# THE EFFECTS OF NAVIGATION SYSTEMS ON TRAFFIC CONGESTION USING REAL-TIME DATA: CASE OF İZMİR

**A Thesis Submitted to**
**the Graduate School of**
**İzmir Institute of Technology**
**in Partial Fulfilment of the Requirements for the Degree of**

**MASTER OF SCIENCE**

**in City Planning**

**by**
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**December 2020**
**İZMIR**

# ACKNOWLEDGMENTS

I am certain that the thesis would not exist without the support of the following individuals.

First of all, I would like to express my sincere gratitude and respect to my supervisor Prof. Dr. Yavuz DUVARCI for all his encouragement, patience, interest, and advice. Without his support and guidance, I would never finish the thesis. Moreover, I would like to thank all professors who gave lectures to me throughout the master's program.

Secondly, I offer my thank to my precious family members; Hwasoon JANG, Jinhee YANG, and Onbit Lim for their unlimited trust. I could continue my study thank to their support.

Also, I would like to thank my boyfriend, Levent Cücük, for helping me to adjust and adapt to a new lifestyle in Turkey. Without his dedication, I would not be able to complete my study.

Lastly, I would like to thank the thesis committee members for their valuable contributions.

# ABSTRACT


## THE EFFECTS OF NAVIGATION SYSTEMS ON TRAFFIC CONGESTION USING REAL-TIME DATA: CASE OF İZMİR

This study tries to define the effects of navigation systems in urban traffic through city area in İzmir, using Google maps. Navigation systems, especially with real-time traffic data is relatively new, and user's rate has been sharply increased along with a spread of smartphone. However, there is no deep understanding of the navigation systems, yet. Therefore, people who utilize navigation systems while driving might trigger unexpected merits and demerits.

The study is conducted on two different scales; (1) commuting trips in the overall city (16 km in a straight line) and (2) short trip in the central business district (2 km in a straight line). Within the study area, the hypothetical trips are generated and the data of travel time and a travel distance of each trip suggested by Google maps is gathered. Compared the data, it is defined that how much time could be saved and how long additional travel distances are caused by Google Maps. Besides, the possible problem in the local streets is investigated. In a narrow local street, the environment should be pedestrian-friendly and suitable for low-speed vehicles, however, navigation systems would lead drivers into the local street. We discover how long are local streets used by the recommendation of the navigation system.

The result shows that during peak hours, the travel time travel distance is longer compared to the off-peak hours. Also, it indicates that by using Google Maps, drivers could save travel time while they drive the longer travel distance during peak hours.



**Keywords:** Intelligent transportation system, Electronic navigation system, Urban roads

# ÖZET


## GERÇEK ZAMANLI VERİ KULLANAN NAVİGASYON SİSTEMLERİNİN TRAFİK SIKIŞIKLIĞI ÜZERİNDEKİ ETKİLERİ: İZMİR ÖRNEĞİ

Bu çalışma Google Haritalar uygulamasını kullanarak navigasyon sistemlerinin İzmir kentsel bölgelerindeki trafiğe etkilerini tanımlamaya çalışmaktadır. Navigasyon sistemleri – özellikle gerçek zamanlı trafik verileri- yeni bir teknolojidir ve kullanım oranları da akıllı telefonların yaygınlaşması ile artış göstermiştir. Fakat,navigasyon sistemleri henüz tam olarak anlaşılmamaktadır. Bu nedenle sürüş sırasında navigasyon sistemi kullanan sürücüler umulmadık olumlu ve olumsuz sonuçlar alabilmektedir.

Bu çalışma iki kapsamda yapılmıştır; (1) şehir genelindeki işe gidiş-geliş yolculukları (16 km uzunluğundaki düz bir çizgide) ve (2) merkezi iş yerlerinde yapılan kısa yolculuklar (2 km uzunluğundaki düz bir çizgide). Bu çalışma alanı içinde varsayımsal yolculuklar oluşturulmuş, Google Haritalar tarafından önerilen her yolcuğun ulaşım süresi ve ulaşım mesafesi verileri toplanmıştır. Veriler kıyaslanarak, Google Haritalar kullanımıyla ulaşım süresinden ne kadar kazanıldığı ve ulaşım mesafesinin ne kadar arttığı tanımlanmıştır. Buna ek olarak, yerel sokaklardaki olası bir problem daha incelenmiştir. Dar yerel sokaklar, yayalara ve düşük hızlı araçlara uygun olmalıdırlar, fakat navigasyon sistemleri sürücüleri yerel sokaklara yönlendirmektedir. Bu çalışmada navigasyon sistemlerinin yönlendirilmesiyle bu yerel sokakların ne sıklıkla kullanıldığı da gözlemlenmiştir.

Sonuçlar, ulaşım süresi ve ulaşım mesafesinin yoğun saatlerde, yoğun olmayan saatlere kıyasla daha fazla olduğunu göstermektedir. Bununla beraber, sürücüler Google Haritalar kullanarak daha uzun mesafeleri tercih ederek zamandan kazanmaktadırlar.



**Anahtar kelimeler:** Akıllı taşıma sistemleri, Elektronik seyir haritaları, Şehiriçi yollar

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# LIST OF ABBREVIATIONS

| | |
|---|---|
| ATIS | : Advanced Traveler Information Systems |
| ATM | : Automated Teller Machine |
| CBD | : Central Business District |
| GHD | : General Directorate of Highway |
| GIS | : Geographical Information System |
| GM | : Google Map application |
| GPS | : Global Positioning System |
| ICT | : Information Communication Technologies |
| IoT | : Internet of Things |
| ITS | : Intelligence Transportation System |
| LOS | : Level of Service |
| PDA | : Personal Digital Assistant |
| RIS | : Route Information Sharing |
| TDM | : Traffic Demand Management |
| U.S. | : United States |
| V2I | : Vehicle to Infrastructure |
| V2V | : Vehicle to Vehicle |
| VANET | : Vehicular ad hoc Network |
| VICS | : Vehicle Information and Communication System |

# CHAPTER 1

# INTRODUCTION

Transportation is an essential part of contemporary social and economic life. It is not only about mobility from A to B but more likely accessibility of the urban activities such as work, education, leisure, and so on. The transportation system has become a concern of the public at large. Over the years, traffic congestion has got severe, because the growth of traffic volume has exceeded the development of road infrastructure (Lindsney and Verhoef, 2001). Cities over the world inevitably face ever-changing reformation, caused by the increasing population and the explosion of the traffic demand. (Varma, 2017). The biggest consequence of the increase is the constant and extraordinary rise of traffic congestion (Lindsney and Verhoef, 2001). Thus, traffic congestion has become one of the biggest problems in urban areas over the world. Traffic congestion is a fairly exhausting time for the drivers as well as the economic and environmental dissipation of the society (Schrank and Lomax, 2009). When the social cost of congestion is monetized, it is worth approximately billions of dollars annually (Schrank and Lomax, 2009). The economic cost is related to fuel consumption, wasted time of individuals, and it has also a significant impact on public health (Levy et al., 2010). Moreover, in a macro perspective, it reduces the productivity of workers, due to travel delay in peak hours (Harriet et al., 2013).

The development of Information Communication Technologies (ICT) has inspired diverse industries (Pisarski, 1991). In the case of transportation, navigation systems with real-time traffic data were developed. Due to rapid growth, not only the privileged, the general public could access navigation systems based on real-time traffic data. In recent years, many private and public transportation organizations without exception, have tried to launch their own systems that guide the traveler to make the optimal choice by producing information with real-time traffic data (Wu et al., 2007). Traditionally, people are used to using a normal paper map and define the shortest route in terms of distance whether there is traffic congestion or not. Drivers rely on their instinct and tend to think the shortest road would be the fastest road regardless of where traffic congestions may happen. This is because instantly provided and reliable data were absent.

It resulted in high congestion in urban areas because the queue keeps increasing throughout peak hours so that the sum of the individual optimum is not equal to the overall optimum. Every driver chooses the best option for themselves, based on their experience and instinct, however, it results in more solid traffic congestion since everyone chooses the shortest route.

On the other hand, by using navigation systems with a smartphone or a dedicated equipment, people could access real-time traffic data easily. Therefore, navigation systems would suggest the shortest way in terms of travel time rather than distance. If all drivers utilize navigation systems based on real-time traffic data, the sum of individual optimums would be equal to the overall optimum since total congestion over the urban area would be diminished. It means there would be almost no congestion caused by a lack of infrastructure over the city. Each driver would choose the route according to the recommendation of navigation systems so that drivers could avoid waiting in the queue. It is the choice for an individual's advantages but also, at the same time, good for overall traffic flow because the congestion could be dispersed over the network. Therefore, total congestion over the urban area would be diminished. In other words, travel time over the network would be equal, which means road traffic would be in equilibrium.

## 1.1. Purpose of the Study

The study tries to assure the possible positive and negative effects of navigation systems in the urban area in general, using Google Maps Application. Navigation systems, especially with real-time traffic data are relatively new and recent concepts, so that there was no deep understanding of navigation systems, yet. On the other hand, the user's rate has been sharply increased along with the spread of smartphones and the development of technologies. Since we do not have enough information about the possible impact of navigation systems, drivers using navigation system might trigger unexpectedly merits and demerits all together. There are two hypotheses of the study. The first one is that navigation systems affect road network both positively and negatively. In a positive way, it could reduce the travel time of each driver, resulting in diminishing congestion over the city. On the other hand, the negative effect is the navigation systems could cause problems with the hierarchical structure of the road systems. The navigation systems do not understand the structure of the network; local streets should be used to access destinations only, while arterial should be used to make a trip at high speed. The other one is navigation systems would realize Wardrop’s equilibrium by distributing traffic evenly over the network.

Through the observation, firstly, we will see which route Google Maps would suggest in both peak and the off-peak hours in İzmir in view of actual users. The main point of observation is to understand how the suggested routes are different from the off-peak hours to the peak hours, assuming that the suggestions in the off-peak hours are general routes. The general route means regular route choice of drivers without the assistance of navigation systems, mostly the shortest path with a simple form

Secondly, we will check the type of road that recommendations of Google Maps. When humans drive, they choose the route that they know and familiar with them. However, Google Maps would guide them into every type of road existing in a city. It means there is a chance it might suggest narrow alleyways which are not convenient and not safe.

Third, it will be estimated that how much time is saved and the long is additional travel distance in the peak hours by using Google Maps. In the peak hours, by using navigations systems, the travel time is expected to be decrease, in contrast, the travel distance might be increased.

Also, the understanding effect of the navigation systems on individual scale and whole city scale is another purpose. When some of the individual’s travel time gets reduced but overall congestion is increased at the same time, the system is not acceptable. The study investigates the system is satisfactory for each driver and helps to reduce overall congestion of the city.

Lastly, the study also tries to define whether the navigation systems follow Wardrop’s principle in İzmir or not. Drivers could choose their optimal route by informed about congestion conditions immediately. Thus, everyone would avoid the congested area. Finally, the network would be in equilibrium condition in terms of traffic volume, which means travel time is the same or similar in each alternative route. It is similar to the equilibrium condition; traffic as if assigned equally over the network.

## 1.2. Overview of Methodology

The study is about explaining the effect of navigation systems with real-time traffic data, utilizing Google Maps Application. It is written in GM shortly in the study. The travel route and the travel time which is suggested by GM in each time (the peak hours and the off-peak hours) will be collected. The study is conducted in two scales; (1) commuting trips overall the city and (2) short trips in Central Business District (CBD). To define the study area, we draw a circle with Konak as its center. Konak is chosen as the center of the circle because it is CBD of İzmir. Also, its location is considered as the traditional center of İzmir. On the circle, eight points and six points were defined evenly — position of some points are modified because of land-use issue — and those are a node of origin and destination of hypothetical trip generated for the study. Since GM suggests different travel route adapting real-time traffic data and its own algorithm, during the peak hours and the off-peak hours, the travel time and distance of hypothetical trips are gathered repeatedly with a certain time interval, then the results will show different delay or routes.

## 1.3. Assumptions and Limitations of the Study

There are several assumptions in the study. The first assumption is that GM makes no error. Sometimes it shows a congested area erroneously because it is not a flawless application. But for the time being, we assume traffic volume and driving speed estimated by GM and recommended routes are always accurate. Secondly, we distribute nodes of origins and destinations of each route evenly on the circle for objectivity. Thus, we create route axes through the defined nodes each crossing from the center of the circle. However, some locations of points are non-residential areas (industrial zone and site of the university for each). There is diminutive modification toward the residential area, as travelers who use the navigation systems are daily commuters who drive cars as everyday activities. Third, drivers follow the navigation systems fully without their own opinions. According to some researches, drivers prefer a familiar route for psychological matters (Qi et al., 2016; Ben-Elia et al., 2008). But in the study, we ignore those factors. Fourth, drivers might start a trip before the peak hours and encounter congestion when they pass the city center. However, we assume the driver starts making a trip when congestion is already occurred over the city, to see a great difference. Lastly, it is impossible to control the usage rate of navigation systems in the study, so that it is impossible to observe different results under different usage rates. Since real-time data and the rate of users is interdependent, it is an important variable. But the study is about what is actually occurring in a non-manipulative environment as a view of the actual user.

## 1.4. Structure of the Thesis

This thesis consists of six chapters. The first chapter is an introduction including the purpose of the study and an overview of the methodology.

Following the introduction, there are literature reviews of relevant previous studies about traffic congestion, navigation systems, and transportation modeling in chapter 2. To explain navigation systems, an understanding of traffic congestion should be preceded. The reasons why congestion happens, and the way how does it affect society are discussed, and also, how human factors work on congestion and route choice pattern is examined. After that, it deals with navigation systems, the main concern of the study. First, we explain types of navigation systems and define which type is the one meant in the study. In addition, its functions and effects on the congested urban area (main roads and local streets) are mentioned. Lastly, there are previous studies about traffic modeling and Wardrop's equilibrium. Navigation systems might make equilibrium condition by assigning traffic evenly over the road network. It makes modeling more correctly by reducing variants of the real model

In chapter 3, a specific spatio-temporal study framework is defined; (1) space: the urban area and CBD, (2) time: the off-peak hours, and the peak hours. The main aim is the peak hours, but to make comparisons, the off-peak hours are included. The general information such as location, population, and car ownership rate of İzmir, the background of the study, comes. Following that, the detailed methodology is explained.

In chapter 4, it deals with quantitative data of observations. There are two groups in each trip; (1) a group of routes that has the same travel distance between the off-peak hours and the peak hours, (2) the other group of routes that has different travel distances between the off-peak hour and the peak hour. The travel time and the travel distance are compared. Moreover, it is focused on the usage of local streets when drivers use navigation systems.

In sequence, there is a general discussion about data results in chapter 5. Using the gathered data, we discuss the general effects of navigations systems in terms of travel time, travel distance, and usage of local streets. Also, there is saved travel time and additional travel distance caused by driving with GM.

Lastly, there is an overall conclusion of the study in chapter 6. It is explained the positive and negative effects of the navigation systems on two scales; commuting trips in the overall city and short trips in CBD. Besides, there is a discussion of navigation systems' impact in the urban area of İzmir overall. The general structure of the study is shown in Figure 1.1.

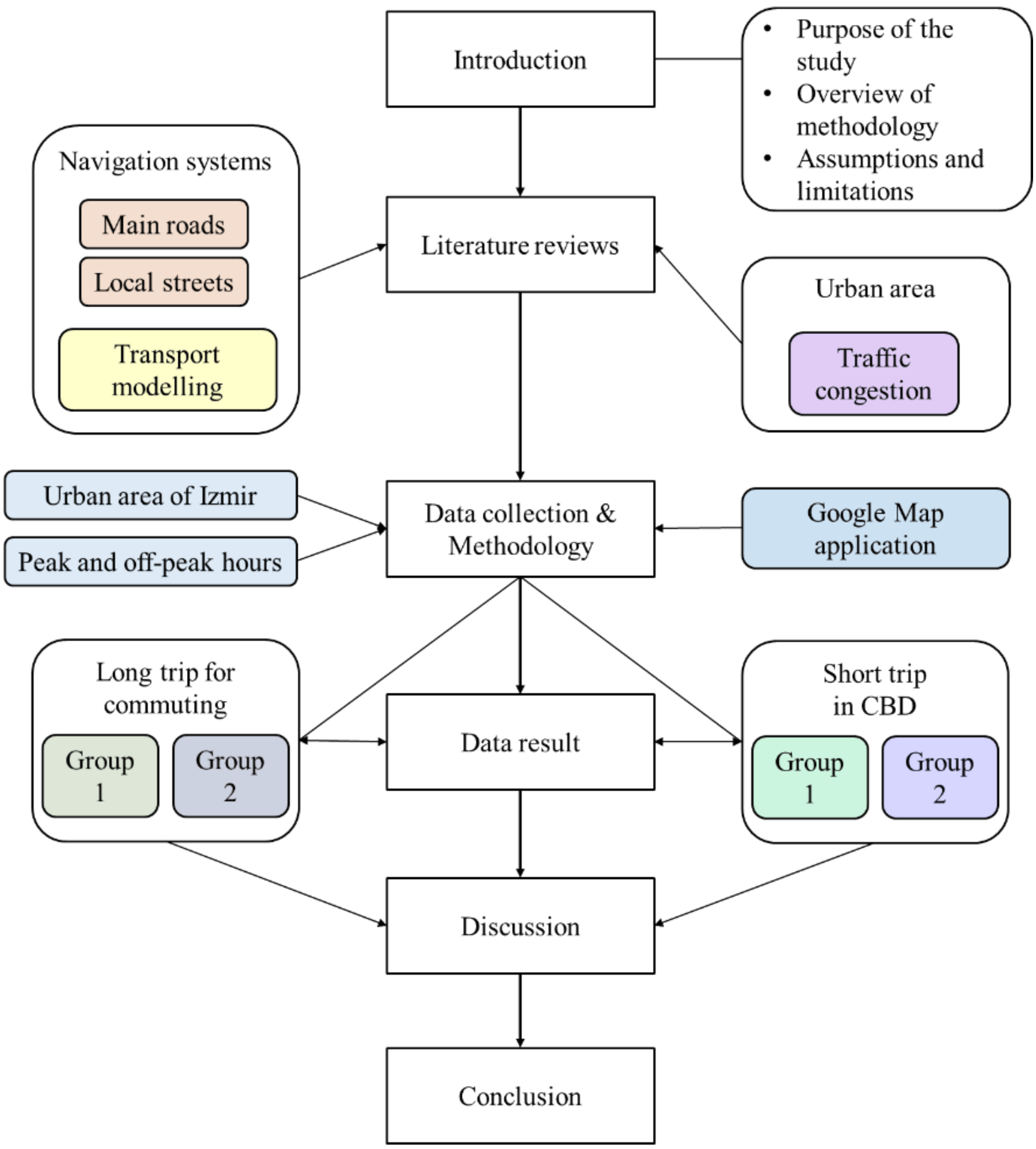


Figure 1.1. Structure of the study.

# CHAPTER 2

# LITERATURE REVIEWS

There are not many previous studies about navigation systems with regard to congestion data since it is a pretty new topic. But still, it is related to some conventional concepts. First of all, there are previous researches about traffic congestion. To conduct research about navigation systems, understanding of congestion is necessary, because the main purpose of navigation systems in the perspective of city planning is dissolving the congestion without an extra investment of infrastructure. Therefore, there are literature reviews about traffic congestion in the first section, and then there is a literature review about the navigation systems and their work logic. Following that, there are reviews of transportation modeling, especially about four-step modeling and Wardrop's equilibrium, which could be actually achieved through navigation systems practically. Navigation systems assign traffic equally over the network, letting drivers avoid road has congestion which is almost the same principle as that of Wardrop's. The navigation systems work for the advantage of individual drivers avoiding congestion, but it also prevents congestion over the network.

## 2.1. Traffic Congestion Problems in the World

Road traffic is a major problem over the world. A huge amount of time and resources has been nothing short of being dumped, because of traffic congestion (Khosroshahi et al., 2011). Traffic congestion is a primary problem of society in terms of waste of time for individuals and social losses. The congestion produces many problems, and a study points out the principal problem that traffic flow could not move smoothly and resultant safety issues, and there are some additional problems; air pollution and noise (Elmberg, 1974). Therefore, it is significant that reducing the traffic congestion to save the resource over the society, even though it is a small proportion of total congestion over the network (Chen et al., 2006).

Once traffic congestion occurs in a place, the problem affects the whole network. Since traffic flow is a fluid-like model rather than a system consisting of independent segments, the hindmost part of the congestion suffers much more although small delays in the front part of the network. In other words, it is important to prevent delays even it is minor, to stabilize flow over the network. A shock wave, considering traffic as a flow of liquid, shows this feature of the traffic flow and congestion (Lighthill and Whitham, 1964). When there are two different types of traffic flow, the shock wave appears in a boundary of those. For example, drivers should reduce the speed of vehicles when they get closer to bottlenecks, and the moment that drivers should apply the brakes is moving toward upstream of flow, accumulating longer queues. The required time to get out of the bottleneck is longer for drivers who access point later (Figure 2.1). It means it is necessary to let drivers avoid the congested area to stop the queue growing more and more.

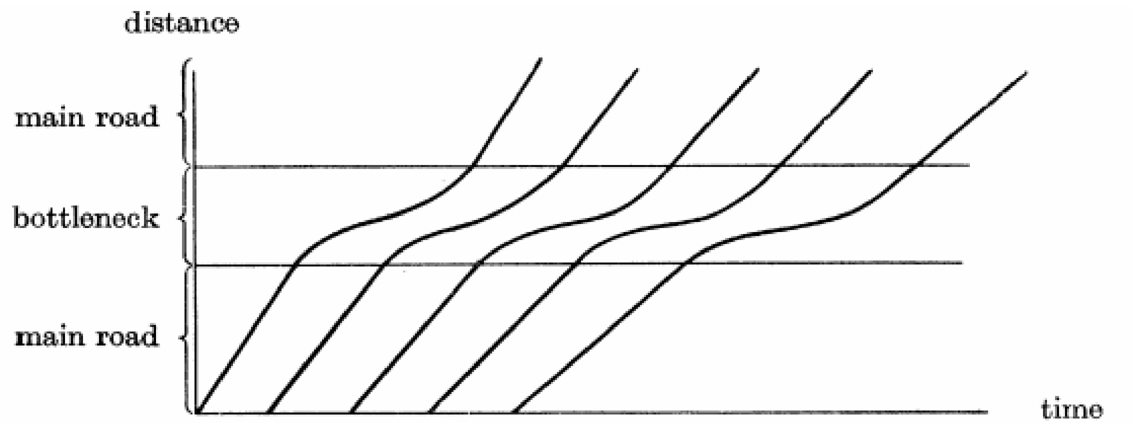


Figure 2.1. Passage of waves through a bottleneck, the capacity of which exceeds the incoming flow rate (Source: Lighthill and Whitham, 1964).

There are some typical measures to reduce traffic congestion through congestion management: (1) Charging the peak-hour tolls; (2) expanding road capacity; and (3) expanding public transit capacity; (4) Living with congestion (Downs, 2004b). These strategies can be divided into two categories: distributing demand and lowering the ratio of volume and capacity. The latter is a certain and assured method but it requires additional investment. On the other hand, it is not necessary to make further investment in the former case, but it is not always a reliable solution; drivers do not always move as the planner expected and there could be unexpected problems. For example, providing a park and ride system may help to attract a proportion of private car users into public transit, but it tends to increase the total length of driving (Saleh and Sammer, 2009). In contrast, navigation systems utilizing real-time traffic data may be a certain and reliable way to prevent traffic congestion without investment.

### 2.1.1. Basic Concept of the Traffic Congestion

Traffic congestion is not caused by a plain and simple reason, but rather complex reasons; traffic volume, quality of roads, and road accidents, severe driving habits (Simdiankin et al., 2018). In another perspective, traffic congestion is considered as a consequence of unsuitable land use, not enough capacity, and growth of traffic demand (Zheng et al., 2018). There are some policies to evade congestion delay; (1) increasing capacity of infrastructure, (2) providing more alternative public transportation (Agudelo and Barrera, 2014), (3) using road more rationally and efficiently (Parrado and Donoso, 2015). In other words, congestion happens because of not enough road infrastructure, not enough public transportation, and inefficiency of using existing roads. Problems of the first two are relatively easy to solve if there is enough budget. It is simple if there are more investment and more funding, even though getting more investment is hard itself. However, we should approach a different way to solve the third problem, such as introducing new technologies.

The most ideal transportation plan is the most optimal plan. There are many studies about optimal road capacity (Los, 1979; Yan and Lam, 1996). The optimization of the road is such a tough task involving several aspects such as safety, environmental impacts, and balance between revenues from road pricing and investment costs (Small and Ng, 2014). A high-capacity road without any congestion could be a nice and comfortable design for drivers, however, at the same time, it could be a superfluous design from other perspectives. There is an explanation of the spill-over effects caused by high-capacity in Spain (Álvarez-Ayuso and Delgado-Rodriguez, 2012). It is not just the problem of wasting resources like construction cost and urban space but also, affects private production. Thus, just increasing the capacity of the road as much as possible could not be a solution in metropolitan regions.

Traffic congestion is an inevitable problem in an urban area. It happens because of the basic concept of transportation. Urbanization is one of the most striking phenomena in the contemporary world (Wirth, 1938). A second industrial revolution allows mass production and mass consumption, following that, people start to accumulate wealth. The appearance of the personally owned vehicle changes the social and economic lives of citizens. The spread of automobiles allows the relocation of urban spatial structure and functional distribution of the city to suburb or exurb, providing transportation alternatives (Kitamura, 1988). A massive investment of transportation infrastructure, such as highway between suburb and city center, encourages people to move further away (Couch et al., 2008). Personal automobiles let people free from distance barriers, on the other hand, it makes people drive further away to get destination overall. Mobility in modern society could be described as “hypermobility”, making unnecessary waste of resources (Schiller et al., 2010). In Figure 2.2, with both urban sprawl and urban growth, we can see that people tend to move to more distant places as suburbs. It means people living in suburbs begin to commute to the city center, making peak hours and off-peak hours. A high percentage of congestion is usually presented by the inappropriate use of resources in infrastructure, and the extension of the residential area to suburb inevitably make inefficient and ineffective usage of infrastructure. One of the Traffic Demand Management (TDM) strategies to reduce congestion is alternative work schedules such as flex-time, compressed workweek, staggered shift. It means that commuting trip is the biggest contributor to congestion during peak hours (Zaman and Haldar, 2014). In other words, congestion would be there as far as the distance of commuting from the suburb to the city center.

