ISTANBUL TECHNICAL UNIVERSITY ★ GRADUATE SCHOOL OF SCIENCE ENGINEERING AND TECHNOLOGY

DETERMINATION OF WALK ACCESS DISTANCE TO URBAN FERRY-BOAT PIERS IN ISTANBUL

M.Sc. THESIS

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Department of Civil Engineering

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Thesis Advisor: Prof. Dr. Kemal Selçuk ÖĞÜT

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ISTANBUL TEKNİK ÜNİVERSİTESİ ★ FEN BİLİMLERİ ENSTİTÜSÜ

İSTANBUL'DA VAPUR İSKELELERİNE YÜRÜME ERİŞİM UZUNLUĞUNUN BELİRLENMESİ

YÜKSEK LİSANS TEZİ

Kiana SANAJOU
(501151430)

İnşaat Mühendisliği Anabilim Dalı

Ulaştırma Mühendisliği Programı

Tez Danışmanı: Prof. Dr. Kemal Selçuk ÖĞÜT

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Kiana SANAJOU, a **M.Sc.** student of İTU **Graduate School of Science Engineering and Technology** student ID 501151430, successfully defended the thesis entitled "**DETERMINATION OF WALK ACCESS DISTANCE TO URBAN FERRY-BOAT PIERS IN ISTANBUL**", which she prepared after fulfilling the requirements specified in the associated legislations, before the jury whose signatures are below.

Thesis Advisor : **Prof. Dr. Kemal Selçuk ÖĞÜT** ....
Istanbul Technical University

Jury Members : **Assoc. Prof. Dr. Hüseyin Onur TEZCAN** ....
Istanbul Technical University

Assoc. Prof. Dr. Mustafa GÜRSOY ....
Yildiz Technical University

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To my mom for her love,

endless support and encouragement.

FOREWORD

As a civil engineer, I believe there is a magic power of civil engineering in effecting radical social and economic changes. From the very outset, it is precisely this magic power of civil engineering that has fascinated me as a scientific discipline. I always was interested in transportation and traffic subjects in my hometown, Urmia.

Urmia is not a developed city in this issue. However, the population of the city is growing, hence, the car-ownership and traffic congestion are increasing. Public transportation can be one of the most important solutions to traffic issues. Maritime transport is one of the public transportation branches in Istanbul. Accessibility to transit stations and find the effective area of the transportation stations is something important which can be used in planning and four-step transportation model of a city. When my professor suggested me to analyze the passenger's walk access distance for ferry piers, as my thesis, I was highly motivated to do this.

I would like to thank my supervisor Prof. Dr. Kemal Selçuk ÖĞÜT for his endless guidance, support and motivation throughout my graduate school life and especially, during my thesis period.

Thanks to Assoc. Prof. Dr. Hüseyin Onur TEZCAN, that always accepted to help me generously.

For the people who always stood beside me in all the hard times, I show my respect and thanks to my sisters. Finally, for the one person who always believed in me, and without her prayers, I wouldn't be the person I am now. I cannot thank her enough for what she has accomplished was miraculous. Mom, thanks for everything.

April 2018

Kiana Sanajou
(Civil Engineer)

TABLE OF CONTENTS

ABBREVIATIONS

PT	**:** Public Transportation
WAD	**:** Walk Access Distance
TTS	**:** Transportation Tomorrow Survey
TTC	**:** Toronto Transit Commission
GIS	**:** Geographic Information System
LRT	**:** Light Rail Transit
CBD	**:** Central Business District
TOB	**:** Transit Onboard
GEE	**:** Generalized estimating equations methods
GPS	**:** Global Positioning System
IMM	**:** Istanbul Metropolitan Municipality
IETT	**:** Istanbul Electricity Tramway Tunnel General Management
ÖHO	**:** Özel Halk Otobüs
OAŞ	**:** Istanbul Otobüs işletmeleri A.Ş.
IDO	**:** Istanbul Deniz Otobüs A.Ş.
K-S	**:** Kruskal-Wallis
A-D	**:** Anderson-Darling

LIST OF TABLES

LIST OF FIGURES

Page

DETERMINATION OF WALK ACCESS DISTANCE TO URBAN FERRY-BOAT PIERS IN ISTANBUL

SUMMARY

Cities and metropolitan areas are the centers of diverse activities, which require efficient and convenient transportation of persons and goods. It is often said that transportation is the lifeblood of cities. All over the world, as the population is growing, the daily needs of life are increasing, similarly. The growth of population follows issues such as economic viability, environmental impacts, regional pattern development. In a developing society, people try to improve the life quality and reach their daily activities. With regard to this, they use public or private transportation systems according to their certain goals.

The high density of activities makes it possible and necessary that high capacity modes, such as bus, light rail, metro, and maritime, have to be used because they are more economical, more energy efficient and occupies less space than private cars. Furthermore, the public transportation modes provide service for everybody, while cars can only be used by those who own and can drive them. Thus, cities need and benefit from public transportation services, which offer greater mobility for the entire population.

Walking is one of the most important transportation modes that transportation planners should consider because of its attractiveness and ease of accessibility. Given the presence of a safe network and convenient pedestrian facilities, as well as the availability of probable destinations within walking distance of one's trip origin, walking can be the best mode for a variety of short trips, such as school trips, running errands, and recreational and exercise trips.

Even though there are lots of mode choices to reach transit stations commuters try to reach a transportation station by walking if the access distance is short. This access distance, from the residences or business centers to the station, is accepted around 300-400 meters for buses and around 700-800 meters for subways and trams, which might be different in various countries due to the local conditions.

The aim of this study is to determine the walk access distance to urban ferry boat piers and examine the relationship between walk access distance and different socioeconomic characteristics of users in Istanbul. Chapter one of this thesis includes the motivation, objectives, and organization. Chapter two contains the literature review and past studies about walk access distance and transit accessibility. Chapter three contains a brief information about public transportation in Istanbul and chapter four comprises the case study. Finally, chapter five is the conclusion chapter.

In order to find the relationship between walk access distance and socioeconomic characteristics of passengers, a survey was conducted at five different inner-city passenger ferry-boat piers in Istanbul, Turkey. The socioeconomic characteristics of commuters used in this study are the gender, the age which is divided into three groups;

under 25, 25-65, and more than 65 years old, availability of car in the household, income; divided into five groups, and purpose of travel; divided into two groups. The groups of income are divided based on the minimum wage in Turkey, which is approximately 1500 Turkish Lira (TL). The purpose of the journey is divided based on the passenger's activities into two groups; obligatory and non-obligatory trips. To investigate the distribution of the dataset at each ferry-boat piers, Chi-Square, Kolmogorov-Smirnov, and Anderson-Darling tests were implemented. Furthermore, to determine the differences in statistical effects of each variable groups Kruskal-Wallis H test and Mann-Whitney U test were done. The results of Kruskal-Wallis H and Mann-Whitney U tests showed that there is no statistical difference between the purpose of travel and the availability of car in the household groups on walk access distances. However, there is a statistical difference between the gender and the profession of passenger groups in term of walk access distance.

With regard to peoples' answers to the question "How long does it take to walk from their origin or destination point to the pier?" and by using the average walking speeds given in the "Urban Roads-Design criteria on sidewalks and pedestrian areas" (TS 12174), the duration converted to distance. Hence, by measuring the real distance from google maps, we tried to estimate how many of passengers guess their walking distance accurately.

In addition, regression analyses were accomplished in order to determine the relationship between different considered variables and walk access distance of passengers.

İSTANBUL'DA VAPUR LİMANİNA YÜRÜME ERİŞİM UZUNLUĞUNUN BELİRLENMESİ

ÖZET

Şehirler, kişilerin ve malların verimli ve rahat bir şekilde taşınmasını gerektiren çeşitli etkinliklerin merkezleridirler. Ulaşımın şehirlerin can damarı olduğu sık sık söylenir. Tüm dünyada nüfus artmasına bağlı olarak günlük yaşam gereksinimleri de artmaktadır. Nüfusun artması; ekonomik yaşanabilirlik, çevresel etkiler, bölgesel gelişme gibi konuları gündeme getirmektedir. Gelişen bir toplumda insanlar yaşam kalitesini yükseltmeye ve günlük etkinliklere erişmeye çalışmaktadırlar. Buna göre, insanlar toplu ve özel taşıma sistemlerini belirli amaçlarına göre kullanmaktadır.

Toplu taşıma istasyonlarına ulaşmak için birçok ulaşım türü seçeneği vardır. Yüksek yoğunluklu etkinlikler, yüksek kapasiteli türlerin kullanılmasını gerektirmektedir. Otobüs, hafif raylı sistem, metro ve deniz taşımacılığı gibi türlerin, daha ekonomik, daha enerji verimli olmaları ve özel taşıtlardan çok daha az alan kaplamaları sebepleriyle kullanımları artmaktadırlar. Ayrıca, toplu taşıma türleri tüm insanlara hizmet verirken, arabalar genellikle yalnızca kendi sahipleri tarafından kullanılmaktadırlar. Bu nedenle, şehirler, daha fazla hareket edebilme olanağı sunan toplu taşıma hizmetlerine gereksinim duymaktadır.

Yürüme, ulaştırma planlamacılar tarafından düşünülmesi gereken en önemli türlerden biridir, çünkü bir ulaşım türünün erişimi ve çekiciliği çok önemlidir. Güvenli bir ağın ve elverişli yaya erişim olanaklarının yanı sıra, yolculuğun yürüme uzaklığında olması okul, iş ve eğlence amaçlı çeşitli kısa yolculuklarda bu türün tercih edilmesine neden olmaktadır. Çevresel unsurların yürüyüş deneyimine etkileri bulunmakta, dolayısıyla yayalar tarafından algılanan hizmet kalitesine de katkıda bulunurlar. Çevresel unsurlar bir yaya geçitin erişim kolaylığına, konforuna ve güvenliğine doğrudan etki edebilir. Örneğin, bir yürüyüş deneyiminde kullanılacak geçitteki kaldırım rampalarının fazlalılığı, yönlendirme tabelalarının eksik oluşu, değişken hava koşulları sebebiyle ortaya çıkabilecek su birikintisi yada buzlanma gibi sorunlar bu deneyimi olumsuz yönde etkileyecektir.

Bu çalışmada, İstanbul'un beş farklı vapur iskelesinde (Beşiktaş, Eminönü, Kadıköy, Karaköy, ve Üsküdar) yolcuların iskeleye yürüme erişim uzunluğunun sosyo-ekonomik özellikleriyle ilişkisini bulmak amaçlanmış, bu kapsamda hafta içi zirve ve zirve dışı saatlerde bir anket çalışması yapılmıştır.

İlk olarak yürüme uzunluklarının istatistiksel dağlımları Ki-Kare, Kolmogorov-Smirnov ve Anderson-Darling testleriyle incelenmiş ve verilerin hangi dağlıma uyumlu olduğu saptanmıştır. Ayrıca, her değişken grubunun istatistiksel etkilerindeki farklılıkları belirlemek için Kruskal-Wallis H ve Mann-Whitney U testleri yapılmıştır.

Buna ek olarak, farklı sosyo-ekonomik değişkenler ile yolcuların yürüme uzunluğu arasındaki ilişkiyi belirlemek için regresyon çözümlemeleri gerçekleştirilmiştir.

Çalışmanın bölümleri ve bu bölümlerde incelenen konular aşağıda kısaca açıklanmaktadır.

Birinci bölüm, çalışmanın kısa bir özetini içermektedir. Bu bölüm tezin motivasyonunu, hedeflerini ve organizasyonunu kapsamaktadır.

İkinci bölüm, yürüyüş erişim uzunluğu ve ulaşım erişilebilirliği ile ilgili literatür taraması ve geçmiş çalışmaları içermektedir. Literatürde erişim ve yürüme uzunluğu ile ilgili yapılan çalışmalar ayrıntılı bir şekilde sunulmaktadır. Bu çalışmalarda toplu taşıma istasyonuna yürüme uzunluğunun yolcuların yaşı, cinsiyeti, yolcuların ortalama geliri, ve taşıt sahipliğile ilişkileri varlıklarının etkileri incelenmiştir.

Tezin üçüncü bölümünde İstanbul'daki toplu taşıma sistemleri hakkında kısa bilgiler verilmektedir. Bu bölümde İstanbul'da toplu taşımanın çeşitli türleri, bu türlerin ortalama günlük kullanım oranları sunulmaktadır.

Dördüncü bölümde tezin saha çalışması açıklanmıştır. Yürüme uzunluğu ile yolculuk yapanların sosyo-ekonomik özellikleri arasındaki ilişkiyi bulmak için İstanbul'un beş farklı şehir içi vapur iskelelerinde 2017 Haziran ve Temmuz aylarında anket çalışması gerçekleştirilmiştir. Yolcuların yürüme uzunluğunu etkileyen sosyo-ekonomik özelliklerini araştırmak amacıyla, yolcular; kadın ve erkek olarak iki gruba, yaş aralığı olarak da 25'den küçük, 25 ve 65 yaş arası, ve 65 yaş üzeri olmak üzere üç farklı gruba ayrılmıştır. Evde otomobil varlığı, dikkate alınan değişkenlerdendir. Türkiye'deki asgari ücret göz önüne alınarak, yolcuların aylık ortalama gelirleri; 1500 TL'ye kadar, 1500 ve 3000 TL arası, 3000 ve 4500 TL arası, 4500 ve 6000 TL arası, ve 6000 TL üzeri olmak üzere beş farklı gruba ayrılmıştır. Yolcuların farklı yolculuk amaçları da dört farklı gruba ayrılarak bu çalışmada yer almaktadır.

Beş iskelede yolcuların yürüme uzunluklarının dağlımlarını bulmak için Ki-Kare, Kolmogorov-Smirnov ve Anderson-Darling testleri yapılmıştır. Her beş iskelede yürüme uzunluklarının Normal Dağılım'a uymadığı görülmüştür. Anketde toplanan verilerin yürüme uzunlukları nasıl etkileri olduğunu görmek için Kruskal-Wallis H ve Mann-Whitney U test yapılmıştır. Kruskal-Wallis H ve Mann-Whitney U testlerinin sonuçları yürüme uzunluğunda seyahat amacı, taşıt sahipliği grupları arasında istatistiksel olarak bir fark olmadığını göstermiştir. Bununla birlikte, cinsıyet ve meslek grupları arasında istatistiksel olarak fark olduğu görülmüştür.

Çok değişkenli regresyon çüzmlemeleriyle her beş iskelede, seçilen değişkenler ve yolcuların yürüme uzunlukları arasındaki ilişki araştırılmıştır.

Beşinci bölümde ise bu tezin sonuçları yer almaktadır. Bu bölümde elde edilen sonuçlar verilmiş ve ileride yapılabilecek çalışmalar konusunda düşünceler belirtilmiştir.

Yolcuların erişim ve yürüme uzunluğundaö her beş iskelede de yolcuların cinsiyet ve taşıt sahipliğinin etken bir değişken olmadıkları görülmüştür. Yaş gruplarına göre yürüme uzunluğu için genel bir sonuca varmak ıse mümkün değildir.

Yolcuların ne iş yaptıklarıyla yürüme uzunlukları arasındaki ilişkinin incelenmesinde her iskelede farklı sonuçlar elde edilmiştir. Örneğin Beşiktaş ve Kadıköy'de ev kadınları diğer gruplara göre daha fazla yürümektedirler.

Yolcuların gelirleri bir başka sosyo-ekonomik değişken olarak göz önüne alınmıştır. Beşiktaş, Kadıköy ve Karaköy'de 4500 ve 6000 TL arasında geliri olan yolcular vapur iskelelerine daha fazla yürümekte, ancak Eminönü ve Üsküdar'da 1500 ve 3000 TL geliri olan yolcular daha fazla yürümektedirler.

Son değişken olarak yolcuların yolculuk amaçları incelenmiş ve her iskelede yolculuk amacına göre yürüme uzunluğunun değiştiği görülmüştür.

1. INTRODUCTION

In urban areas, where the population is increasing continuously, the daily activities lead to traffic congestion in peak-hours and make the usage of public transportation more important than private transportation. There is a wide range of transportation systems including different combinations of technological, economic, social and geographical aspects which can be used by passengers.

Urban transportation is one of the most important factors that provide the life of a city. There is a linear relationship between transportation and urban development, and a large transport network increases economic activity in urban areas. Rapid developing regions can support transportation development, support the use of new transportation technologies and services.

The form of a city has a major effect on the lifestyle of its residents. There is a relationship between the growing and expanding urban metropolitan region with the adequate and competitive transportation service. People want to travel to reach places in order to meet daily needs. Hence, the growing population requires more access to business activities, education, employment and leisure opportunities.

There are several transportation modes for people such as public and private transportation modes. The transportation planners must make sure that all modes of PT are available for the entire society. Moreover, walking is an important way of transportation that should not be ignored. It means that the pedestrian environment around PT stations should be adequate and appropriate.

The PT has a great effect on the regional design and improvements, the economic growth, the environmental impacts, and the maintaining acceptable levels of quality of life. Nevertheless, providing and maintaining a high-quality public transportation (PT) service requires continuous monitoring and evaluation. An important issue in this context is the walk access distance (WAD) to the PT system, and how it is related to socioeconomic characteristics of PT users.

Walking can be defined as a mode of transportation that people choose to reach their destination. Hence, it is important to be aware of how much the PT users are keen to walk so that the effective service area of a transit station receives special attention from planners and developers (O'Sullivan and Morrall, 1995).

In most of the metropolitan areas, users access the PT system more often by walking than by any other access modes. Correspondingly, the PT system will be touched largely by the proximity of public transport service to the regional population.

How far a person is satisfied to walk to a specific PT station depends on how that station serves the services. The PT service must be as attractive as possible in terms of the time from the user's point of departure to the point of destination. PT properties alone cannot maximize the attractiveness of PT service (O'Sullivan and Morrall, 1995).

A critical parameter in PT planning and transit mode share analysis is the level of accessibility to transit services by population and employment. PT accessibility relates to the ability of dwellers and employees to reach PT facilities, including bus, railway, and ferry stations (Zhao et al, 2003).

1.1 Motivation

Pedestrian and PT travel work well together. Every PT trip begins and ends with pedestrian travel. Good pedestrian facilities make the trip to PT stations more convenient, safe, and enjoyable. Real and even perceived delays of sidewalks, inadequate signage, dangerous walkways, poor appearance, and factors that create a sense of insecurity make people do not feel safe or comfortable for walking to stations. Consequently, they are likely to choose other modes of travel, such as private transportation.

1.2 Objectives

This thesis aims to determine the relationship between WAD to urban ferry piers and different attributes of the passengers. The WAD that is used here is the distance between the trip origin or destination location and ferry piers.

The study area is determined as five inner-city ferry piers in Istanbul, where a survey was conducted to obtain attributes of ferry transit users.

1.3 Thesis Organization

The relationship between WAD to piers and socioeconomic characteristics of riders are considered in this study. The first chapter has introduced the motivation, objectives, and organization of thesis. Chapter two contains literature review of previous studies related to access distance to transit and service area calculations. Chapter three presents brief information about public transportation of Istanbul. Chapter four presents data of the study and discusses properties and distributions of data and the mathematical estimation models. Finally, chapter five concludes by summarizing the major findings of this study.

2. LITERATURE REVIEW

The distance walked by commuters to access PT stations is an important index of a PT system's ability to attract people to its service area. Transportation system forms the foundation by which economic development can occur and the means by which society interact. Passengers should be allowed to set a distance that the walker will normally regard and arrange the stops accordingly. These areas that are within walking distance are called access areas. This distance of walking can be reduced in the intensive areas of the city and more in the surrounding areas (Utku, 1988).

Access to PT is the occasion to use the service. This may be expounded in terms of vicinity to and the cost of using transport service which is not focused on this subject (Jansson, 1993). A transportation service is unlikely utilized when the distance or obstacles to access a service area is too high at either the origin or destination of the journey. Correspondingly, if the cost is either extremely expensive or unaffordable then utilization of the service is similarly unlikely. Accessibility is the suitability of the public transport network to get individuals from their system entry point to their system exit point in a reasonable amount of time. The PT system and complement service accessibility are highly affected by access. This relationship is illustrated in Figure 2.1.

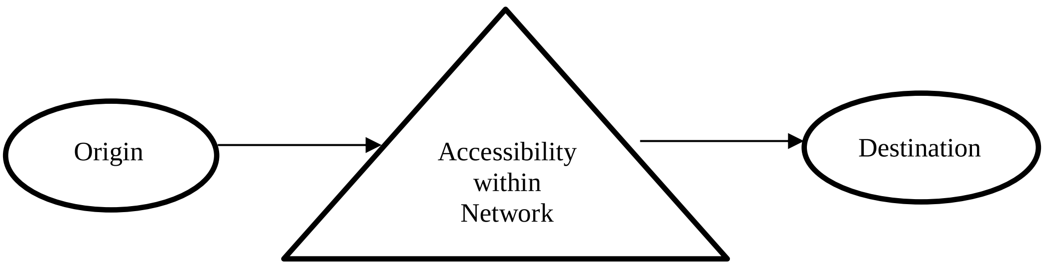


Figure 2.1: Public transportation system access (Murray et al, 1998).

PT accessibility is affected by many factors, including safe, pleasant, comfortable streets for walking to transit facilities, the topography of the environment, parking facilities for cars and bicycles, handicap access, and so on.

