including Havalimanı, Develi, Sağlık, Belevi, and Selçuk—were not selected by any respondents as their closest stop. This lack of selection for these stations likely reflects their lower accessibility or the limited residential areas surrounding them.

These findings highlight the influence of demographic factors and stop accessibility on the selection of IZBAN stations by passengers.

Table 9. Closest IZBAN stations to participants.

Station	Frequency	Percent (%)	Station	Frequency	Percent (%)
Aliağa	16	2.6	Salhane	4	.7
Biçerova	3	.5	Halkapınar	57	9.4
Hatundere	5	.8	Alsancak	15	2.5
Menemen	30	5.0	Hilal	30	5.0
Egekent 2	18	3.0	Kemer	10	1.7
Ulukent	8	1.3	Şirinyer	98	16.2
Egekent	20	3.3	Koşu	34	5.6
Ata Sanayi	16	2.6	Inkılap	18	3.0
Çiğli	36	5.9	Semt Garajı	16	2.6
Mavişehir	20	3.3	Esbaş	9	1.5
Şemikler	18	3.0	Gaziemir	9	1.5
Demiröprü	9	1.5	Sarnıç	7	1.2
Nergiz	16	2.6	Cumaovası	6	1.0
Karşıyaka	27	4.5	Tekeli	1	.2
Alaybey	9	1.5	Pancar	1	.2
Naldöken	4	.7	Kuşçuburun	1	.2
Turan	2	.3	Torbalı	7	1.2
Bayraklı	19	3.1	Tepeköy	7	1.2

The results of the t-test, as shown in Figure 2, indicate a significant difference between rural and non-rural station passenger counts, with a p-value of 0.0147, which is below the 0.05 threshold for statistical significance. The t-statistic of -2.5849 indicates that the rural group has a lower mean passenger count than the non-rural group. The degrees of freedom for the test are 31, reflecting the number of independent observations in the data. Cohen's d value of -1.0103 suggests a large effect size, meaning that the difference between the two groups is substantial in terms of standard deviations. Overall, the findings indicate that rural stations have fewer passengers than non-rural stations, and this difference is both statistically significant and practically meaningful.

The results presented in Table 10 highlight significant differences in travel behavior and preferences between urban and rural travelers. Urban commuters generally have shorter travel times (-0.234, $p < .001$), including reduced access time to the platform (-0.097, $p = .016$), waiting time (-0.088, $p = .031$), and in-vehicle time (-0.283, $p < .001$). They also live closer to IZBAN stations (-0.084, $p = .038$) and pay significantly higher rent (-0.454, $p < .001$). In terms of preferences, urban travelers prioritize comfort over waiting time (-0.117, $p = .004$) and are less willing to wait longer for cheaper tickets (-0.124, $p = .002$). Their commutes are typically shorter (-0.186, $p < .001$), and they mostly access IZBAN by walking or using public transport.

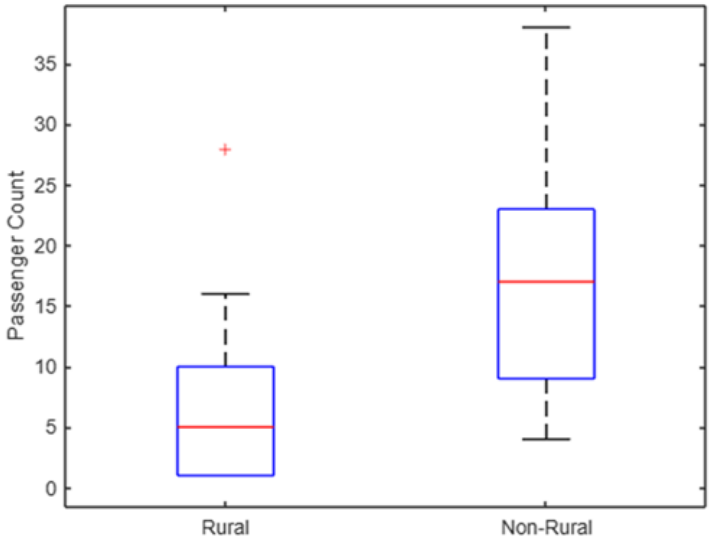

Figure 2. Comparison of passenger counts between rural and urban stations

Table 10. Correlation and Interpretation of Travel Variables Between Urban and Rural Travelers