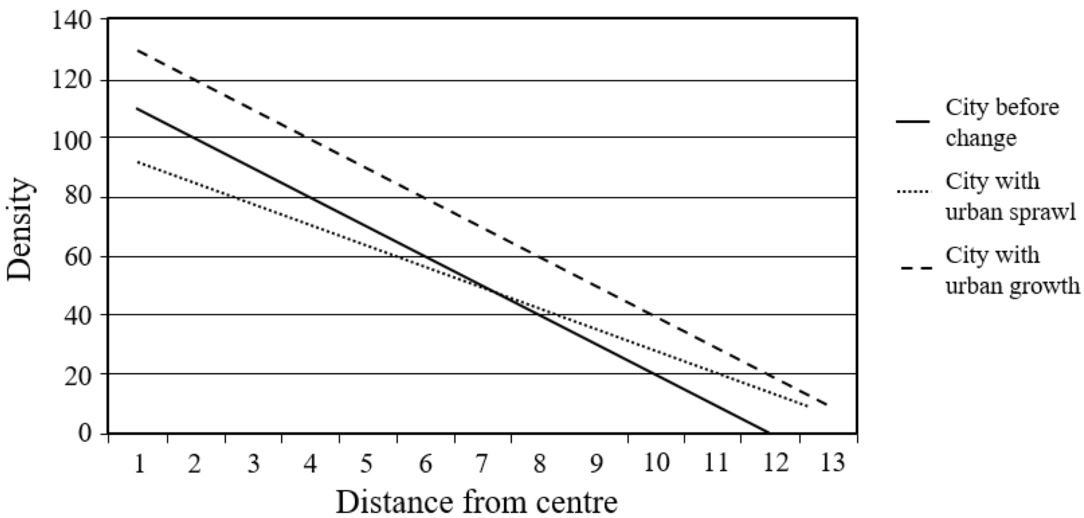


Figure 2.2. Urban sprawl and urban growth.
(Source: Couch et al., 2008)

The purpose of driving is to get to the destination quickly and safely. It does not matter in medium dense, however, under highly congested conditions, it is not simple to achieve it. Also, congestion makes modeling difficult and complex. It is not easy to make modeling in traffic-jam because there are more variables and the estimated error is complex (Nagel et al., 2003). There are many studies trying to model the traffic in the congested area from the 1950s (Chowdhury et al., 2000; Greenshields et al., 1935; Porikli and Li, 2004; Yukawa and Kikuchi, 1995). Those studies try to model the traffic from a statistical approach, microscopic approach, vehicle tracking, or other methods. There are various methods of evaluation of features and also, those features are multidimensional and complicated (Nijkamp and Blaas, 2012). In other words, if we could reduce the traffic congestion overall, it would be easy to model the traffic by reducing a cumbersome variable. It would result in a more precise and efficient design and planning of transportation. Transportation, especially in the urban area, an appropriate and proper design not only saves costs but also improves citizens' life quality (Zohrehvandi and Ghazanfari, 2013).

### 2.1.2. Human Factors in Traffic Congestion and Using Navigation Systems

Human beings do not move rationally every time (Di and Liu, 2016). It could be triggered by a lack of information, misunderstanding, or mistake. It also could be just habit, propensity, or prejudice. In the case of driving, whether there is traffic congestion or not, drivers tend to think the shortest path is the fastest one. Also, people prefer a familiar route that they have experienced before (Qi et al., 2016).

There are 10 criteria of the route selection defined by a study; shortest distance, least time, fewest turn, most scenic/aesthetic, first noticed, longest leg first, many curves, many turns, different from previous, and shortest leg first (Golledge, 1995). Among all, only the first two factors are about rational decisions, the others are about personal preferences which are hard to be uniformed. Besides, in his experiment, it shows only 15.6 % of drivers choose the same route in a trip, in contrast, 62.9% choose the same route in the other trip. The result clearly indicates human factors are not subtle in route choices. It means there is a chance that drivers might not follow the navigation systems, because they rely on personal preferences rather than a recommendation of navigation systems. It would not be easy to exclude an individual's experience and their preferences totally. However, if people follow it, the condition of the road would be simpler, because it is possible to exclude ununiformed factors from the route choice process.

The hot stove effect indicates the phenomenon people who touch the hot stove never touch it again whether it is hot or not (Denrell and March, 2001) and it also could be applied on route choice. When a person experiences failure about his or her decision, he or she avoids choosing the same choice. In the case of the route choice, people eschew the route with more variables, and they prefer the familiar route that they always take (Ben-Elia et al., 2008). Navigation systems help drivers to make reasonable route-choice at bifurcation nodes of the network. But there is still a chance that drivers use their individual routes based on their past experience (Qi et al., 2016).

### 2.1.3. The Congestion Costs upon Society

There are many studies that try to estimate or calculate the congestion cost. First, the cost of congestion could be calculated as below (Goodwin, 2004).

$$Economic\ Cost\ of\ Congestion = \left(T_{free\ flow\ speed} - T_{actual\ speed}\right) * V \\ = \boldsymbol{delay_{total} * value_{time}} \quad (2.1)$$

Where T is time and V is traffic volume, the cost of congestion is the difference between the time at free-flow speed and the time at actual speed multiplied by the volume of traffic, which means low-speed vehicles on the road cause cost. In other words, the cost of congestion could be expressed by total congestion delays multiplied by the value of time experienced by persons. In both ways, it is obvious that travel time is a more important value rather than distance. Since navigation systems make drivers take the fastest route in terms of travel time — the suggested route could be longer than the regular route in the peak hour —, it is a suitable choice to reduce the cost of congestion.

On the other hand, he also argues comparison of free-flow speed and actual speed model has inherent problems (Goodwin, 2004). Free-flow speed is only existing in a computer simulation. Thus, he suggests a marginal cost of congestion is more realistic than the total cost of congestion. Marginal costs of congestion are about only one particular vehicle in congestion, and its time costs rather than time costs over the whole network. There are specific costs of congestion in each area and each type of road (Table

2.1). Especially in central London, the difference between main road (motorway and trunk and principal) and others is huge. It means the time-consuming, congestion cost, is bigger inside of a city.

Table 2.1. Estimate of marginal congestion cost for London.
(Source: Goodwin, 2004)

| Area and road type | | Congestion cost pence per car-km |
|---|---|---|
| Central London | Motorway | 54 |
| | Trunk and principal | 71 |
| | Other | 188 |
| Inner London | Motorway | 20 |
| | Trunk and principal | 54 |
| | Others | 94 |
| Outer London | Motorway | 31 |
| | Trunk and principal | 28 |

Second, there is a study to estimate the opportunity cost of traffic congestion (OC) with a value of time and mode of the vehicle like below (Ali et al., 2014).

$$OC = \sum_{m=1}^{m} (VOT_m * Delay_m * V_m * Vocc_m) \qquad (2.2)$$

Where VOT is the value of time, Delay is travel delay in time unit, V indicates the number of vehicles, Vocc is average vehicle occupancy for a specific model, and m is mode — car, truck, public transportation, bike, three-wheeler, taxi, and office van —, OC is calculated. In the estimation, time delays and a time value, and a total number of vehicles are main factors. It tries to define time values using socio-economic survey data, and the time delays take an important role in the estimation again.

They estimate vehicle operating costs (VOC) with a delay because the fuel consumption is increased when there is a delay on the road. Thus, VOC is also closely related to the congestion cost. Where L is the length of the stretch, FC is fuel cost, Delay is travel delay, and V is the number of vehicles, and m is mode — same to Fiture3 —, VOC is calculated as below.

$$VOC = L * \sum_{m=1}^{m} (FC_m * Delay_m * V_m) \tag{2.3}$$

Third, there is an estimation of time cost and operating cost according to the different speeds of the vehicle (Johnson, 1964).

$$unit\ Operating\ Cost = 1.829 + 0.312 * unit\ Time\ cost \tag{2.4}$$

It considers time-price and money prices altogether. Excluding coefficients, it indicates that simply unit operating cost is decided by time cost. Again, the time cost is decided by the number of vehicles per minute, density, and speed, which are the factors directly related to congestion. (Johnson, 1964)

In the case of the highway, it is slightly different from the inner-city road. Urban traffic congestion is affected by parking cars, turning traffic, traffic lights, stop signs, pedestrians, and other interruption, however, there is no such effect on the highway (Dewees, 1979).

$$MEC = \frac{(v_0^2 - v^2)}{2 * v^3} \tag{2.5}$$

In the formula, MEC is marginal external time cost, v0 is free-flow speed, and v is the actual speed of vehicles. In this case, the time cost is more controlled by speed since the denominator including a cube of actual speed, which contains the concept of congestion. As the speed of the vehicle decreased, marginal external time cost soars very rapidly. There are only minor differences among the method to estimate the congestion cost based on time delay. In the case of marginal congestion cost, a vehicle-kilo meter is an essential factor, but it is a related time delay again. Therefore, it is important to reduce delayed time on congestion to waste of resources.

## 2.2. The Navigation Systems and Congestion Problems

Navigation systems are a part of the Intelligence Transportation System (ITS). It provides better travel decisions by estimating travel time and by optimizing the travel route (Cheng et al., 2020). Navigation systems, especially with real-time traffic data could be a useful and beneficial solution for the traffic congestion in an urban area by providing information to drivers. The efficient operation of existing road networks is expected to be achieved through dynamic traffic management schemes that make use of available and anticipated advanced technologies. Advanced Traveler Information Systems (ATIS) that one of the navigation systems that use real-time data would take an important role to reduce traffic congestion (Kaysi et al., 1993).

Route choice is affected by several factors. There is a study that lists two key factors; perception and knowledge of current road conditions (Uang and Hwang, 2003). It consists of delay, expected travel time, congestion level, the existence of alternative routes, travel conditions on these routes, affinity toward taking risks, thresholds of tolerance traffic conditions, and certainty of meeting travel goals. Navigation systems with real-time traffic data could release the traffic congestion by producing better quality of routing choice in terms of the shortest travel time because the systems help people to understand those factors. Besides, when drivers choose the route, personal preferences and individual circumstances are also significant factors such as trip type, time of day, and other considerations (Adler et al., 1993). In this regard, navigation systems help drivers to make the best trip and to diversify their route choice behaviors, and uniformly dissipate the congestion away. In an urban area, navigation systems with real-time traffic data would let drivers choose the best route under the given condition (Khosroshahi et al., 2011). In a sense, this is the real implementation of Wardrop's principle which was defined years ago with no input of real-time ICT and usually thought to be theoretical and only default condition, assuming traffic is assigned over the all route with the same travel time.

### 2.2.1. Types of Navigation Systems

The forms of navigation systems have been transformed and modified along with the innovation of technologies, but its purpose is always the same. It is that delivering information and data to users. In the case of the paper map, it is only visual and static information, in contrast, a digital map could provide visual, auditive, and dynamic data with wire or wireless communication. There are several ways to distinguish types of navigation systems since it is a combination of software, hardware, and communication. For example, to use GM, application, which is software provided by Google, smartphone, which is hardware, and cellular data are necessary. In this section, we roughly divide types of navigation systems according to technological development, from a traditional map to a digital map.

### 2.2.1.1. Traditional Map

The word "traditional" is a term to distinguish from the digital map. Mostly it is paper, book, or leaflet, but it could be a digital picture on a computer or smartphone. It is simple, easy and cheap, and everyone could access data without the internet. But there is no update so that if there are any changes in the network, people should prepare a new one. It is impossible to understand the situation of the road in real-time. Also, there is much data on only one layer, sometimes it is hard to understand. In Figure 2.3, for example, infrastructure, landforms, symbols, and extra data appear altogether, it is hard to understand at once.

Figure 2.3. An example of the paper map.
(Source: http://www.intermemory.net/what-does-the-future-hold-for-paper-maps/)

### 2.2.1.2. Digital Map Using GIS and GPS

Navigation systems have been improved from the paper map since the development of Geographical Information System (GIS) and Global Positioning System (GPS). GPS is a satellite-based navigation system developed by the U.S. Department of

Defense. It is a system broadcast signal from the receiver and allows accessing information of the exact time, location, and speed with 21 or more satellites. It allows us to pinpoint a specific location on the earth, and it could be applied to many different industrial fields.

It was developed for military purposes originally, but it is open to the public in the 1990s (Dana, 1997). According to the U.S. government (NCO, 2006), it is applied to agriculture, aviation, environment, marine, public safety & disaster relief, rail, recreation, road & highways, space, surveying & mapping, and timing. It contributes to productivity, high-quality communication, convenience, and reliability across a society. Combining GPS and GIS together, the general public could understand GPS data easily through GIS and visualization. Diverse types of navigation systems are including in this type. For example, there is a device embedded in an automobile, an exclusive device, a Personal Digital Assistant (PDA), portable navigation (a smartphone) (Figure 2.4). GPS provides information about the topology of the road network, present location, driving direction, speed, facilities such as gas station, and global timing (Ahmad et al., 2019).


Figure 2.4. An example of the digital map.
(Source: https://buy.garmin.com/en-US/US/p/684273)

Compared to the paper map, it is easy to understand while driving, since it provides visual, text, and voice data at the same time. Also, it shows only a specific part of the map that drivers need most, for example, junctions, intersection, and crossroads by zooming. There is a comparison of the effect of navigation systems and paper maps while driving, and it finds out drivers' performance is much better with a digital navigation system, and in an unfamiliar situation, navigation systems help to save time and gasoline (Lee and Cheng, 2008). In contrast, there is a study that argues there is not much difference between using a paper map and a digital map (Antin et al., 1990). The navigation systems could be easy on the eye and provide better information and interface, however, this level of navigation systems might be not useful to choose the route because they still cannot provide congestion data.

#### 2.2.1.3. Digital Map Using Real-Time Traffic Data

In the study, navigation systems mean this type. The internet or the other types of communication technology is needed for this type to connect to real-time information. Applications like GM, Yandex, and Apple map are the representative example (Figure 2.5). Development of the smartphone (portable device), application (software), and telecommunication (cellular mobile communication) make this type possible to make service to the public. It is an almost similar type to the one in 2.2.1.2, but it is one-step more improved by providing real-time traffic information. It helps people to choose the shortest route in terms of travel time. It gives temporal obstacles such as accident, speed camera, gas station, and gas price to improve the convenience of drivers, not only traffic flow data.

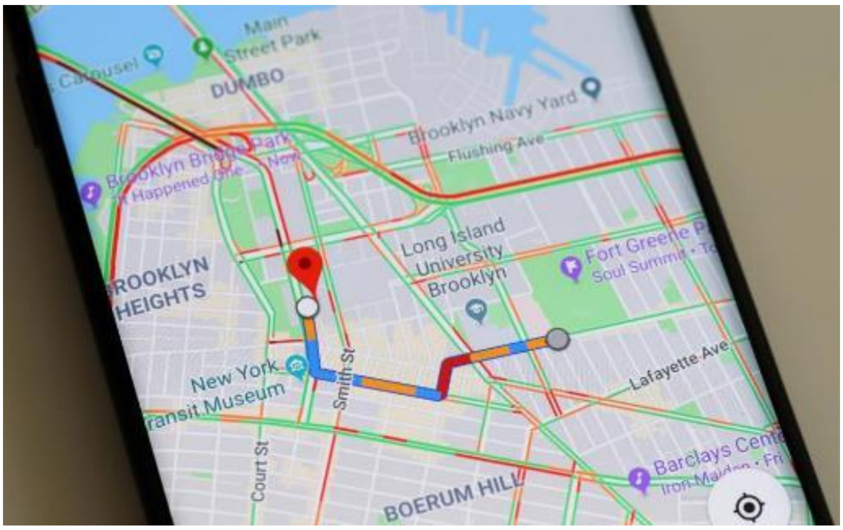


Figure 2.5. An example of the digital map with real-time traffic data.
(Source: https://edition.cnn.com/2019/10/21/tech/google-maps-reporting-trnd/index.html)

There are many similar algorithms or notions like GM, but their main purposes are slightly different. There is ATIS, which is more focused on travel information such as hotels, Automated Teller Machine (ATM), police station, and public transportation information (Singh et al., 2014). It provides information to make more comfortable travel rather than daily commuting purpose. Vehicular ad hoc Network (VANET) has also a similar concept; real-time information and navigator, but it is based on the connection among vehicles and infrastructure (Figure 2.6). It aims at avoiding collisions and keeping safe by using Vehicle to Infrastructure (V2I) or Vehicle to Vehicle (V2V) communication (Calandriello et al., 2007). V2V and V2I are some of the parts of the Internet of things (IoT). IoT is a system that actuators and things around them are all connected with a network to collect and to exchange data (Al Mamun et al., 2017). Route Information Sharing (RIS), just like its name, is the system that drivers send their shortest route (mostly the shortest time distance) to information sever, and sever returns optimal route (the shortest travel time) based on accumulated data (Yamashita et al., 2004b). Vehicle Information and Communication System (VICS) is a system providing congestion, accident, restriction information, and helping drivers to make a safe and smooth trip (Tamura and Hirayama, 1993).

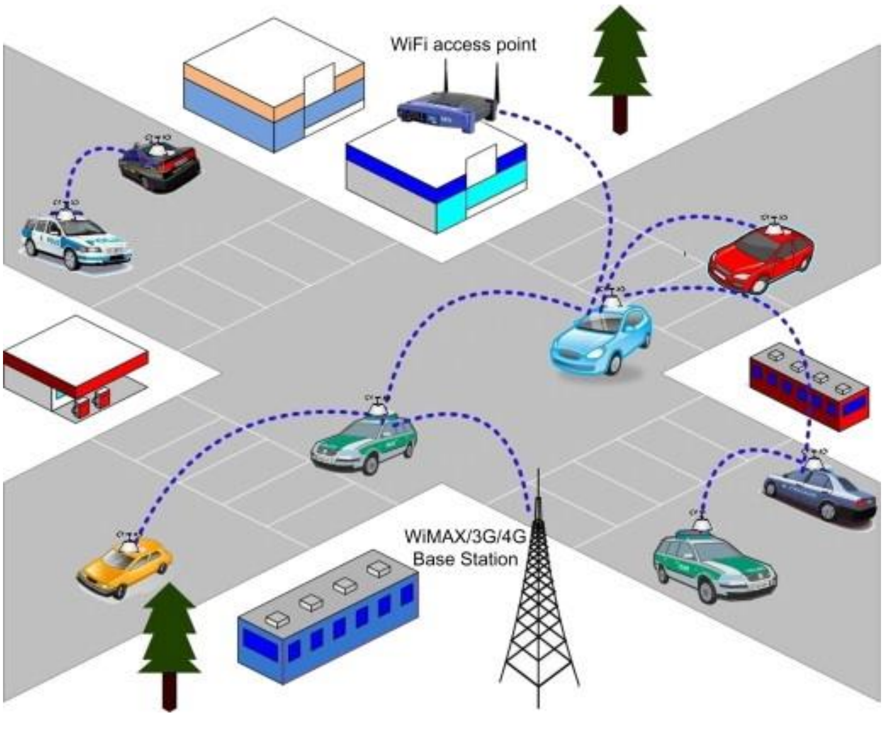


Figure 2.6. An example of a VANET.
(Source: Badis and Rachedi, 2015)

### 2.2.2. Purpose of GPS and Navigation Systems

GPS is developed as a tool for navigation and is widely used for military purposes in the U.S. In the case of the private sector, it is applied for means of transportation, such as automobiles, ships, and airplanes (Chao and Ding, 1998). It was introduced to the private sector for the first time to aviation transportation, following that, it is instituted to marine and road transportation (Parkinson et al., 1995). It was more useful for marine and aviation transportation since it is hard to recognize their accurate position in the middle of the ocean or the sky. GPS is an appropriate option not only to pinpoint its location but also to clarity its safety to avoid the other ships or aircraft.

In contrast, the GPS navigation is not much important in road transportation. There are the roads, the physical facility in road transportation, and it is easy to understand its structure and connectivity from road signs and cities or towns because most roads are built around the settlement. Traditional analog maps were enough to travel the city before the advent of a metropolitan area. Road network was simple, and speed of development was slow thus, it was possible to use the old map for a relatively long time. Road network has become complex and been changed rapidly, and traffic density has increased so that it has become hard to understand it from 2D maps. Since there is no notion of ‘update’ for a paper map, people should buy a new version. By the time, along with urban sprawl and the development of ITS, the conventional map loses its power. Because of complexity of the network, drivers are slowly responsive to paper maps from external stimuli (Srinivasan and Jovanis, 1997). Moreover, urban expansion has resulted in traffic congestion inside of the city and multiple alternative routes. It is hard to make rational decisions while traveling without navigation systems.

### 2.2.3. The Effects of Navigation Systems on the road network

Navigation systems suggest alternative route or detour to drivers and let them avoid congestion. It could have both possible and negative effects. There are many studies about the advantage of navigation systems. It reduces congestion, in consequence, drivers could save time and gasoline. Due to its convenience and effectiveness, more and more people use it. According to Google news (Russell, 2019), more than a billion people use GM every month and more than 5 million active applications and websites. However, when there is a new technology, we should exercise caution against unexpected problems or side effects caused by it. The invention of the steam engine makes people live better. Nevertheless, Svante Arrhenius who is a Swedish scientist, argued fossil fuel might result in enhanced global warming by the greenhouse effect, for the first time. After him, more and more people have understood it is true and has tried hard to solve this problem with Kyoto Protocol (Dessai et al., 2003). Like this, if people abuse a new technology, the consequences might be severe and critical. Thus, in this section, we will discuss the disadvantages of navigation systems as well as the advantages to understand the systems better.

#### 2.2.3.1. Reducing Congestion and Saving Resources

The biggest advantage of navigation systems is saving time by avoiding traffic congestion and finding a way to get to the destination. It makes evenly distributed traffic over the road network. When congestion occurs, navigation systems lead the individual driver into the optimal routes, thus overall congestion is reduced. Most of the navigation systems or applications could recommend the best route using real-time traffic flow data and historic data to predict traffic flow (Sha et al., 2013). According to an experiment of hypothetical driving with real-time traffic data, when drivers discover an unknown route, real-time information is useful to find the best route (Ben-Elia et al., 2008). Navigation systems make safe and enjoyable driving by providing guidance for routing, supporting safe driving, and provision of miscellaneous information (Kitajima et al., 2009). It is helpful to avoid congestion, discover the unknown area, and also to maintain a comfortable and safe environment by noticing accident or construction over the network.

There are some studies that use navigation systems which is not exactly the same as GMs, but similar in terms of suggesting the shortest travel time instead of the travel distance. A social navigation (Van den Bosch et al., 2011), is a system that drivers choose routes to make minimum travel time. The social navigation aims to minimize travel time, fuel consumption and $CO_2$ emission in not only individual scale but also entire network scale. It means navigation systems brings equilibrium condition. In a simulation, the social navigation can reduce the time delay by 10 to 20 per cent. ATIS, which helps drivers to find the destination and to avoid congestion, could be considered one of the major successes of ITS. Through the simulation (Barth et al., 2007), it shows there is a significant difference in travel time (127 per cent longer in a route) in a congested environment without ATIS. There is a simulation with different ratios of usage of RIS, which suggests the shortest time route using shared information (Yamashita et al., 2004a). The result shows when more drivers use RIS, the average travel time is declined, and the effect of RIS is bigger in the radial and ring network rather than the lattice network.

With the development of wireless communications and GPS, navigation systems could provide information about real-time traffic flow, speed, and road conditions. It makes it drivers possible to choose the optimal route among all alternatives and to estimate travel time (Kim and Gerla, 2011). A result of simulation with navigation algorithm shows that travel time is decreased by 11.5%, and travel speed is increased by 13%, by using alternative paths (Jabbarpour et al., 2014). Also, there is a study that local obstacle avoidance systems enable the real-time reaction to external events on the network without unnecessary stops (Bouffouix et al., 1993). Introduces navigation systems using beacon — a method of wireless networks — and sharing traffic data is also helpful to choose the best option for drivers (Terroso-Saenz et al., 2012). They add environmental information like weather conditions, making more precise traffic congestion detection. Congestion avoidance mechanisms with real-time traffic data remarkably reduce the trip time of vehicles and vehicle density of the network (Garip et al., 2015). Also, it is proved by simulation that the navigator could generate advice in appropriate timings (Miura et al., 2002). Each of study use different type of navigation systems but it is clear that the shared information and the instantly provided data could reduce the travel time.

Navigation systems could solve the waste of resources by providing real-time information to drivers. The congestion game is a good example of a dilemma when there is not enough data (Rosenthal, 1973). It explains how self-interest agents use limited resources using game theory with a payoff structure (Clarke and Wright, 1964). It could explain several concepts such as traffic behavior and communication network (Roughgarden and Tardos, 2004). In the congestion game, the choice of players in the system affects each other's results. For example, in Figure 2.7, it is supposed that two players choose the route from s to t. There are three choices; s →w →t, s →w →v →t, s →v →t. Each player could not understand which one the other will choose. The information is limited so both players would choose s →w →v →t, which is not the optimal option for both.

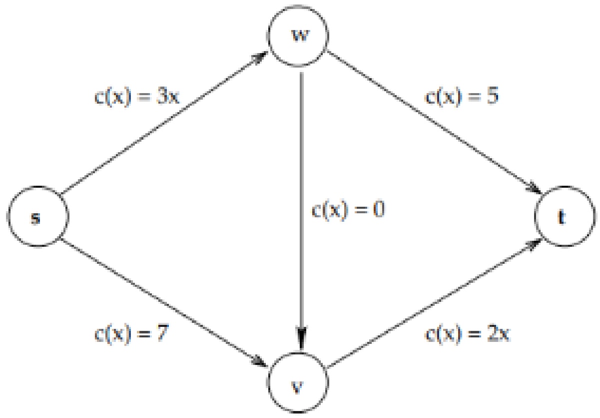


Figure 2.7. An example of congestion game.
(Source: Roughgarden, 2010)

As shown in Table 2.2, the ideal way to minimize overall travel cost is the case that one chooses s →v →t, and the other chooses s →w →t. However, each player could not see the whole system thus, they make the decision to minimize their own travel time. Both players choose the route of s →w →v →t, because it has a minimum expected result, considering the other's choice. They choose the optimal option for themselves, but it only makes them waste resources more. This situation is Nash equilibrium, the stable state of the system (Balon et al., 2008).

Table 2.2. Each travel cost of the number of cases.

| | | Route choice of player 2 | | |
|---|---|---|---|---|
| | | s →w →t | s →w →v →t | s →v →t |
| Route choice of player 1 | s →w →t | (11,11) | (11, 8) | (8, 9) |
| | s →w →v →t | (8, 11) | (10,10) | (7,11) |
| | s →v →t | (9, 8) | (11, 7) | (11,11) |

In summary, when navigation systems with real-time traffic data are introduced to drivers, the problem of information shortages would be solved. It is found navigation systems providing real-time information greatly reduce the travel time of not only individual drivers but also the overall system by numerical experiments, and it gives a more significant effect under congested conditions (Du et al., 2015). Also, high-quality and reliable real-time data make a better route compared to historically accumulated information (Du et al., 2013).

### 2.2.3.2. Increasing Traffic Problems in Local Streets

There are some researches that point out the negative effects of real-time navigation systems. When drivers face heavy congestion while driving, they would take a bypass that reduces the travel time and drive comfortably, if there is a system that informs it (Chen et al., 2017). Then, it is very possible that a large volume of traffic would run into this light traffic corridor in a short time and make it congested within a short time. Each type of road has its own role of mobility and accessibility (Figure 2.8). The higher-level roads, arterials are operated for purpose of mobility, on the other hand, local streets are for accessibility.

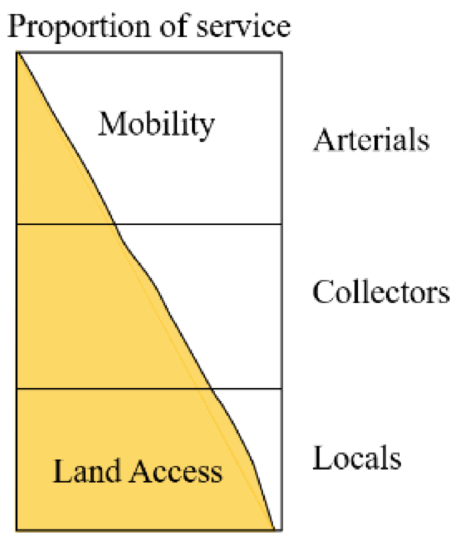


Figure 2.8. The relationship between mobility and accessibility.
(Source: Dong et al., 2013)

There are expected roles of type of roads; the trip starts in a local street, and then it is collected by a collector, following this, it takes the highest level of the road system, arterial, and after the arterial, to get the destination, drivers take a collector, and a local street (Dong et al., 2013). Local streets or low-level roads are designed to access a specific building or a place or to connect to a collector (Table 2.3). In other words, there should not be a through traffic in a local road. Nevertheless, navigation systems might recommend the route putting local road middle of the trip.