Easy access depends on the design of a community. Naturally, traditional communities are revealed in a grid system, in which streets form a grid and residential and commercial developments are along the streets. Henceforward, in such communities street blocks are small and roads are well connected. However, in recent years new improvements tend to be enclosed by a local street system design that limits access from the development to major roads (Murray et al, 1998).

One of the first studies about WAD was accomplished by Neilson and Fowler in 1972. The aim of the study was to verify the connection between PT ridership and WAD in low-density Florida area. The procedure for this study involved conducting a survey on PT passengers to determine their origin points and other trip characteristics. WAD was obtained as the airline distance between the origin point and the PT access point. Based on this scheme, percentages of total PT trips within each walking distance segment were obtained. For example, 60% of all trips originated within 1.8 miles. As mentioned above, the study used the airline distance as the walking distance, which means that it ignored the effect of street geometry (Neilson and Fowler, 1972).

Lam and Morrall investigated the effect of weather conditions on WAD to buses in the city of Calgary, Canada in 1982. They had determined some criteria for selecting bus stops such as the residential density, the spacing and location of bus stops, the passenger volumes, the route type and the headway. Using these criteria, two to five stops were selected in each of five residential areas throughout the city. Moreover, a university, a downtown, two industrial sites, and three suburban shopping centers were also surveyed. Bus passengers were asked to select the exact origin of their walking trip to the bus stops on a map. From a distribution of WAD, the mean WAD was found as 322 m in summer and 329 m in winter. Correspondingly, it was found that the 75th percentile of the total distribution was 450 m, which was considered as the primary catchment area by the city of Calgary Transportation Department (Lam and Morrall, 1982).

Jia, inspected the WAD and service areas in the metropolitan Toronto area, Canada in 1992. In this study, data were obtained from the 1986 Transportation Tomorrow Survey (TTS) dataset for four PT routes, which included the Toronto subway system, two Toronto Transit Commision (TTC) bus routes, and streetcar route. In this paper, the WAD was calculated by using a combination of the Geographic Information Systems (GIS) programmer/Information and C programming and assumed that the

WAD is the shortest network path between the origin and the PT access point. Jia found that a high percentage of the sampled population has WAD less than 100 m. Additionally, as the WAD increased, the number of PT users generally decreased. The results showed that the service area of the PT route was found to vary with the mode of PT. The mean of WAD for the subway was found as 1511 m and was the largest while bus routes have the smallest service area (Jia, 1992).

O'Sullivan and Morall, provided guidelines for pedestrian access to light-rail transit (LRT) stations in 1995. Their dataset was based on observations in Calgary, Canada. They interviewed LRT passengers during the morning and evening peak periods. The distances were measured off the maps. The WAD was calculated for 23 of Calgary's 31 LRT stations, which included Central Bussiness District (CBD), transfer and local stations. Their results showed that commuters of buses walked more than LRT users to reach bus stations and LRT stations. Using bus walking standards would result in an underestimation of LRT walking distance by about one half (O'Sullivan and Morall, 1995).

Zhao, Chow, Li, Ubaka, and Gan, investigated a methodology for estimating PT walking accessibility at the home end of PT trips in 2003. Moreover, by considering some variables such as the anticipated population growth, the employment data, the information about PT routes, and the type of the street shape they tried to predict PT walk accessibility at the home end for future years. In this paper, the data was from 2000 Southeast Florida Transit Onboard (TOB) survey. They compared the results with buffer method, regression analysis and as well as with network ratio methods. Buffer method and network ratio methods showed that both procedures tended to overestimate the PT walk accessibility. Regression analysis also showed that the new PT walk accessibility measure was a stronger predictor of PT use than buffer method and network ratio method (Zhao et al, 2003).

Givoni and Rietveld, examined issues such as WAD to a PT station and egress modes after getting off from the railway stations. This study was done on two lines of railway stations with regard to the service area of stations in the Netherlands in 2007. Furthermore, they examined the impact of the availability of car in the household may affect the mode choice of trips to the station. Moreover, they investigated the passenger's cognition of the station and of the journey to the station on the overall perception of traveling. The results of this paper showed that most of the commuters choose walking, bicycle and public transport to get to or from the railway station and the availability of a car did not have a strong effect on the choice of access mode to the station (Givoni and Rietveld, 2007).

Alshalalfah and Shalaby, explored the relationship between WAD to PT and several characteristics of the PT service and PT users in the city of Toronto, Canada in 2007. The data of this project consisted of two parts, the GIS files of the PT route network were gained from TTC and the trip, demographic, and socioeconomic characteristics of the studied PT riders were extracted from the 2001 TTC dataset, in the morning peak hours (6-9 a.m.) on a regular weekday. The results showed that in the downtown, the WAD was lower than other parts of the city. Furthermore, the socioeconomic parameters such as dwelling type of the household, number of vehicles available in the household, the PT frequency showed a significant relationship with access distance in Toronto. In general, it was found that about 60% of individuals were willing to live within 300 m of PT service area (Alshalalfah and Shalaby, 2007).

Weinstein, Schlossberg, and Irvin, investigated the lengths of the trip and peoples' route selections for walking through the five railway stations in California and Oregon, USA in 2008. The data was collected from a survey performed on weekday mornings. The results showed the passengers were willing to walk an average of half a mile to the rail station (Weinstein et al, 2008).

Hoback, Anderson, and Dutta, investigated the WAD to PT stations in Detroit, USA in 2008. In this paper, to determine WAD, buffer method was conducted by considering the straight-line WAD. The results showed that passengers were willing to walk about 1300 m per round trip to access PT stations (Hoback et al, 2008).

Acikgoz, investigated the accessibility and availability of the bus stations in Istanbul. The data was collected during weekday morning (7:30-9:30) and evening (16:00-20:00) peak hours in 2010. In this study, the relationship between accessibility to the stations with socioeconomic characteristics was determined. The results showed that the WAD to the bus stations in Istanbul is approximately between 400-600 m. The socioeconomic characteristics that were examined in this study are the gender, the age, the availability of the car in the household, the profession, and the income of the passengers. The results of the socioeconomic characteristics showed that the availability of the car and high-income level decrease the WAD. Consequently, when the income level increases passengers want to use private transportation systems such as taxi and private car. Particularly in the coming years, the increase of the income might narrow the bus accessibility areas (Acikgoz, 2010).

Park, Choi, and Lee, probed the environmental factors that can encourage transit users' modal shift from driving to walking. The micro-level walkability which was measured at the route-level and thus named "path walkability" was investigated in this research. A station user survey was conducted in downtown Mountain View, California in 2014. Their variables were users' access mode choice to the station, socio-economic status, and trip origins and walking routes of transit users. Walkability factors such as "sidewalk amenities", "traffic impacts", "street scale and enclosure", and "landscaping elements" was used to group the 38 paths of the study area. The basic model based on utility function was first estimated without walkability variables. The expanded model included the four path walkability variables. The results showed that adding the walkability variables significantly improve the predictability of the mode choice model. Moreover, the micro-level walkability influences access mode choices in a statistically significant way and having more walking-conductive walkability available for access trips increases the chance of choosing walking over driving and could be a cost-beneficial encouraging for more walking to the transit station (Park et al, 2014).

Durand, Tang, Gabriel et al, pursued to identify the correlation between distance to a transit stop and the probability it will be accessed by walking and its relationship by the trip, personal or household factors by using data from 2012 California Household Travel Survey. They used linear multiple regression models and generalized estimating equations methods (GEE) in their analysis. The results showed that for each mile increase in distance from the point of origin to the transit stop, the probability of active access decreased by 12%. With other factors held equal, at two miles from a transit stop there is a 50% chance someone will walk to a stop against non-active means. Hence, individuals appear to be willing to walk further to reach transit than existing guidelines indicate (Durand et al, 2015).

Chia, Lee, and Kamruzzaman, examined the WAD to PT by using 2009 South-East Queensland Household Travel Survey of Brisbane, Australia in 2016. This research explored the differences of walking time of individuals with different socioeconomic specifications. They used decay function for walking time which provided a simple and effective way to display and compare the distribution of walking time among different groups. Their results showed that the walking time was the most sensitive among part-time workers, individuals with high-income, and aged travelers. Although they found that walking time of post-secondary students who were studying and working simultaneous was not that much sense to other individuals (Chia et al, 2016).

Huang, Moudon, Zhou, Stewart, and Saelens, examined walking behavior of participants who were living within one mile of one of 13 LRT line in Seattle using before (2008) and after the opening of the Seattle area LRT (2010). They used a previously developed algorithm for walking efforts. The results of this study express that the individual-level change in the respect of daily walking within a one-quarter Euclidean mile of an LRT station and there was a shift in walking activity to the station after the LRT opening. Some variables such as being male, college education, normal weight status, less access to cars and frequent LRT use were also significantly affiliated with greater positive changes in the proportion of the walking area of the station (Huang et al, 2017).

Zacharias, and Zhao, investigated local environmental factors in walking distance at metro stations of three cities in China. The data was collected from existing metro users from 2012 to 2014. The independent variables that were used in this study are commercial land use, intersection density, total road length, distance to the nearest metro station, theoretical catchment area and built form density, and the dependent variable is walking distance toward the station. The results of this paper showed that local stations had high variability in the potential walking environment. Land use distribution was most significant in the walking distance. As well as they found that the willingness to walk to such destinations from the metro station is greater than the willingness to walk the same distance from home to metro station (Zacharias et al, 2017).

Zuo, Wei, and Rohne, explored the transit service area coverage by non-motorized mode choices such as walking and bicycle by using Global Positioning System (GPS) data in Cincinnati, USA. In this project, the data from 2009 to 2010 GPS-based Household Travel Survey in the Cincinnati metropolitan area was used. The result suggests that bicycle enables people to access the transit service. The bicycle-transit catchment area is estimated at 1.7 and 2.3 times of the size of pedestrian-transit catchment area at home and activity ends, respectively. As a result, more households and employment can reach the transit service via bicycling than walking. Suburbs, where near half of the population and employment are located, are partly underserved. In suburbs only 27.14% of population can access transit by walking, but the percent is increased to 50.96% if using a bicycle (Zuo et al, 2018).

3. PUBLIC TRANSPORTATION IN ISTANBUL

While people are traveling with specific purposes each day, their request for transport from one point to another point is responded by; walking, bicycle, motorcycle, private car, taxi, minibus, bus, tram, light railway, metro and if it is available maritime transportation. The mode share for PT commuting is affected by some significant variables such as income, population, jobs intensity, PT type, walkability, PT service frequency and so on.

Istanbul is one of the biggest and most populated cities in the world. It consists of two parts, European Side and Asian Side which are separated by Bosphorus. Each side has a form of peninsula covered by Black Sea, Bosphorus and the Marmara Sea. Two sides of Istanbul are connected with three highway bridges (The Bosphorus, the Fatih Sultan Mehmet, and the Yavuz Sultan Selim Bridge), one undersea rail tunnel (Marmaray), one undersea highway tunnel (Eurasia Tunnel), and maritime transportation (ferries, passenger boats).

The population in Istanbul is growing every day, and data from Istanbul Metropolitan Municipality (IMM) shows that with current population increase and economic growth there is a rapid rise in the number of cars in recent years. With respect to this increase in population and number of cars, it is important to pay more attention to PT and improve its quality to encourage people to use PT system instead of private cars. In Istanbul, PT mainly relies on highway transit (83.80%), while rail (13.90%) and maritime (2.30%) transits are present. Table 3.1 shows the percentage and number of daily number of passengers for different PT modes in Istanbul in 2016 (URL-1).

IMM successfully introduced contactless Istanbul Card for paying fares across all modes which allows discounted transfers within the PT network (buses, railways, and ferries transportation system), however further actions should be considered to improve the efficiency and attractiveness of PT system.

Table 3.1: Daily number of passengers of different PT modes in Istanbul, 2016 (URL-1).

System		Passenger / Day	%	
Highways	Metrobus	800,000	8.27	83.80
	IETT	927,546	9.59	
	ÖHO*	1,441,334	14.90	
	OAŞ**	795,504	8.22	
	Minibus	2,100,000	21.71	
	Shared Taxi	110,000	1.14	
	Taxi	1,100,000	11.37	
	Subscription bus	2,400,000	24.81	
	Total	**9,674,384**	**100**	
Railways	Metro	613,062	38.19	13.90
	Light Metro	308,420	19.21	
	Tram	497,230	30.97	
	Tunnel-Funicular	48,837	3.04	
	Nostalgic Tram	1,983	0.12	
	Cable Car	5,966	0.37	
	TCDD (Marmaray)	129,895	8.09	
	Total	**1,605,393**	**100**	
Maritime	IDO A.Ş.	20,610	7.80	2.30
	City Lines	106,357	40.25	
	Private Ferries	137,285	51.95	
	Total	**264,252**	**100**	

* ÖHO: Özel Halk Otobüs
** OAŞ: Istanbul Otobüs Işletmeleri A.Ş
*** TCDD: Türkiye Cumhuriyeti Devlet Demiryolları
**** IDO A.Ş.: İstanbul Deniz Otobüsleri

PT in Istanbul can be categorized into four groups such as:

- Paratransit transportation
- Bus transportation
- Rail transportation
- Maritime Transportation

Paratransit transportation: The services characteristics of this type of transportation lies between conventional public transportation and private car transportation system. In Turkey, paratransit system is implemented with various types of vehicles and organization modes. Generally, in Istanbul, minibus (jitney), shared taxi (dolmuş), taxi, and subscription buses are the subsets of paratransit which is used for many years. Paratransit system is more effective than the private car in terms of capacity and economic issues, however, these systems are less efficient compared with bus transportation.

Bus transportation: Bus transport has an important place in urban PT all over the world. As this system is more economical and flexible than other transportation systems, most of the metropolitans pay more attention to this system. Nevertheless, bus transportation system is low in-service levels because they use a fixed route and generally use roads that are already dense.

The public bus system in Istanbul includes approximately 4145 buses, of which 3060 operated by Istanbul Electricity, Tramway and Tunnel General Management (IETT) (URL-2) and 1085 managed by the private operators (Özel Halk Otobüs, "ÖHO" and Istanbul Otobüs Işletmeleri A.Ş., "OAŞ") under the license of IMM (URL-3). The IETT contains different type of buses, different service routes and different type of bus stations for serving passengers. Most of the buses in Istanbul work from 05:00 or 06:00 until 20:00 or 21:00. However, in some central routes, there are buses working 24 hours (URL-4).

Rail transportation: Rail transport is a mean of transferring of passengers and goods on wheeled vehicles running on rails. In Istanbul, there are different kind of railway transportation systems such as metro, light train, tramway, nostalgic tram, funicular and cable car. Some of these modes have very high capacity and they are not affected by weather conditions. However, the investment cost is quite high compared to highway systems. Meanwhile, Istanbul is a hilly city, constructing railway system is more expensive because of these natural obstacles.

Maritime transportation: Istanbul is a city which has two parts, Asian Side and European Side. Moreover, there are five small islands that accommodates individuals. Ferries between these two sides and islands have played an important role in carrying passengers. In Istanbul, sea public transport is operated by both private and public sector.

IDO A.Ş. (Istanbul Sea Buses Corporation) is the major company of ferry transit which services under the supervision of IMM. IDO A.Ş. is operating 24 sea buses, 18 ferries and 11 vehicle ferries (URL-5). IDO A.Ş. services are the fast ferry, the sea bus, the inner-city passenger ferry, the inner-city vehicle ferry and Mavi Marmara passenger ferry. The difference between these services is that the fast ferry carries both passengers and cars at high speeds, while sea bus, inner-city passenger ferry, and Mavi

Marmara passenger ferry carry only passengers, and inner-city vehicle ferry is just for vehicles.

Another public sea transit company is Istanbul City Lines which works again under the supervision of IMM. This company is a modern enterprise in urban maritime transportation in Istanbul, with a strong brand value and a great corporate reputation, offering an alternative in transportation by providing public maritime transportation services, protecting the ferries, the shipyards, and quays that are symbols of Istanbul's cultural heritage. Istanbul City Line is operating with 28 sea buses and 2 vehicle ferries (URL-6). Their services are such as inner-city passenger transit and inner-city vehicle transit. This company is making public passenger transportation with daily approximately 600 scheduled trips and annually transfers 40 million people within the Istanbul Harbor.

Turyol and Dentur A.Ş. both are private companies of public sea transit in Istanbul. They are specialized in passenger transport with small to medium size boats. Dentur just serves services for carrying passengers. However, Turyol is the leader corporation in private sector. This company has 60 ships, 2 passenger-vehicle ships, and 8 sea tourism ships (URL-7). Hence, Turyol gives services such as inner-city passenger transit, inner-city vehicle transit and transit between some other cities and Istanbul. This company is making public passenger transportation with daily approximately 470 scheduled trips and daily transit 50.000 people within the Istanbul Harbor. Table 3.2 shows the detailed characteristics of ferry companies in Istanbul.

Table 3.2: Detailed characteristics of ferry-boat companies in Istanbul.

Company	# Passenger ferry-boats	Passenger Capacity	Length (m)	Routes		# Daily round-trip
IDO A.Ş.	53	350-1500	35-80	Inner Istanbul Ferry Lines	Beşiktaş-Bostancı	10
					Bostancı-Kadıköy-Yenikapı-Bakırköy	12
Istanbul City Lines	28	600-2100	40-75	Inner Istanbul Ferry Lines	Beşiktaş-Kadıköy	32
					Eminönü-Üsküdar	46
					Kadıköy-Eminönü	42
					Karaköy-Kadıköy	52
					Bostancı-Karaköy	5
					Haliç line	17
				Bosphours Lines	From Bophorus-To Bosphorus	12
					Sarıyer-Anadolu Kavağı-Rumeli Kavağı	13
					Küçüksu-Beşiktaş	3
					Çengelköy-Sarıyer	6
					Anadolu Kavağı-Üsküdar	1
					Üsküdar-Örtaköy	3
					Rumeli Kavağı-Eminönü	12
					Küçüksu-Emirgan	7
				Islands Lines	Bostancı-Adalar	3
					Eminönü-Kadıköy-Adalar	11
Dentur A.Ş.	41	250-1000	37-49	Inner Istanbul Ferry Lines	Avcılar-Adalar	1
					Beşiktaş-Kadıköy	30
					Beşiktaş-Adalar	6
					Eminönü-Bebek	1
					Üsküdar-Beşiktaş	1
					Üsküdar-Kabataş	1
				Islands Lines	Beşiktaş-Adalar	6
					Avcılar-Adalar	1
Turyol	60	500-850	35-42	Inner Istanbul Ferry Lines	Beşiktaş-Kadıköy	30
					Eminönü-Karaköy-Üsküdar	38
					Eminönü-Bakırköy	2
					Eminönü-Kadıköy	48
					Bakırköy-Kadıköy	6
				Islands Lines	Bakırköy-Adalar	1
					Eminönü-Kadıköy-Adalar	6
					Karaköy-Adalar	7

Figures 3.1-3.4 shows the ferry piers, routes that are active at inner Istanbul ferry lines, Bosphours lines, and Islands lines of each maritime transportation company.

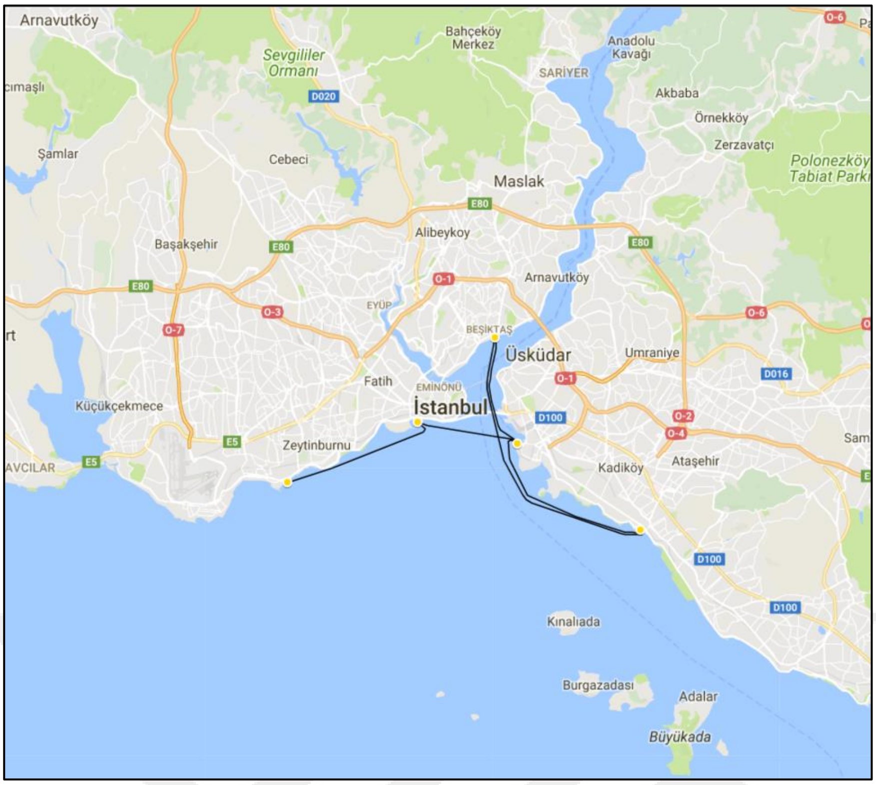


Figure 3.1: Active routes of IDO company.