Variable	Correlation	p-value	Interpretation
Mean travel time	-0.234	<.001	Urban travelers have shorter travel times compared to rural travelers.
Access time to platform	-0.097	0.016	Urban travelers take slightly less time to reach the platform.
Waiting time for train	-0.088	0.031	Urban travelers experience slightly shorter wait times.
In vehicle time	-0.283	<.001	Urban travelers spend significantly less time inside the vehicle.
Waiting time or ticket price	-0.124	0.002	Urban travelers are less willing to tolerate longer waiting times for cheaper tickets.
Comfort or waiting time	-0.117	0.004	Urban travelers value comfort more over waiting time.
Distance to IZBAN stop	-0.084	0.038	Urban travelers live closer to an IZBAN station.
Rent price	-0.454	<.001	Urban areas have significantly higher rental prices.
Travel distance	-0.186	<.001	Urban travelers commute shorter distances.
Access to IZBAN	0.082	0.043	Rural travelers are slightly more likely to access IZBAN using taxis or their own cars. Urban travelers are slightly more likely to access IZBAN by foot or public transportation.
Arrival station	0.142	<.001	Rural travelers are more likely to arrive at rural stations.
Comfort or travel time	0.281	<.001	Rural travelers are more willing to sacrifice travel time for comfort.

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On the other hand, rural travelers depend more on taxis or private cars to reach IZBAN (0.082, p = .043). Their journeys frequently begin or end at rural stations (0.142, p < .001), and they demonstrate a stronger preference for comfort over shorter travel times (0.281, p < .001).

5. CONCLUSION AND DISCUSSIONS

This study aimed to investigate the differences in travel behavior between urban and rural passengers using the IZBAN public transportation system in Izmir. The scope of the research included an analysis of commuter patterns, access methods, and preferences across different geographic contexts. A quantitative methodology was employed, using survey data and statistical analyses (including t-tests and effect size measures) to identify significant behavioral differences between the two groups.

The results highlight a clear distinction in both commuter patterns and preferences, as urban travelers demonstrate shorter travel times, reduced access and waiting times, and closer proximity to IZBAN stations, contributing to their higher rental prices. These findings are statistically significant, with p-values consistently below 0.05 and Cohen's d values indicating large effect sizes, particularly for the differences between rural and non-rural stations (t-statistic of -2.5849, p = 0.0147). Urban travelers' tendency to prioritize comfort over waiting time and their general reliance on walking or public transportation further emphasize the ease of access and efficiency in urban environments. Conversely, rural travelers experience longer commutes, with more reliance on private cars and taxis for access to IZBAN, and they demonstrate a stronger preference for comfort over shorter travel times.

The study's analysis reveals that the proximity to public transportation and the quality of the commute influence residential choices, with urban dwellers facing higher rents due to the benefits of accessibility and convenience (p-value < 0.001). Rural commuters, on the other hand, are more likely to use private transport modes and are more willing to sacrifice travel time for comfort. These findings underline the crucial role that transit systems, such as IZBAN, play in shaping travel behavior and residential patterns, contributing to both commuter satisfaction and urban housing market dynamics.

By providing statistical evidence of the significant differences in travel behavior between rural and urban passengers, this research not only deepens our understanding of commuter preferences but also informs urban planners and policymakers seeking to optimize transportation systems and address housing affordability. The implications of these findings extend beyond Izmir, offering valuable lessons for other cities with similar characteristics, such as Paris, Istanbul, and Berlin, where the dynamics of public transportation are similarly intertwined with residential choices and urban development. The study paves the way for future research exploring how public transportation systems can be further integrated with urban planning to promote accessibility, affordability, and sustainability across diverse regions.

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Conflicts of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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