Table 2.3. The relationship between functional classification and travel characteristics. (Source: FHWA, 2013)

| Type | Arterial | Collector | Local |
|---|---|---|---|
| Distance severed | Longest | Medium | Shortest |
| Access points | Few | Medium | Many |
| Speed limit | Highest | Medium | Lowest |
| Distance between routes | Longest | Medium | Shortest |
| Usage | Highest | Medium | Lowest |
| Significance | Statewide | Medium | Local |
| Number of travel lanes | More | Medium | Fewer |

The hierarchy of roads is deeply related to the establishment of planning of transportation (Eppell et al., 2001). Not only land use, but also many objectives such as travel patterns and barriers are considered when roads are planned. Especially, local streets are required a low-speed environment and pedestrian priority. However, the navigation systems might divert vehicles inside of local streets that require lower speeds. For example, in Figure 2.9, the shortest route is A, which is using only arterial. On the contrary, in the peak hour GM suggests bypass route, B and C, using an arterial, a collector, and local streets. It is because GM recommends the route according to the travel time.

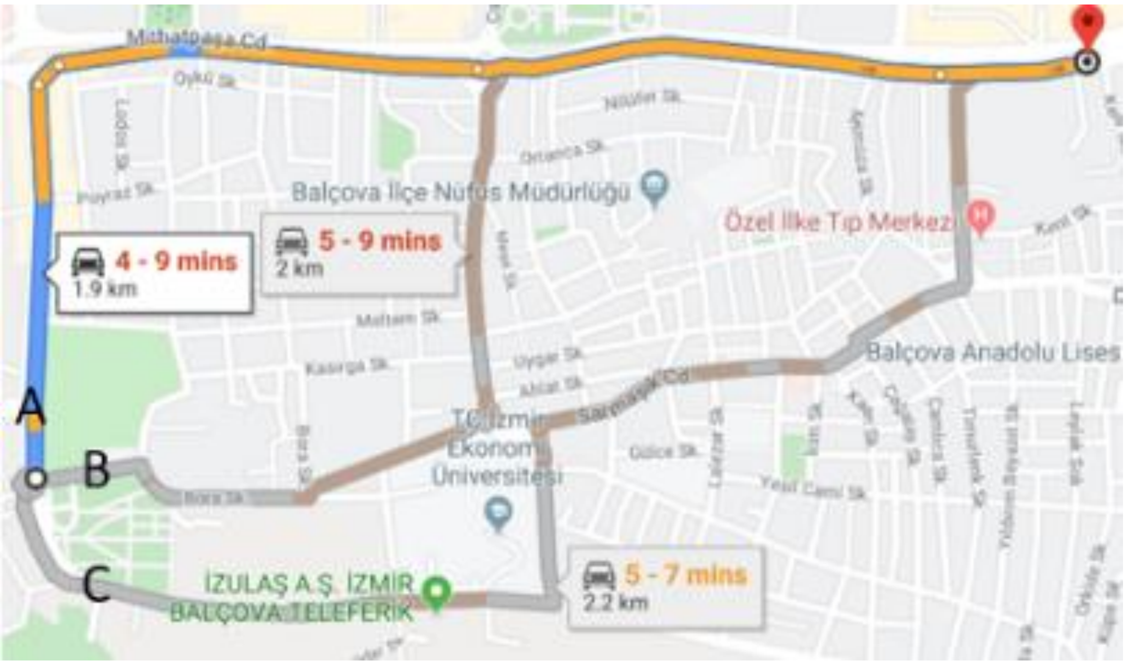


Figure 2.9. An example of local streets usage.
(Source: https://www.google.com/maps)

Traffic congestion mostly happens at a similar spot and at a similar time repeatedly. This could result in heavier congestion in detour because people decided to choose the very same alternative route in a short time under the highly dynamic behavior of the whole system (Wedde et al., 2008). It means if navigation systems recommend the same detour to a massive number of drivers, there might be heavier congestion in the detour. In addition, there is a study that argues Yandex (a navigation application) is good for analyzing highway and streets which have heavy traffic, but it is not enough for small roads (Simdiankin et al., 2018).

In addition, from the perspective of management, navigation systems might affect road structure negatively. There is an expected role of a specific road, it means an investment of each road is different (Van Hiep and Sodikov, 2017). The major network, arterial carries much traffic so that the largest financial resource should be allocated, making stronger and more resistant roads (Table 2.4). On the other hand, in local level streets, priority is less than the major network. It means it is not ready for a sudden car rush recommended by GM.

Table 2.4. Components of road asset management system of each type of the roads (Source: Van Hiep and Sodikov, 2017)

| | Goals | Budget | Asset | Performance |
|---|---|---|---|---|
| Arterial | High speed, safety, and riding quality | High importance weight | High cost | Performance prediction 10 years and more |
| Collector | Moderate speed, safety, and riding quality | Moderate importance weight | Moderate cost | Performance prediction from 5 to 10 years |
| Local | Satisfactory speed, safety, and riding quality | Satisfactory importance weight | Satisfactory cost | Performance prediction up to 5 years |

## 2.3. Transportation Modelling and Navigation Systems

The study is not about transportation modeling itself, however, navigation systems have a substantial effect on it. The real world is complicated and there are many variables. Modeling is making the real world simpler and more intelligible based on the scientific method for a specific purpose (Griffiths, 2010). It is simulacra of the real world, and it reflects some part of the reality. A successful model represents reality well, and it is important to choose appropriate variables to build it (Goldsmith, 1972). Also, the model should be simpler than the real system, but, at the same time, it should contain most of its significant factors and be a close approximation to the real system to avoid the wrong answer (McCullagh et al., 2014). In other words, modeling is an approximation for the real world, including complex systems and chaotic behaviors, using simulation and visualization (Banks, 2009). Modeling has the importance that it enables people to understand the system by visualization, to access hypothetical options, and to estimate possible risks (Cernosek and Naiburg, 2004). The navigation systems could make the real-world simpler to make the equilibrium condition, so that accuracy of modeling would be increased.

In the case of transportation, modeling is widely used to estimate and anticipate future traffic data by abstracting the real world, finding observed patterns, and making law-like relationships (Mller and Schroer, 2014). The role of models in the transportation sector is predicting future condition, by simplifying the real world to make it manageable and by avoiding extraneous detail to focus on determining features (O'Flaherty, 1996). Transportation modeling methods could be classified under two large groups; microscopic traffic model and mesoscopic traffic model. Microscopic models are applied individual's behavior level (Mller and Schroer, 2014). Each vehicle and driver are considered as an object and its detailed movement is the main concern. Mesoscopic modeling deals with more general phenomenon over the whole network. Speed-density relationships and queueing theory are representative examples of mesoscopic modeling. Compared to microscopic modeling, it is hard to make simplification in mesoscopic modeling. Traffic modeling, just like the other modeling, has value in terms of the saving resources and the planning for the future. Since modeling could not represent all factors in the real world, there is a gap between the result of modeling and the real world. Only one incorrect variable could make totally the wrong result, even though the other environments are flawless (Xia et al., 2017). Wrong modeling of transportation results in a serious problem such as heavy congestion. The development of a more accurate model is a primary objective to make better decisions. It has been continuing to try to develop a more precise, exact, and accurate model of transportation in several respects. For example, there is a study that tries to combine GIS and disaggregate transportation modeling (Goodchild, 1998). The other develops approximate inference algorithms to model an individual's travel time and to predict the destination (Gogate et al., 2012). Another suggests the human mobility model sustainably and economically (Huang et al., 2018). In the freight traffic sector, a multimodal transportation of freight by using flexible-time and scheduled to solve flow problems (Moccia et al., 2011). The introduction of navigation systems could be one of the elements to make a better transportation model.

### 2.3.1. Four-Step Modelling

To predict traffic volumes and their impacts like congestion and pollution, the four-step model is widely used (Mller and Schroer, 2014). The four-step modeling follows these steps; trip generation, trip distribution, modal split, and trip assignment (Figure 2.10). There is a specific aim of each step, and eventually, it aims to find the future traffic demand. To explain shortly, in the first step, the total number of trips is estimated, and then the numbers are distributed to a specific origin and destination pair. Third, the trips are divided into available modes. Lastly, the number of trips in each mode is assigned to the current or planned road (Mller and Schroer, 2014). The navigation systems could be contributed to trip assignment, the last stage of the four-step transport model, and help to increase the accuracy of the step, furthermore, of all steps.

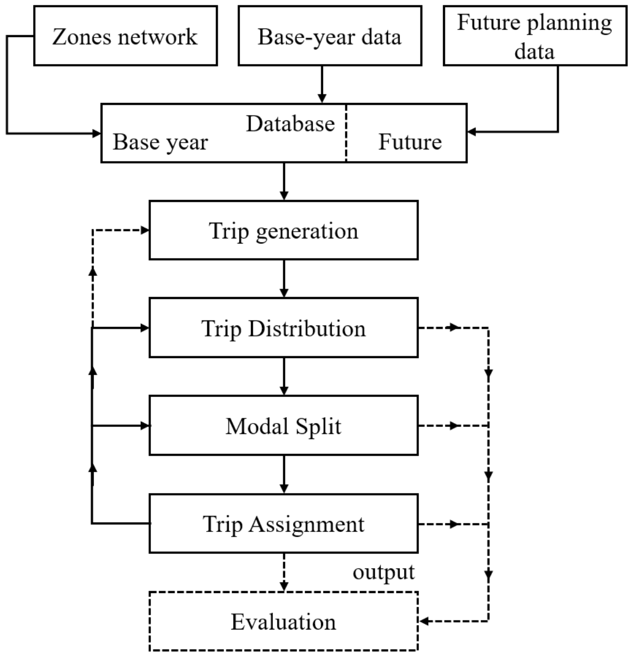


Figure 2.10. The classic four-step transport model.
(Source: Ortúzar and Willumsen, 2011)

Trip assignment step is assigning traffic volumes which are estimated by previous steps over the road network. In congested situations, methods such as equilibrium trip assignment, incremental assignment, stochastic method, and all or nothing assignment are applied in the trip assignment step. Equilibrium assignment based on Wardrop's equilibrium was considered by many researchers as the default procedure. According to Wardrop, under equilibrium condition, all driver has equal and minimum costs regardless of their route (Wardrop, 1952). In other words, if there is congestion in an urban road from the utility point of view, drivers would take a bypass to avoid congestion, and finally, the travel time between the urban road and the bypass would be equal, which means the efficiency of the used road becomes maximum.

Nevertheless, it is a theoretical and idealistic concept for modeling, so that it is hard to apply directly in the real world. Excepting a few cases, drivers do not have to pay the cost that they produce by choosing a specific road (Correa and Stier-Moses, 2010). In other words, every vehicle on the network contributes to traffic congestion, while waiting inside the queue, but they do not have to take responsibility for under-utilized roads. The situation could be described by Braess' paradox. It occurs because, when drivers try to minimize their travel time, they do not concern with decisions of the others who use the same network (Pas and Principio, 1997). When there is a new shortcut between two nodes, all drivers may "rationally" choose it. Everyone thinks the new shortcut would be faster, resulting in heavy congestion in it. It makes the higher sum of travel time over the network compared the sum of it without the new shortcut. A selfish routing also represents the real-world problem well. Naturally, drivers choose the route to minimize their own travel time without considering the consequence of the behavior (Roughgarden, 2002). Without cooperation, all of the drivers choose the same route, mostly the shortest route, resulting in heavy congestion in a specific route.

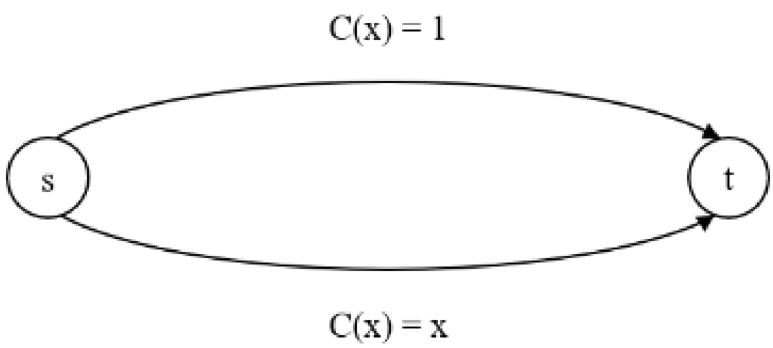


Figure 2.11. Pigou's example.
(Source: Pigou, 1920)

In Figure 2.11, when a person drives from s to t, it always takes 1 hour in the upper route, on the other hand, it takes different time (x) according to congestion in the other route. When we assume x is always less than 1 hour, everyone would take a lower route. Everyone chooses the optimal route for themselves, but there is a waste of infrastructure in the upper route, and there is congestion on the lower road. It shows the sum of individual optimum and optimum of society could be different in a specific case since drivers choose the route selfishly.

## 2.3.2. Wardrop's Equilibrium

There are many concepts used to transportation modeling, such as utility maximization & generalized cost, equilibrium, aggregation of individuals' decisions, and ignoring irrelevant dimensions of response (O'Flaherty, 1996). Equilibrium is one of the fundamental concepts used widely in transportation modeling. It refers that if there are two parallel roads, drivers would choose not congested one in order to reduce travel time so that the travel time of the parallel roads would be under equilibrium condition. Nonetheless, in the real world, the equilibrium condition does not realize easily, because the systems and networks are complex. The vicious circle is the most popular example of disequilibrium (O'Flaherty, 1996). For example, in the CBD area, there should be a virtuous circle of demands of buildings operating and supply of public transportation system. However, in the real world, unlimited demands of buildings or facilities result in heavier congestion at some points, since without proper restrictions or policies, it is hard to find balancing (Turner, 1926). Another example is subsidies for public transportation fares and subsidies. Subsidies are provided to make a stable business of operators, but it results in perpetuating deficits (Bly et al., 1980).

It shows there are two notions of Wardrop's equilibrium; (1) travel time of each route would be equal, (2) the overall travel time on the network would be the same (Wardrop, 1952). The first criterion is expressed like below.

$$Q = \sum_{i=1}^{j} p_i - \frac{1}{t} \sum_{i=1}^{j} p_i b_i \tag{2.6}$$

Where i is a route, p and b are constants depending on street width, intersection, length of the route, and a queue of the route, and t is travel time, Q, the total traffic flow is estimated. In other words, when Q is given, it is possible to find t, appropriate travel time. The equation shows there is only one t, which over all i, the alternative routes have the same travel time, under an equilibrium situation.

The second criterion is a more macroscopic version of the equilibrium situation. One of the examples is illustrated in Figure 2.12. There are three routes, and each of them has different capacity and conditions, so that travel time is all different. When traffic is assigned into each route, the minimum travel time and the travel time assigned traffic equally over the routes are the same, especially when additional traffic flow is high.

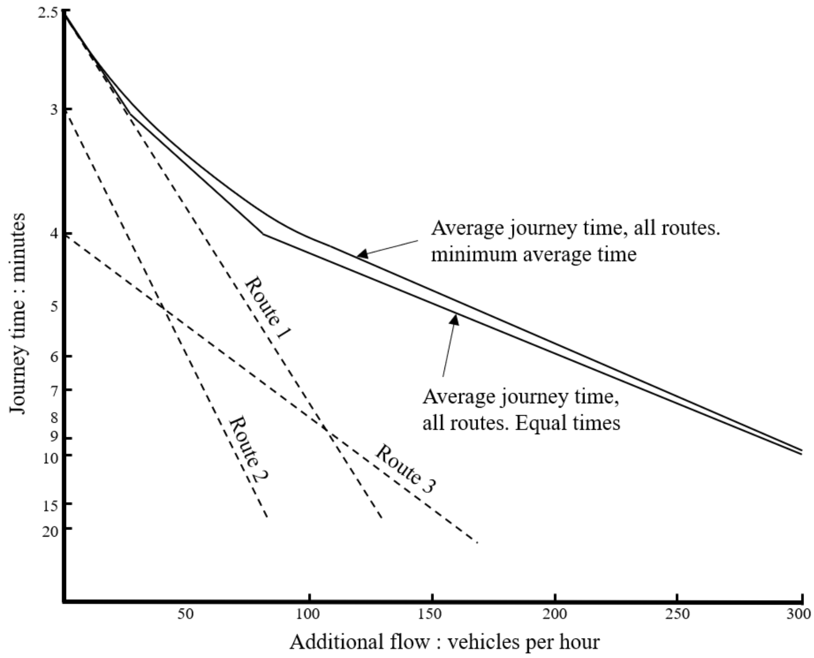


Figure 2.12. Average journey time of minimum average and equal time of Wardrop's equilibrium (Source: Wardrop, 1952).

However, there is a limitation of it, even the proposer points out in his paper, it excludes the other factors such as state of the road and psychological factors to make a mathematical estimation, thus, it is good for suggesting a general line rather than complicated network (Wardrop, 1952). In addition, it indicates the assumption that drivers would choose the route with minimized travel cost is for easy and convivence mathematical descriptions (Correa and Stier-Moses, 2010).

It is almost impossible to suggest the optimal traffic assignment because there are several factors that cannot be generalized. For example, drivers are free to use every alternative and to react to a situation according to their own interests such as comfort, convince, and even their mood (Roughgarden and Tardos, 2002). However, when every driver utilizes the navigation systems, the limitation would be overcome. Since the navigation systems distribute traffic to minimize travel time for individuals, travel time would be the same with average travel time under equilibrium, which means Wardrop's equilibrium is realized. In addition, the navigation systems could solve the Braess' paradox and achieve absolute equilibrium condition. Therefore, the navigation systems could be a good mediator. In terms of governance collaborative traffic flow navigation systems based on explicit assignment strategies in smart transportation networked environments are highly accurate and operative equipment for decision-making in the transportation area (Zakharov and Krylatov, 2014). It shows sharing the information among drivers is a key point to reduce congestion and reduce travel time for drivers. The navigation systems with real-time data could be better at achieving equilibrium of traffic compared to collaborative traffic flow navigation systems since it distributes traffic volume sensitively in real-time.

# CHAPTER 3

# DATA COLLECTION AND METHODOLOGY

## 3.1. Study Area

The study area is conducted in İzmir, Turkey. İzmir is a large metropolitan region consisting of both urban areas and countryside and there is a clear congestion pattern in the peak hours (Figure 3.13). İzmir is chosen as the study area since there is a serious traffic congestion problem in the urban area, which is hard to solve by simplistic solutions in a short time. Moreover, the population has grown and it is expected to be continued so that congestion will get heavier in the future. The traffic congestion problem is discussed deeply in 3.1.1.1.

The urban area is concentrated near the Gulf of İzmir (Figure 3.1). There are several highways and arterial across the city and tangled local streets without a clear pattern. There is a spatio-temporal frame of the study; the urban area and the peak hours. The administration area of İzmir embraces the outskirts of the city such as Bergama, Çeşme, Selçuk, and Urla (Figure 3.2). However, the study covers only the central urban area, to see the commuting trip which passes CBD or short trip inside of CBD.

Figure 3.1. The map of the urban area of İzmir.
(Source: https://www.worldmap1.com/map/turkey/İzmir-map.asp)

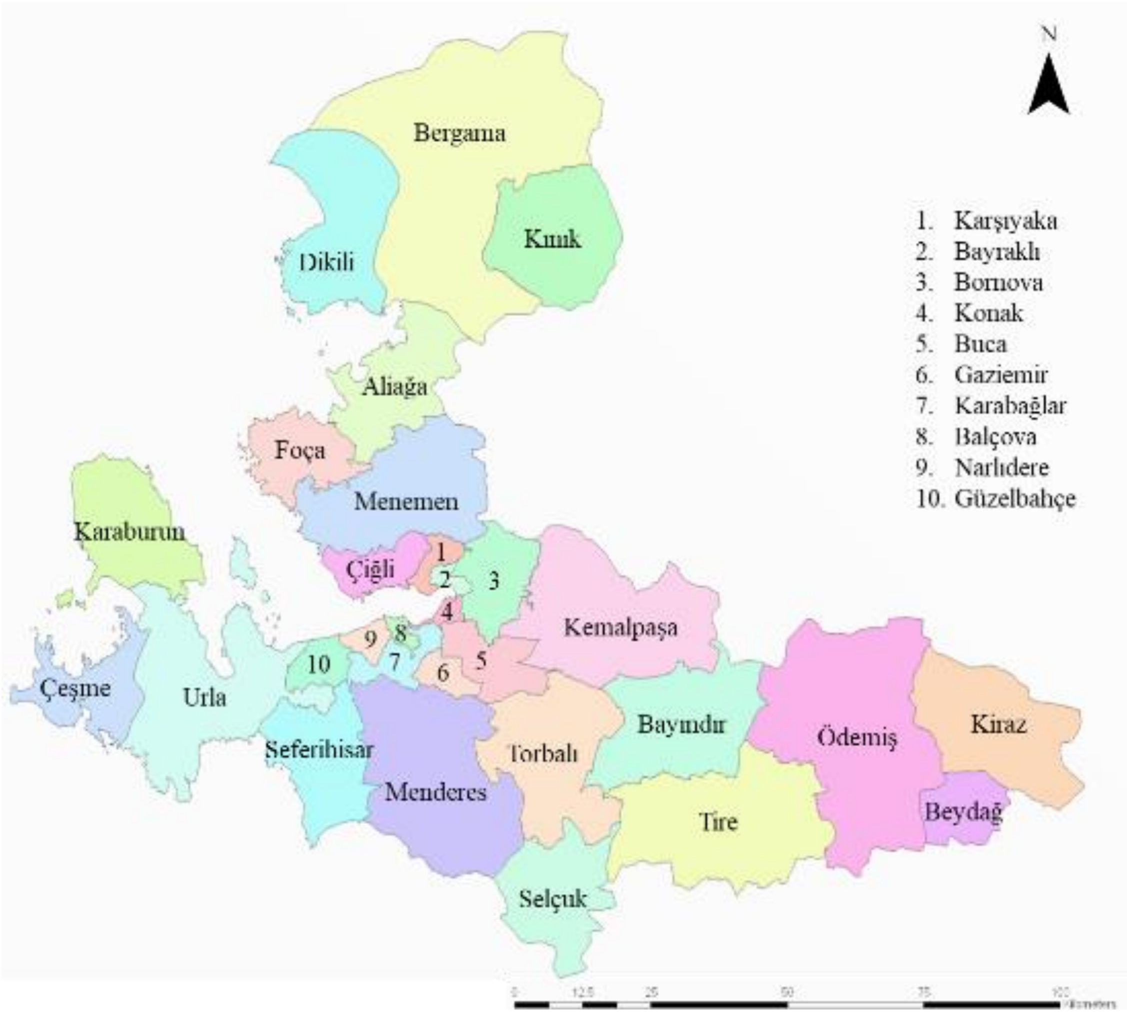


Figure 3.2. The administrative districts of İzmir.

### 3.1.1. General Information of İzmir

According to the Ministry of Industry and Technology, İzmir is the second biggest trade hub of Turkey located western-most, alongside the Aegean Sea (Figure 3.3). The city is located at the end of the Gulf of İzmir and the urban area is developed near the seaside (Figure 3.1). There are mountains around the central settlement, and other smaller settlements and road networks are scattered along with valleys.


Figure 3.3. The location of İzmir.
(Source: https://www.investinİzmir.com/en#neden-İzmir)

Seven highways are passing İzmir, D-300, D-550, D-565, O-5, O-30, O-31, and O-32 (Figure 3.4). Both O and D indicate highway for high-speed vehicles, but O refers to controlled-access highway (Otoyol in Turkish) and D indicates State road (Devlet in Turkish) (Table 3.1).

Table 3.1. Road types and management authorities in Turkey.
(Source: KGM, 2020)

| Type | | Management authority |
|---|---|---|
| Highway | Highway (Otoyol) | General Directorate of Highway (GHD) under the Ministry of Transport, Maritime Affairs and Communications |
| | State road (Devlet yolu) | |
| | Provincial road (Il yolu) | GDH and Provincial Special Administration Directorates |
| | Village road (Koy yollari) | |
| Touristic roads | Touristic road (Turistik Yollar) | GDH with funding provided by the Ministry of Culture and Tourism |
| | Forest road (Orman Yollari) | Ministry of Forestry |
| | Urban roads (Sehirici Yollari'dir) | Municipalities |

D-300 is one of the main highways of Turkey, a horizontal straight line, from westernmost of Turkey, Çeşme to easternmost of the country, the Iranian border. Inside of İzmir, it passes the central part of İzmir, used for alternative route avoiding urban roads. D-550 provides connectivity from the northern part of İzmir, near the Greek border, and it is one of the options for drivers who want to visit the northern part of İzmir, Menemen. D-565 is joined into D-300 from the north-east direction. It does not affect much urban trips since it starts the edge of the urban. O-5, O-31, and O-32 are highways that run from outside of İzmir, respectively Istanbul, Aydin, and Çeşme. Those also do not have an impact on travel inside of İzmir. O-30 takes a key role in connection inside of İzmir. The intercity highways, O-5, O-31, and O-32, are connected to this to access the inner city. Also, it connects all urban areas of İzmir, drawing a big circle on the edge of the urban area.

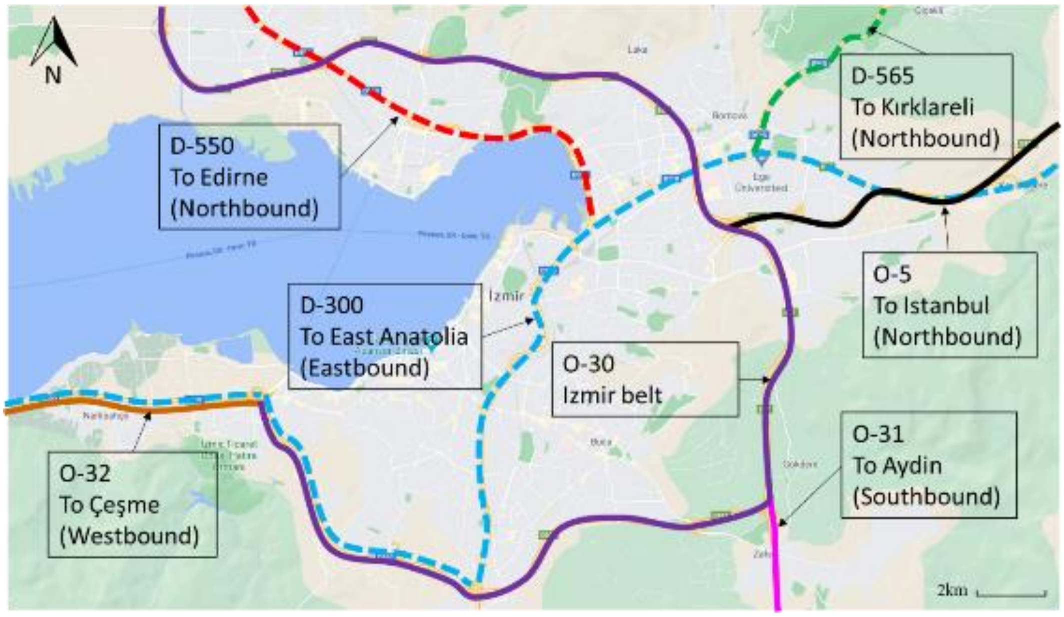


Figure 3.4. Main road systems in İzmir.
(Source: http://google.com/maps)

The population is approximately 4.32 million in 2019 according to the Turkish Statistical Institute (TURKSTAT, 2020). Excepting the year of 2010, the population of İzmir shows the same growth pattern as the total population of Turkey (Figure 3.5). The population is steadily growing up overall, which means it is expected to the city needs more road infrastructure (Downs, 2004a).