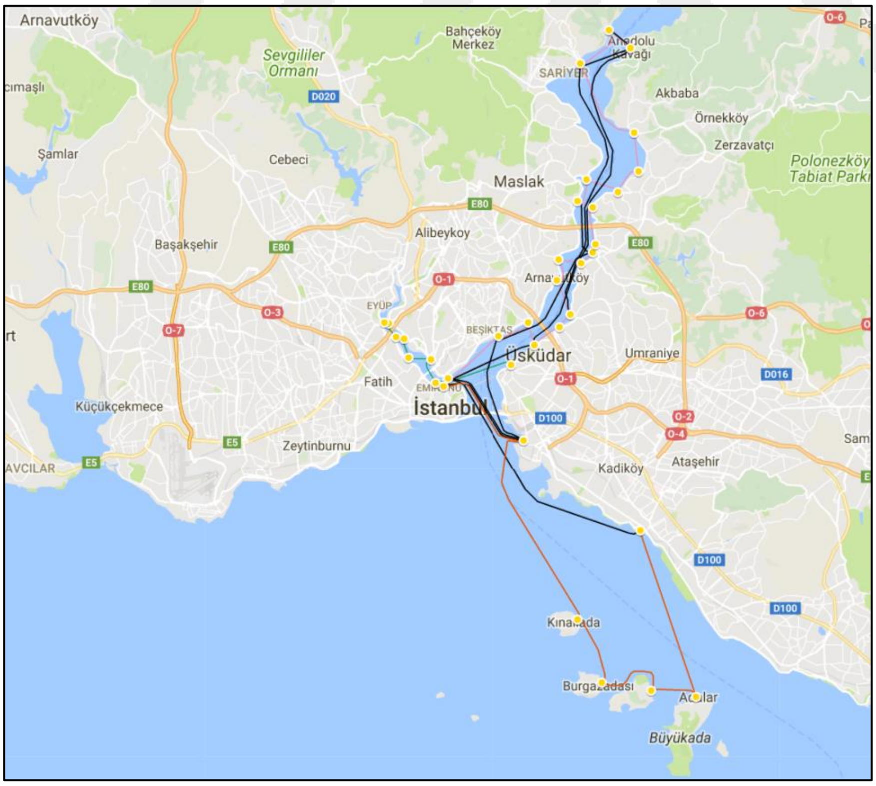


Figure 3.2: Active routes of Istanbul City Lines company.

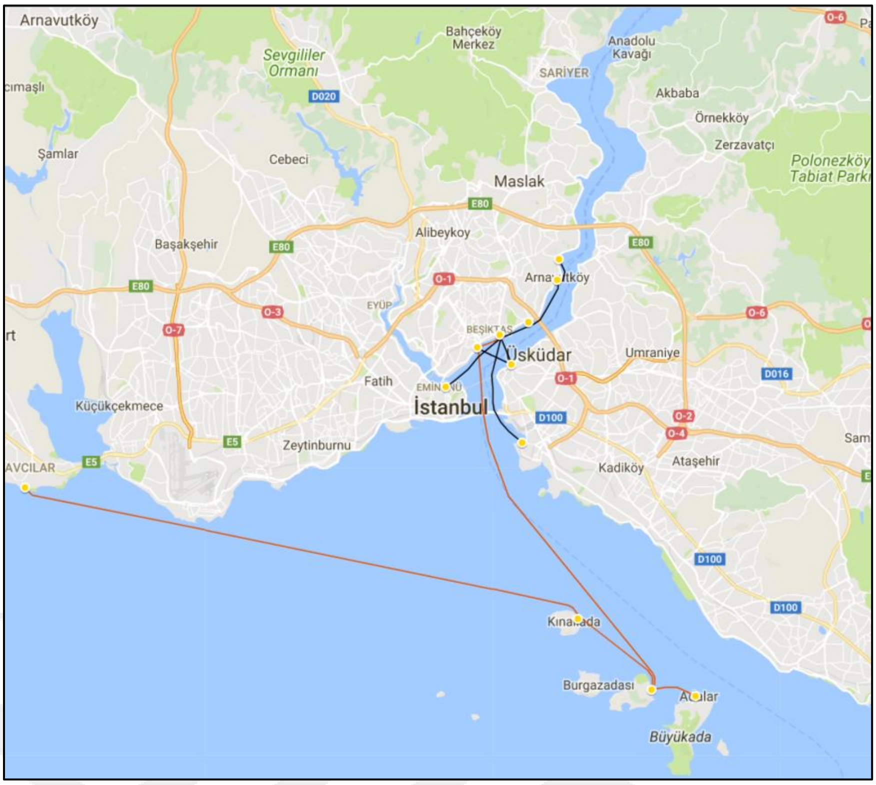


Figure 3.3: Active routes of Dentur company.

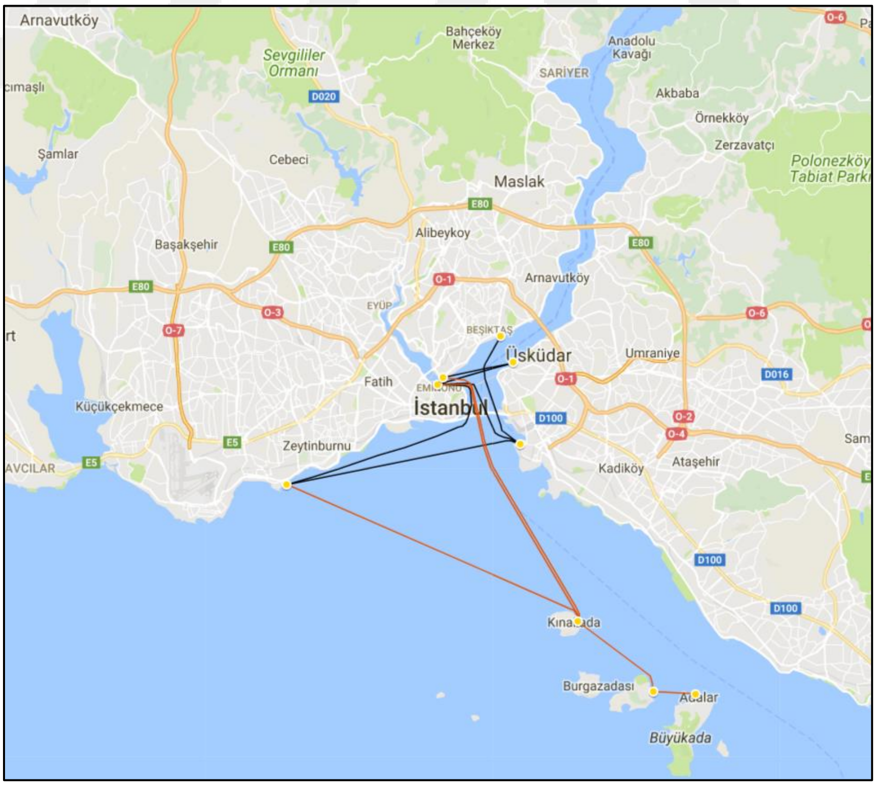


Figure 3.4: Active routes of Turyol company.

4. CASE STUDY

The aim of this study is to determine the WAD to urban ferry-boat piers and examine the relationship between WAD and different socioeconomic characteristics of users in Istanbul.

In order to collect data, a field study was conducted at five different inner-city passenger ferry piers of Turyol company and a questionnaire was used to gather data about passenger's origin and destination points and their socioeconomic characteristics. After investigation of the statistical distributions of WAD and determine the effects of some variables on it, a multiple regression analysis is conducted to evaluate these effects.

4.1 Data of the Study

Istanbul is one of Eurasia cities which is located in northern-western of Turkey on a total area of 5343 km^2. The Bosphorus, which connects the Sea of the Marmara to the Black Sea divides the city into European Side (Historic and economic centers) and Asian Side (more residential part), hosting a population of around 14.8 million residents (URL-8). Maritime transportation constitutes approximately 2.30% of PT in Istanbul, about 264.252 daily trips are made by sea public transit commuters in Istanbul (URL-1).

The data of this study are collected, at five different ferry-boat piers which are located in "Beşiktaş", "Eminönü", "Kadıköy", "Karaköy", and "Üsküdar". The survey was completed on ferry-boat by the observer. Since each trip took about 20 minutes people had enough time to answer questions. These piers and the investigated routes are shown in Figure 4.1. Three of these piers are on the European Side and the other two piers are on the Asian Side.

Data are gathered during weekdays, at off-peak hours and peak hours from June 20 to July 25 in 2017. Weekend data are not included in this study because during weekdays most of the passengers try to get somewhere as soon as possible, hence they accustomed their routes and stops. Nevertheless, weekends are people's leisure time and service time of ferries can affect passengers route choice.

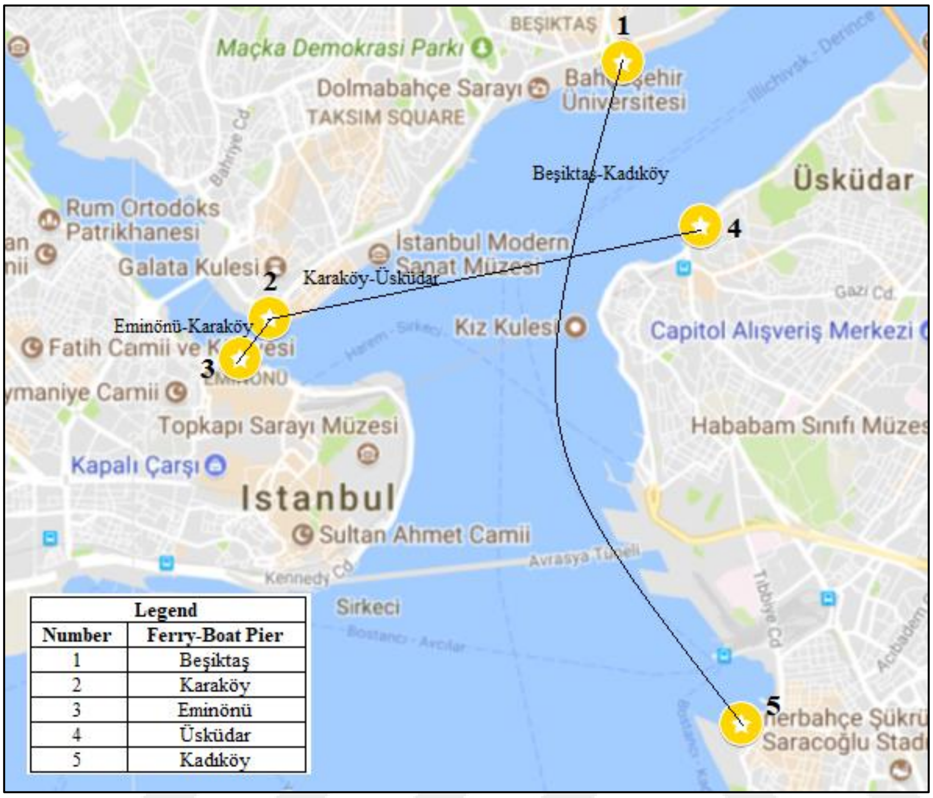


Figure 4.1: Location of observed piers in Istanbul.

The survey was conducted to determine the walking distance to the ferry piers. The survey consisted of 352 participants. The first question was “Did you walk to the pier or you came by another mode?” if the answer was “Yes” the observer was going to continue the questionnaire. Therefore, the survey was not concluded with passengers who came to the pier by another mode such as taxi, bus, and so on. As well as if a passenger will walk to his/her destination was added to data of another ferry pier. For example, at Beşiktaş-Kadıköy pier, if a passenger walked to the Beşiktaş pier and will walk to his/her destination at Kadıköy pier, that passenger with same social characteristics is added at both piers just with different WADs.

In the questionnaire the gender, age, household size, profession, availability of car in the household, how long did they walk to the pier, origin point and destination point of passengers were asked. Survey questions are shown in Appendix A.

In this research, the passengers’ prediction of walking time to the pier are compared with the calculated values (measured by “Google maps”) and the declared walking time by passengers are converted to distance by multiplying the duration between origin or destination of travel and pier, to the walking speed given in Turkish standards (TS 12174). Since the numbers that passengers said for WAD is based on their guess, the WADs that are found from Google maps are used in the analysis.

4.2 Data Analysis

This analysis could be viewed as a study of the demand side of PT, that is how walking behavior and proximity to PT are related to different socioeconomic characteristics of PT users. Correspondingly, this analysis could be viewed from the supply perspective, where the WAD could be seen as an indication of how much PT supply is provided to commuters.

4.2.1 Properties of the data

As it is explained above the survey consist of 352 passengers. By considering origin and destination points of passengers the number of observations is obtained 573. In Beşiktaş pier 110, Eminönü pier 128, Kadıköy pier 101, Karaköy pier 101, Üsküdar pier 133 passenger data were used in this research. Figure 4.2 is given to understand the content of survey.

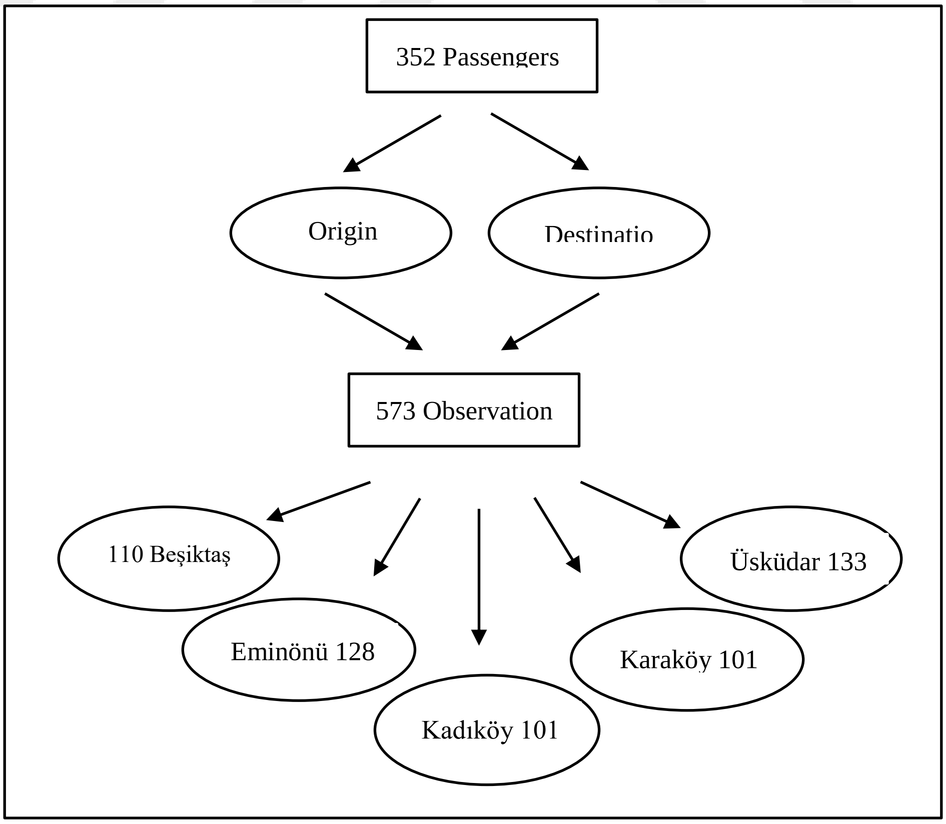


Figure 4.2: Detail of number of the data used in the survey.

The number of passengers at each pier, descriptive statistics of WAD and passenger's features are given in Table 4.1, respectively. As mentioned before, the socioeconomic data of one participant is used twice if he/she walks from origin to the pier and from pier to the destination.

Approximately, 61% of passengers are male and 39% are female. The passenger's age is divided into three groups. 25% of passengers are under 25-years old, 72% of passengers are between 25–65-years old, which shows most of the travelers are from young portion of society who are more eager to walk more to access ferry-boat piers, about 2% of the passengers are older than 65-years old.

The other socioeconomic parameter of passengers considered in this study is the availability of car in the household. Approximately 53% of the passengers have an automobile, and 47% of passengers don't have an automobile and use PT to reach their destination.

Most of the interviewers in this research had a salaried job. The second group refers to self-employed commuters. Correspondingly, student and housewife groups were the third and fourth group.

In Turkey, the minimum wage of a worker, which is determined by the government is about 1500 Turkish Lira (TL). By considering the minimum wage the income is divided into five groups. The first group is users who earn between 0-1500 TL, they consist approximately 20% of the sample. Second group's income is between 1500-3000 TL, their share is the biggest one which is about 34%. The third group's users earn between 3000-4500 TL, they include 24% of passengers. The fourth group is users with income between 4500-6000 TL, they include 15% of passengers. The last group of survey is the group with more than 6000 TL, this group has the least share which is 7%.

The purpose of the trip is divided into two groups based on users' activities. The first group relates to obligatory activities such as going to work and school, their share is approximately 44%. The second group is non-obligatory activities such as going for shopping, have fun with friends, visiting historical places and so on. They include around 56% of the survey.

Table 4.1: Descriptive statistics of data.

Variables		Beşiktaş		Eminönü		Kadıköy		Karaköy		Üsküdar		Total	
		Number	%	Number	%	Number	%	Number	%	Number	%	Number	%
		110	19.20	128	22.34	101	17.63	101	17.63	133	23.21	573	-
Gender	Men	69	62.73	71	55.47	62	61.39	69	68.32	80	60.15	351	61.26
	Women	41	37.27	57	44.53	39	38.61	32	31.68	53	39.85	222	38.74
Age	Under 25	38	34.55	26	20.31	36	35.64	17	16.83	29	21.80	146	25.48
	25 to 65	69	62.73	99	77.34	62	61.39	83	82.18	102	76.69	415	72.43
	Over 65	3	2.73	3	2.34	3	2.97	1	0.99	2	1.50	12	2.09
Marital Status	Single	77	70.00	62	48.44	68	67.33	49	48.51	63	47.37	319	55.67
	Married	28	25.45	61	47.66	29	28.71	47	46.53	61	45.86	226	39.44
	Other	5	4.55	5	3.91	4	3.96	5	4.95	9	6.77	28	4.89
Automobile	Yes	60	54.55	73	57.03	56	55.45	52	51.49	65	48.87	306	53.40
	No	50	45.45	55	42.97	45	44.55	49	48.51	68	51.13	267	46.60
Job	Housewife	3	2.73	11	8.59	3	2.97	1	0.99	6	4.51	24	4.19
	Student	43	39.09	30	23.44	35	34.65	20	19.80	25	18.80	153	26.70
	Salaried	40	36.36	45	35.16	39	38.61	47	46.53	57	42.86	228	39.79
	Self-employed	24	21.82	42	32.81	24	23.76	33	32.67	45	33.83	168	29.32
Income	0-1500	24	21.82	33	25.78	19	18.81	16	15.84	25	18.80	117	20.42
	1500-3000	35	31.82	45	35.16	32	31.68	34	33.66	48	36.09	194	33.86
	3000-4500	27	24.55	31	24.22	26	25.74	23	22.77	32	24.06	139	24.26
	4500-6000	15	13.64	12	9.38	15	14.85	23	22.77	20	15.04	85	14.83
	Over 6000	9	8.18	7	5.47	9	8.91	5	4.95	8	6.01	38	6.63
Purpose of Journey	Obligatory	56	50.91	44	34.37	42	41.58	48	47.52	63	47.37	253	44.15
	Non-obligatory	54	49.09	84	65.63	59	58.42	53	52.48	70	52.63	320	55.85

4.2.2 Average walking distance to piers

Statistical information about WAD to ferry piers of study area such as mean, standard deviation, minimum and maximum are given in Table 4.2. Standard deviation has been calculated to see if WADs are similar or different. It is understandable from Table 4.2, the WAD of Beşiktaş, Eminönü Üsküdar are similar to each other. On the other hand, WAD of Kadıköy and Karaköy seem to be similar to each other.

Table 4.2: Statistical information of WAD (m).

Ferry piers	Mean	Sta. Dev.	Min.	Max.
Beşiktaş	1183	708	14.00	4100.00
Eminönü	967	700	260.00	4900.00
Kadıköy	824	572	180.00	3600.00
Karaköy	640	397	240.00	2400.00
Üsküdar	1260	662	93.00	3600.00

The average of WADs at Beşiktaş, Eminönü, and Üsküdar piers are about 1200 m, 1000 m, and 1300 m, respectively. In Karaköy and Kadıköy piers the mean of WAD to reach the piers are about 650 m and 850 m, correspondingly. Hence, piers can be divided into two groups due to the mean value of WAD. Üsküdar with a mean value of 1300 m is the pier people walk more to reach and Karaköy with a mean value of 650 m is the pier people walk less through the other ferry piers. Even though by considering the standard deviation of WAD data at each pier it is understandable that Beşiktaş, Eminönü, and Üsküdar piers as they have standard deviation close to each other fall into one group. Also, Karaköy and Kadıköy piers place in one group because of the same reason. Figure 4.3 shows the relative frequency distributions of WAD at the different piers. It can be seen that the distribution of WAD varies at each pier.

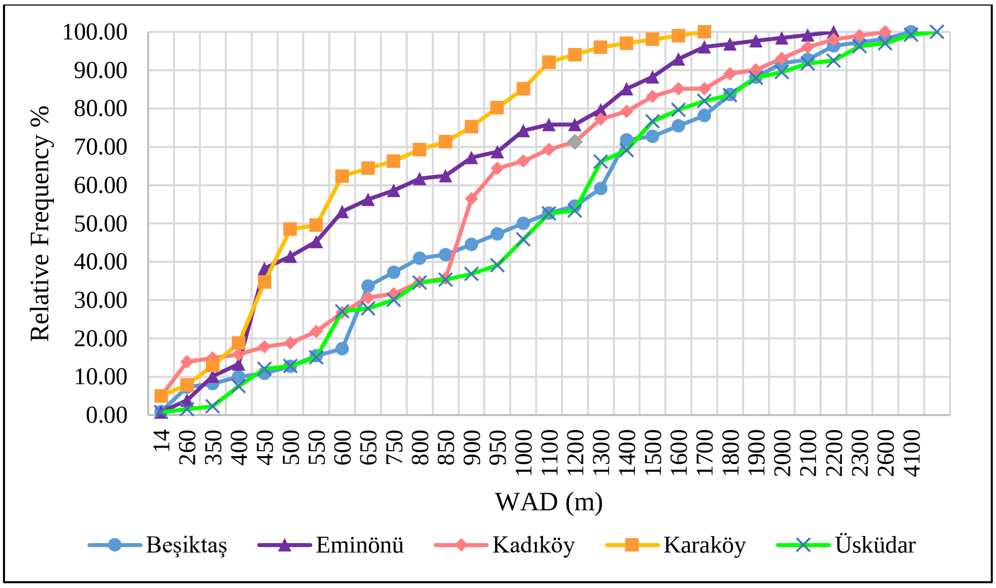


Figure 4.3: Relative frequency distributions of WAD at five different ferry piers in Istanbul.

The change of WADs at each inner-city ferry pier in this study are given in Figures 4.4 to 4.9. It is understandable from figures that the change of WAD at each zone is different which is summarized in Table 4.3. The groups are 20% of each piers data. Hence, it is understandable how many percentages of users are coming from which distance to use the ferry-boat piers.

Table 4.3: The change of WAD of each pier.

Percentage of users	Beşiktaş	Eminönü	Kadıköy	Karaköy	Üsküdar	Total
20%	0-650	0-500	0-400	0-400	0-650	0-450
40%	0-800	0-550	0-700	0-450	0-1100	0-650
60%	0-1400	0-850	0-750	0-550	0-1400	0-1000
80%	0-1800	0-1400	0-1200	0-850	0-1700	0-1500
100%	0-4100	0-4900	0-3600	0-2400	0-3600	0-4900

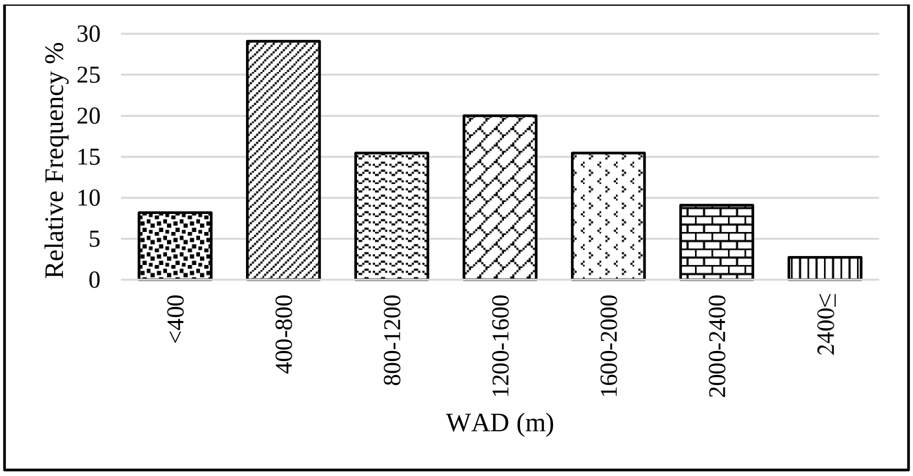


Figure 4.4: The relative frequency of passengers according to WAD at Beşiktaş.

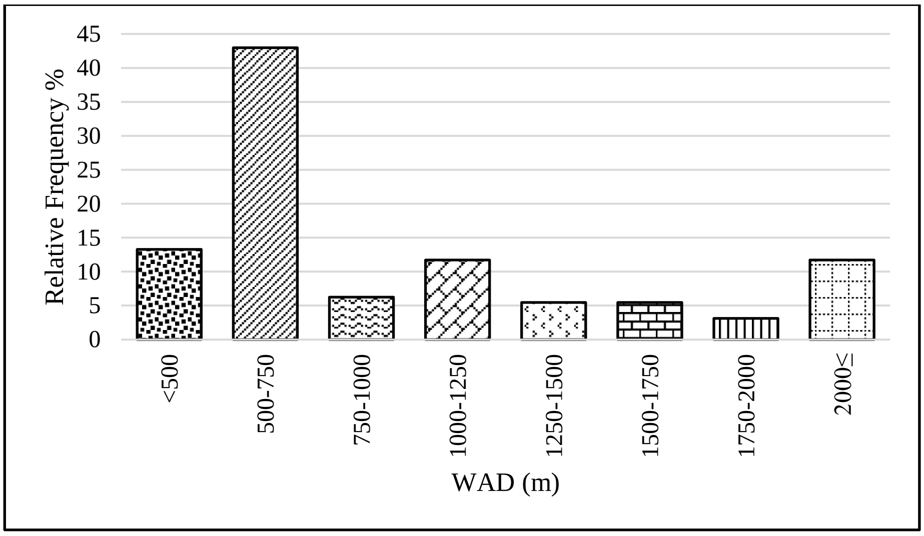


Figure 4.5: The relative frequency of passengers according to WAD at Eminönü.

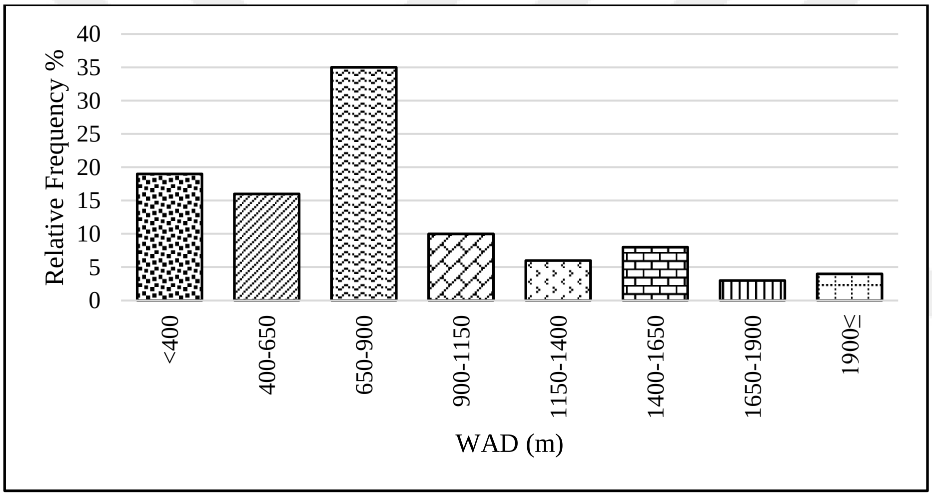


Figure 4.6: The relative frequency of passengers according to WAD at Kadıköy.

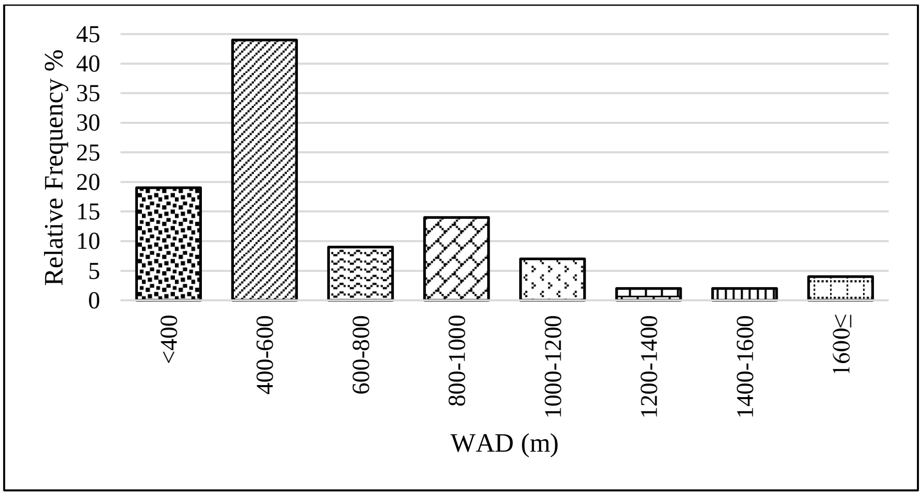


Figure 4.7: The relative frequency of passengers according to WAD at Karaköy.

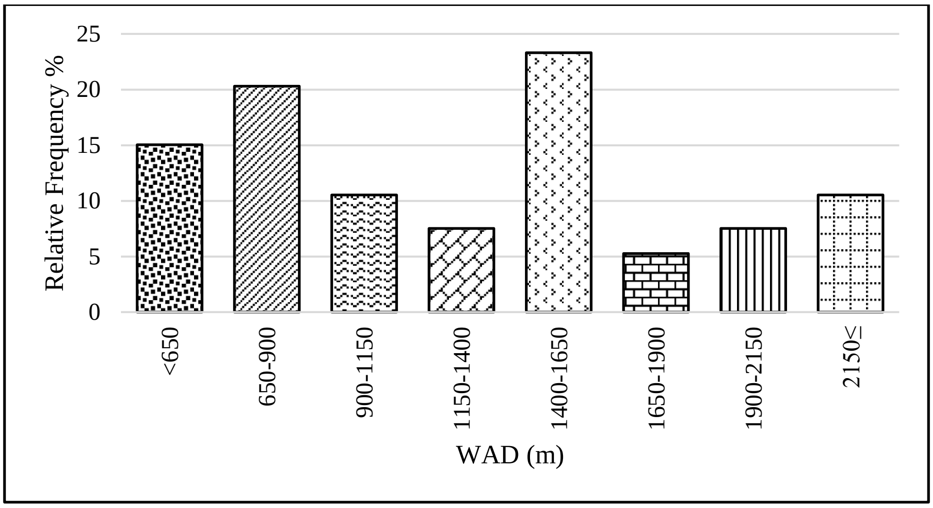


Figure 4.8: The relative frequency of passengers according to WAD at Üsküdar.

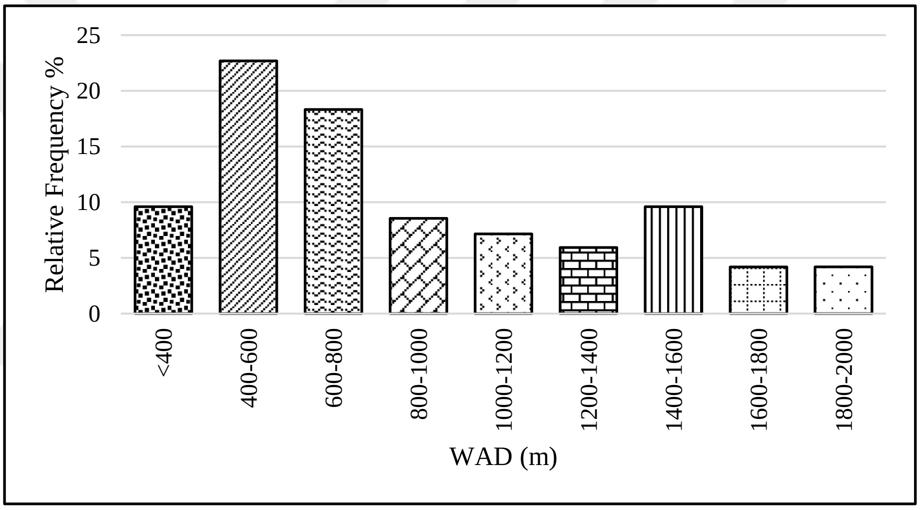


Figure 4.9: The relative frequency of passengers according to WAD of total data.

By using ArcGIS 10.3.1 software, at each pier, the buffer analysis was implemented. The radius of each buffer is the mean value of WAD at each pier. In Figures 4.10-4.14, the impact areas of surveyed piers are shown on the map. Each point is one of the origin or destination of passengers of public sea transportation. As it is understandable from figures below only some people are coming from somewhere out of the buffering circle at each pier.

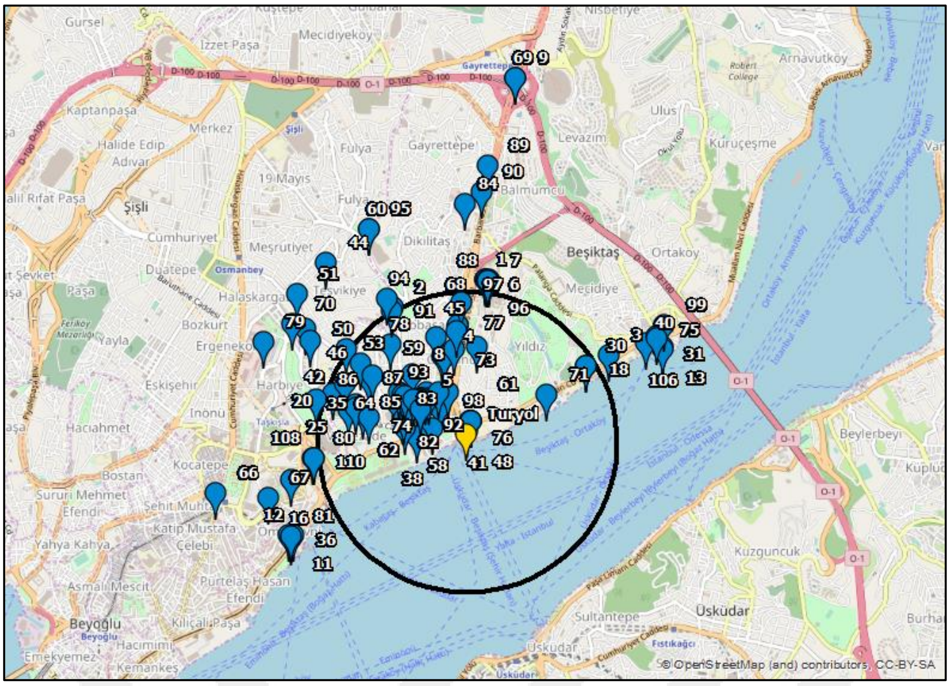


Figure 4.10: Effective area of Beşiktaş ferry pier.

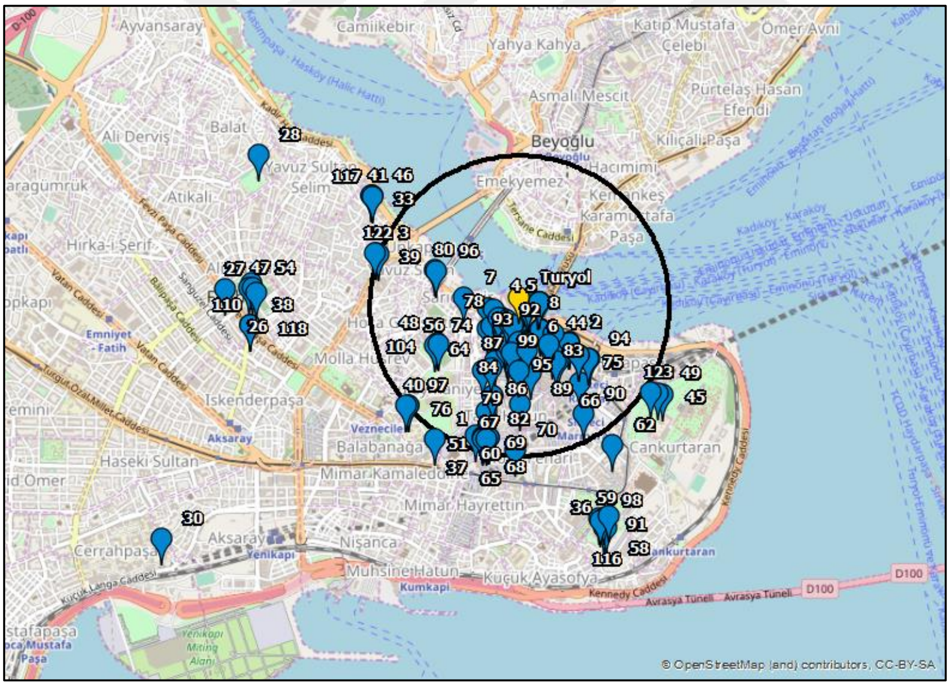


Figure 4.11: Effective area of Eminönü ferry pier.

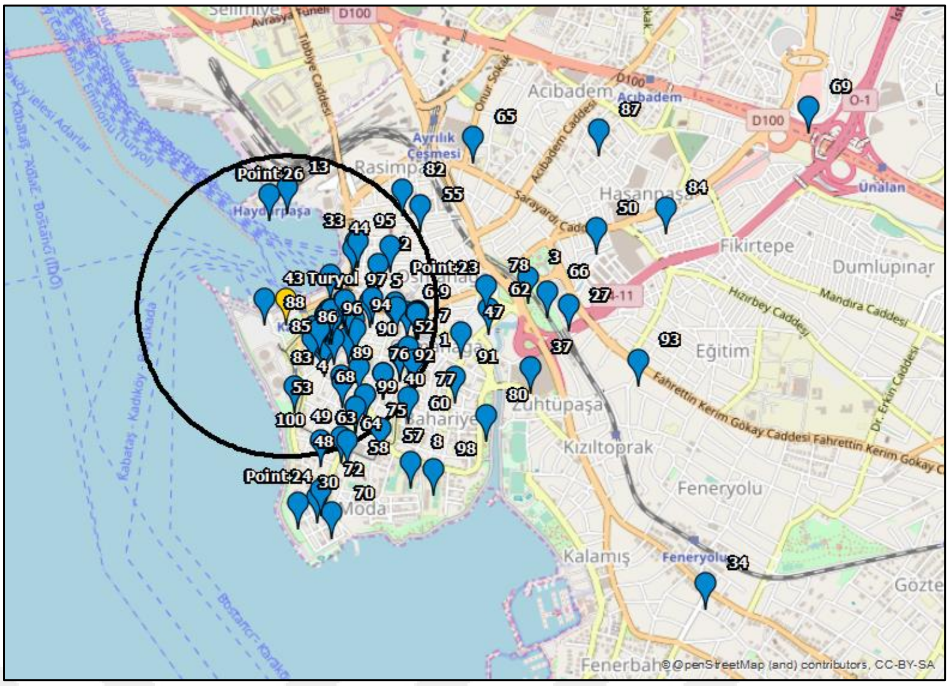


Figure 4.12: Effective area of Kadıköy ferry pier.

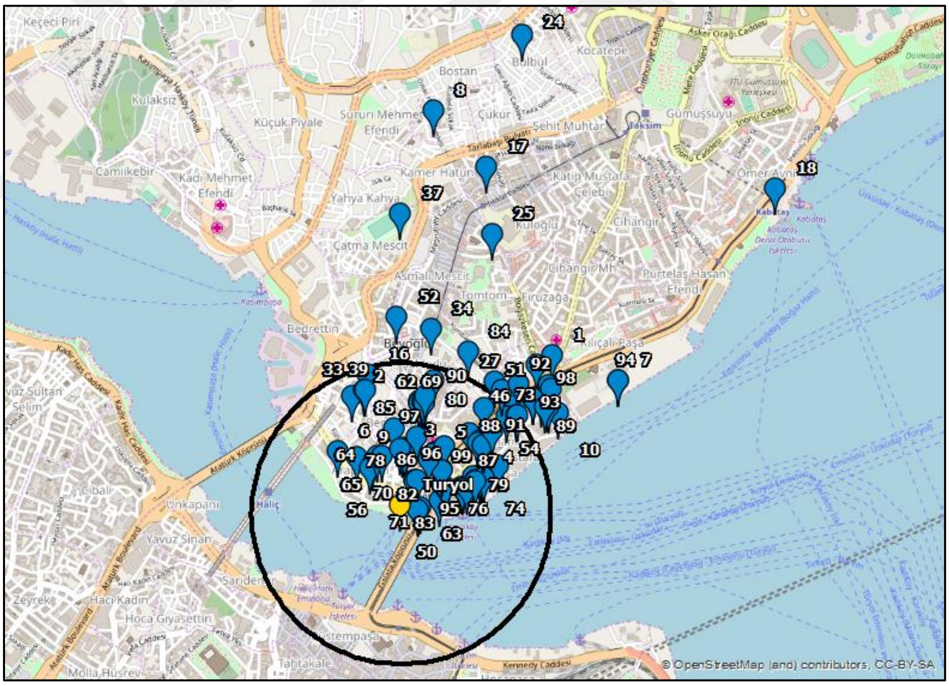


Figure 4.13: Effective area of Karaköy ferry pier.