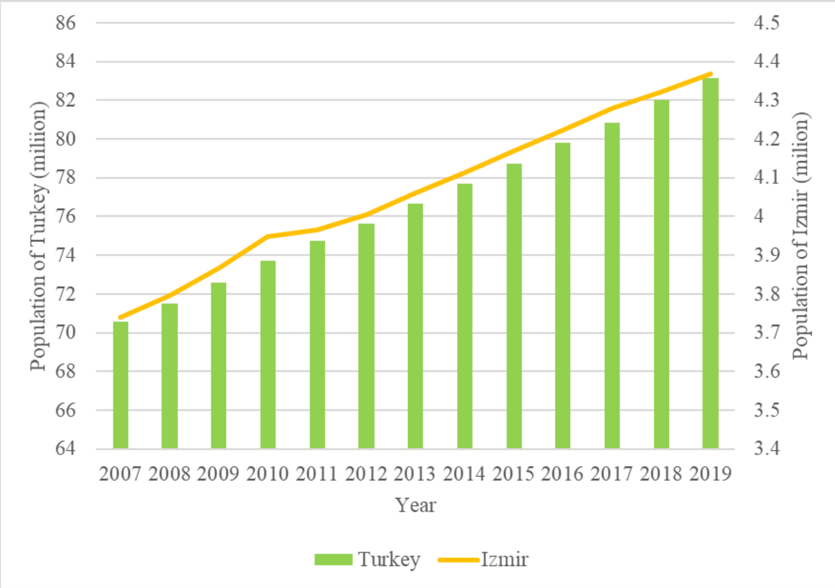


Figure 3.5. The population growth in Turkey and İzmir.
(Source: TURKSTAT,2020) (TURKSTAT, 2020)

Population distribution by age in İzmir shows that it is a young city (Figure 3.6). Under 65 age takes up around 88 per cent of the total population. There is no upper limit of the age for driving, however, the possibility of a car crash increases exponentially over the age of 75 (Guerrier et al., 1999). Assuming that age between 20 and 75 could drive, approximately 71 per cent of the population is able to drive.

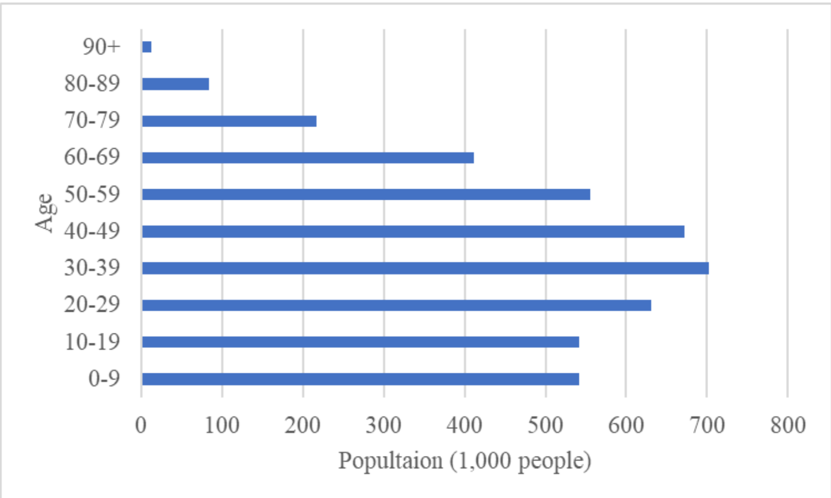


Figure 3.6. Population by age in 2019 of İzmir.
(Source: TURKSTAT,2020) (TURKSTAT, 2020)

The density of the road tends to go upwards sloping overall, excepting declining in 2005 (Figure 3.7). Total motorway length per capita also tends to grow. Even though there was some regression between 1999 and 2004, it makes a rapid rise especially between 2006 and 2008.

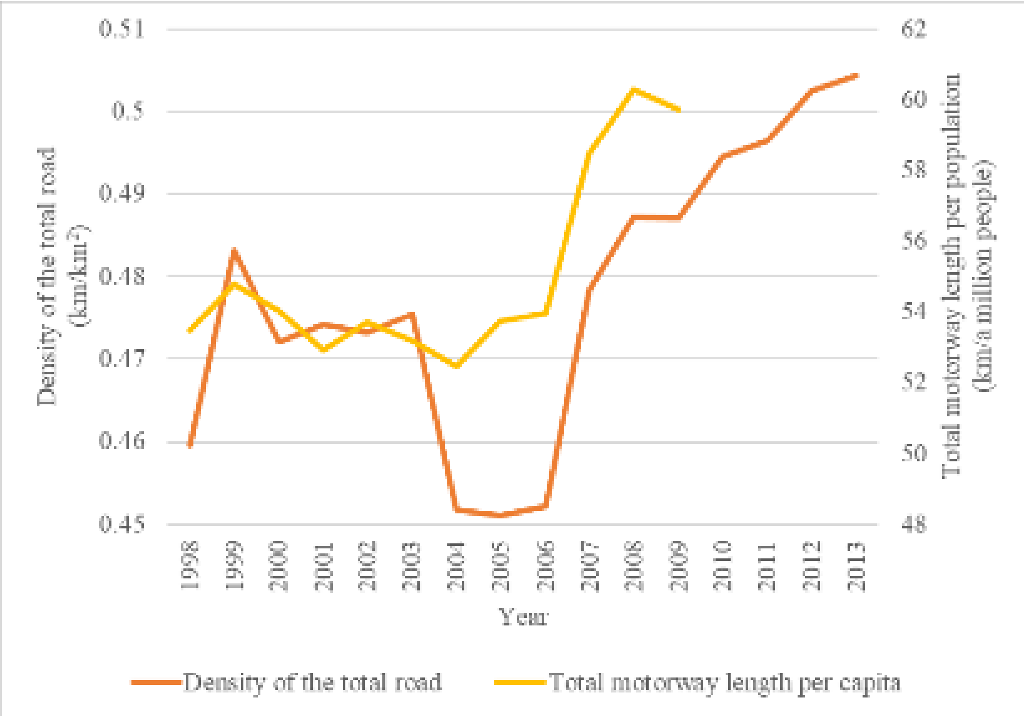


Figure 3.7. The growth density of the total road and the total motorway length per capita in İzmir (Source: TURKSTAT,2020).

The number of motor vehicles per capita is rising consistently (Figure 3.8). With considering population growth, it is clear that possession of the private car is increasing. The usage of the private car instead of the other means could cause traffic congestion (Metz, 2018). In other words, the growth of private cars would lead to more congested in İzmir.

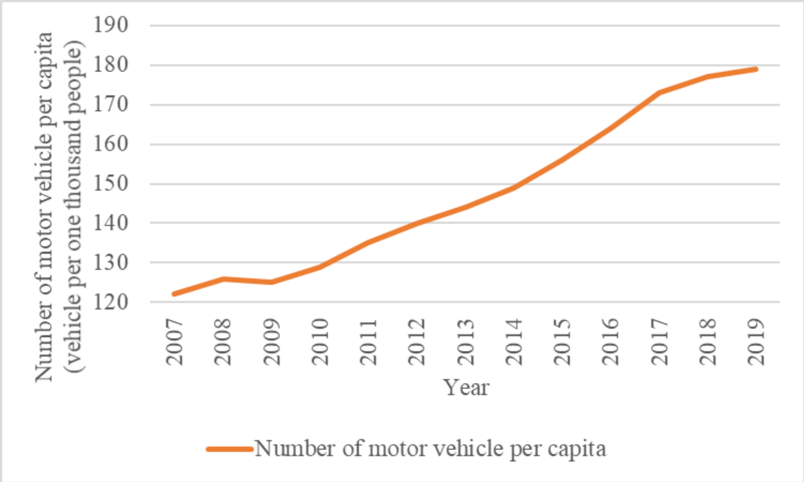


Figure 3.8. The growth of the number of motor vehicles per capita in İzmir.
(Source: TURKSTAT,2020)

#### 3.1.1.1. Serious Traffic Problem of İzmir

İzmir is the third biggest city in Turkey in terms of population, and the growth will have been continuing. According to İzmir transportation master plan, urban growth and asymmetry of traffic capacity and demand will be continued. Also, the urban population will be increased by 3 per cent, 34 per cent, 14 per cent, 16 per cent in 2030 (respectively, at Konak & Karabağlar, at Balçova & Narlıdere, at Bayraklı & Bornova, and Buca, & Gaziemir) (Table 3.2). On the other hand, job openings will be raised most at Bayraklı & Bornova by 106%, and least at Balçova & Narlıdere, where population growth is the highest. Since people will make commuting trips, the imbalance might cause more serious traffic problems in the future.

Table 3.2. The expected population and job opening growth in İzmir in 2030.
(Source: Bogazici proje A. S., 2019)

| District | Population increase | Job opening increase |
|---|---|---|
| Konak, Karabağlar (center) | 3% | 63% |
| Balçova, Narlıdere (south-west) | 34% | 33% |
| Bayraklı, Bornova (east) | 14% | 106% |
| Buca, Gaziemir (south) | 16% | 35% |

Currently, there is heavy traffic congestion in the peak hours over the İzmir. New constructions of big shopping malls, industrial zones, business sectors, gas stations, parking lots, hospitals, education centers are major contributors to traffic congestion in İzmir (Bogazici Proje A. S., 2019). In İzmir, industrial aggregations are located most in Aliağa, Bergama, Buca, Kemalpaşa, Torbalı, Menemen, Menderes Tire and Çiğli (İZTO, 2020). Considering the population of the districts (Table 3.3), there might be heavier congestion in the future, since the industrial zone is getting bigger outside of high population district, Konak and Bornova. The imbalance among land-use of the urban area in İzmir would make the traffic congestion more serious (Duvarcı and Yigitcanlar, 2019).

Table 3.3. Population by the districts in İzmir in 2019.
(Source: https://www.citypopulation.de/en/turkey/İzmir/)

| District | Population |
|---|---|
| Bornova | 450,992 |
| Konak | 351,572 |
| Çiğli | 200,211 |
| Torbalı | 185,908 |
| Gaziemir | 137,808 |
| Kemalpaşa | 107,556 |
| Menderes | 97,123 |
| Narlıdere | 65,737 |

In İzmir, traffic tends to focus on the city center in the present, and the phenomenon will remain in the future (Bogazici Proje A. S., 2019). It says with conventional solutions, the growth of traffic congestion would be out of control. It means without developing other means, the congestion problem in İzmir would keep growing.

There should be a development of road in some specific districts, in Narlıdere, Balçova, Konak, Buca, Bornova, Bayraklı, Karşıyaka, and Çiğli because there is heavy congestion (Bogazici proje A. S., 2019). In Mithatpaşa, Inonu, and Esrefpaşa of the Konak, the center of the city, parking on the road causes congestion.

An evening rush is more severe in İzmir, especially on Friday (Table 3.4). The morning peak is around 1 hour between 7 a.m. to 8 a.m., on the other hand, the evening peak is around 2 hours between 6 p.m. to 8 p.m. Congested period is the shortest in the Sunday. In addition, drivers spend 15 minutes (per 30 minutes) more in the morning peak hours and 21 minutes (per 30minutes) more in the evening peak. The total time lost in rush hour in 2019 is around 140 hours.

Table 3.4. The average weekly traffic congestion by the time of day in İzmir in 2019. (Source: Tomtom, 2020)

| | Mon | Tue | Wed | Thu | Fri | Sat | Sun |
|---|---|---|---|---|---|---|---|
| 12:00 AM | 6 | 4 | 4 | 4 | 5 | 7 | 12 |
| 1:00 AM | 1 | 1 | 1 | 0 | 1 | 2 | 5 |
| 2:00 AM | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 3:00 AM | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4:00 AM | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5:00 AM | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6:00 AM | 4 | 5 | 5 | 4 | 5 | 2 | 0 |
| 7:00 AM | 31 | 27 | 28 | 26 | 26 | 7 | 1 |
| 8:00 AM | 56 | 49 | 48 | 46 | 46 | 13 | 4 |
| 9:00 AM | 34 | 31 | 30 | 28 | 29 | 14 | 4 |
| 10:00 AM | 23 | 22 | 22 | 22 | 23 | 16 | 5 |
| 11:00 AM | 23 | 21 | 21 | 21 | 23 | 19 | 7 |
| 12:00 PM | 24 | 22 | 22 | 22 | 24 | 26 | 11 |
| 1:00 PM | 27 | 25 | 24 | 25 | 21 | 37 | 17 |
| 2:00 PM | 34 | 31 | 31 | 31 | 32 | 42 | 22 |
| 3:00 PM | 35 | 32 | 32 | 32 | 38 | 40 | 24 |
| 4:00 PM | 37 | 35 | 35 | 34 | 44 | 35 | 22 |
| 5:00 PM | 45 | 44 | 44 | 43 | 53 | 34 | 21 |
| 6:00 PM | 67 | 66 | 67 | 66 | 80 | 34 | 23 |
| 7:00 PM | 50 | 49 | 51 | 50 | 70 | 32 | 22 |
| 8:00 PM | 20 | 21 | 22 | 22 | 36 | 24 | 19 |
| 9:00 PM | 12 | 13 | 13 | 14 | 17 | 16 | 15 |
| 10:00 PM | 11 | 11 | 11 | 12 | 13 | 15 | 15 |
| 11:00 PM | 8 | 8 | 8 | 9 | 12 | 15 | 12 |

There is an origin-destination table of İzmir at the district level in Table 3.5. Trips inside of each distinct are prominent rather than inter-district trips. Trips between Karabağlar, Buca, Bornova, and Karşıyaka, and Konak, also make up a large portion of the total trip. In the northern part of İzmir, Karşıyaka, and Çiğli, and central part, Bornova and Kemalpaşa have huge travel to each other. Besides that, trips between Karşıyaka, and Çiğli, and Bornova is noticeable.

Table 3.5. The origin and destination matrix of total traffic in İzmir in April 2019.
(Source: Tomtom, 2020)

| | | Destination | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Konak | Karabağlar | Buca | Bornova | Kemalpaşa | Torbalı | Menderes | Gaziemir | Güzelbahçe | Karşıyaka | Çiğli |
| origin | Konak | 228,815 | 40,503 | 32,691 | 67,955 | 8,035 | 4,875 | 4,911 | 16,268 | 5,352 | 26,431 | 11,918 |
| | Karabağlar | 39,232 | 122,050 | 21,928 | 21,190 | 3,573 | 5,022 | 6,764 | 21,859 | 2,495 | 4,856 | 4,118 |
| | Buca | 34,067 | 21,276 | 205,966 | 40,617 | 5,606 | 8,883 | 7,884 | 23,958 | 2,103 | 6,914 | 6,073 |
| | Bornova | 65,308 | 19,725 | 38,372 | 483,203 | 30,848 | 11,549 | 7,023 | 19,458 | 2,719 | 34,980 | 24,690 |
| | Kemalpaşa | 7,942 | 3,396 | 5,210 | 30,707 | 117,493 | 3,678 | 1,135 | 2,203 | 304 | 4,698 | 3,298 |
| | Torbalı | 4,988 | 5,022 | 9,070 | 12,501 | 3,584 | 142,791 | 9,387 | 8,662 | 494 | 2,627 | 1,713 |
| | Menderes | 4,882 | 6,396 | 7,545 | 7,179 | 1,264 | 9,197 | 86,505 | 16,123 | 701 | 1,618 | 1,192 |
| | Gaziemir | 17,022 | 21,053 | 23,105 | 18,498 | 2,280 | 7,883 | 15,609 | 115,540 | 2,043 | 4,988 | 3,798 |
| | Güzelbahçe | 4,964 | 2,518 | 1,941 | 2,698 | 277 | 552 | 678 | 2,281 | 27,371 | 857 | 434 |
| | Karşıyaka | 26,650 | 4,884 | 6,450 | 33,775 | 4,470 | 2,230 | 1,537 | 4,841 | 848 | 168,113 | 40,983 |
| | Çiğli | 11,747 | 4,094 | 5,716 | 23,920 | 3,425 | 1,765 | 1,147 | 3,890 | 477 | 43,310 | 128,963 |

### 3.1.2. Spatial Frame of the Study

There are two dimensions of the study area; (1) commuting trip, (2) short trip in CBD (Figure 3.11). A circle with a radius of 8 km is for commuting trips in the overall city. The average trip duration is 31.4 minutes in İzmir (Bogazici Proje A. S., 2019). It should be converted into a distance to conduct the study. In Turkey speed limit in a built-up area is 50 km/h and also, typical automobile speed in the urban area is 53 km/h in Turkey (Karaca et al., 2009). With a speed of 50 km/h, the average travel distance is 32 km. However, 32 km distance embraces a too bigger area of İzmir, including mountain and countryside (Figure 3.9). In addition, the spatial factor is within the urban area and the temporal factor in the peak hours, so we cut the average speed of the vehicles by half because there is congestion. Therefore, the distance for each trip corresponds to 16 km in the study.

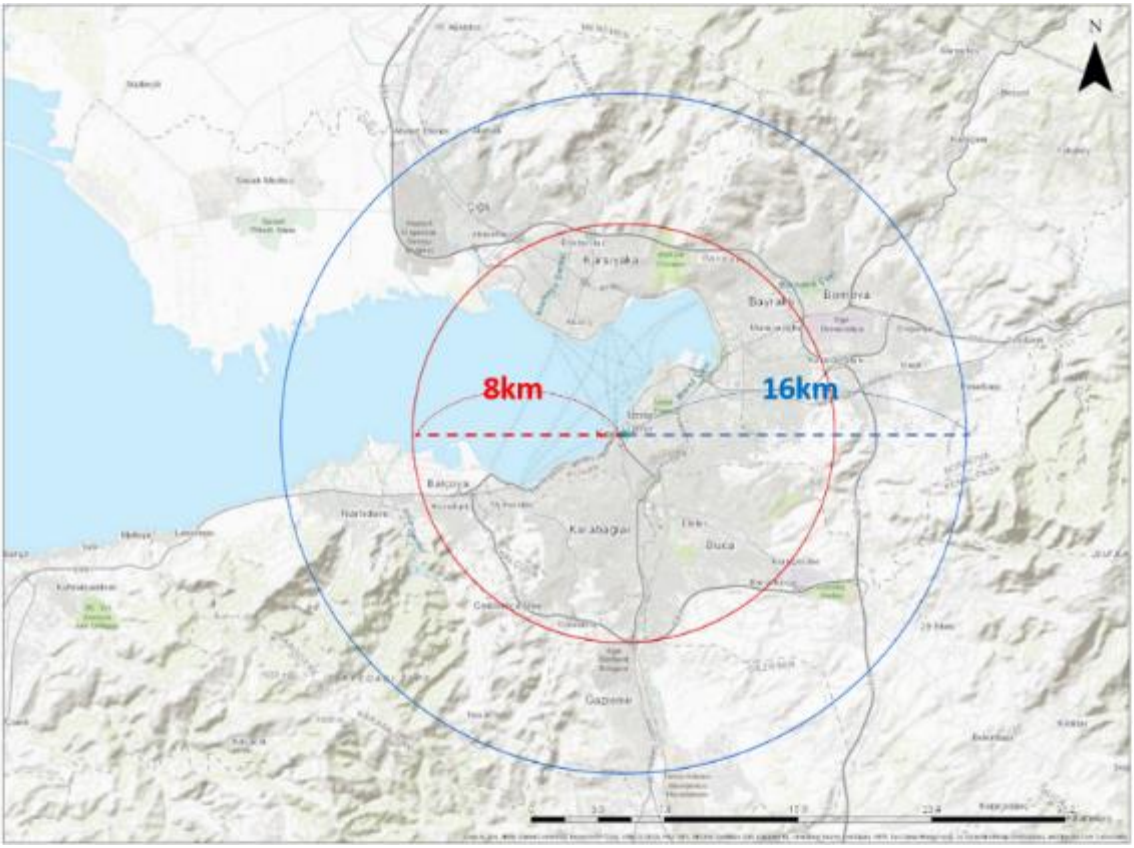


Figure 3.9. The comparison of travel distance 16 km and 32 km.

For the trip inside of CBD, a minimum distance to drive is applied. A preference for walking over driving declines sharply before around 1 km (Pw in Figure 3.10). Preference to driving over walking (Pd in Figure 3.10) is steadily increased from the start, and those two parameters cross at around 3.8 km.

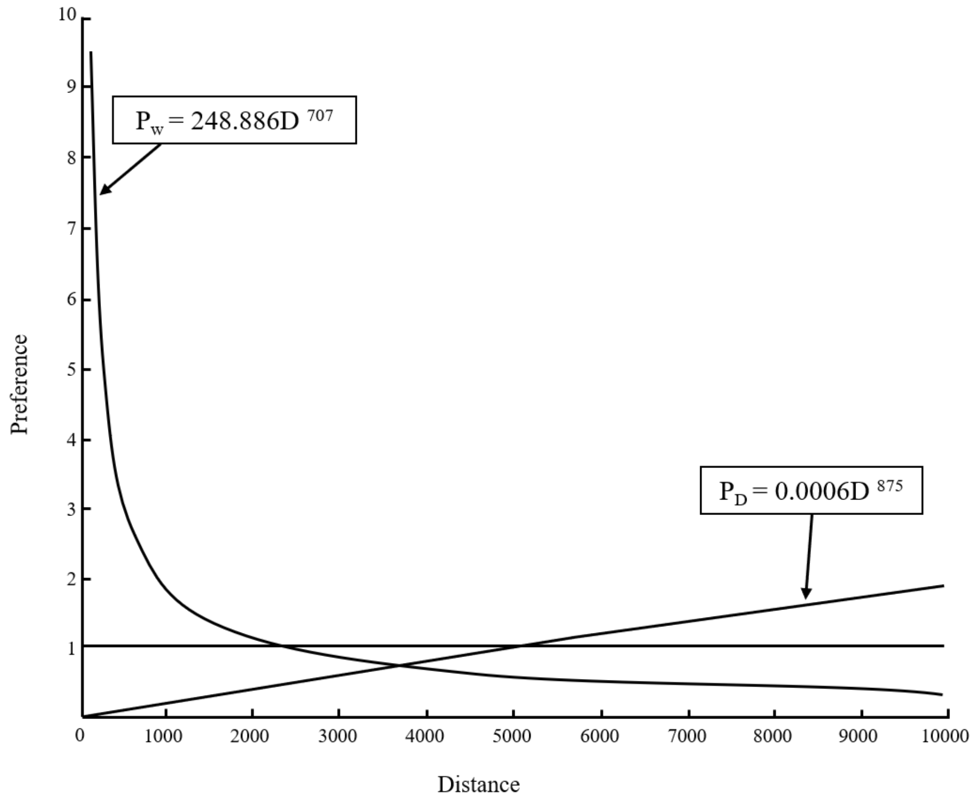


Figure 3.10. The preference graph for walking over driving (Pw) and driving over waking (Pd) (Source: Gärling and Loukopoulos, 2007).

The result of the survey says people start to choosing driving at 2 km (Table 3.6). In the case of İzmir, there is no data about the distance threshold for driving. However, 80 per cent of İzmir citizens can walk 500 meters at their maximum speed, without problem (Bogazici Proje A. S., 2019). After that, they feel tired and get slow down. Considering that people who own a car tends to prefer to drive even distance is short (Loukopoulos and Gärling, 2005) and the other studies, we assume, people choose to drive from 2 km in İzmir.

Table 3.6. The number of respondents who chose to drive.
(Source: Gärling et al., 2000)

| Travel distance (km) | Driving Choice |
|---|---|
| 0.8 | 0 (0 %) |
| 1.4 | 0 (0 %) |
| 2 | 7 (11.7 %) |
| 2.6 | 15 (25 %) |
| 3.2 | 21 (35 %) |
| 3.8 | 40 (66.7 %) |
| 4.4 | 53 (88.3 %) |

Therefore, the study area of the study is the circle with a radius of 8 km for commuting travel and 1 km for a short trip in CBD (Figure 3.11). The centers of each circle are both Konak, CBD of İzmir, but they are not exactly the same. The center of the commuting trips (blue line in Figure 3.11) is Atatürk Meydanı, near government buildings, shopping malls, metro stations, and the ferry dock of Konak. The one of short trips (red line in Figure 3.11) is Fevzipaşa Boulevard, the slightly north-western direction of Atatürk Meydanı. It is the center of the business of İzmir, and there is a large floating population in business time.

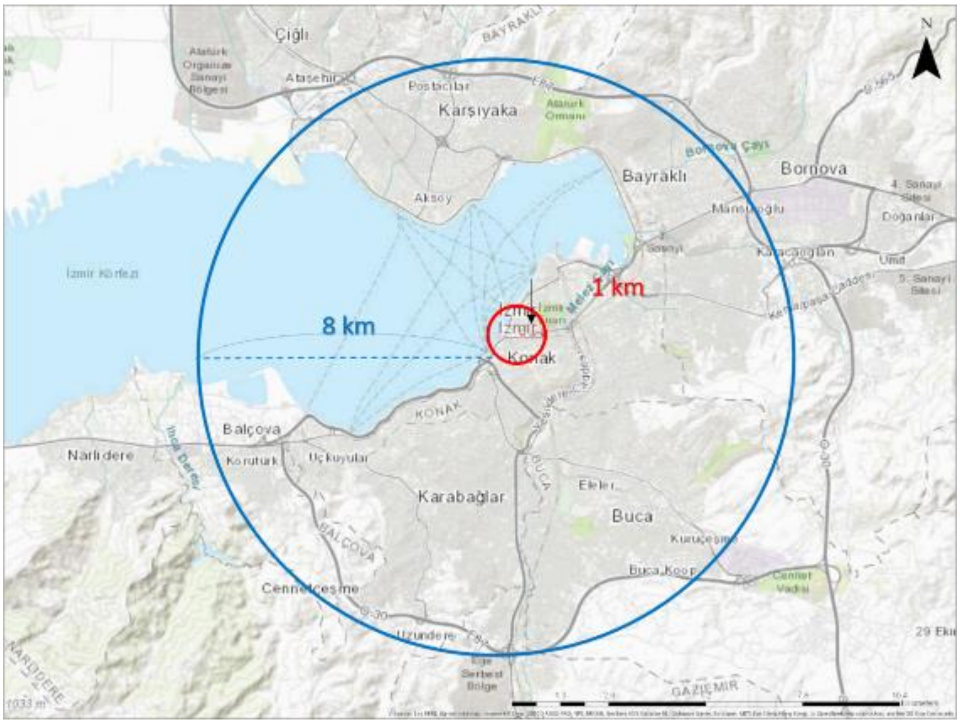


Figure 3.11. The study area.