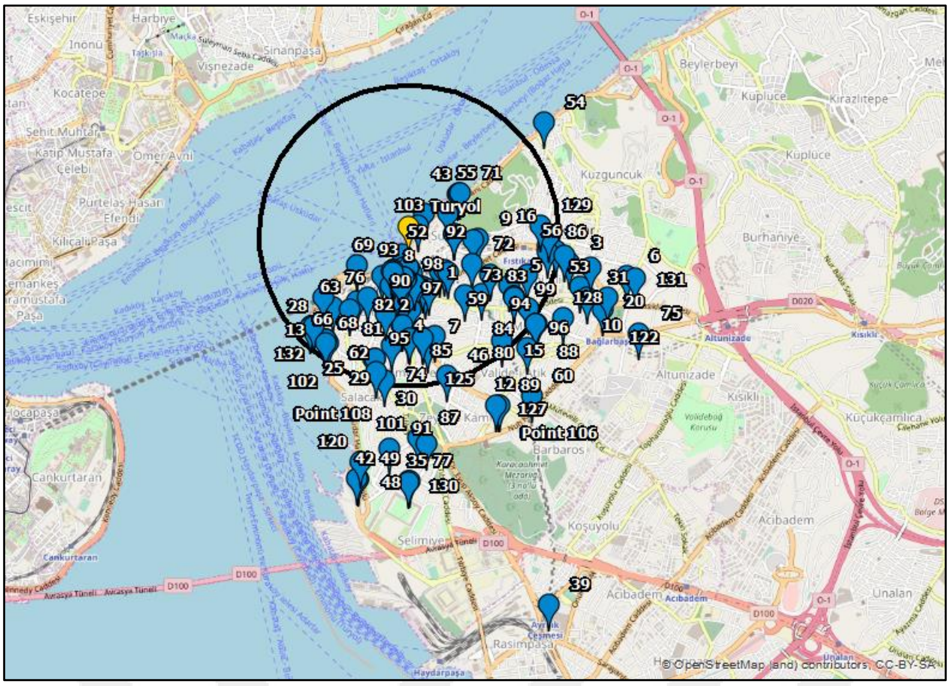


Figure 4.14: Effective area of Üsküdar ferry pier.

4.3 Determination of Statistical Distribution of Data

In this section, the statistical distributions of passengers WAD are investigated. The methods for accuracy and conformity of data for all distribution have been applied by Chi-Square test, Kolmogorov-Smirnov test, and Anderson-Darling test. To find the distributions EasyFit 5.5 Professional software is used. This software helps to deal with uncertainty and make informed decisions by analyzing probability data and selecting the best fitting distribution to the sample.

There are 65 distributions in this software such as; Beta, Burr, 4 parameter Burr, Cauchy, Chi-squared, 2 parameter Chi-squared, Dagum, 4 parameter Dagum, Erlang, 3 parameter Erlang, Error, Error Function, Exponential, 2 parameter Exponential, Fatigue Life, 3 parameter Fatigue life, Frechet, 3 parameter Frechet, Gamma, 3 parameter Gamma, Generalized Extreme Value, Generalized Gamma, 4 parameter Generalized Gamma, Generalized Logistic, Generalized Pareto, Gumbel Max, Gumbel Min, Hypersecant, Inverse Gaussian, 3 parameter Inverse Guassian, Johnson SU, Kumaraswamy, Laplace, Levy, 2 parameter Levy, Log-Gamma, Log-Logistic, 3 parameter Log-Logistic, Log-Pearson 3, Logistic, Lognormal, 3 parameter Lognormal, Nakagami, Normal, Pareto, Pareto 2, Pearson 5, 3 parameter Pearson 5,Pearson 6, 4 parameter Pearson 6, Pert, Phased Bi-Exponential, Phased Bi-Weibull, Power Function, Rayleigh, 2 parameter Rayleigh, Reciprocal, Rice, Student’s t, Triangular, Uniform, Wakeby, Weibull, 3 parameter Weibull, and Johnson SB. The common best-fitted probability of three tests which are ranked by the software had chosen at each pier.

As it is explained below, the Chi-Squared test is used to determine if a sample comes from a population with a specific distribution. In the standard applications of the test, the observations are classified into mutually exclusive classes, and there is some theory, or say null hypothesis, which gives the probability that any observation falls into the corresponding class. The Chi-Square is calculated by Equation 4.1 (Burry, 1999).

$$\chi_{sta}{}^{2} = \sum_{i=1}^{m} \frac{(E_i - O_i)^2}{E_i} \tag{4.1}$$

Where:

m: Number of classes

E_i: The expected frequency of type i

O_i: The number of observation of type i

The class ranges for all distribution models are determined with equal probability. The number of classes has been calculated by the WAD of passengers, which is given in Equation 4.2 (Bury, 1999).

$$m = 1 + 3.3 * log(n) \tag{4.2}$$

Where n is the number of observations which is the number of passengers at each pier in this survey, and the formula used for the degree of freedom is m-k-1 where the k is the number of parameters in the selected distribution function (Bayazıt, 1996). With regards to the total number of passengers m is calculated as 7 at Beşiktaş, 8 at Eminonü, Kadıköy, Karaköy, and Üsküdar pier for WAD.

The Kolmogorov-Smirnov test is another test that is used to decide if a sample comes from a population with a specific distribution. This test is based on the empirical distribution function. Several goodness-of-fit tests, such as Anderson-Darling test and the Cramer-Von-Mises test are refinements of this test. These refined tests are generally considered to be more powerful than the original one.

The Kolmogorov-Smirnov test is defined by:

H_0: The data follow a specific distribution.

H_a: The data do not follow the specified distribution.

The statistics of the Kolmogorov-Smirnov test is defined as Equation 4.3 (Bury, 1999).

$$D = \max\left(F(Y_i) - \frac{i-1}{N}, \frac{i}{N} - F(Y_i)\right) \tag{4.3}$$

Where:

N: Total number of data in all groups

F: The theoretical cumulative distribution of the specified distribution

Y_i: Ranked data

Finally, the Anderson-Darling test which is statistical test of whether a given sample of data is drawn from a given probability distribution or not was used. It is a modification of the Kolmogorov-Smirnov test and gives more weight to the tails than Kolmogorov-Smirnov test. The Anderson-Darling test makes use of the specific distribution in calculating critical values.

The Anderson-Darling test is defined as:

H_0: the data follow a specified distribution.

H_a: the data do not follow the specified distribution.

The Anderson-Darling test statistics is defined as Equations 4.4 and 4.5 (Bury, 1999).

$$A^2 = -N - S \tag{4.4}$$

$$S = \sum_{i=1}^{N} \frac{(2i-1)}{N}\left[Ln\,F(Y_i) + Ln(1 - F(Y_{N+1-i)}))\right] \tag{4.5}$$

Where:

N: Total number of data in all groups

F: The cumulative distribution function of the specified distribution

Y_i: Ranked data

With regard to Chi-Squared test, Kolmogorov-Smirnov test, and Anderson-Darling test, at 5% level of significance, the critical values and statistical values of each distribution are given in Table 4.4. To select the apporoprate distribution, among the tests, sum all the statistical values and critical values of the common distributions, then divided the sum of statistical values to the sum of the critical values and select the smallest value of this division to find the best fitted distribution.

- According to Chi-Squared test, in Kolmogorov-Smirnov test and Anderson-Darling test results of Beşiktaş zone showed that the best-fitted probibility distribution of data is “3 parameters Gamma distribution”.
- According to the results of three tests at Eminönü zone, there is only “3 Parameters Inverse Guassian Distribution” which is fitted to the dataset.
- The results of three tests at Kadıköy zone showed the approprate distribution in this zone is “Generalized Gamma Distribution”.
- Karaköy pier’s data are fitted to the ranked distributions of three tests by EasyFit software. At this pier the data are fitted to the “3 Parameters Log-Logistic Distribution”.
- The same thing was conducted at Üsküdar pier’s data and the best-fitted distribution to this pier’s dataset was “Nakagami Distribution”.

In Table 4.5 and 4.6 distribution models, their probability density functions and parameters are given.

Table 4.4: Results of χ2, K-S, and A-D tests to investigate the distribution of WAD at Beşiktaş.

	Chi-squared test				Kolmogorov-Smirnov test			Anderson-Darling test		
Pier	Distribution	df	Critic.	Stat.	Distribution	Critic.	Stat.	Distribution	Critic.	Stat.
Beşiktaş	3 parameters Log-Logistic	3	7.81	9.89	Wakeby	0.13	0.08	3 Parameters Gamma	2.50	1.03
	4 Parameters Generalized Gamma	2	5.99	9.89	Pert	0.13	0.09	Burr	2.50	1.04
	3 Parameters Lognormal	3	7.81	9.90	3 Parameters Weibull	0.13	0.09	4 Parameters Generalized Gamma	2.50	1.06
	4 Parameters Pearson 6	2	5.99	9.92	Weibull	0.13	0.09	3 Parameters Weibull	2.50	1.06
	Gumbel Max	4	9.49	12.50	Gamma	0.13	0.10	Gamma	2.50	1.07
	Johnson SU	2	5.99	9.99	Burr	0.13	0.10	Generalized Gamma	2.50	1.09
	3 Parameters Weibull	3	7.81	12.59	Generalized Pareto	0.13	0.10	Gumbel Max	2.50	1.12
	Pert	3	7.81	12.59	Generalized Gamma	0.13	0.10	3 Parameters Lognormal	2.50	1.13
	-	-	-	-	3 Parameters Gamma	0.13	0.10	Generalized Extreme Value	2.50	1.14
	-	-	-	-	4 Parameters Generalized Gamma	0.13	0.10	Johnson SU	2.50	1.16
	-	-	-	-	3 Parameters Lognormal	0.13	0.11	Pearson 6	2.50	1.16
	-	-	-	-	Gumbel Max	0.13	0.11	Dagum	2.50	1.17
	-	-	-	-	Pearson 6	0.13	0.11	4 Parameters Pearson 6	2.50	1.17
	-	-	-	-	Dagum	0.13	0.11	2 Parameters Rayleigh	2.50	1.30
	-	-	-	-	4 Parameters Pearson 6	0.13	0.11	3 Parameters Log-Logistic	2.50	1.38
	-	-	-	-	Johnson SU	0.13	0.11	Rayleigh	2.50	1.39
	-	-	-	-	Generalized Extreme Value	0.13	0.11	Weibull	2.50	1.44
	-	-	-	-	Beta	0.13	0.11	Generalized Logistic	2.50	1.54
	-	-	-	-	Normal	0.13	0.11	Rice	2.50	1.69
	-	-	-	-	3 Parameters Log-Logistic	0.13	0.12	Lognormal	2.50	2.08
	-	-	-	-	Log-Pearson 3	0.13	0.12	Normal	2.50	2.09
	-	-	-	-	2 Parameters Rayleigh	0.13	0.12	Logistic	2.50	2.21
	-	-	-	-	Lognormal	0.13	0.12	Log-Logistic	2.50	2.44

Table 4.5: Results of χ2, K-S, and A-D tests to investigate the distribution of WAD at Eminönü.

	Chi-squared test				Kolmogorov-Smirnov test			Anderson-Darling test		
Pier	Distribution	df	Critic.	Stat.	Distribution	Critic.	Stat.	Distribution	Critic.	Stat.
Eminönü	-	-	-	-	-	-	-	3 Parameters Inverse Gaussian	2.50	2.45

Table 4.6: Results of χ2, K-S, and A-D tests to investigate the distribution of WAD at Kadıköy.

	Chi-squared test				Kolmogorov-Smirnov test			Anderson-Darling test		
Pier	Distribution	df	Critic.	Stat.	Distribution	Critic.	Stat.	Distribution	Critic.	Stat.
Kadıköy	Burr	4	9.49	5.19	Weibull	0.14	0.13	Wakeby	2.50	1.08
	Generalized Extreme Value	4	9.49	5.20	Generalized Gamma	0.14	0.13	Generalized Logistic	2.50	1.25
	3 Parameters Frechet	4	9.49	5.21	Gumbel Max	0.14	0.13	Dagum	2.50	1.27
	3 Parameters Log-Logistic	4	9.49	5.26	Pert	0.14	0.13	Burr	2.50	1.31
	-	-	-	-	-	-	-	Generalized Extreme Value	2.50	1.38
	-	-	-	-	-	-	-	Generalized Gamma	2.50	1.40
	-	-	-	-	-	-	-	3 Parameters Frechet	2.50	1.42
	-	-	-	-	-	-	-	3 Parameters Pearson 5	2.50	1.46
	-	-	-	-	-	-	-	4 Parameters Pearson 6	2.50	1.46
	-	-	-	-	-	-	-	Pearson 6	2.50	1.49
	-	-	-	-	-	-	-	3 Parameters Log-Logistic	2.50	1.49
	-	-	-	-	-	-	-	Log-Pearson 3	2.50	1.53
	-	-	-	-	-	-	-	Gamma	2.50	1.55
	-	-	-	-	-	-	-	Weibull	2.50	1.59
	-	-	-	-	-	-	-	3 Parameters Lognormal	2.50	1.59
	-	-	-	-	-	-	-	3 Parameters Inverse Gaussian	2.50	1.63
	-	-	-	-	-	-	-	3 Parameters Fatigue Life	2.50	1.71
	-	-	-	-	-	-	-	Gumbel Max	2.50	1.72
	-	-	-	-	-	-	-	Erlang	2.50	1.83
	-	-	-	-	-	-	-	Log-Logistic	2.50	1.84
	-	-	-	-	-	-	-	Lognormal	2.50	1.86
	-	-	-	-	-	-	-	Fatigue Life	2.50	1.97
	-	-	-	-	-	-	-	Cauchy	2.50	2.11
	-	-	-	-	-	-	-	Log-Gamma	2.50	2.28
	-	-	-	-	-	-	-	Inverse Gaussian	2.50	2.40
	-	-	-	-	-	-	-	Johnson SB	2.50	2.47

Table 4.7: Results of χ2, K-S, and A-D tests to investigate the distribution of WAD at Karaköy.

	Chi-squared test				Kolmogorov-Smirnov test			Anderson-Darling test		
Pier	Distribution	df	Critic.	Stat.	Distribution	Critic.	Stat.	Distribution	Critic.	Stat.
Karaköy	Lognormal	5	11.07	4.01	Frechet	0.14	0.10	3 Parameters Lognormal	2.50	0.80
	Fatigue Life	5	11.07	4.03	3 Parameters Lognormal	0.14	0.10	3 Parameters Pearson 5	2.50	0.80
	Frechet	5	11.07	5.82	3 Parameters Inverse Gaussian	0.14	0.10	3 Parameters Inverse Gaussian	2.50	0.81
	3 Parameters Log-Logistic	4	9.49	5.87	3 Parameters Fatigue Life	0.14	0.10	Log-Pearson 3	2.50	0.82
	3 Parameters Pearson 5	4	9.49	5.90	3 Parameters Log-Logistic	0.14	0.10	3 Parameters Frechet	2.50	0.82
	3 Parameters Frechet	4	9.49	5.97	3 Parameters Pearson 5	0.14	0.11	3 Parameters Fatigue Life	2.50	0.85
	Log-Logistic	5	11.07	6.64	3 Parameters Frechet	0.14	0.11	3 Parameters Log-Logistic	2.50	0.85
	3 Parameters Fatigue Life	4	9.49	8.60	Log-Pearson 3	0.14	0.11	Generalized Extreme Value	2.50	0.87
	3 Parameters Inverse Gaussian	4	9.49	8.62	Inverse Gaussian	0.14	0.12	Frechet	2.50	0.92
	3 Parameters Lognormal	4	9.49	8.64	Generalized Extreme Value	0.14	0.12	Pearson 5	2.50	0.96
	Logistic	5	11.07	8.79	Johnson SB	0.14	0.12	Pearson 6	2.50	0.96
	Log-Pearson 3	4	9.49	9.07	Generalized Pareto	0.14	0.12	Generalized Logistic	2.50	1.06
	Pearson 5	5	11.07	9.30	Pearson 6	0.14	0.13	Log-Gamma	2.50	1.22
	Generalized Extreme Value	4	9.49	9.32	Pearson 5	0.14	0.13	Log-Logistic	2.50	1.45
	Pearson 6	4	9.49	9.33	Generalized Logistic	0.14	0.13	Lognormal	2.50	1.47
	Generalized Logistic	4	9.49	9.74	-	-	-	Fatigue Life	2.50	1.63
	Pert	4	9.49	9.96	-	-	-	Inverse Gaussian	2.50	1.65
	Hypersecant	5	11.07	10.89	-	-	-	-	-	-

Table 4.8: Results of χ2, K-S, and A-D tests to investigate the distribution of WAD at Üsküdar.

	Chi-squared test				Kolmogorov-Smirnov test			Anderson-Darling test		
Pier	Distribution	df	Critic.	Stat.	Distribution	Critic.	Stat.	Distribution	Critic.	Stat.
Üsküdar	Cauchy	5	11.07	6.26	Wakeby	0.12	0.07	Nakagami	2.50	0.76
	-	-	-	-	Generalized Pareto	0.12	0.08	Weibull	2.50	0.76
	-	-	-	-	Log-Pearson 3	0.12	0.08	Rayleigh	2.50	0.77
	-	-	-	-	Pert	0.12	0.08	Rice	2.50	0.77
	-	-	-	-	Beta	0.12	0.08	3 Parameters Weibull	2.50	0.77
	-	-	-	-	Rice	0.12	0.09	Log-Pearson 3	2.50	0.77
	-	-	-	-	Rayleigh	0.12	0.09	4 Parameters Generalized Gamma	2.50	0.78
	-	-	-	-	2 Parameters Rayleigh	0.12	0.09	2 Parameters Rayleigh	2.50	0.80
	-	-	-	-	Nakagami	0.12	0.09	Johnson SB	2.50	0.82
	-	-	-	-	3 Parameters Weibull	0.12	0.09	Burr	2.50	0.86
	-	-	-	-	Weibull	0.12	0.09	Generalized Extreme Value	2.50	0.95
	-	-	-	-	4 Parameters Generalized Gamma	0.12	0.09	3 Parameters Gamma	2.50	0.96
	-	-	-	-	Johnson SB	0.12	0.09	4 Parameters Pearson 6	2.50	1.02
	-	-	-	-	Burr	0.12	0.10	3 Parameters Fatigue Life	2.50	1.03
	-	-	-	-	Generalized Extreme Value	0.12	0.10	3 Parameters Inverse Gaussian	2.50	1.04
	-	-	-	-	Normal	0.12	0.10	3 Parameters Lognormal	2.50	1.07
	-	-	-	-	3 Parameters Gamma	0.12	0.11	Generalized Gamma	2.50	1.07
	-	-	-	-	4 Parameters Pearson 6	0.12	0.11	3 Parameters Pearson 5	2.50	1.09
	-	-	-	-	Generalized Logistic	0.12	0.11	Gamma	2.50	1.25
	-	-	-	-	3 Parameters Pearson 5	0.12	0.11	3 Parameters Log-Logistic	2.50	1.36
	-	-	-	-	3 Parameters Lognormal	0.12	0.11	Generalized Logistic	2.50	1.39
	-	-	-	-	3 Parameters Inverse Gaussian	0.12	0.11	Gumbel Max	2.50	1.48
	-	-	-	-	3 Parameters Fatigue Life	0.12	0.11	Normal	2.50	1.49
	-	-	-	-	Error	0.12	0.11	Error	2.50	1.59
	-	-	-	-	3 Parameters Log-Logistic	0.12	0.11	Pearson 6	2.50	1.72
	-	-	-	-	Gamma	0.12	0.11	Logistic	2.50	1.87
	-	-	-	-	-	-	-	Lognormal	2.50	1.90
	-	-	-	-	-	-	-	Log-Logistic	2.50	2.18
	-	-	-	-	-	-	-	Log-Gamma	2.50	2.34
	-	-	-	-	-	-	-	Hypersecant	2.50	2.34

Table 4.9: Distribution models and their probability density functions (Bury, 1999).

Distribution Model	Cumulative Distribution Function	Probability Density Function
3 Parameters Gamma	$\frac{\Gamma_{\frac{x-\gamma}{\beta}}(\alpha)}{\Gamma(\alpha)}$	$\frac{(x-\gamma)^{\alpha-1}}{\beta^{\alpha}\,\Gamma(\alpha)}\exp(-\frac{x-\gamma}{\beta})$
3 Parameters Inverse Gaussian	$\emptyset\left(\sqrt{\frac{\lambda}{x-\gamma}}\left(\frac{x-\gamma}{\mu}-1\right)\right)+\emptyset\left(\sqrt{\frac{\lambda}{x-\gamma}}\left(\frac{x-\gamma}{\mu}+1\right)\right)\exp(2\lambda/\mu)$	$\sqrt{\frac{\lambda}{2\pi(x-\gamma)^{3}}}\exp(-\frac{\lambda(x-\gamma-\mu)^{2}}{2\mu^{2}(x-\gamma)})$
Generalized Gamma	$\frac{\Gamma_{(x/\beta)^{k}}(\alpha)}{\Gamma(\alpha)}$	$\frac{k(x)^{k\alpha-1}}{\beta^{k\alpha}\,\Gamma(\alpha)}\exp(-(x/\beta)^{k})$
3 Parameters Log-Logistic	$(1+(\frac{\beta}{x-\gamma})^{\alpha})^{-1}$	$\frac{\alpha}{\beta}(\frac{x-\gamma}{\beta})^{\alpha-1}\,(1+(\frac{x-\gamma}{\beta})^{\alpha})^{-2}$
Nakagami	$\frac{\Gamma_{\frac{mx^{2}}{\Omega}}(m)}{\Gamma(m)}$	$\frac{2m^{m}}{\Gamma(m)\Omega^{m}}\,X^{2m-1}\exp(-\frac{m}{\Omega}x^{2})$

Table 4.10: Parameters of distribution models at each pier.

Pier	Distribution Model	Parameter
Beşiktaş	3 Parameters Gamma	$\alpha = 2$ $\beta = 373.04$ $\gamma = -109.79$
Eminönü	3 Parameters Inverse Gaussian	$\lambda = 881.61$ $\mu = 765.53$ $\gamma = 201.35$
Kadıköy	Generalized Gamma	$k = 1.0527$ $\alpha = 2.1934$ $\beta = 397.4$
Karaköy	3 Parameters Log-Logistic	$\alpha = 2.0375$ $\beta = 314.4$ $\gamma = 202.6$
Üsküdar	Nakagami	$m = 0.98113$ $\Omega = 2.0216E + 6$

4.4 The Effect of Peak Hours and off-Peak Hours on WAD

The purpose of trip is an important criterion in choosing the travel mode. In this study, as the survey was conducted during the whole day without considering peak and off-peak hours, the purpose of trip of passengers is investigated in order to determine its relationship with WAD. As it is mentioned before, the purpose of the trip can be divided into two groups:

- Obligatory trip (work, school)
- Non-obligatory trip (shopping, meet with a friend, visiting historical places)

The aim of obligatory trips is doing something that should be done daily by passengers such as going to work or school. However, the non-obligatory trips include shopping and so on. According to the aim of travels the origin of trips can be; home, work, school, shopping mall and so on.

As it is seen in Figure 4.15, at Beşiktaş, Eminönü, Karaköy, and Üsküdar zones most of the people whose purpose of travel is non-obligatory walk more than another group. However, at Kadıköy zone people with obligatory purpose walk more than another group. Generally, there is no differences between obligatory and non-obligatory trips so the peak hours and off-peak hours seems to be not important.

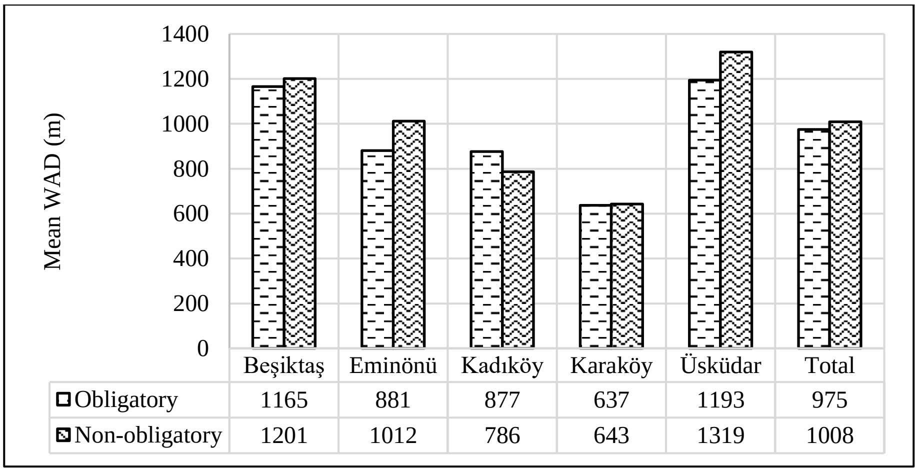


Figure 4.15: Mean WAD based on different purpose of travel groups.

In the following, the Mann-Whitney U test was conducted to show there are no statistical differences between these groups. The Mann-Whitney U test is a non-parametric test of the null hypothesis that two samples come from the same population against an alternative hypothesis that two samples are from different populations. Moreover, this test does not require the assumption of normal distribution like t-test. In Mann-Whitney U test, when the samples sizes are large (n>20), the value of U approaches to the normal distribution and so the null hypothesis should be tested by Z-test or P-value. In order to calculate the U statistic (U_{sta}); first, all the data must be ranked together; ignoring which group belong to. Then each group ranks must be added up (T_1, T_2) and U_{sta} will be calculated with Equation 4.6 (Burry, 1999):

$$U_{sta} = min\begin{cases} U_1 = (n_1 * n_2) + \left(n_1 * \frac{n_1 + 1}{2}\right) - T_1 \\ U_2 = (n_1 * n_2) + \left(n_2 * \frac{n_1 + 1}{2}\right) - T_2 \end{cases} \tag{4.6}$$

Where:

n_1 and n_2: Number of data in the first and second group, correspondingly.

T_1 and T_2: Sum of ranks in the first and second group, correspondingly.

After calculating U_{Sta}, the value of Z_{Sta}can be calculated with Equation 4.7 (Bury, 1999) and to test the null hypothesis, it must be compared with the critical Z value (Z_{cri}), obtained from Z table for the assumed level of significance.

$$U_{sta} \rightarrow Z_{sta} = \frac{U_{sta} - \mu_u}{\sigma_u} \tag{4.7}$$

$$\sigma_u = \sqrt{\frac{n_1 n_2 * (n_1 + n_2 + 1)}{12}} \qquad , \qquad \mu_u = \frac{n_1 n_2}{2}$$

At 5% level of significance, the results of Mann-Whitney U test for WAD of obligatory and non-obligatory groups are shown in Table 4.7. Z_{Sta} is smaller than Z_{Cri}, at all inner-city ferry piers which means these groups are from the same population and have the same characteristic.

Table 4.11: Results of Mann-Whitney U test for purpose of trip groups at each pier.

Pier	Purpose of Trip	Mean of WAD	Zsta	Zcri
Beşiktaş	Obligatory	1165	-0.14	±1.96
	Non-obligatory	1201		
Eminönü	Obligatory	872	-0.55	±1.96
	Non-obligatory	1018		
Kadıköy	Obligatory	877	-1.05	±1.96
	Non-obligatory	786		
Karaköy	Obligatory	647	-0.64	±1.96
	Non-obligatory	634		
Üsküdar	Obligatory	1193	-0.88	±1.96
	Non-obligatory	1319		

4.5 Socioeconomic Characteristics

The socioeconomic characteristics analyzed in this study include gender of the passenger, age of the passenger, availability of automobile in the household, profession of the passenger, and income of the passenger. The following is a discussion of the results obtained from the analysis. In an effort to investigate if there are any statistical differences between each value of some socioeconomic characteristics, Mann-Whitney U test and Kruskal-Wallis H test has been tried.

4.5.1 Gender of the passenger

The results of this analysis show no specific pattern as shown in Figure 4.17. According to the figure, the access distance for both males and females at each pier are very close to each other. Just at Eminönü and Kadıköy piers, women walk more than men. This slight difference in WAD does not tell much about any inherent pattern that might differentiate between men and women.

As it can be seen in Figure 4.16, the mean WAD of women in Eminönü and Kadıköy is bigger than men's. However, in Beşiktaş, Karaköy and Üsküdar women's WAD is smaller than men's. In order to evaluate the statistical significance of this differences, Mann-Whitney U test, which is a powerful test when the data groups are not normally distributed, is conducted between men and women groups at each inner-city ferry piers.

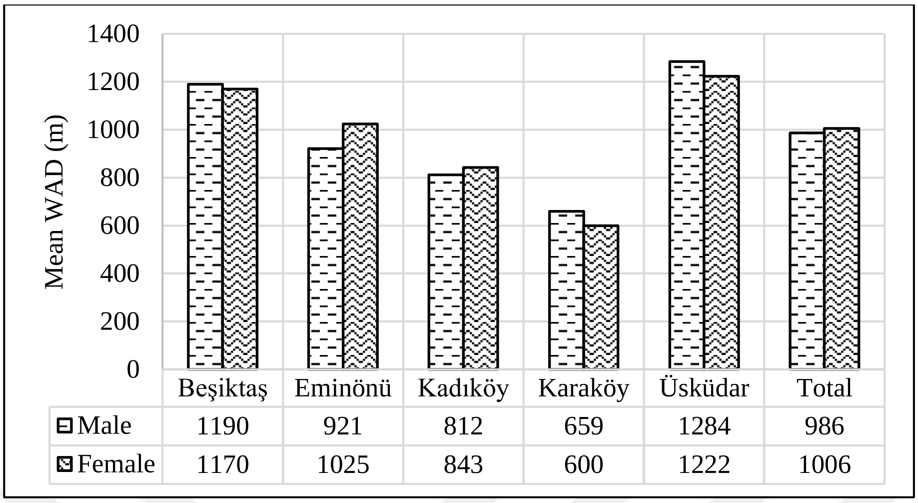


Figure 4.16: Mean WAD based on different gender groups.

At 5% level of significance, the results of Mann-Whitney U test for WAD of men and women groups are shown in Table 4.8. Z_{Sta} is bigger than Z_{Cri}, in Beşiktaş, Eminönü, and Kadıköy. The null hypothesis is rejected which means the effect of gender on WAD is statistically significant and these groups are from different population with different characteristics. However, in Karaköy and Üsküdar the Z_{Sta} is not bigger than Z_{Cri} which means these groups are from the same population and have the same characteristic.

Table 4.12: Results of Mann-Whitney U test for gender groups at each pier.

Pier	Gender	Mean of WAD	Zsta	Zcri
Beşiktaş	Men	1190	-10.34	±1.96
	Women	1170		
Eminönü	Men	921	-3.34	±1.96
	Women	1025		
Kadıköy	Men	812	-7.68	±1.96
	Women	843		
Karaköy	Men	659	-0.02	±1.96
	Women	600		
Üsküdar	Men	1284	-0.27	±1.96
	Women	1222		

4.5.2 Age of the passenger

Access distance was calculated for three groups of age. These groups were chosen to reflect the different age groups. The groups include:

- Under 25-years old
- 25-65-years old

- Older than 65-years old

Figures 4.17-4.22 show the relationship between the data and the equation of the trend line. At each inner-city ferry pier tried to find the biggest R-Squared, though the value of the R-Squared at all of the piers are too small, and the best equation which shows the relationship between the age of the passengers and WAD to the piers. From the trend lines and equations which are given in the below, it is understandable that at Beşiktaş and Kadıköy ferry piers' passengers that fall over 65 age group walk more than other groups to access pier. At Eminönü passengers under 25 age group walk more than other groups, and at Karaköy, Üsküdar ferry piers commuters of 25-65 age group walk more to access pier. When looking at to the total data, it is seen that when the age goes older the distances that people want to traverse through the inner-city piers are increasing.

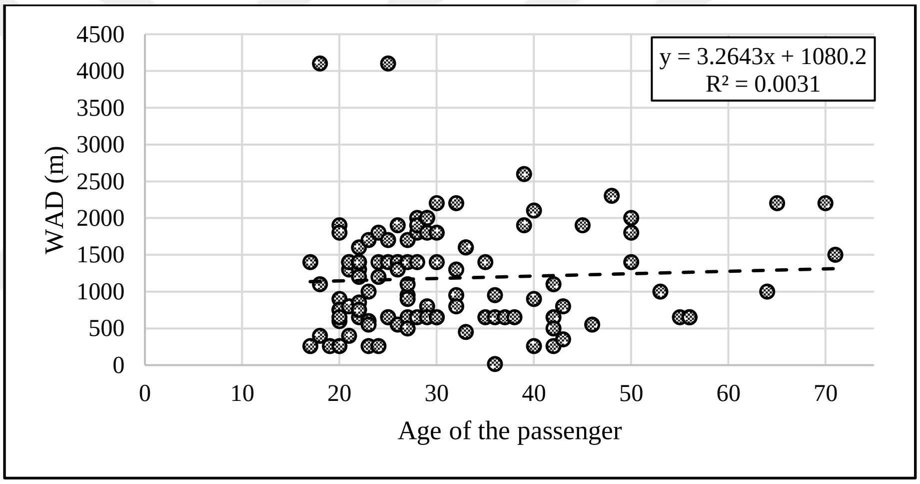


Figure 4.17: Relationship between WAD and the age of the passengers at Beşiktaş.

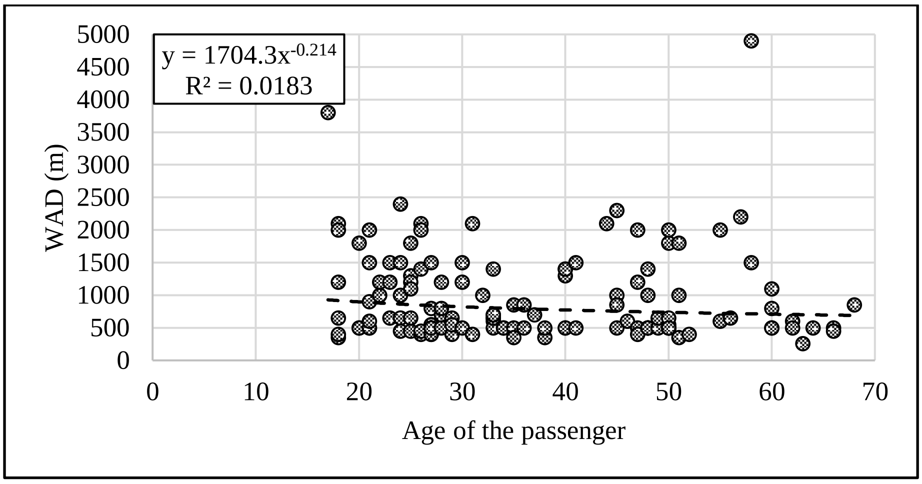


Figure 4.18: Relationship between WAD and the age of the passengers at Eminönü.

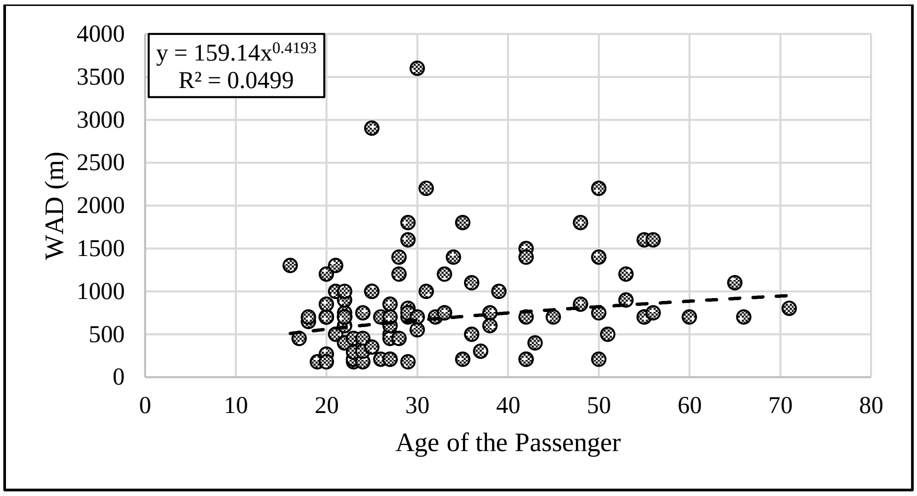


Figure 4.19: Relationship between WAD and the age of the passengers at Kadıköy.

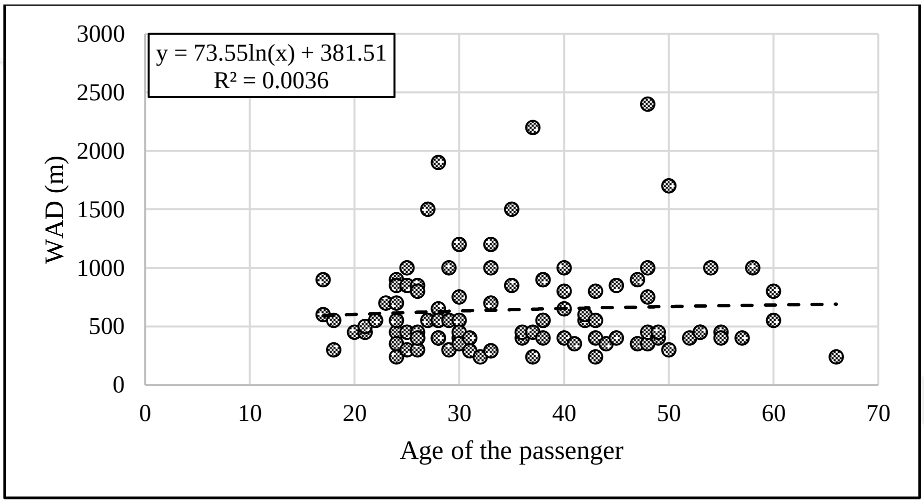


Figure 4.20: Relationship between WAD and the age of the passengers at Karaköy.

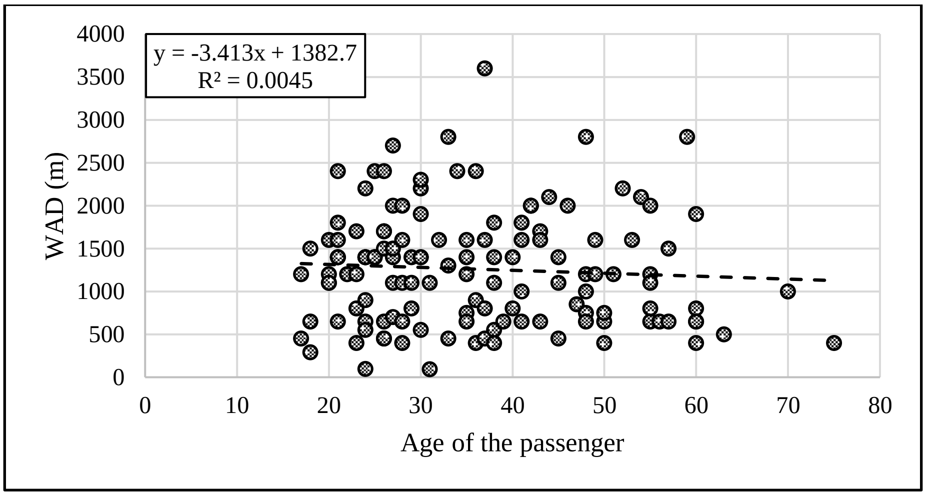


Figure 4.21: Relationship between WAD and the age of the passengers at Üsküdar.

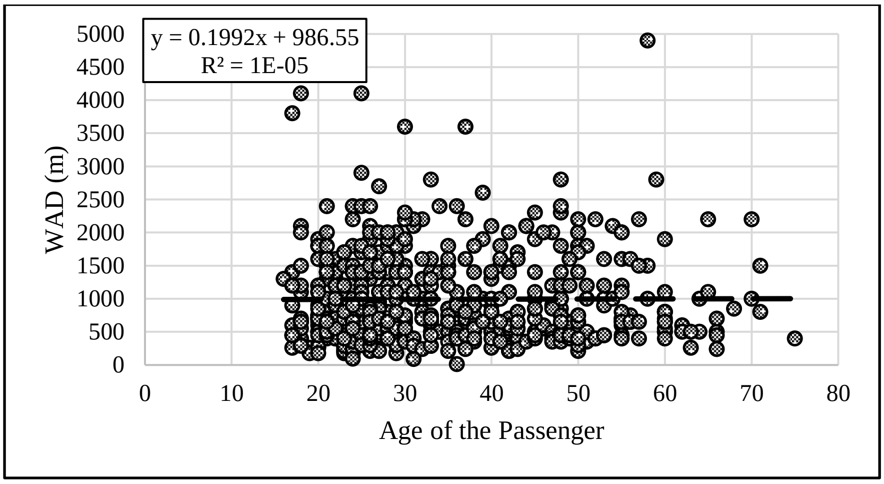


Figure 4.22: Relationship between WAD and the age of the passengers at of total data.

4.5.3 Availability of automobile in the household

The statistical analysis of availability of car in the household show that there is slight difference on WAD, between passengers who have a car and who do not have a car. However, the passengers who do not have a car, walk a little bit more than passengers who have a car. Figure 4.23 shows that there is no specific relationship between having a car and WAD to transit piers.

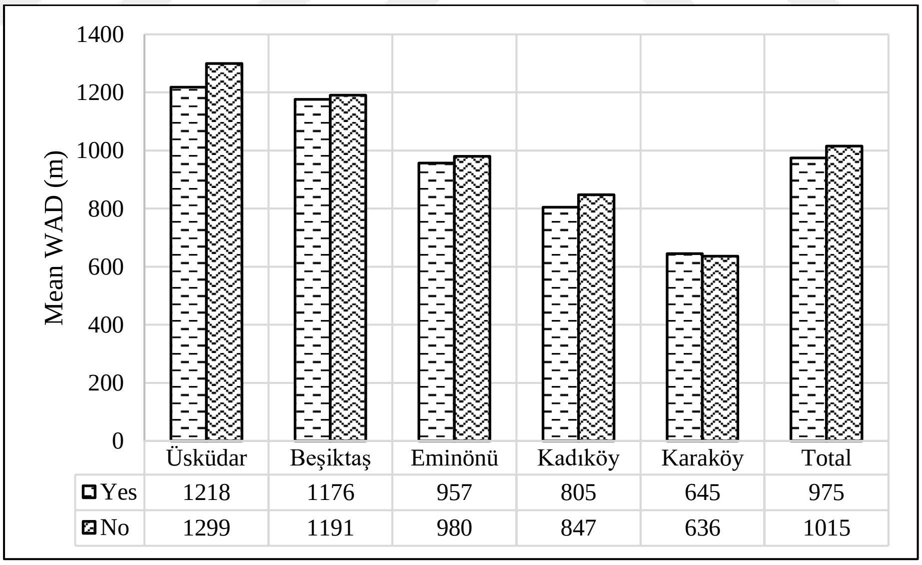


Figure 4.23: Mean WAD based on availability of a car in the household.