The distance defined in the study area is straight-line distance, not distance on the network. Straight-line is not precise, because a vehicle should move along with the network. But it is proved by some studies, that there is a high correlation between straight-line and actual route on the network (Boscoe et al., 2012; Phibbs and Luft, 1995; Cooper, 1983). Also, the study is about observing alternative routes and their travel time over different time periods. Thus, a straight-line is chosen rather than a specific route.

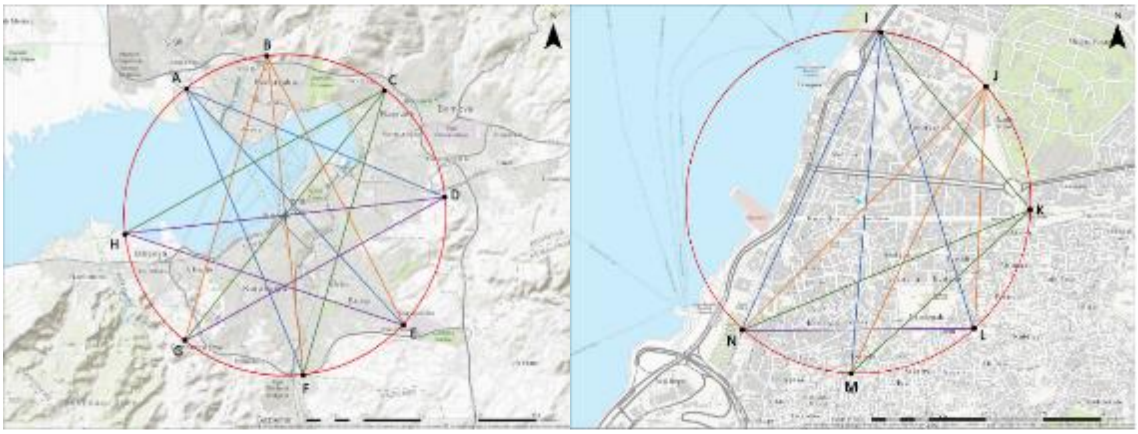


Figure 3.12. The hypothetical routes of each study area (left: 16 km and right: 2 km).

In the case of a bigger area, within 16 km, the only urban area is embraced (left figure in Figure 3.12). There are 8 points (nodes) on the circle. Those nodes are placed as evenly as possible. However, there are some diminutive modifications to allow all dots to be land-based. There could be total of 28 routes from 8 nodes, but only 12 routes are chosen. Because minor trips such as between node A and node B or node B and node C is too short, it is not the concern of the study. There is no significant congestion even during the peak hour and it is too short to be a commuting trip. Thus, only most far 3 trips from each node are selected. In the case of a smaller area, CBD of İzmir and intercity train station, Basmane station is included. There are 6 points (nodes) on the circle. Each node is also distributed as possible as evenly, but there are small modifications because of land-use issues. There could be a total of 15 routes, but only 10 routes are chosen. Since the trip from node A and B, B and C, C and D, D and E and E and F are shorter than 2 km, the threshold for driving in the study, they are excluded.

### 3.1.3. Time Frame of the Study

The specific hour when the off-peak hours and the peak hours begin and end vary by city. In the case of İzmir, it is defined that the peak hour in İzmir is from 7 a.m. to 8 a.m. and from 6 p.m. to 7 p.m. through the observation. In addition, according to Figure 3.13, the evening peak is bigger than the morning peak in İzmir. The off-peak hour is from 9 a.m. to 5 p.m. after the morning peak, and from 8 p.m. to next-day 6 a.m. after the evening peak and before the morning peak. In the study, to observe the difference between the peak hours and the off-peak hours, from 10 p.m. to 11 p.m. is chosen, since there is some minor congestion during around noon.

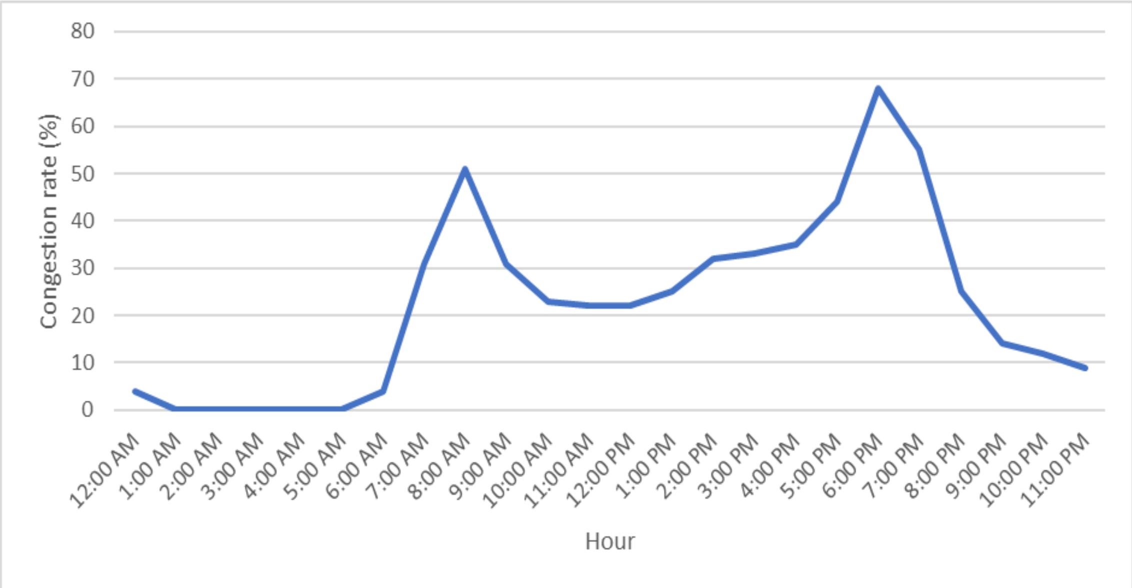


Figure 3.13. The congestion rate in İzmir in 2018.
(Source: Tomtom, 2020)

## 3.2. Methodology

When there is an input of origin and destination, GM returns several routes with a specific travel time and travel distance. The shortest route in terms of travel time among them is selected as suggested routes. The suggested routes and its travel times and distance that GM suggests during the peak hours, from 6 p.m. to 7 p.m., and the off-peak hours, from 11 p.m. to 12 a.m. are gathered at an interval of six minutes on weekdays.

The traffic is generated even in a second, but with too little time interval, there is no difference of suggestion, so that the time interval is decided to six minutes after trying several time intervals (1 minute to 15 minutes). The number of data that is gathered per day is 10. Between the certain nodes, hypothetical trips are generated repeatedly. The number of data is 200 for each route (Table 3.7).

Table 3.7. The number of observations of each study area.

| Study area | Off-peak hours | Peak hours |
|---|---|---|
| Commuting trips in the overall city (12 routes) | 2,400 | 2,400 |
| Short trip in CBD (10 routes) | 2,000 | 2,000 |

In the off-peak hours, GM usually suggests the shortest path that drivers could think out easily. Thus, we consider the suggested route in the off-peak hours as a general route without supporting of navigation systems. On the other hand, in the peak hours, the suggested route is slightly more complex to avoid the congested area. For example, it differs from a trip to a trip, sometimes it recommends a route that makes drivers take the highway, get out of it, and then re-take the same one to avoid congestion at a point of the highway. In other cases, it suggests a route that heads for the opposite direction of the general route and lets drivers follow a winding path. These types of suggestions are almost impossible to bring to mind without helping of the navigation systems, even though the driver is acquainted with the area. Therefore, the comparison of suggested routes in the peak hours and the off-peak hours indicates the contrast of the general route without navigation systems and the optimal route that GM suggests.

The travel distance is compared between the off-peak hours and the peak hours, and the difference in usage of local streets is examined to see the negative effect of navigation systems on local streets. The travel time, again, is compared between the off-peak hours and the peak hours, and the difference of travel time is analyzed whether Wardrop's equilibrium is realized or not. In addition, the comparisons of travel time and a travel distance of the shortest route in the peak hours and the general route (same to the route of the off-peak hours and most similar one) in the peak hours shows the effects of navigation systems. It is expected the shortest route is not suggested in the peak hours, because many vehicles piled on in a short period of time, making congestion. Thus, the suggested route in the peak hours is mostly faster in terms of travel time, and longer in terms of travel distance. By comparing those, we could understand how much time is saved by using GM and how much longer is additional or less travel distance than the general route caused by using GM (Table 3.1).

Table 3.8. The main comparison of the study.

| Variables to make the comparisons | | Expected results |
|---|---|---|
| The travel distance of the suggested route in the peak hours | The travel distance of the suggested route of the off-peak hours | The difference of usage of local street |
| The travel time of the suggested route in the peak hours | The travel time of the suggested route in the off-peak hours | Realization of Wardrop's principle |
| The travel distance of the suggested route in the peak hours | The travel distance of the general route in the peak hours | Additional travel distance by taking the bypass |
| The travel time of the suggested route in the peak hours | The travel time of the general route in the peak hours | Saved travel time by using GM |

To gather data, Google's Puppeteer library written with JavaScript is used. It allows scraping the data in specific hours. The script automates the process by gathering specific information (the travel time and the travel distance) from the application (GM).

### 3.2.1. Google Maps (GM)

GM is the main method of the study. With the fast spread of smartphones, many ICT companies make navigation applications, Yandex, GM, Apple map, and so on. Brothers Lars and Jens Rasmussen developed Google Maps as c++ program in 2004 (Lanning et al., 2014). After that, Google introduced an embedded real-time traffic program that allows users to glance at the congestion conditions in 2007 (Malykhina, 2007). Among the applications, GM is chosen. The advent of the smartphone has encouraged the phenomenon since people do not need to buy exclusive devices. In Turkey, approximately 50 percent of people have a smartphone in 2018 (Statista, 2019). With the increase of smartphone usage, Navigation applications such as GMs or Apple Maps have been dominant either. In addition, GM is the most popular navigation application (Panko, 2018). The market share of GM among navigation applications is 70% in 2019 (Karakas, 2019).

GM suggests different travel routes adapting real-time traffic data and its own algorithm. For example, in the peak hours, it diverts drivers to a highway which could avoid congestion in the urban area. The travel distance itself is relatively longer, however, travel time is shorter yet very close to the original shortest route at the off-peak hours. In the case of the off-peak hours, it lets drivers take the shortest road because there is no congestion even in central İzmir (Figure 3.14).

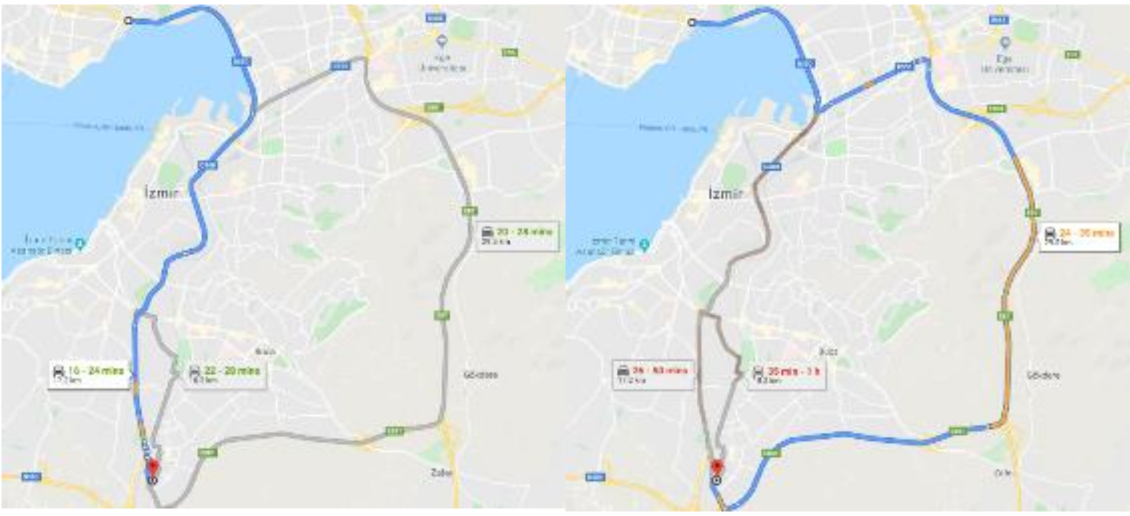


Figure 3.14. Examples of the different suggested route in the off-peak hour (left) and the peak hour (right) in İzmir.

When drivers choose origin and destination, the sever returns the best option, mostly the route with the shortest travel time, and some alternatives based on Dijkstra's Algorithm (Dijkstra, 1959). It is used for many navigation systems, not only GM to find the shortest travel path, considering travel time, or distance, or other constraints (Lanning et al., 2014). It chooses the optimal option at each step so that the combination of all options would be optimal (Habib et al., 2010).

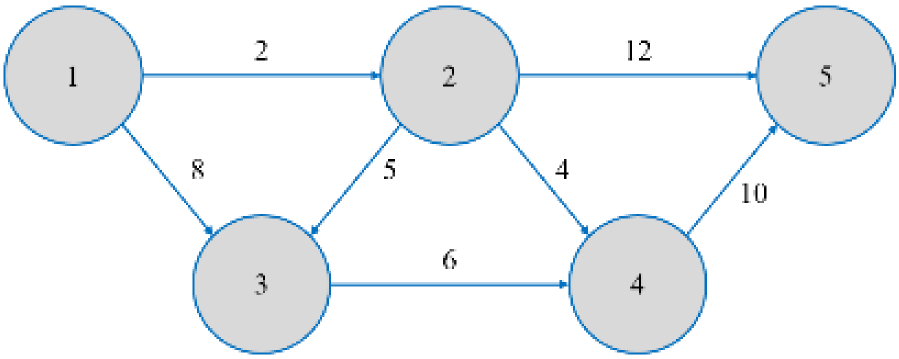


Figure 3.15. An example of Dijkstra's Algorithm.
(Source: Winston, 2004)

For example, in Figure 3.15, a circle is each node, and a line between the circles is each street with a certain travel time and we assume that there is a trip between node 1 and node 5. From node 1, there are two options, to node 2 or node 3. 2 is smaller than 8 so that the next node is 2, and then 6 is smaller than 14. Therefore, the next one is node 4, and finally node 5, with a total 16 travel time. However, the shortest travel time is 14, not 16. To confirm the chosen route is optimal, we should check the answer of 14 minus 10 (the shortest travel time minus travel time between nodes 5 and 4). With the answer 4, there is no way to get node 1 form node 4, so the chosen route is not the shortest route. On the other hand, with the answer of 14 minus 12 (the shortest time minus travel time between node 5 and 2), which is 2, it is possible to reach node 1. When we check all possible route from node 5, (to node 4 and node 2), it is clear that the shortest route is node 1 – 2 – 5.

In the example, there is no real-time traffic data, however, GM applies real-time traffic data, and perdition of data based on historical data. Crowdsourcing is the main method to gather traffic data by tracking the movement of android phones on networks and assuming traffic congestion rate by the speed of moving of them (Brindle, 2020). Adding to it, traffic sensors and collaboration with other applications such as Waze, which is providing information on accidents in real-time are the other sources (Sharama, 2017).

# CHAPTER 4

# DATA RESULTS

## 4.1. Results of the Commuting Trips in the Overall City

The data results of each route that GM provided show different patterns. There are two primary groups of results according to the travel distances. In the first group, there is no difference in travel distance between the peak hours and the off-peak hours. Regardless of traffic congestion, GM suggests the same or similar route, but there are differences in the travel time. It mostly suggests the highway both in the peak and off-peak hours.

In the second group, there are significant differences in the travel distance and the travel time between the peak hours and the off-peak hours. In the peak hours, it suggests highway rather than urban roads. GM mostly suggests perimeter highway, O-30 (Figure 3.4) avoiding the congestions in the central area. On the other hand, in the off-peak hours, it suggests the shortest routes mostly using the urban roads. Overall, there are not many alternatives and there is almost no usage of local streets. The travel time of each route is approximately 29 minutes in the peak hours and 24 minutes in the off-peak hours on average. The graphs of the travel time show a similar trend between the peak and the off-peak hours (Figure 4.1).

The average length of each route is around 28 km in the peak hours, and 24 km in the off-peak hours. The patterns of the graphs are exactly the same as each other. The gap is bigger at the route A-F, B-G, B-F, C-H, and C-F, which means the alternative routes suggested in the peak hours are much longer than the general route (Figure 4.2).

The length of the usage of local streets is relatively short, compared to the whole trip, however, the local streets which are used for the alternative ways are the same or similar over all routes. It means when a lot of people use GM, there is a high chance that heavy traffic suddenly appears at the local streets. The total travel distance over the 200 observations is 32,763 km and the total length of local streets over the 200 observations is 349 km. The ratio of the usage of local streets is 1.07 per cent. The portion is not that significant, but the pattern of suggestion might be a problem because the road that used for the bypass is all similar over the routes in the commuting trips in the overall city.

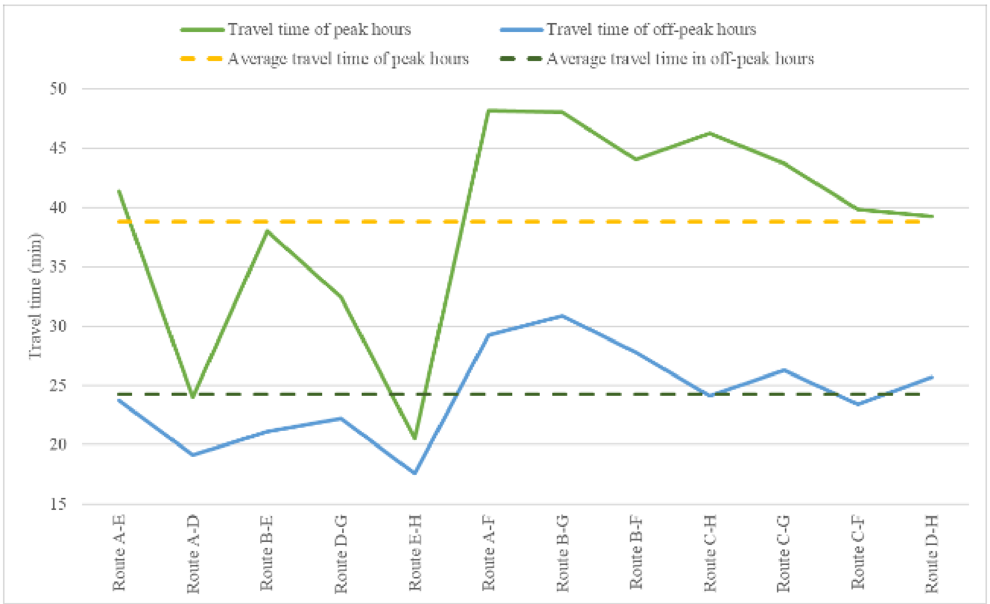


Figure 4.1. The travel time for each route in commuting trips in the overall city.


Figure 4.2. The travel distance for each route in commuting trips in the overall city.

### 4.1.1. Group 1 of the Commuting Trips in Overall City

The routes that are mainly recommended by GM in group 1 are all passing O-30, İzmir belt in this group. There are some small variations in the peak hours, but the overall route is similar (Table 4.1). Especially in the off-peak hours, the recommended routes are exactly the same during the observations, so that standard deviation is zero. The route D-G shows the biggest difference in travel distance between the peak hours and the off-peak hours (around 1.4 km), and there are only differences of under 500 m in the other routes. The relatively big difference of the route D-G is caused by a small variation in the peak hours, while the overall route is the same. There is a travel time difference of approximately 10 minutes between the peak hours and the off-peak hours, and the difference in travel distance is approximately 0.1 km on average.

Table 4.1. Average travel time and travel distance of group 1, commuting trips in the overall city (n=200 in the peak hours and the off-peak hours each).

| | | Peak hours | | Off-peak hours | |
|---|---|---|---|---|---|
| | | Mean | SD | Mean | SD |
| Route A-E | Travel time (min) | 41.385 | 8.687586 | 23.72 | 0.594447 |
| | Travel distance (km) | 30.9245 | 0.746213 | 30.6 | 0 |
| Route A-D | Travel time (min) | 23.98 | 4.782674 | 19.12 | 0.325777 |
| | Travel distance (km) | 20.591 | 0.432614 | 20.8 | 0 |
| Route B-E | Travel time (min) | 38.025 | 8.876278 | 21.13 | 0.337147 |
| | Travel distance (km) | 26.761 | 1.108432 | 26.2 | 0 |
| Route D-G | Travel time (min) | 32.465 | 2.667273 | 22.205 | 0.440392 |
| | Travel distance (km) | 25.8475 | 1.006009 | 27.2 | 0 |
| Route E-H | Travel time (min) | 20.555 | 0.787449 | 17.575 | 0.562099 |
| | Travel distance (km) | 21.899 | 0.141418 | 21.8 | 0 |
| Average | Travel time (min) | 31.282 | 5.160252 | 20.75 | 0.451972 |
| | Travel distance (km) | 25.2046 | 0.686937 | 25.32 | 0 |

Checking the route in group 1 from the map, it shows that routes mostly does not penetrate the city center, excepting the route A-E (Figure 4.3). It indicates the routes pass the less congested roads so that there is not much difference between the peak hours and the off-peak hours.

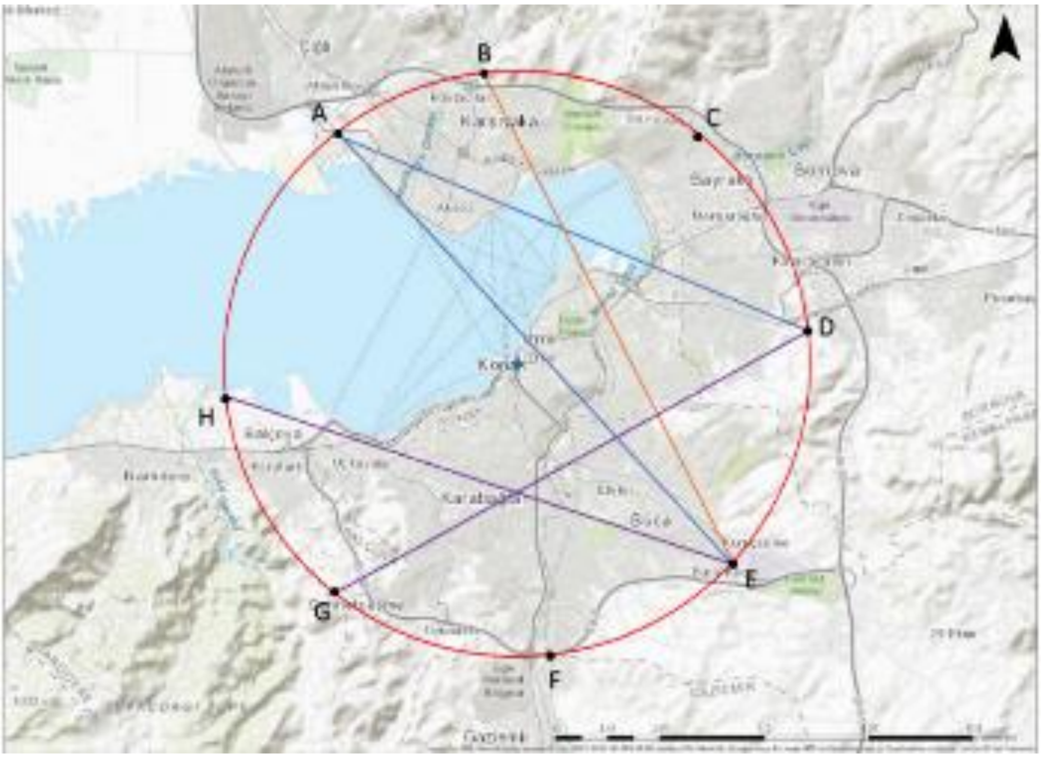


Figure 4.3. The routes of group 1, commuting strip.

Overall, there is less usage of local streets in this group. The total hypothetical travel distance is 25,298 km, but the length of local streets that are used is only 234.35 km. The ratio of the usage of local streets is around 1 per cent (Table 4.2).

Table 4.2. The total travel length and the length of local streets in the peak hours of group 1, commuting trips in the overall city.

| | Length of local streets (km) (A) | Total travel distance (km) (B) | Ratio (%) (A/B) |
|---|---|---|---|
| Route A-E | 83.05 | 6,184.9 | 1.34 |
| Route A-D | 48.64 | 4,118.2 | 1.18 |
| Route B-E | 98.02 | 5,352.2 | 1.83 |
| Route D-G | 4.64 | 5,262.9 | 0.09 |
| Route E-H | 0 | 4,379.8 | - |
| Total | 234.35 | 25,298 | 0.93 |

#### 4.1.1.1. Route A-E

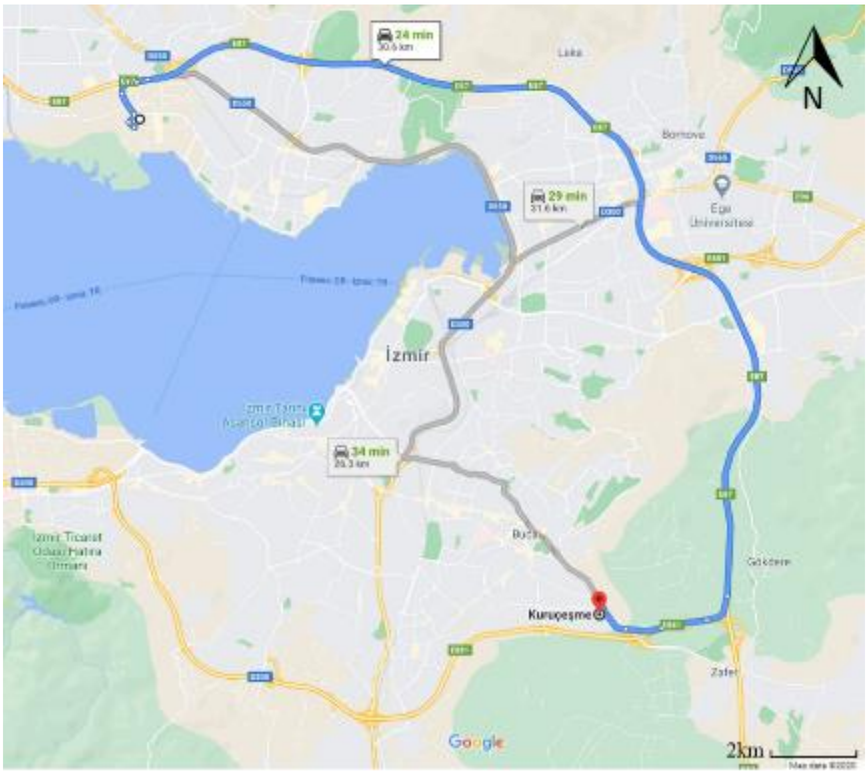


Figure 4.4. The most suggested route in the off-peak hours and the peak hours of the route A-E.

Regardless of congestion, there is only one route suggested most (30.6 km) (Figure 4.4). There is an alternative route with the shortest travel distance (26.3 km), but it is never suggested since drivers always encounter minor congestion when they pass through the city center. It is because even in the off-peak hours, there is minor congestion in D-300 near Buca. Thus, the route with O-30, İzmir belt is recommended in the peak hours and the off-peak hours both. In the case of heavily congested hours, there is only a minor difference; how to pass the congested area of D-300 with the general resemblance (Figure 4.5). It takes a complicated bypass to avoid heavy congestion in the highway.

The alternative routes are almost impossible to think without navigation systems because it repeatedly gets out of the highway and re-takes it. The usages of local streets are 2.57 km (in the case of the route 32.6 km) and 1.1 km (in the case of the route 32.9 km). The total local streets usage rate is 1.34 per cent.