In order to show if there are statistical differences between availability of car in the household or not Mann-Whitney U test was conducted at each pier. The results of the test showed that as the statistical values are smaller than the critical values, there are no statistical differences and all groups at each pier are from the same population with same characteristics. Table 4.9 is given to show the results of the test.

Table 4.13: Results of Mann-Whitney U test for availability of car groups at each pier.

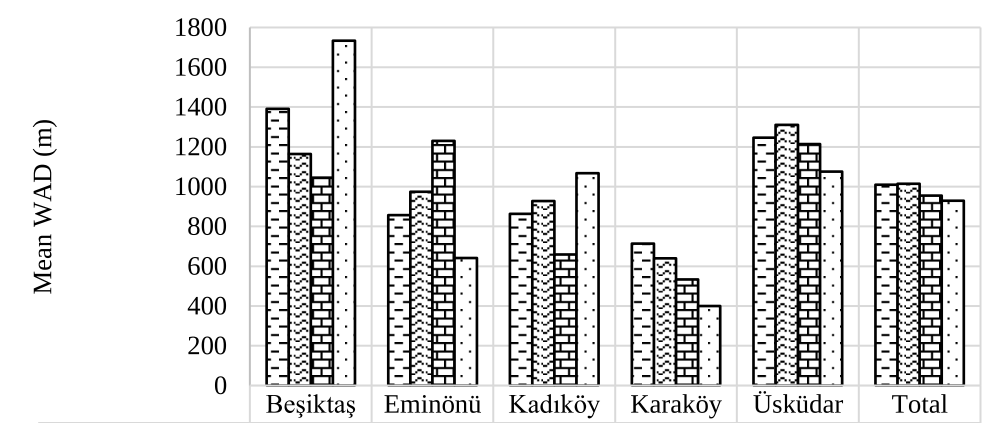
Pier	Availability of car	Mean of WAD	Zsta	Zcri
Beşiktaş	No	1191	-0.10	± 1.96
	Yes	1176		
Eminönü	No	980	-0.84	± 1.96
	Yes	957		
Kadıköy	No	847	-0.07	± 1.96
	Yes	805		
Karaköy	No	636	-0.55	± 1.96
	Yes	645		
Üsküdar	No	1299	-0.34	± 1.96
	Yes	1218		

4.5.4 Profession of the passenger

Commuters are grouped into four occupations. These groups are:

- Self-employed
- Salaried
- Student
- Housewife

Figure 4.24 shows the mean WAD for these different groups in each pier. It is understandable that there is no relationship between passengers' profession and how long they walk to access transit as it is given in below.



	Beşiktaş	Eminönü	Kadıköy	Karaköy	Üsküdar	Total
# Self-employed	1390	856	864	713	1247	1010
# Salaried	1165	974	928	640	1310	1015
# Student	1045	1230	659	534	1214	954
# Housewife	1733	641	1067	400	1075	929

Figure 4.24: Mean WAD based on different profession groups.

In order to investigate whether there are statistically significant differences between two or more groups of independent variables or not, Kruskal-Wallis H test which is a rank-based non-parametric hypothesis test is used. This test is considered the non-parametric alternative to the one-way ANOVA test and an extension of the Mann-Whitney U test to allow the comparison of more than two independent groups. However, it is a non-parametric test and it does not assume a normal distribution of the dataset. The null hypothesis in this test is “all groups are from the same population” and the alternative hypothesis is “at least one group is from the different population”.

When there are more than five data in each group, Kruskal-Wallis H test statistic approximately behaves like Chi-square distribution, having degrees of freedom equal to the number of groups minus one and so the critical value of Kruskal-Wallis H test should be obtained from Chi-square table. In order to calculate the test statistics of this test, first all the data must be ranked; ignoring which group they belong to. Then the total ranks for each group must be calculated (T_1,T_2,…) and H statistic (H_{Sta}) will be calculated using Equation 4.8 (Bury, 1999):

$$H_{sta} = \left[\frac{12}{N * (N+1)} * \sum_{i=1}^{m} \frac{{T_i}^2}{n_i}\right] - 3 * (N+1) \qquad (4.8)$$

Where:

N: total number of data in all groups

m: Number of groups

T_i: Sum of ranks in group i

n_i: Number of data in group i

Four different profession groups were considered to investigate the effect of passengers’ profession on WAD to pier. In order to evaluate the statistical differences between profession groups, as these groups do not have a normal distribution, Kruskal-Wallis H test is conducted. Calculated values of Kruskal-Wallis H test are given in Table 4.10 show that WAD at Kadıköy, Karaköy, and Üsküdar piers are coming from the same population, however, the results of Beşiktaş and Eminönü piers show that at least one of the profession groups are not from the same population. Nevertheless, Kruskal-Wallis H test does not determine which groups are different from others.

Table 4.14: Results of Kruskal-Wallis H test of different profession groups at piers.

Pier	Groups	Mean of WAD	Hsta	Hcri
Beşiktaş	Housewife	1733	6.88	5.99
	Salaried	1165		
	Self-employed	1390		
	Student	1045		
Eminönü	Housewife	641	9.53	5.99
	Salaried	974		
	Self-employed	856		
	Student	1230		
Kadıköy	Housewife	1067	4.56	5.99
	Salaried	928		
	Self-employed	864		
	Student	659		
Karaköy	Housewife	400	2.30	5.99
	Salaried	640		
	Self-employed	713		
	Student	534		
Üsküdar	Housewife	1075	0.75	5.99
	Salaried	1310		
	Self-employed	1247		
	Student	1214		

4.5.5 Income of the passenger

The income of PT users of this study was divided into five groups. These groups include:

- 0 – 1500 TL
- 1500 – 3000 TL
- 3000 – 4500 TL
- 4500 – 6000 TL
- More than 6000 TL

Figures 4.25-4.30 show the relationship between the data and the equation of the trend line. As it is mentioned before, at each inner-city ferry pier tried to find the biggest R-Squared, though the value of the R-Squared at all of the piers are too small, and the best equation which shows the relationship between the income of the passengers and WAD to the piers. The results interpreted that at Beşiktaş, Kadıköy and Karaköy passengers who earn between 4500-6000 TL are willing to walk more than other groups to reach the pier. At Eminönü and Üsküdar piers, passengers with income between 1500-3000 TL walks more than other groups. Meanwhile, at Beşiktaş, Eminönü, Karaköy whose income is more than 6000 TL walk lesser to access the pier, they use other PT systems to reach inner-city ferry piers. At Kadıköy and Üsküdar people with 0-1500 walks less than other groups.

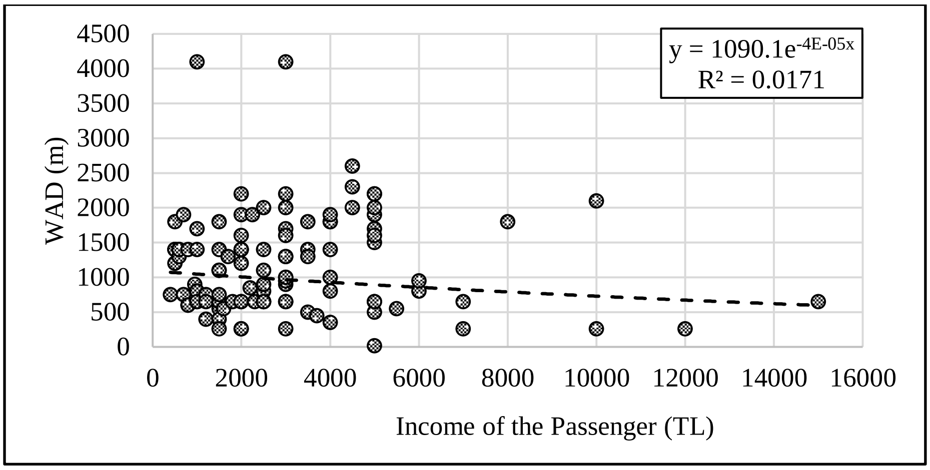


Figure 4.25: Relationship between WAD and the income of the passenger at Beşiktaş.

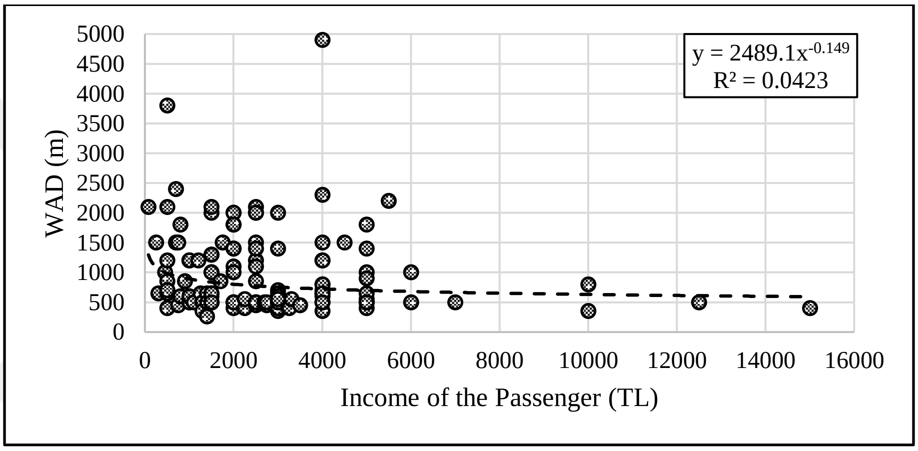


Figure 4.26: Relationship between WAD and the income of the passenger at Eminönü.

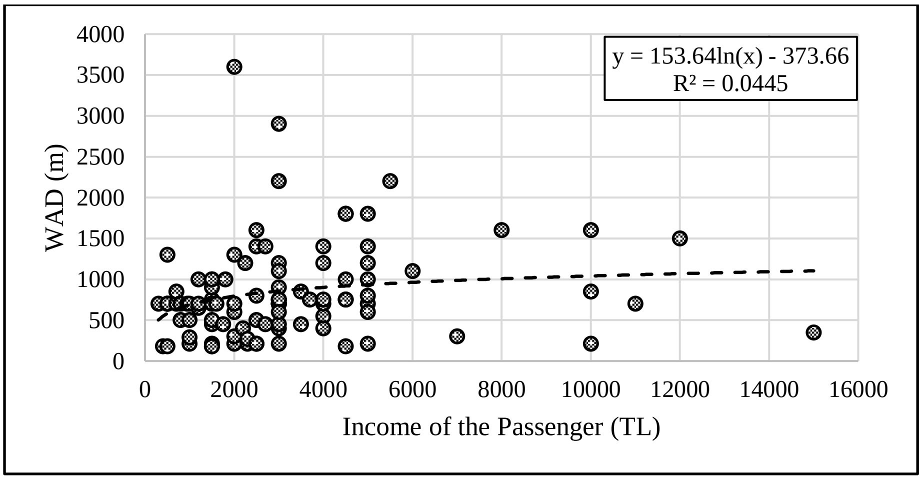


Figure 4.27: Relationship between WAD and the income of the passenger at Kadıköy.

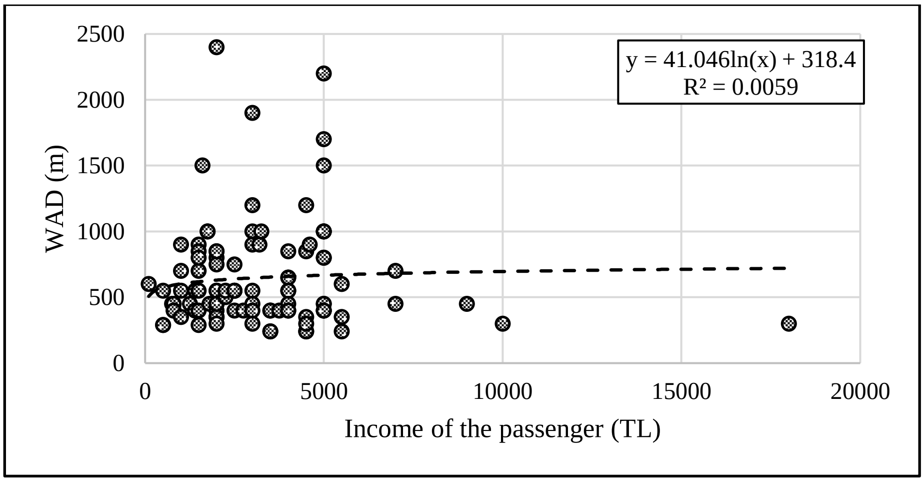


Figure 4.28: Relationship between WAD and the income of the passenger at Karaköy.

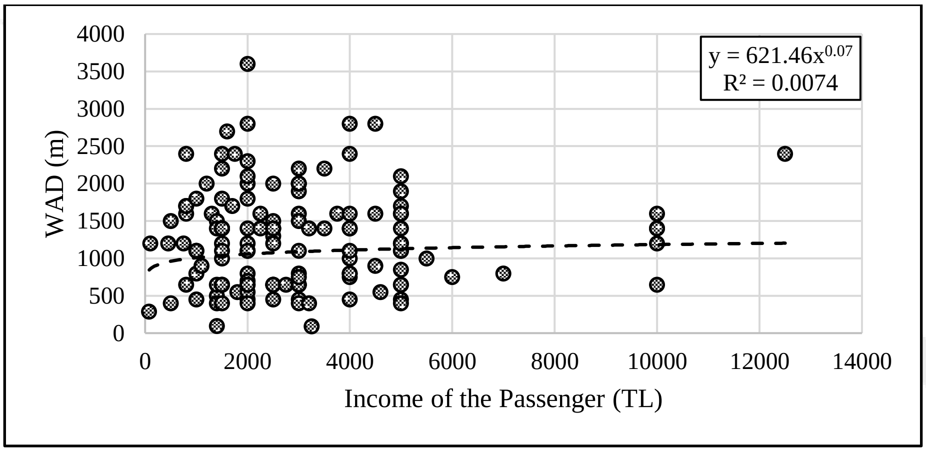


Figure 4.29: Relationship between WAD and the income of the passenger at Üsküdar.

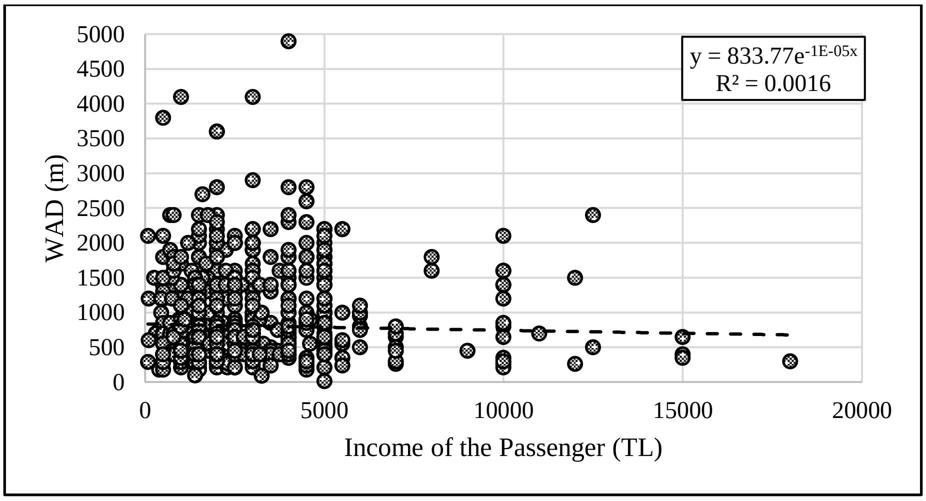


Figure 4.30: Relationship between WAD and the income of the passenger of total data.

4.6 Accuracy at the precepted WAD

In order to understand how many of passengers guess true the distance they walk to ferry piers, the estimated time by passengers is converted to distance by using the table of pedestrian speeds according to different age and gender with regard to “Urban Roads-Design criteria on sidewalks and pedestrian areas of Turkish Standard” (TS 12174) which is given in Table 4.11.

With regard to comparing of the distance people guess and the true distance which is determined by Google maps, and considering 100 m as error threshold distance at Beşiktaş approximately 15% of passengers guess true their walking distance to ferry pier. At Eminönü about 22% estimated the true distance. At Kadıköy, Karaköy, and Üsküdar about 15%, 16%, and 8% of commuters computed true their WAD to the transit pier, respectively.

Table 4.15: Pedestrian speeds according to different age and gender (TS 12174).

Pedestrian group	Pedestrian speed (m/s)
Women with children	0.7
Children (6-10 years old)	1.1
Women (over 50 years old)	1.3
Women (up to 50 years old)	1.4
Men (over 55 years old)	1.4
Men (40-55 years old)	1.6
Men (until age 40)	1.7
Youth	1.8

To understand the relationship between declared distance which is people’s guess about the distance they walk through the ferry-boat piers and calculated distance which is determined by Google maps, trend lines of data which is best-fitted have been drawn at each pier.

Figures 4.31-4.36 show the relationship between data and the equation of the trend line. From the value of R-square which is given in figures below, it is seen that when the value is low the accurate guessing by people is low and when the R-square value increases the accurate guessing with compare to calculated WAD is high, too. The equations show that at Beşiktaş, Eminönü, Kadıköy, Karaköy, and Üsküdar piers the guesses of people are overestimating of the real WADs. The independent variable which is shown by X is people’s guess or declared WAD and the dependent variable which is shown by Y is the google maps distance or calculated WAD. Generally, the predicted value for time by people is 5 or 10 min, hence this causes some data to be stacked in vertical columns at declared WAD in figures.

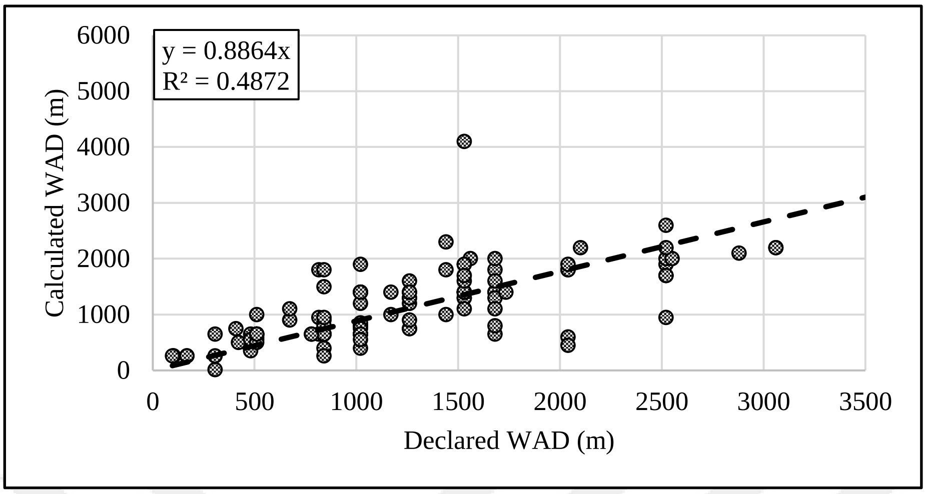


Figure 4.31: Relationship between people's guess and Google maps about WAD at Beşiktaş.

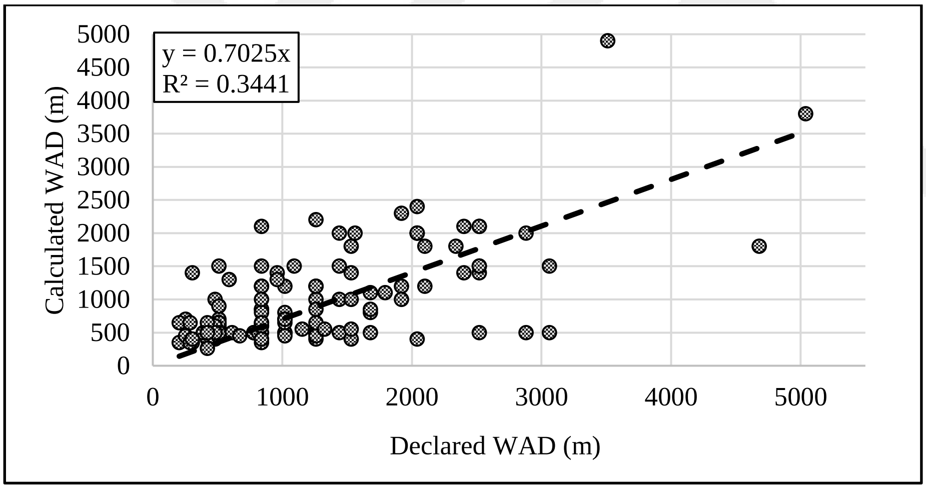


Figure 4.32: Relationship between people's guess and Google maps about WAD at Eminönü.

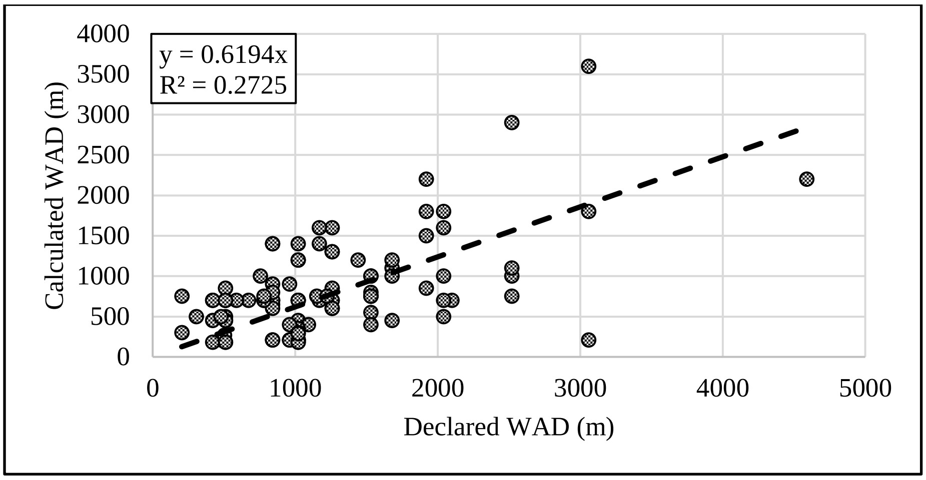


Figure 4.33: Relationship between people’s guess and Google maps about WAD at Kadıköy.