Table 4.3. The number of observations by the travel distance of the route A-E.

| Travel distance | Number of observations | |
|---|---|---|
| | Off-peak hours | Peak hours |
| 30.6 km | 200 | 168 |
| 32.6 km | 0 | 29 |
| 32.9 km | 0 | 3 |
| Total | 200 | 200 |

In the off-peak hours, over all observation, it shows only one route, 30.6 km. It might mean traffic is calm enough to not use navigation systems. In the peak hours, it is suggested the same route mostly (84 per cent), but there are some alternative routes in highly congested period for 32 times (16 per cent) (Table 4.3).

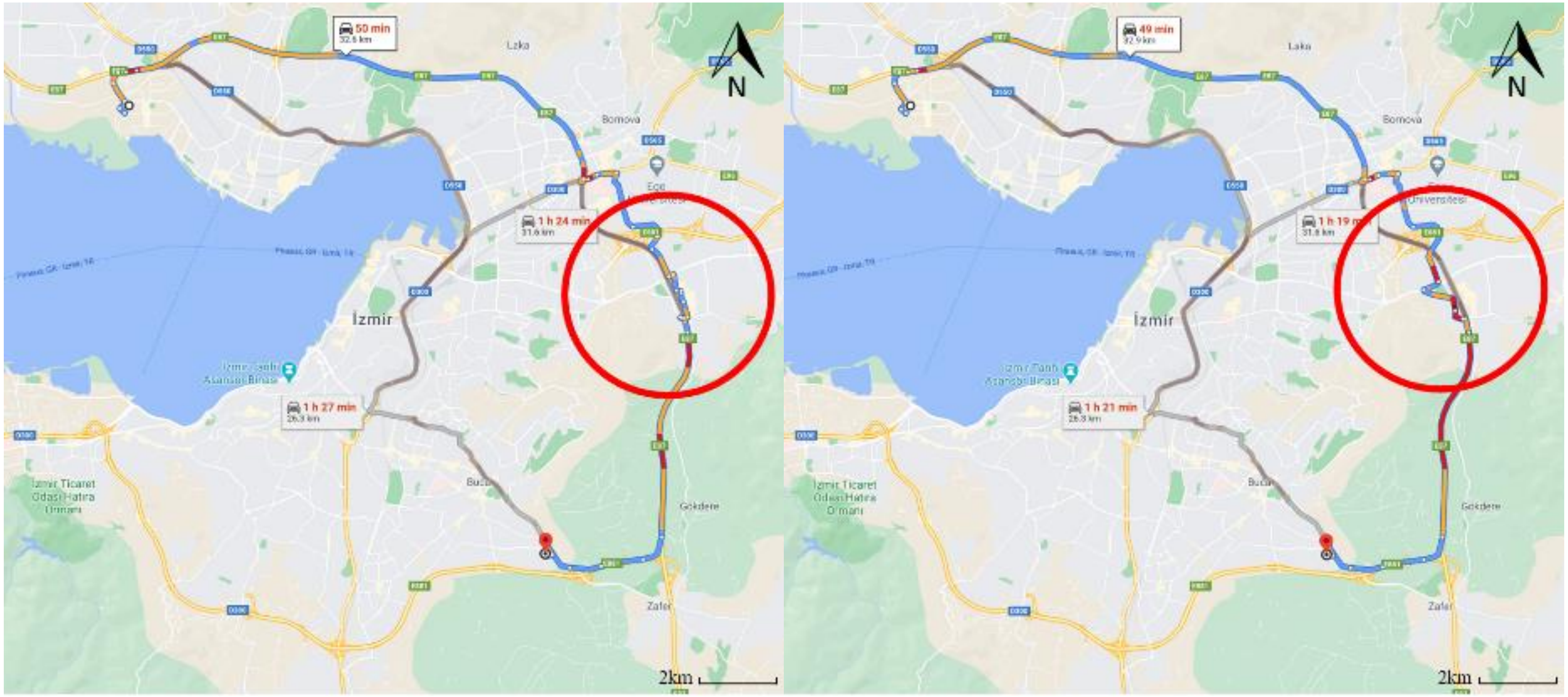


Figure 4.5. The alternative routes in the peak hours (left: 32.9 km and right: 32.6 km) of the route A-E.

## 4.1.1.2. Route A-D

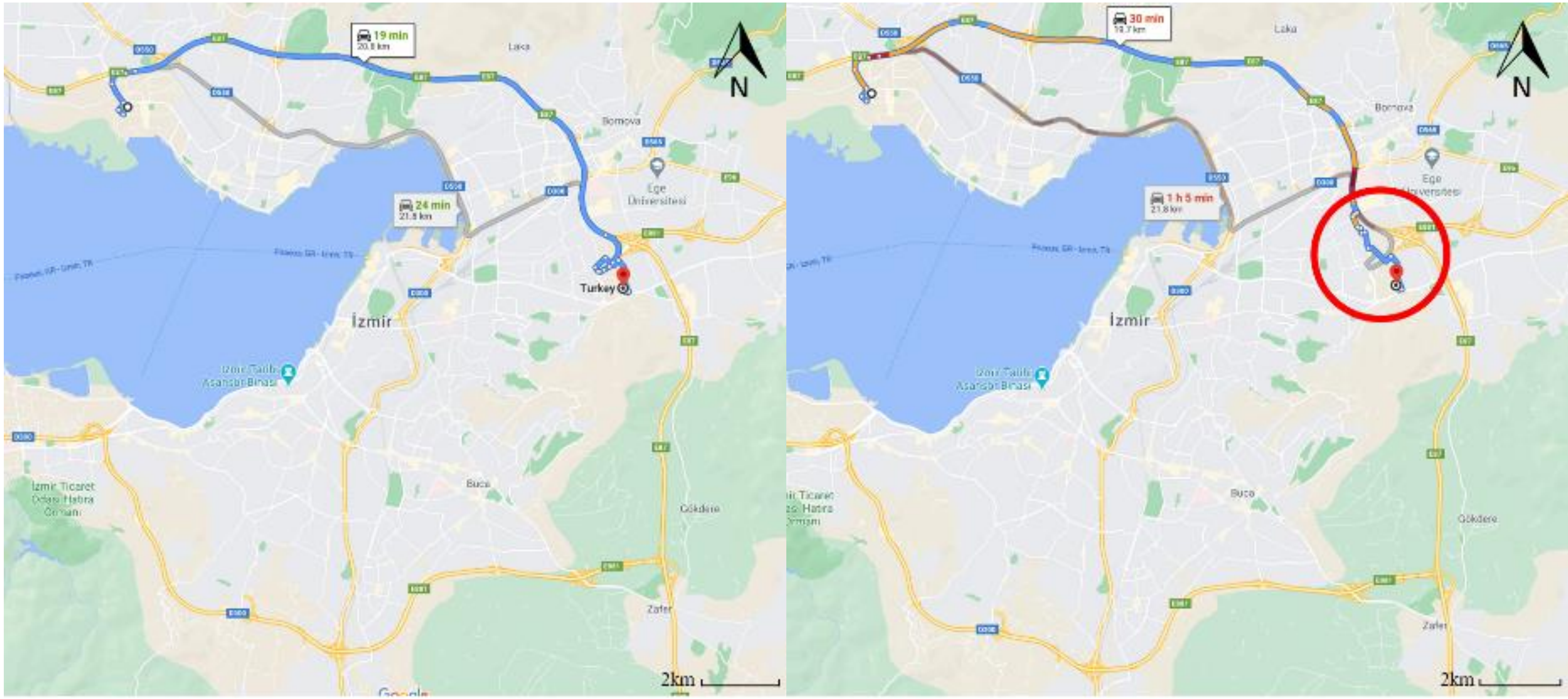


Figure 4.6. The most suggested route (left: 20.8 km) and the alternative route in the peak hours (right: 19.7 km) of the route A-D.

There is no congestion even in the peak hours. It is because the whole route is weighted in the northern part. Both in the peak and the off-peak hours, the route of 20.8km is most suggested (Figure 4.6). The salient point is that the alternative route passing the local streets is shorter than the general route, leaving the highway early. This is because there is minor congestion near the exit of the highway, so take the other exit is faster in the peak hours.

During the heavily congested time, mostly on Friday evening, there is an alternative suggestion lets vehicles exit before interchange, using 1.28 km of local streets. There is a trivial difference at how to get the destination in the alternative route compared to the general route. The total local streets usage rate is 1.18 per cent.

Table 4.4. The number of observations by the travel distance of the route A-D.

| Travel distance | Number of observations | |
|---|---|---|
| | Off-peak hours | Peak hours |
| 20.8 km | 200 | 162 |
| 19.7 km | 0 | 38 |
| Total | 200 | 200 |

The most favored route is 20.8 km regardless of the time period (Table 4.4). There is no variation in the off-peak hours yet, there is another suggestion for 38 times (19 per cent) in the peak hours, to avoid congestion.

### 4.1.1.3. Route B-E

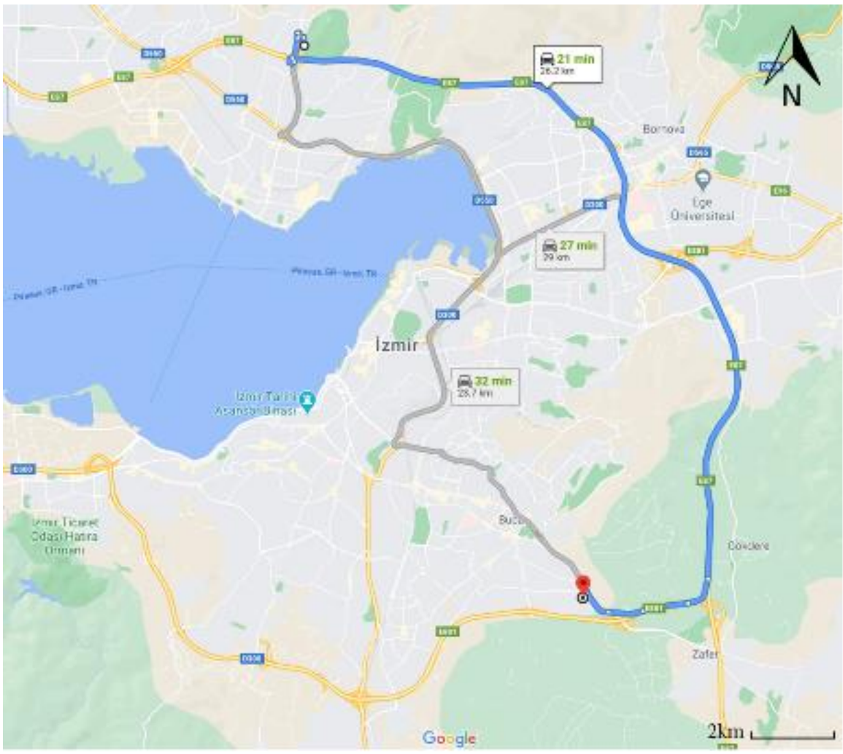


Figure 4.7. The most suggested route in the off-peak hours and the peak hours of the route B-E.

Because of congestion near Buca, even in the off-peak hour, the suggested route is using O-30, İzmir belt (Figure 4.7). Also, the other alternative route, that never be recommended, is longer than the most suggested route in terms of travel distance. Thus, regardless of the peak hours or the off-peak hours, the same route is suggested. The shortest route equals the route using the highway. Excepting the heavily congested time, the optimal route suggested by GM is the very same. The pattern of the detour is similar to the route A-F, B-G, and B-F, using local streets near the intersection in Bornova.

In high congested time, there are a few suggestions to take the alternative route (Figure 4.8). The frequency is not high, but it includes some local streets travel, each 2.57 km (in case of the route 28.9 km), and 1.1 km (in case of 29.2 km). The total local street usage rate is 1.83 per cent.

Table 4.5. The number of observations by the travel distance of the route B-E.

| Travel distance | Number of observations | |
|---|---|---|
| | Off-peak hours | Peak hours |
| 26.2 km | 200 | 159 |
| 28.9 km | 0 | 36 |
| 29.2 km | 0 | 5 |
| Total | 200 | 200 |

The alternative routes appear less, compared to total observation, however, there is local streets usage (Table 4.5). In the off-peak hours, the same route is suggested 100 per cent, and there are only 41 times of suggestions for the alternative routes (20.5 per cent).

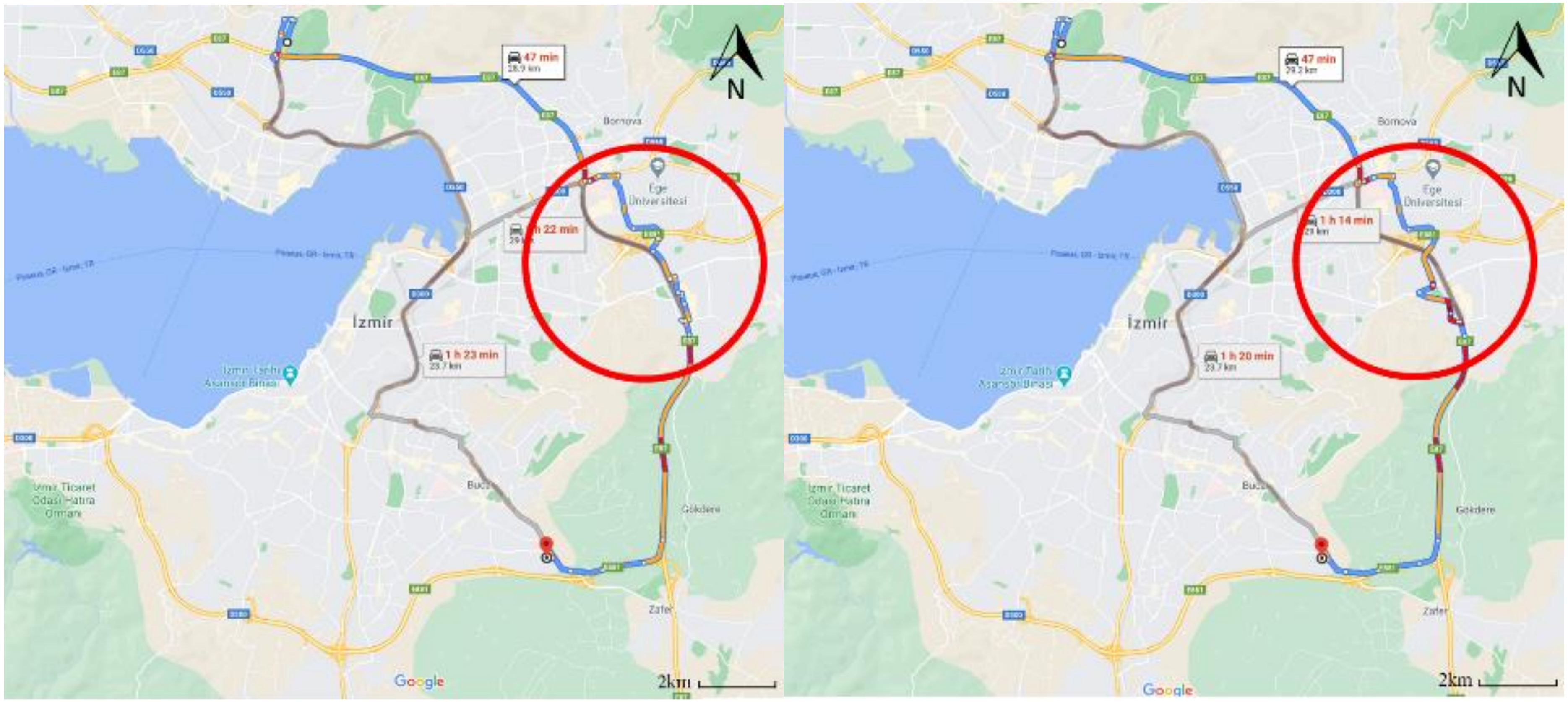


Figure 4.8. The alternative routes in the peak hours (left: 28.9 km and right: 29.2 km) of the route B-E.

### 4.1.1.4. Route D-G

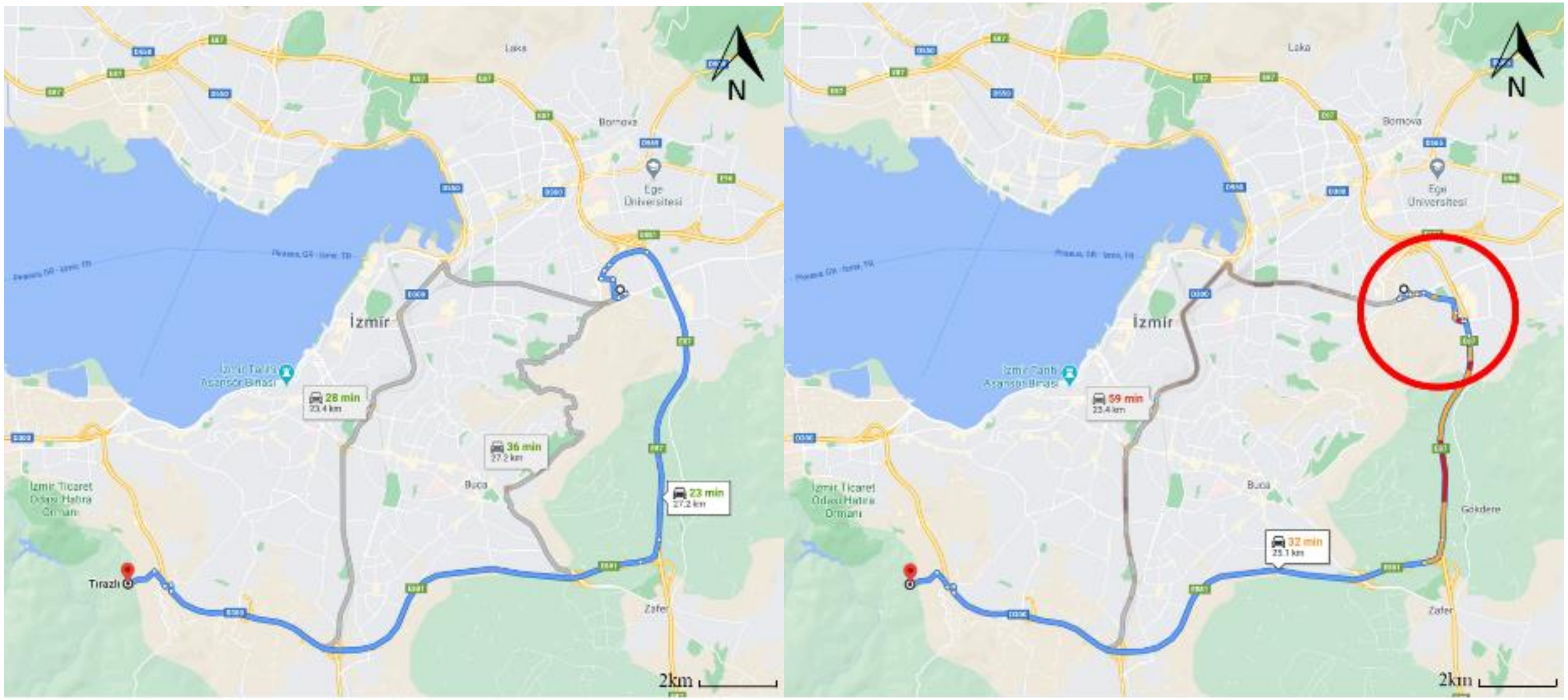


Figure 4.9. The most suggested route in the off-peak hours (left: 27.2 km) and the peak hours (right: 25.1 km) of the route D-G.

Because of congestion near Bornova, Karabağlar and Buca even in the off-peak hours, the shortest route in terms of travel distance (23.4 km) and the other alternative route using the urban road are not recommended (Figure 4.9). There are some alternative routes, take the highway later than the typical route. The shortest route in terms of travel distance is suggested in the peak hours, not in the off-peak hours. This is because, in the peak hours, GM leads the driver into the highway later to avoid congestion in the main interchange. On the other hand, it does not have to use the urban roads in the off-peak hours. To reduce travel time, taking the highway as possible as fast is more helpful in the off-peak hours. The total travel length is shorter in the peak hours, but there is a little usage of local streets.

The frequency of recommendation is low, but it contains the usage of local streets (1.16 km) (Figure 4.10). In the case of the route 25.1 km, it takes only collectors, but in heavily congested time, GM suggests avoiding even collector and to take a local street. The ratio of usage of local streets is only 0.09 per cent, the lowest among routes in group 1 of commuting trips.

Table 4.6. The number of observations by the travel distance of the route D-G.

| Travel distance | Number of observations | |
|---|---|---|
| | Off-peak hours | Peak hours |
| 27.2 km | 200 | 71 |
| 25.1 km | 0 | 124 |
| 25.2 km | 0 | 4 |
| Total | 200 | 200 |

The most suggested routes in the off-peak hours and the peak hours are different, but the overall routes are similar. The only difference is how to get the highway, O-30. In the peak hours it leads drivers into the highway directly 75 times (37.5 per cent), but mostly, it suggests the route that drivers could avoid the big intersection (Table 4.6).

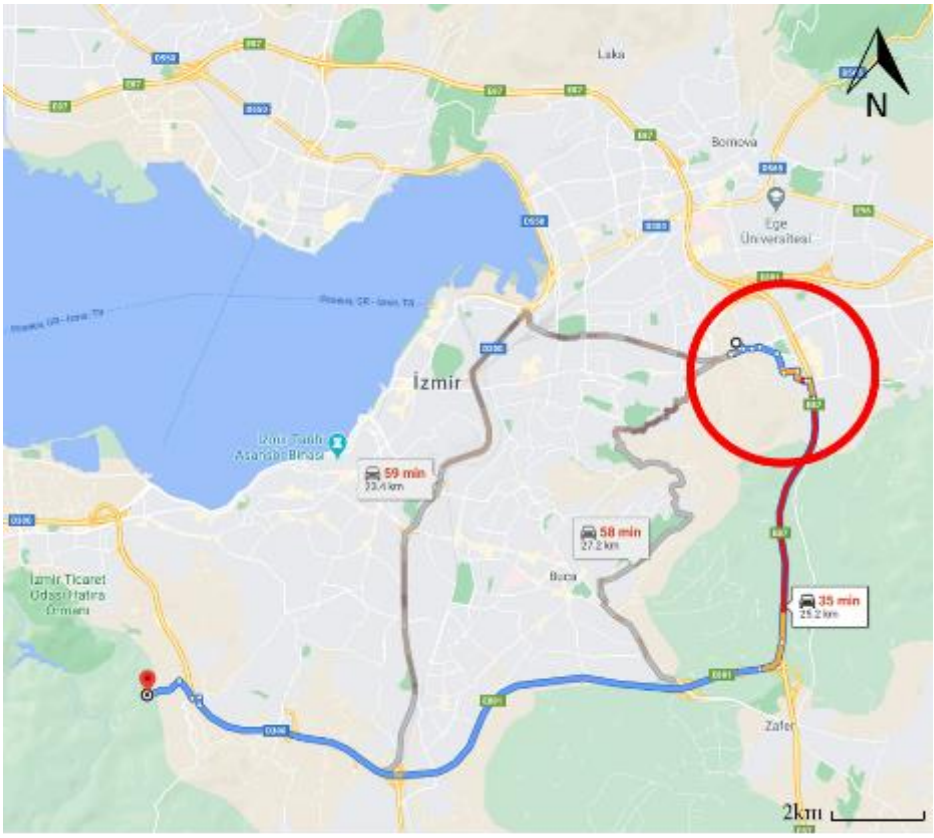


Figure 4.10. The alternative routes in the peak hours of the route D-G.

### 4.1.1.5. Route E-H

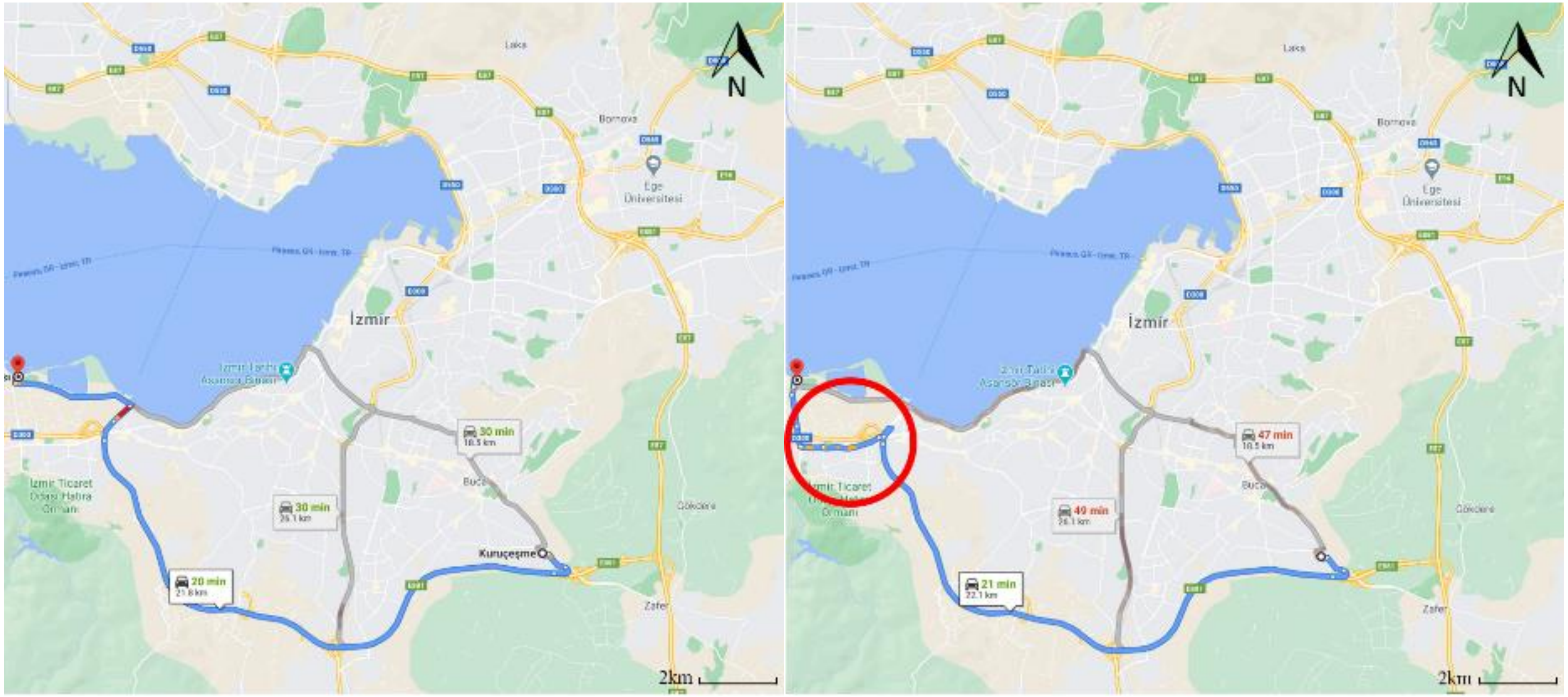


Figure 4.11. The most suggested route (left: 21.8 km) and the alternative route in the peak hours (right: 22.1 km) of the route E-H.

It shows the simplest results in commuting trips in the overall city (Figure 4.11). The route does not pass through the center of İzmir, there is almost no congestion even in the peak hours, excepting the entrance of the highway near Balçova. Travel time is also almost the same between the peak hours and the off-peak hours. There is the shortest route across the city center, along with arterial near the seaside, but it near gets suggested over the observation. it seems like, even in the off-peak hours, the minor congestion near the city center makes the result. The highway, O-30 is the main path of the route.

To avoid congestion near Balçova, the alternative route is suggested, but there is no usage of local streets (Figure 4.11). There is less than 1km difference between the suggested route of the peak hours and the off-peak hours.

Table 4.7. The number of observations by the travel distance of the route E-H.

| Travel distance | Number of observations | |
|---|---|---|
| | Off-peak hours | Peak hours |
| 21.8 km | 200 | 134 |
| 22.1 km | 0 | 66 |
| Total | 200 | 200 |

The most suggested route is the same in the both off-peak and peak hours (Table 4.7). There are 66 times of suggestion for the alternative route (33 per cent) in the peak hours.

### 4.1.2. Group 2 of the Commuting Trips in the Overall City

There is a clear pattern of the recommendation of the routes in this group. In the peak hours, the routes using O-30 is mostly suggested, on the other hand, in the off-peak hours, the shortest route using D-300 or boulevard along with seaside is suggested in general. Thus, the difference in travel distance is substantial. The gaps are between around 5 km to 9 km (Table 4.8). It is the greatest in the route A-F and the smallest in the route C-F. There is no variation of travel route in the off-peak hours in group 1, however, in group 2, there are some differences even in the off-peak hours, excepting the route C-H and C-G. There is a travel time difference of around 17 minutes between the off-peak hours and the peak hours, and the difference in travel distance is around 9 km.

Table 4.8. The average travel time and travel distance of group 2, commuting trips in the overall city (n=200 in the peak hours and the off-peak hours each).

| | | Peak hours | | Off-peak hours | |
|---|---|---|---|---|---|
| | | Mean | SD | Mean | SD |
| Route A-F | Travel time (min) | 48.2 | 9.842988 | 29.27 | 1.448305 |
| | Travel distance (km) | 35.9215 | 2.414048 | 26.705 | 2.206768 |
| Route B-G | Travel time (min) | 48.02 | 10.17483 | 30.89 | 0.632376 |
| | Travel distance (km) | 38.9795 | 0.993157 | 29.68 | 1.263162 |
| Route B-F | Travel time (min) | 44.03 | 9.53592 | 27.78 | 1.094344 |
| | Travel distance (km) | 32.468 | 1.105389 | 24.264 | 2.257384 |
| Route C-H | Travel time (min) | 46.285 | 6.151666 | 24.16 | 1.717308 |
| | Travel distance (km) | 28.3465 | 9.116388 | 19.9 | 0 |
| Route C-G | Travel time (min) | 43.74 | 6.690006 | 26.265 | 0.668588 |
| | Travel distance (km) | 30.2815 | 3.316838 | 24.2 | 0 |
| Route C-F | Travel time (min) | 39.89 | 6.251665 | 23.425 | 0.613397 |
| | Travel distance (km) | 23.649 | 2.982175 | 18.524 | 1.179142 |
| Route D-H | Travel time (min) | 39.27 | 2.795743 | 25.69 | 0.77906 |
| | Travel distance (km) | 33.201 | 0.858126 | 19.1 | 0 |
| Average | Travel time (min) | 44.205 | 7.348975 | 26.78286 | 0.99334 |
| | Travel distance (km) | 31.83529 | 2.969446 | 23.19614 | 0.986637 |

When it comes to map, it is clear that most routes are relatively long, passing through the city center (Figure 4.12). The route A-F, C-H, and B-G are the longest routes considering the pattern of the network. Other than those, all routes penetrating the city center, expecting the route C-F. Comparing to group 1, it is clear that longer trips that have to pass the entire urban area of İzmir show more differences between the off-peak hours and the peak hours.

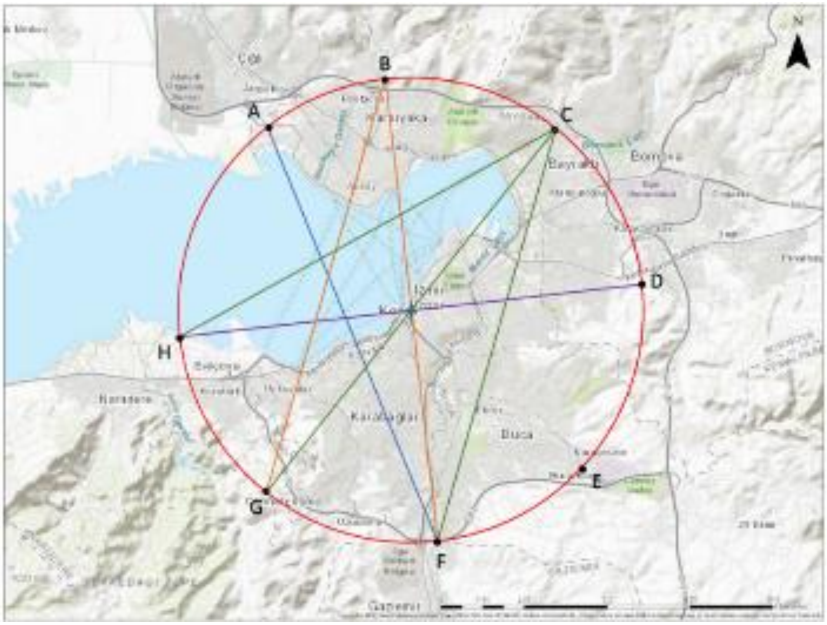


Figure 4.12. The routes of group 2, commuting trips in the overall city.

There are some routes with local streets in high congested time, mostly in the Friday evening peak hours (Table 4.9). The usage of local streets is zero in the off-peak hours, so that usage of local streets is higher in the peak hours. However, it does not make up a huge portion of the total trip. Compared to group1, it is slightly high at 1.15 per cent.

Table 4.9. The total travel length and the length of local streets in the peak hours of group 2, commuting trips in the overall city.

| | Length of local streets (km) (A) | Total travel distance (km) (B) | Ratio (%) (A/B) |
|---|---|---|---|
| Route A-F | 42.95 | 7,184.3 | 0.6 |
| Route B-G | 46.21 | 5,629.2 | 0.82 |
| Route B-F | 146 | 5,706.2 | 2.56 |
| Route C-H | 120.9 | 5,669.9 | 2.13 |
| Route C-G | 22.93 | 6,580.7 | 0.35 |
| Route C-F | 85.93 | 4,729.8 | 0.53 |
| Route D-H | 0 | 4,729.8 | - |
| Total | 464.92 | 40,229.9 | 1.15 |

### 4.1.2.1. Route A-F

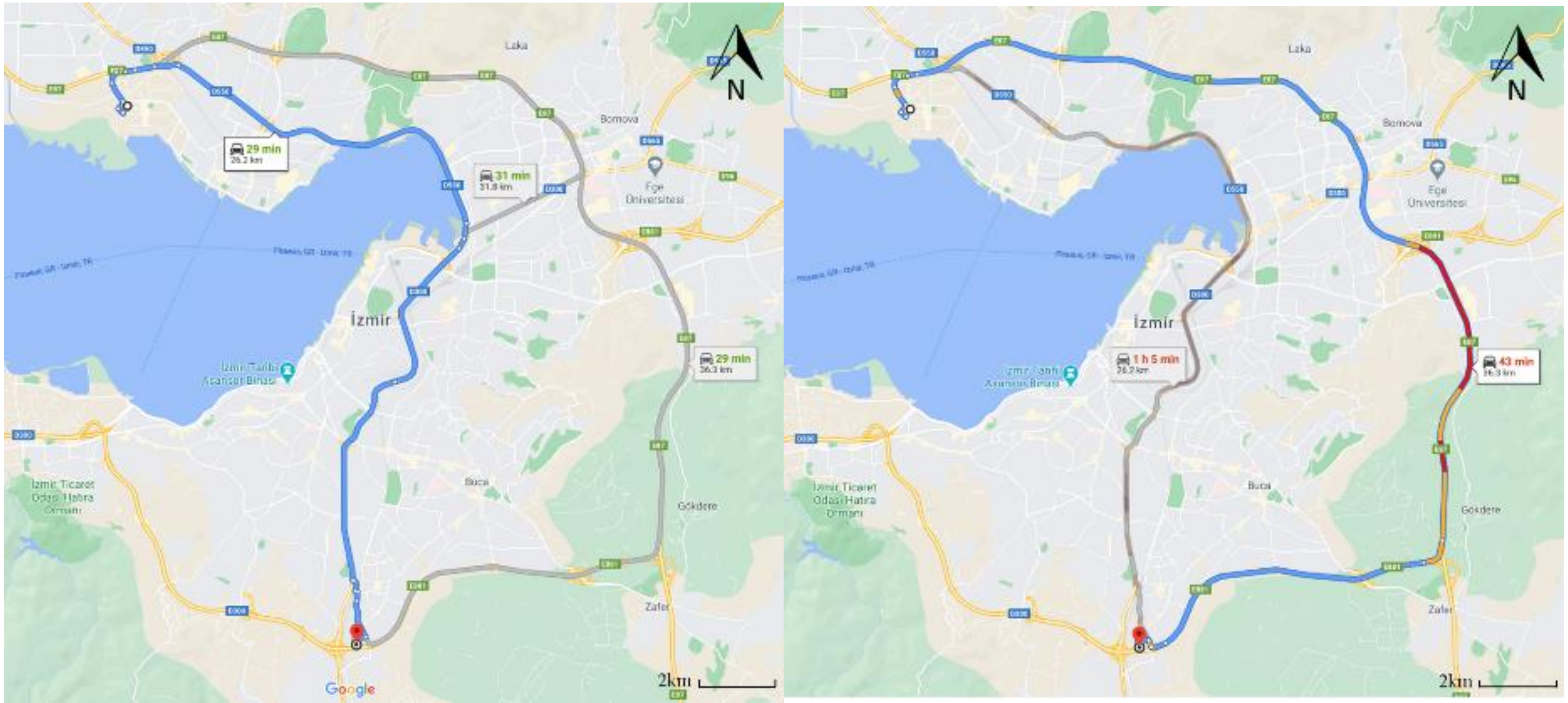


Figure 4.13. The most suggested route in the off-peak hours (left: 26.2 km) and the peak hours (right: 36.3 km) of the route A-F.

In the off-peak hours, the shortest in terms of travel distance is recommended, 26.2 km using D-300, which is penetrating the center of İzmir. In contrast, O-30 is used in the peak hours even travel distance is longer (36.3 km) (Figure 4.13). In most congested hours, another route is suggested (Figure 4.14). It is overall similar to the most suggested route in the peak hour, but it leads cars to get out of the highway for a while because there is high congestion in the intersection. In case of the off-peak hours, sometimes the minor congestion near Buca appears, and GM leads drivers into a longer detour. In the case of the peak hours, when traffic gets severe, the highway becomes full of congestion, so that shorter route is faster. It indicates, when traffic volume grows in the future, there might be a lack of infrastructure in İzmir.

Local streets usages are respectively 2.57 km (in case of 38.1 km) and 1.1 km (in case of 38.4 km). The total local street usage rate is 0.6 per cent. Even though the length of local streets is similar to each other, the ratio is not high. It is because that the routes used local streets are barely recommended only in a highly congested period, mostly on Friday evening.

Table 4.10. The number of observations by the travel distance of the route A-F.

| Travel distance | Number of observations | |
|---|---|---|
| | Off-peak hours | Peak hours |
| 26.2 km | 190 | 11 |
| 36.3 km | 10 | 170 |
| 38.1 km | 0 | 15 |
| 38.4 km | 0 | 4 |
| Total | 200 | 200 |

In the off-peak hours, the same route is recommended for 95 per cent (190 times), and the frequency of the recommendation of the alternative route in the peak hours is 30 times, 15 per cent (Table 4.10). The frequency is not much but in the off-peak hours, sometimes the most suggested route in the peak hours (36.3km) is recommended, and also, the most suggested route in the off-peak hours (26.2km) is recommended in the peak hours.

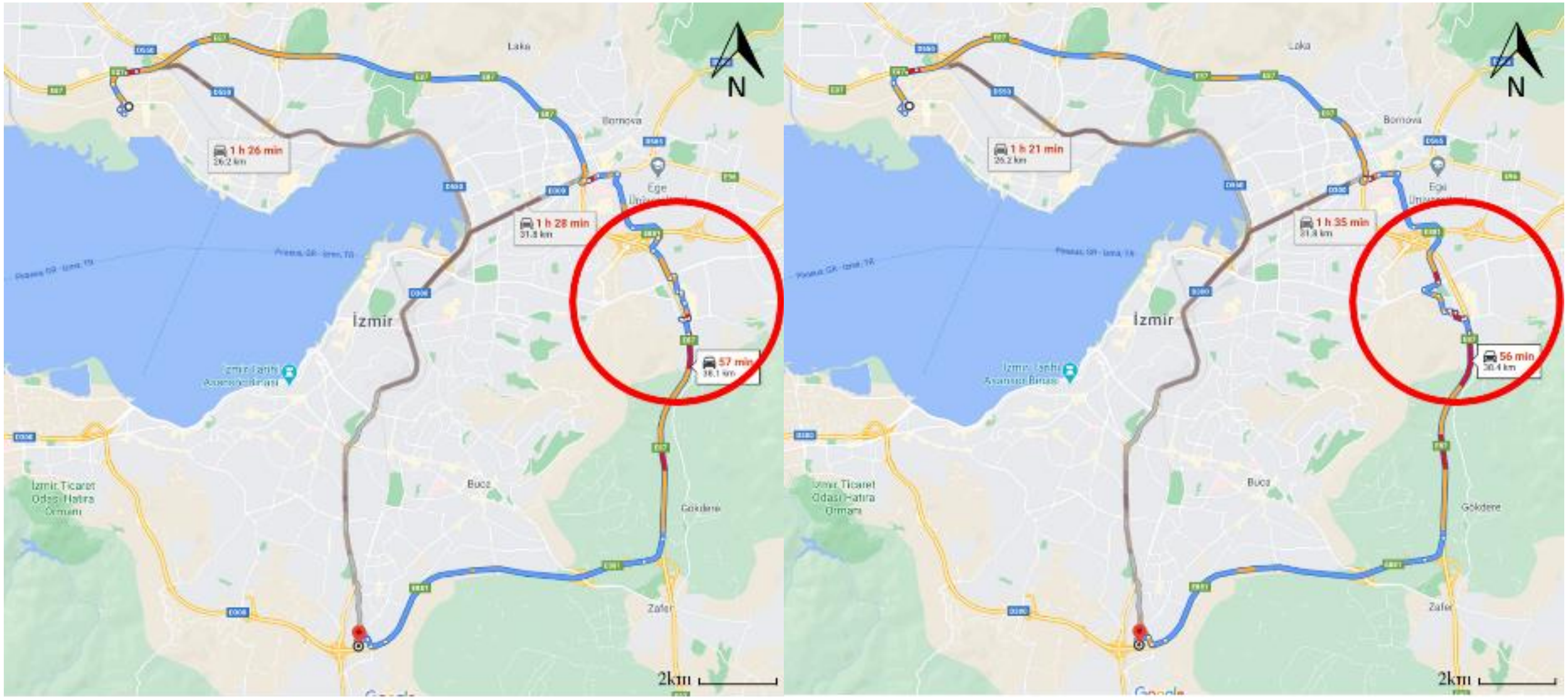


Figure 4.14. The alternative routes in the peak hours (left: 38.1 km and right: 38.4 km) of the route A-F.

### 4.1.2.2. Route B-G

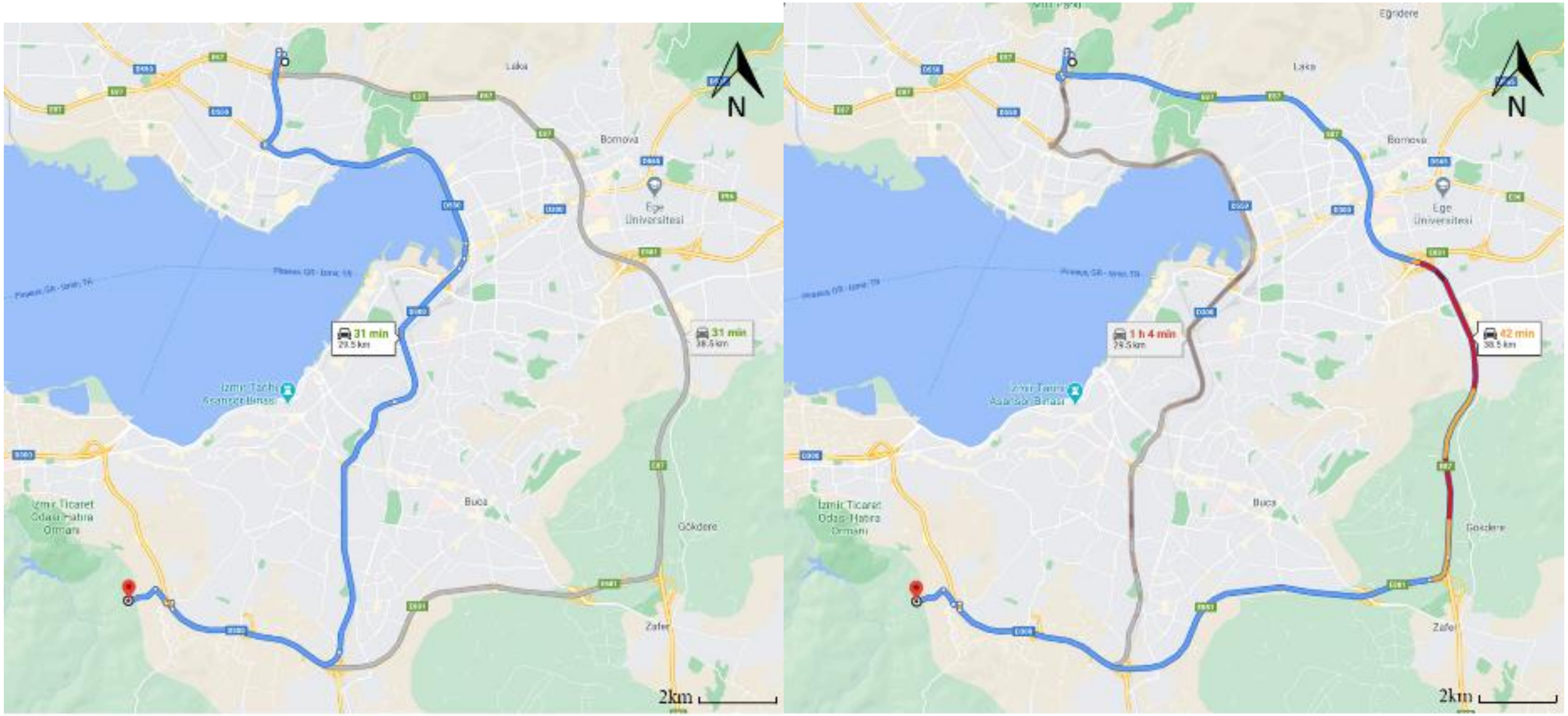


Figure 4.15. The most suggested route in the off-peak hours (left: 29.5 km) and the peak hours (right: 38.5 km) of the route B-G.

In the off-peak hours, the shortest route, using D-300 is recommended since there is less congestion overall. In the peak hours the longer route, using O-30 is suggested. There is no special issue about local streets issue in most suggested routes both in the off-peak hours and the peak hours (Figure 4.15). The shortest route is never recommended in the peak hours, which means that there is strong congestion in D-300, the highway across the city center. Also, there are a few suggestions for alternative routes in the off-peak hours. The number is subtle for now, but when traffic volume grows more it might recommend detour more often. There are some alternative routes, in congested time (Figure 4.16). GM leads drivers into local streets to avoid congestion near Bornova. The pattern of detours is the exactly same as the route A-F.

The usage of local streets is 1.1 km (in case of 41 km) and 2.57 km (in case of 41.3 km). The total usage rate of local streets is 0.82 per cent. The alternative routes appear only in extremely congested time so that the usage rate of local streets is low.

Table 4.11. The number of observations by the ravel distance of the route B-G.

| Travel distance | Number of observations | |
|---|---|---|
| | Off-peak hours | Peak hours |
| 29.5 km | 196 | 0 |
| 38.5 km | 4 | 162 |
| 41 km | 0 | 35 |
| 41.3 km | 0 | 3 |
| Total | 200 | 200 |

In the off-peak hours, the shortest route is recommended 196 times (98 per cent), and in the peak hours, the ratio of the most suggested route is 81 per cent (Table 4.11). The alternative routes are suggested by 19 per cent in the peak hours. The shortest route is never suggested in the peak hours, while there are little recommendations of a route of 38.5 km in the off-peak hours (2 per cent).

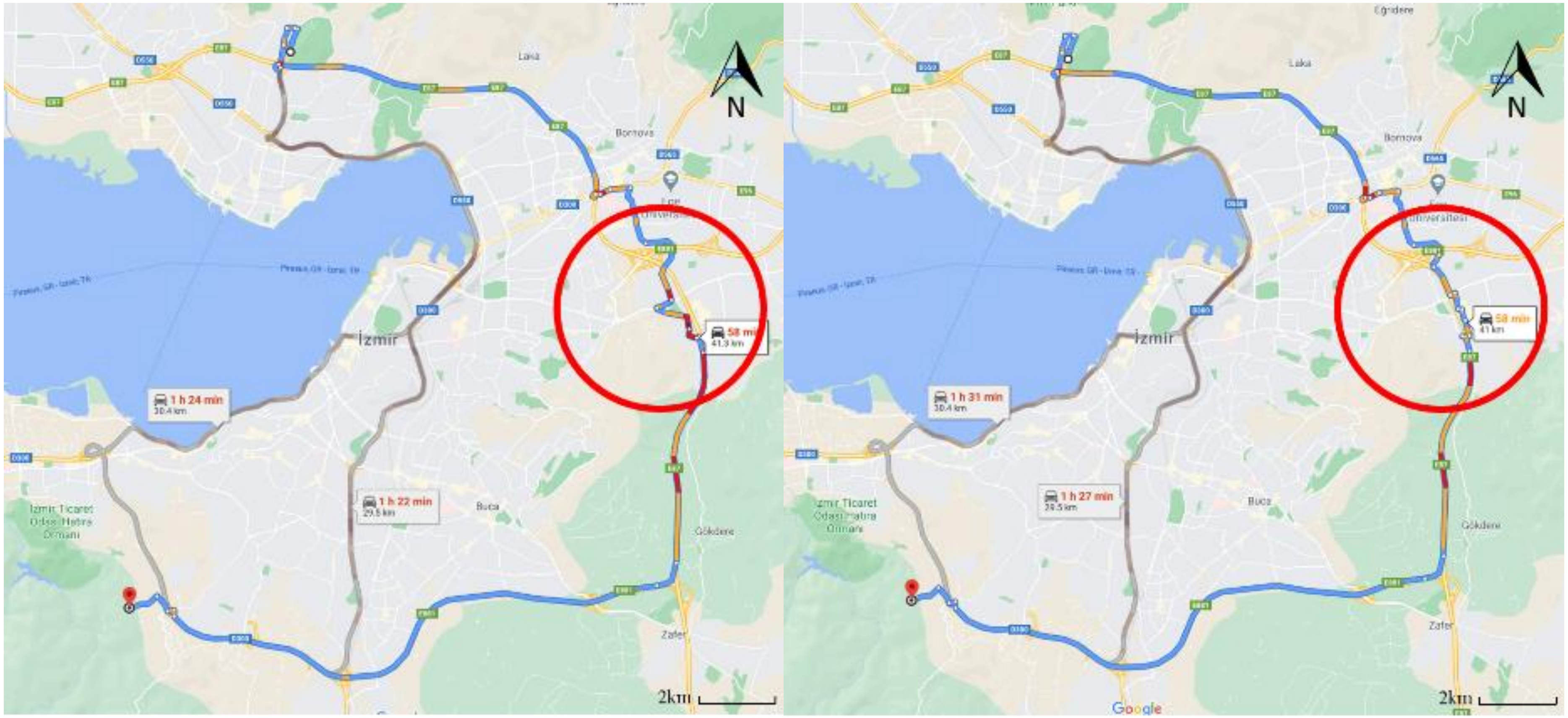


Figure 4.16. The alternative routes in the peak hours (left: 41.3 km and right: 41 km) of the route B-G.

### 4.1.2.3. Route B-F

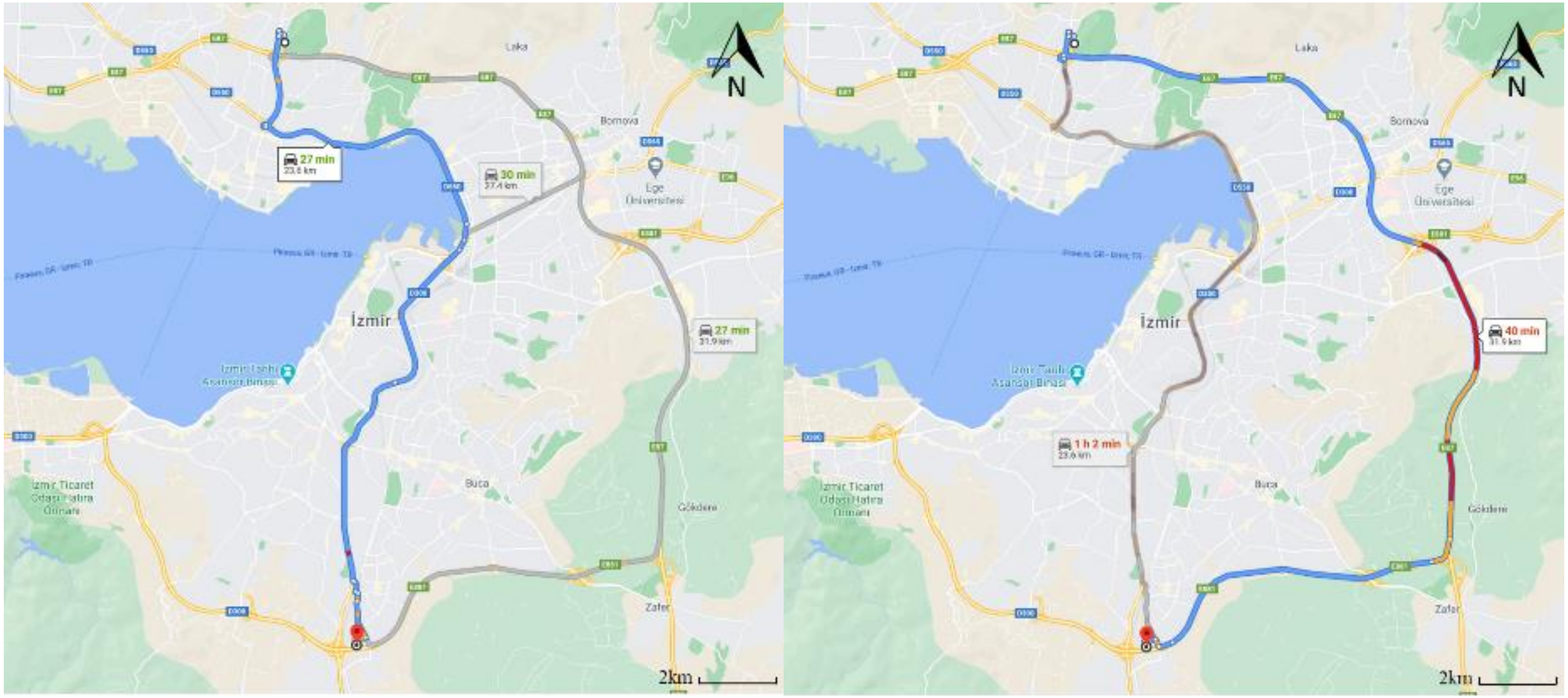


Figure 4.17. The most suggested route in off-peak hour (left: 23.6 km) and the peak hours (right:31.9 km) of the route B-F.