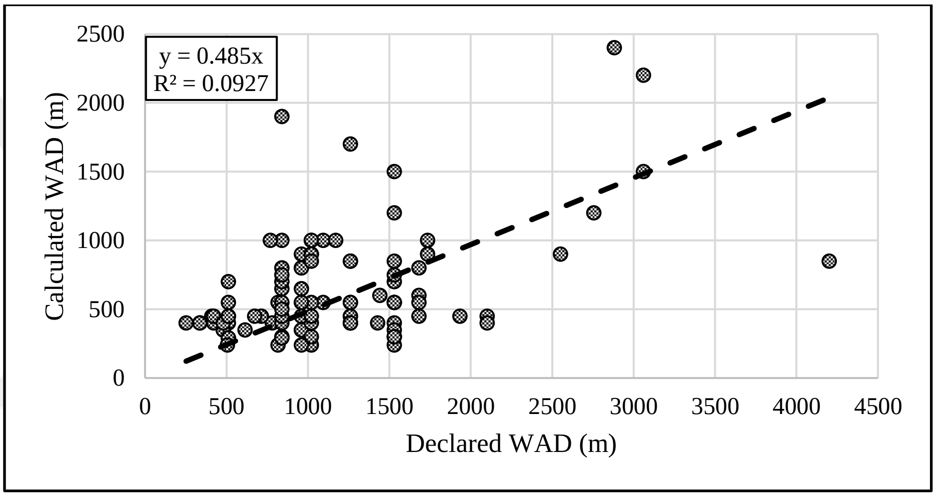


Figure 4.34: Relationship between people’s guess and Google maps about WAD at Karaköy.

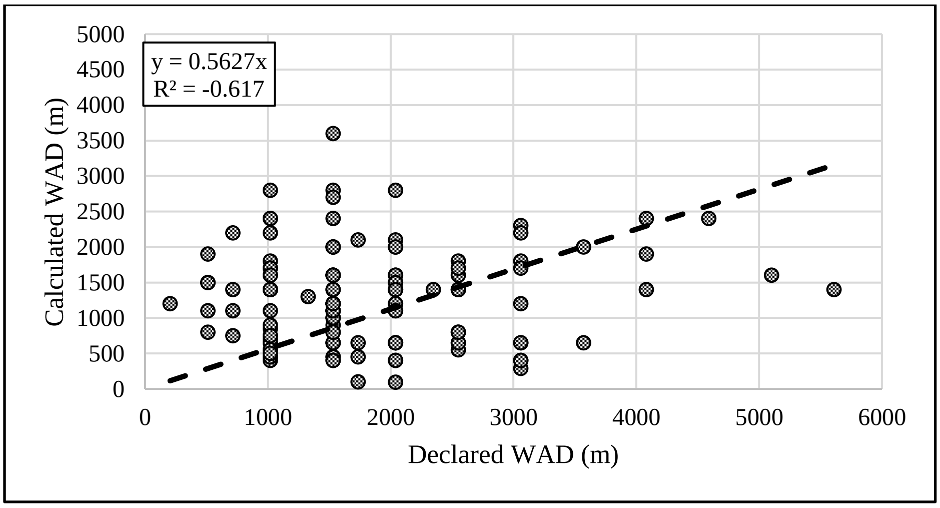


Figure 4.35: Relationship between people’s guess and Google maps about WAD at Üsküdar.

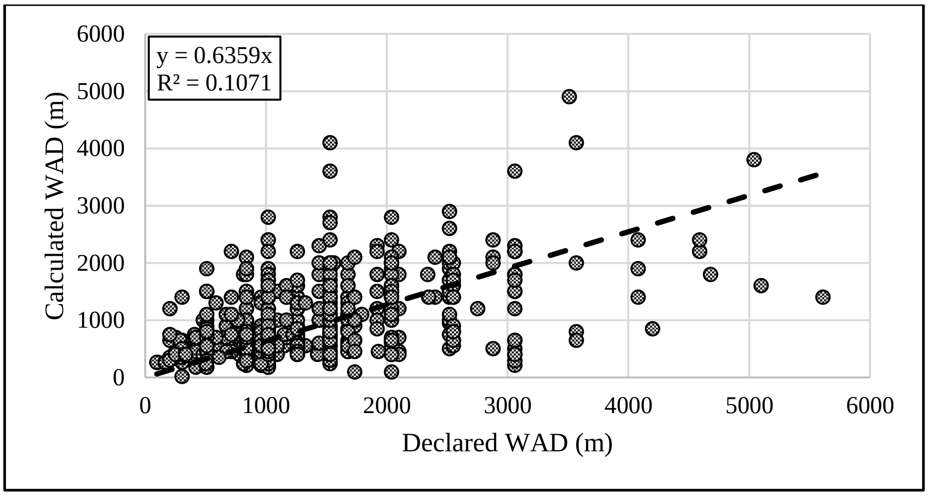


Figure 4.36: Relationship between people's guess and Google maps about WAD of total data.

4.7 Mathematical models of WAD to transit pier

In order to understand the effect of independent variables on WAD, multiple regression models are developed. In statistical modeling, the regression analysis is a set of statistical processes for estimating the relationship between variables. It includes many techniques for modeling and analyzing several variables when the focus is on the relationship between a dependent variable and one or more independent variables. More specifically, regression analysis helps one understand how the typical value of the dependent variable changes when any one of the independent variables are varied, while the other independent variables are held fixed.

Multiple regression is an extension of simple linear regression. This type of regression analysis is used when there are several independent variables. The equation for multiple linear regression is given in Equation 4.9 (Bury, 1999):

$$Y = b_0 + b_1X_1 + b_2X_2 + \cdots + b_nX_n \quad (4.9)$$

Where b_0 is the intercept, and b_1 through b_n are the regression coefficients for each of the independent variables X_1 through X_n.

In this thesis, the independent variables which are investigated in multiple linear regression analysis are the gender of the passenger, the age of the passenger, the availability of car in the household, and the income of the passenger.

In regression analysis, the independent variables may be influenced not only by quantitative variables such as income, price and so on but also by qualitative variables such as gender (male or female), profession (salaried, self-employed, student, and housewife), availability of car in the household (with car, without car). Such variables do not have any natural scale of measurement and usually indicate yes or no, acceptance or rejection, so they are defined on a nominal scale. Therefore, these variables take the value "0" or "1" to indicate the absence or presence of some categorical effect that may be expected to shift the outcome. Usually, the absence of attribute indicates with "0", and "1" indicates the presence of the attribute. For example, "1" indicates that the person is male and "0" indicates that the person is female. Similarly, "1" may indicate the availability of car in the household and "0" indicates that there is no car in the household. The choice of "1" and "0" to identify a category is arbitrary. These variables are called indicator or dummy variables. And if a qualitative variable has n levels, then n-1 dummy variables are required and each of them takes value 0 and 1.

In Table 4.12 used four independent dummy variables in the WAD model at each pier are given. The correlation matrix of all variables with dependent variable was calculate for each pier. Equation 4.10 shows the multiple linear regression which is used at each pier and total study area:

$$Y = b_0 + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 \tag{4.10}$$

Where:

Y: WAD to pier

b_0: Intercept

X_1, X_2, X_3, and X_4: Independent variables as defined in Table 4.12.

b_1, b_2, b_3, and b_4: Coefficients of variables.

When all of the independent variables' coefficients are equal to zero, the value of the WAD is equal to intercept. In this case, the model is called the "base model". At all piers, the base model includes the female passengers who do not have car in their household. A small p-value (typically ≤ 0.05) indicates strong evidence against the null hypothesis, so reject the null hypothesis. This means at 5% level of significance, the variables with less than 0.05 P-values can be eliminated from the regression model.

Table 4.16: Used independent variables in WAD model.

Variable	Variable Notation	Explanation
Gender	X1	1, if Male 0, if Female
Age	X2	-
Availability of car	X3	1, if "Yes" 0, if "No"
Income	X4	-

The results of multiple linear regression models are given in tables below. At all piers, the correlations between independent variables and dependent variables are small. Since the relationship between the variables is small, the value of R-Square is very low. Regarding to these results of correlation matrixes and values of R-Squared, interpretation of mathematical models is complex.

The independent variables' coefficients in multiple linear regression models expected to be the same as their sign with dependent variable in the correlation matrix. However, in some variables at all piers, it is not true. This can be because of some other variables that are not considered in this thesis or can be because of the low correlation between variables.

4.7.1 The walk access model at Beşiktaş pier

Tables 4.13, 4.14 show the correlation matrix of independent variables with the dependent variable, and final regression model for WAD at Beşiktaş pier. As it is mentioned above, at 5% level of significance, at Beşiktaş pier the sign of independent variables tried to be the same as their sign in the correlation matrix with dependent variable.

Table 4.17: Correlation matrix of passengers' WAD at Beşiktaş pier.

Variables	X_1	X_2	X_3	X_4	Y
X_1	1.00				
X_2	-0.03	1.00			
X_3	0.13	-0.06	1.00		
X_4	0.06	0.36	0.01	1.00	
Y	0.01	0.06	-0.01	-0.04	1.00

Table 4.18: Final regression model for WAD at Beşiktaş pier.

Regression Statistics	
Multiple R	0.09
R Square	0.01
Adjusted R Square	-0.03
Standard Error	718.44
Observations	110.00

	Coefficients	Standard Error	t Stat	P-value
Intercept	1082.73	227.14	4.77	0.00
X1	30.75	143.25	0.21	0.83
X2	4.78	6.16	0.78	0.44
X3	-10.87	138.98	-0.08	0.94
X4	-0.02	0.03	-0.67	0.50

4.7.2 The walk access model at Eminönü pier

Tables 4.15, 4.16 show the correlation matrix of independent variables with the dependent variable, and final regression model for WAD at Eminönü pier.

Table 4.19: Correlation matrix of passengers' WAD at Eminönü pier.

Variables	X_1	X_2	X_3	X_4	Y
X_1	1.00				
X_2	0.11	1.00			
X_3	0.07	0.07	1.00		
X_4	0.27	0.28	0.25	1.00	
Y	-0.07	-0.07	-0.02	-0.14	1.00

Table 4.20: Final regression model for WAD at Eminönü pier.

Regression Statistics	
Multiple R	0.15
R Square	0.02
Adjusted R Square	-0.01
Standard Error	703.03
Observations	128.00

	Coefficients	Standard Error	t Stat	P-value
Intercept	1157.55	195.68	5.92	0.00
X1	-53.76	129.96	-0.41	0.68
X2	-1.90	4.77	-0.40	0.69
X3	26.81	129.23	0.21	0.84
X4	-0.04	0.03	-1.24	0.22

Respectively, the sign of variable X3 which is the availability of car in the household is not the same in the correlation matrix with dependent variable and regression model.

4.7.3 The walk access model at Kadıköy pier

Tables 4.17, 4.18 show the correlation matrix of independent variables with the dependent variable, and final regression model for WAD at Kadıköy pier.

Table 4.21: Correlation matrix of passengers' WAD at Kadıköy pier.

Variables	X_1	X_2	X_3	X_4	Y
X_1	1.00				
X_2	0.07	1.00			
X_3	-0.06	0.06	1.00		
X_4	0.12	0.44	-0.07	1.00	
Y	-0.03	0.18	-0.04	0.15	1.00

Table 4.22: Final regression model for WAD at Kadıköy pier.

Regression Statistics	
Multiple R	0.21
R Square	0.04
Adjusted R Square	0.00
Standard Error	571.46
Observations	101.00

	Coefficients	Standard Error	t Stat	P-value
Intercept	612.76	177.54	3.45	0.00
X1	-58.19	117.82	-0.49	0.62
X2	6.49	5.01	1.29	0.20
X3	-48.97	115.41	-0.42	0.67
X4	0.02	0.02	0.81	0.42

Correspondingly, at 5% level of significance, at Kadıköy pier the sign of independent variables tried to be the same as their sign in the correlation matrix with dependent variable.

4.7.4 The walk access model at Karaköy pier

Tables 4.19, 4.20 show the correlation matrix of independent variables with the dependent variable, and final regression model for WAD at Karaköy pier. Correspondingly, at 5% level of significance, at Kadıköy pier the sign of independent variables tried to be the same as their sign in the correlation matrix with dependent variable.

Table 4.23: Correlation matrix of passengers' WAD at Karaköy pier.

Variables	X_1	X_2	X_3	X_4	Y
X_1	1.00				
X_2	0.24	1.00			
X_3	0.11	0.02	1.00		
X_4	0.21	0.27	0.21	1.00	
Y	0.07	0.04	0.01	-0.02	1.00

Table 4.24: Final regression model for WAD at Karaköy pier.

Regression Statistics	
Multiple R	0.09
R Square	0.01
Adjusted R Square	-0.03
Standard Error	403.62
Observations	101.00

	Coefficients	Standard Error	t Stat	P-value
Intercept	571.23	140.33	4.07	0.00
X1	58.42	90.40	0.65	0.52
X2	1.37	3.76	0.37	0.72
X3	10.01	82.40	0.12	0.90
X4	-0.01	0.02	-0.42	0.68

4.7.5 The walk access model at Üsküdar pier

Tables 4.21, 4.22 show the correlation matrix of independent variables with the dependent variable, and final regression model for WAD at Üsküdar pier. The results show that the signs of the independent variables are the same with their sign in the correlation matrix with dependent variable.

Table 4.25: Correlation matrix of passengers' WAD at Üsküdar pier.

Variables	X_1	X_2	X_3	X_4	Y
X_1	1.00				
X_2	0.12	1.00			
X_3	0.21	0.00	1.00		
X_4	0.27	0.25	0.34	1.00	
Y	0.05	-0.07	-0.06	0.04	1.00

Table 4.26: Final regression model for WAD at Üsküdar pier.

Regression Statistics	
Multiple R	0.14
R Square	0.02
Adjusted R Square	-0.01
Standard Error	666.07
Observations	133.00

	Coefficients	Standard Error	t Stat	P-value
Intercept	1376.55	185.13	7.44	0.00
X1	76.31	123.93	0.62	0.54
X2	-4.82	4.64	-1.04	0.30
X3	-132.94	124.43	-1.07	0.29
X4	0.03	0.03	0.84	0.40

4.7.6 The walk access model of total study area

Tables 4.23, 4.24 show the correlation matrix of independent variables with the dependent variable, and final regression model for WAD for total data of study area.

Table 4.27: Correlation matrix of passengers' WAD for total data of piers.

Variables	X_1	X_2	X_3	X_4	Y
X_1	1.00				
X_2	0.09	1.00			
X_3	0.09	0.02	1.00		
X_4	0.19	0.31	0.15	1.00	
Y	-0.01	0.00	-0.03	-0.02	1.00

Table 4.28: Final regression model for WAD for total data of piers.

Regression Statistics	
Multiple R	0.036
R Square	0.001
Adjusted R Square	-0.006
Standard Error	665.763
Observations	573.000

	Coefficients	Standard Error	t Stat	P-value
Intercept	1016.46	89.03	11.42	0.00
X1	-13.53	58.37	-0.23	0.82
X2	0.51	2.29	0.22	0.82
X3	-36.56	56.52	-0.65	0.52
X4	-0.004	0.01	-0.33	0.74

The results show that the signs of the independent variables are the same with their sign in the correlation matrix with dependent variable.

64

5. CONCLUSION

This study examines the relationship between several socioeconomic characteristics of PT users and WAD. These factors are the gender, the age, the availability of car in a household, the income of passengers, and the purpose of travel. The case study conducted in five different public maritime piers in Istanbul with interviewing users of the PT system.

With regard to mean values of WAD at each pier, users of Üsküdar pier walk more than other piers and users of Karaköy walk lesser than other groups.

By determining the one-fifth of total data and doing the same thing separately at each pier, the change area of piers was tried to find.

At five zones of the study area, peoples' purpose of travel was different. At Beşiktaş, Eminönü, Karaköy, and Üsküdar zones passengers whose aim is a non-obligatory trip walk more to reach the piers. This may be because of "Carşi-Bazaar or shopping malls", "Historical places", or "Exercise", and so on. At Kadıköy zone passengers whose aim is an obligatory trip walk more. By conducting the Mann-Whitney U test at all five inner-city ferry piers, it is showed that there are no statistical differences between obligatory and non-obligatory groups. Hence, the peak hours and off-peak hours was not considered in this study.

The socioeconomic characteristics of users can be interpreted as below:

- The gender groups of passengers which are male and female at each pier showed that there are no big differences between men and women in WAD to PT area. Due to the Mann-Whitney U test, the gender groups of passengers at Beşiktaş, Eminönü, and Kadıköy are from different populations with different characteristics. However, at Karaköy, and Üsküdar the gender groups are from same populations and have same characteristics.
- There is nothing general about the age of passengers which is divided into three groups at all five piers. At Beşiktaş and Kadıköy, passengers over 65-years old walk more to access pier. At Eminönü passengers under 25-years old are

willing to walk more to use the pier. At Karaköy and Üsküdar commuters between 25-65-years old have the biggest average which means they walk more than other age groups to use the ferry pier.

- The other socioeconomic characteristic of passengers is the availability of car in the household. However, the mean values of this parameter show that this factor has no effect on WAD in Istanbul. Although, the results of Mann-Whitney U test showed there are no statistical differences between having a car and do not have a car in the household.
- Another variable that was considered is passenger's profession and its relationship with WAD. At Beşiktaş and Kadıköy housewife group walk more maybe they have much more free time to walk through the PT piers. At Eminönü, Karaköy and Üsküdar students group, self-employed and salaried group are willing to walk more, correspondingly. Due to the Kruskal-Wallis H test, the dataset of Beşiktaş and Eminönü are coming from the different population with different characteristics.
- Income can have effect on WAD of passengers. People with low income want to walk more, however, passengers with high income do not want to walk more and prefer other mode choices. Analysis of this factor at different piers showed something interesting. At Beşiktaş and Kadıköy, Karaköy commuters with 4500-6000 TL, at Eminönü and Üsküdar who has earned 1500-3000 TL walks more through the public sea piers.

The mathematical models can be interpreted as below:

The regression models are considered to mathematically describe the relationship between some predictors and the response variable. The socio-economic characteristics of passengers used as independent variables and the distance people walk through the piers considered as the dependent variable in regression models at each ferry-boat pier.

R-squared is a goodness-of-fit measure for linear regression models. Generally, the model with higher R-square is selected. However, the value of R-squared at each pier is very low and near to the zero. This means that the variability of the response data around the mean at each model is at a low level, and the low correlation between the variables may has affected the value of R-square. This can be because of some other variables that are not considered in this thesis.

This thesis focused on finding the relationship between WAD and socio-economic characteristics of transit users, and the interpretation of the distributions. Some work still can be done in this field including:

Other modes of access to transit, other than walk, can be included in the analysis to study the effect of the access mode on access distance to transit.

The inclusion of off-peak trips in the analysis to investigate the effect of the time of the day in which the trip is made on walk access distance to transit.

Cross-analysis of the different attributes of the trip-maker, which would make the analysis more challenging and productive.

How ridership and access distance are affected by transit service characteristics, such as spacing and frequency (combined), based on land use, socio-economic and demographic characteristics. This should help with determining effective service configurations with regards to service spacing and frequency to achieve highest possible ridership at acceptable access distances.

YÖK

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APPENDIX

APPENDIX A:

Istanbul Technical University Transportation Engineering Program
ACCESS TO FERRY-BOAT PIERS SURVEY

Since this questionnaire will be conducted on footsteps, the first question is whether you walked to the pier, and those who answered YES will fill the questionnaire.

Date: ………
Clock: ....….
Pier: ……..…

1. Start point of the trip (Home / Work / Other):

----

2. Sex: Male ☐ Female ☐
3. Age: ----------
4. Marital Status: Married ☐ Single ☐ Other ☐
5. Household Size (including children): ----------
6. Do you have a car? Yes ☐ No ☐
7. Career: Self-employed ☐ Salaried ☐ Housewife ☐ Student ☐
8. Monthly revenue per family (TL): ----------
9. Purpose of the journey?
   Home/Work ☐ Home/School ☐ Home/Shopping ☐ Other ☐
10. Are you going to walk when you get off? Yes ☐ No ☐
11. End point of the trip (Home / Work / Other):
    ----
12. How far is the distance from the start point of the journey to here (pier)? ------
13. How far is the distance from here (pier) to the end point of the journey? -------
14. Why did you choose Turyol company to travel? -----------------------------------

CURRICULUM VITAE

Name Surname: Kiana SANAJOU

Place and Date of Birth: Urmia - 25.07.1992

E-Mail: k.sanajou@gmail.com

EDUCATION :

- B.Sc.: Civil Engineering from Urmia University, Urmia, Iran.

PUBLICATIONS, PRESENTATIONS AND PATENTS:

JOURNALS

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