In the off-peak hours, the shortest route is recommended across the city center, using D-300 (23.6 km). On the other hand, in the peak hours, using the outskirt road is used. There is no local streets usage in both cases (Figure 4.17). The general pattern of the shortest route and alternative routes are similar to the route A-F, B-G, B-F, C-G, and C-F, so that the result is similar too. Since there is always a minor congestion level in D-300, sometimes the detour using O-30 is recommended. The frequency of alternative routes using local streets in the peak hours is most high among similar routes (the route A-F, B-G, B-F, C-G, and C-F).

In alternative routes, there are some usages of local streets. In the route of 34.5 km, there is a bypass in the northern part, to get highway faster and near the intersection in Bornova, using 6.1 km of local streets. In the case of 34.7 km, it is similar to the other one, but it takes a different bypass near Bornova intersection, using 1.1 km of local streets (Figure 4.18). The total local streets usage rate is 2.6 per cent.

Table 4.12. The number of observations by the travel distance of the route B-F.

| Travel distance | Number of observations | |
|---|---|---|
| | Off-peak hours | Peak hours |
| 23.6 km | 184 | 0 |
| 31.9 km | 16 | 158 |
| 34.5 km | 0 | 20 |
| 34.7 km | 0 | 22 |
| Total | 200 | 200 |

In the off-peak hours, 92 per cent of recommendation is the shortest route, and in the peak hours, alternative routes are recommended 42 times (21 per cent) (Table 4.12). The shortest route is never recommended in the peak hours, but the most suggested route in the peak hours is sometimes recommended in the off-peak hours (16 times).

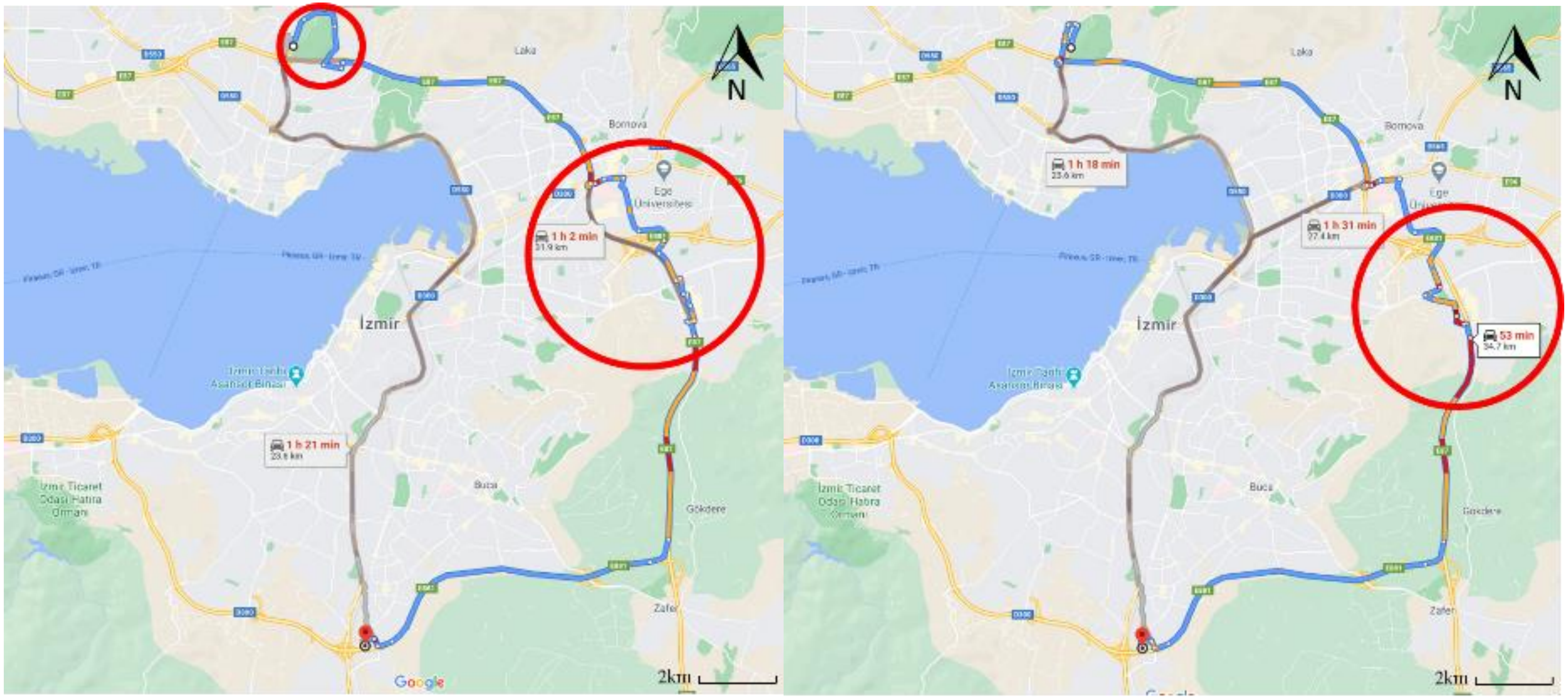


Figure 4.18. The alternative routes in the peak hours (left: 34.5 km and right: 34.7 km) of the route B-F.

## 4.1.2.4. Route C-H

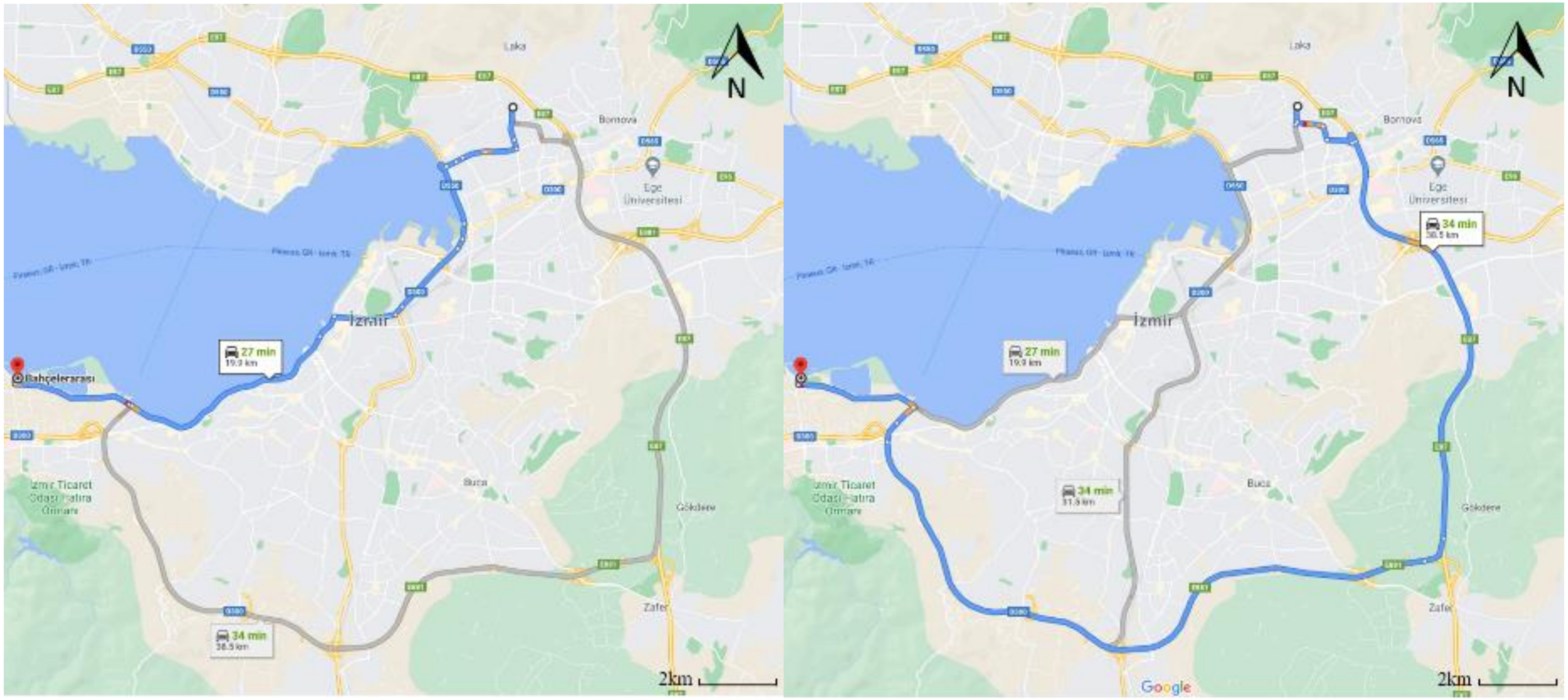


Figure 4.19. The most suggested route in the off-peak hours (left: 19.9 km) and the peak hours (38.5 km) of the route C-H.

In the off-peak hours, the shortest route across the city center using boulevard along with seaside, on the other hand, it is a route with using roads outside of urban, O-30 in the peak hours (Figure 4.19). It shows the greatest gap of the travel distance of all routes. At the origin of the node, each route makes drivers face the exact opposite direction so that it would be hard to choose a route without the support of the navigation system.

When congestion gets more serious, it starts to suggest routes across the city center with a small variation. In the case of 20.2 km, it does not use the highway near Konak, but it still uses the only boulevard along with the seaside, not local streets. In the case of 20.5 km, there is only 0.3 km difference of travel distance than the previous route, it contains the usage of local streets at a distance of 3.1 km (Figure 4.20). The total local streets usage rate is 2.1 per cent.

Table 4.13. The number of observations by the travel distance of the route C-H.

| Travel distance | Number of observations | |
|---|---|---|
| | Off-peak hours | Peak hours |
| 19.9 km | 200 | 35 |
| 20.2 km | 0 | 37 |
| 20.5 km | 0 | 39 |
| 38.5 km | 0 | 89 |
| Total | 200 | 200 |

In the off-peak hours, there is not any recommendation rather than the shortest route, 19.9 km (Table 4.13). In contrast, in the peak hours, basically, it suggests the longest bypass, 38.5 km most, but when congestion gets severe, the route gets shorter. The difference of frequency recommendation of 38.5km and 20.2 km & 20.5 km is similar (respectively 89 times and 76 times). This is because the detour is much longer than the shortest route so that when the congestion becomes heavier, travel time gets shorter even drivers should cross the city center. There is the least amount of highway in the route of 20.2 km and 20.5 km, and mostly it leads drivers into urban arterial. It could be interpreted as the congestion in the highway is serious.

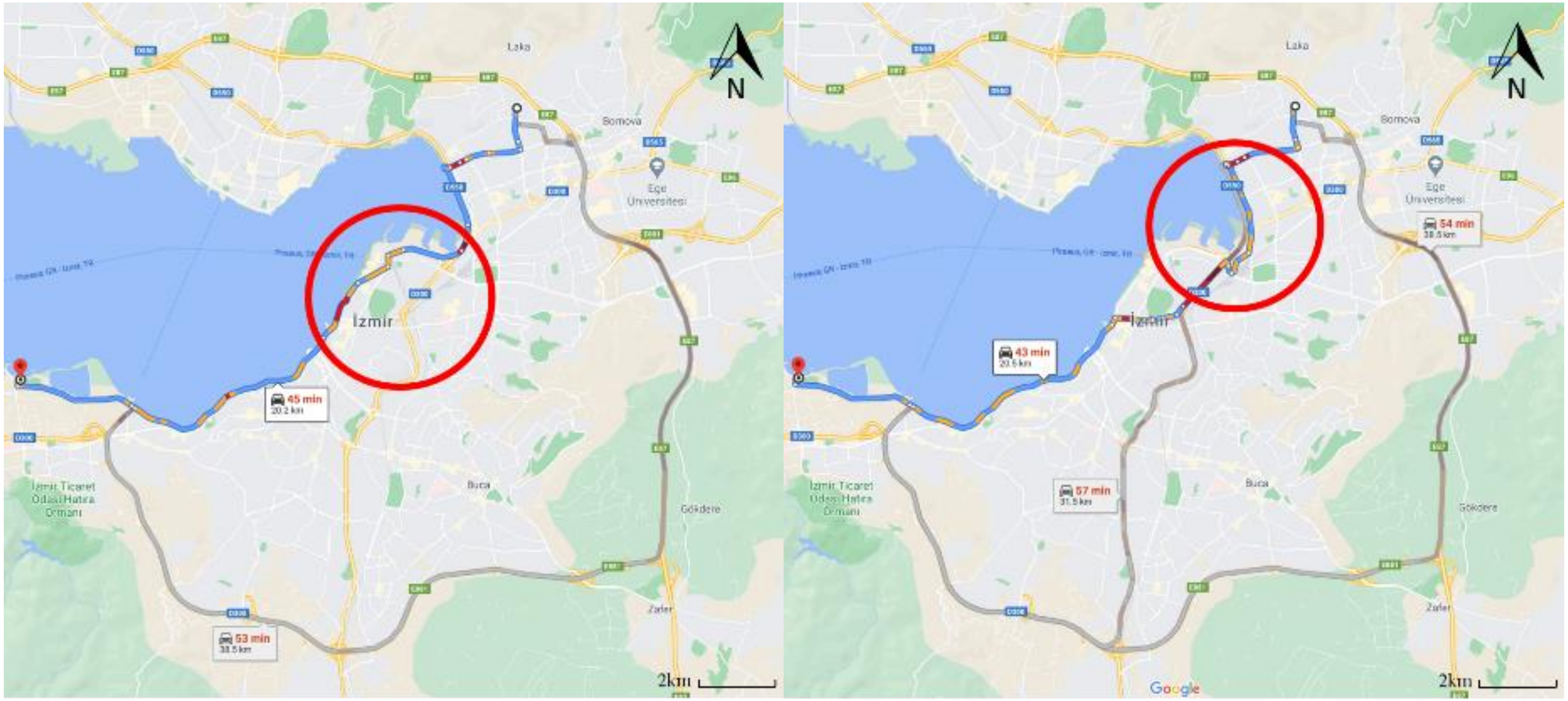


Figure 4.20. The alternative routes in the peak hours (left: 20.2 km and right: 20.5 km) of the route C-H.

### 4.1.2.5. Route C-G

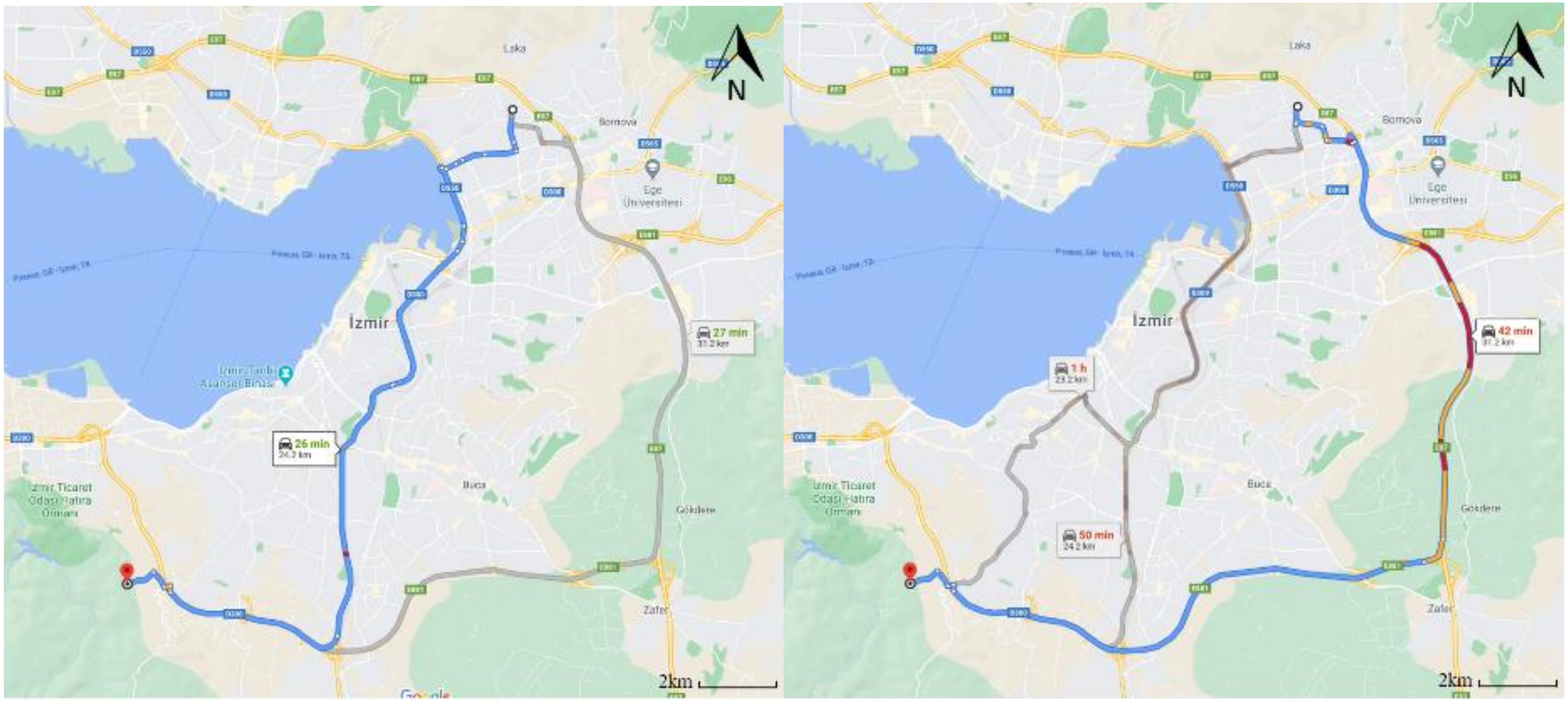


Figure 4.21. The most suggested route in the off-peak hours (left: 24.2 km) and the peak hours (right: 31.2 km) of the route C-G.

In the off-peak hours, the second shortest route, 24.2 km, using D-300 is suggested, on the other hand, in the peak hours, the outskirt bypass, using O-30 is recommended (Figure 4.21). When congestion becomes heavier, it suggests some alternatives using local streets (Figure 4.22). Urban roads and D-300 are used to access the highway while avoiding congestion near the intersection of Bornova. The overall pattern of the shortest route and the alternatives is similar to the route A-F, B-G, and B-F, but the frequency of suggestion of the shortest route in the peak hours is higher than others. It means the congestion level in the alternative route, O-30 is high.

The two most recommended routes do not utilize local streets thus, the usage rate of local streets is low. The usages of local streets are 1.57 km at the route of 38.3 km and 1.1 km at the route of 33.5 km respectively. The total local streets usage rate is 0.35 per cent, which is the least among the routes in group 2 of commuting trips.

Table 4.14. The number of observations by the travel distance of the route C-G.

| Travel distance | Number of observations | |
|---|---|---|
| | Off-peak hours | Peak hours |
| 24.2 km | 200 | 38 |
| 31.2 km | 0 | 145 |
| 33.5 km | 0 | 8 |
| 38.3 km | 0 | 9 |
| Total | 200 | 200 |

In the off-peak hours, the shortest route is suggested 100 per cent, without any variation at all over the observation, and the alternative route is recommended 27.5 per cent in the peak hours (Table 4.14). But the alternative routes using local streets appear only 17 times (8.5 per cent). The shortest route is recommended in the peak hours 38 times, but the route of 31.2km, the most suggested route in the peak hours, does not appear in the off-peak hours.

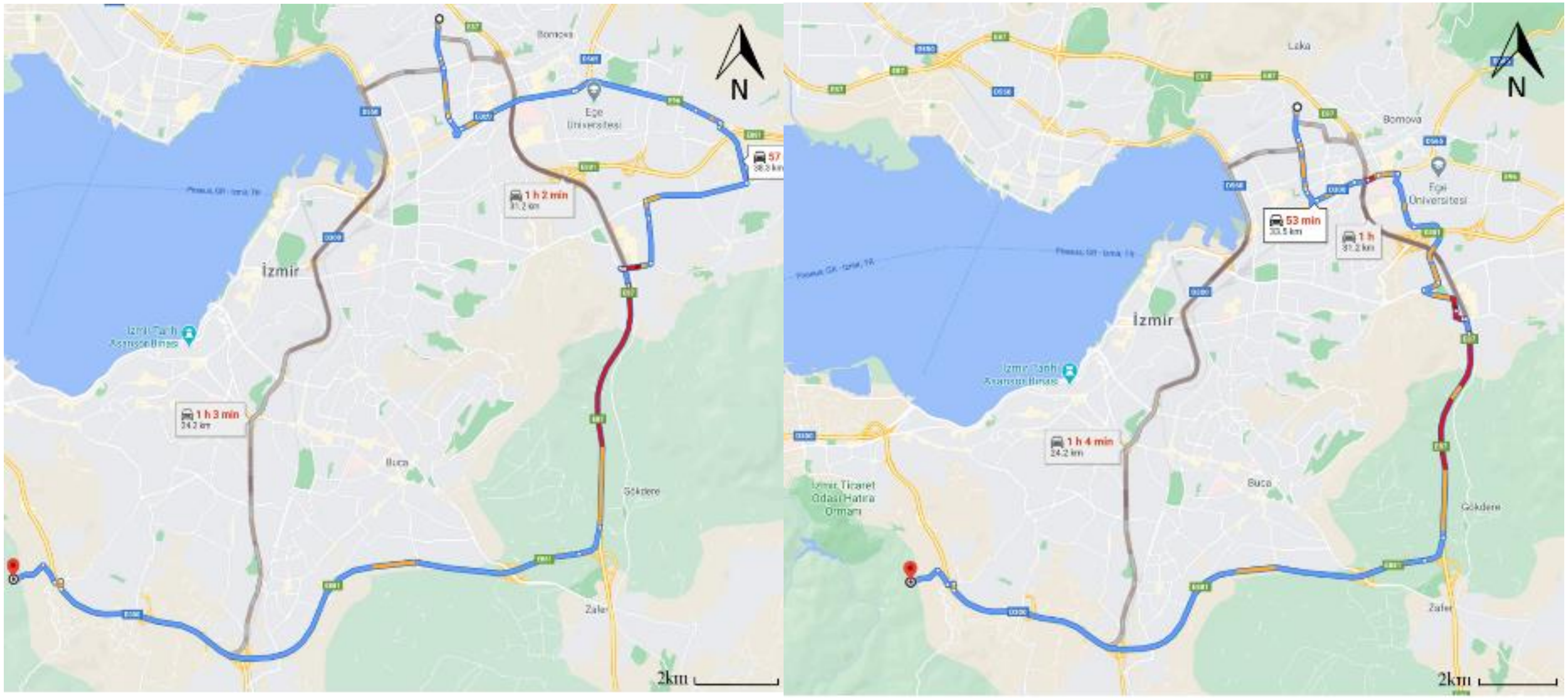


Figure 4.22. The alternative routes in the peak hours (left: 38.3 km and right: 33.5 km) of the route C-G.

### 4.1.2.6. Route C-F

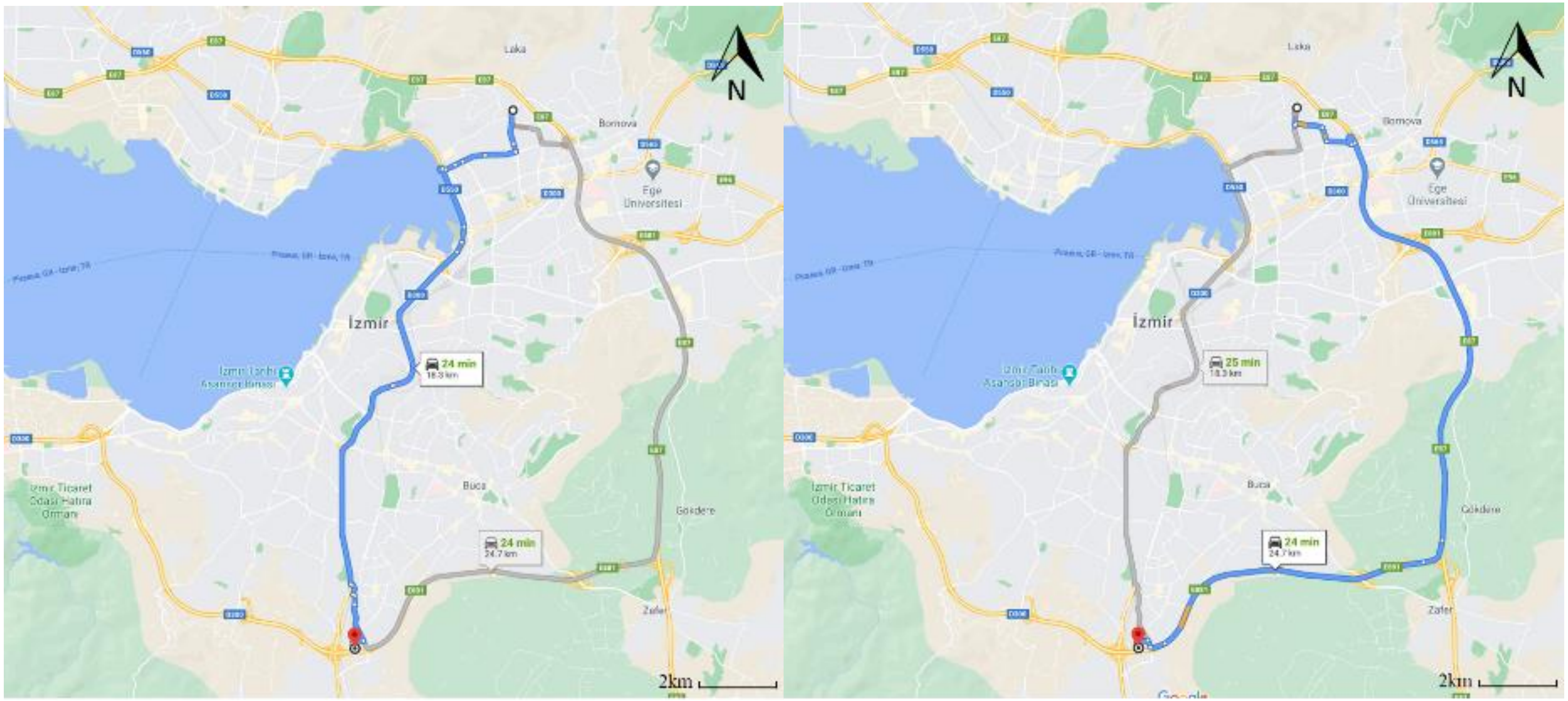


Figure 4.23. The most suggested route in the off-peak hours (left: 18.3 km) and the peak hours (right: 24.7 km) of the route C-F.

In the off-peak hours, the shortest route across the city center, using D-300 is recommended, on the other hand, in the peak hours, the route, using the highway in outside of the urban area, O-30 is suggested. In a normally congested period, the route is simple, with only two alternatives (Figure 4.23). The pattern of the alternative route is similar to the route C-G, avoiding congestion near Bornova (Figure 4.24). The local streets usage is 2.57 km at the route of 26.4 km, and 1.57 km at the route of 31.7 km. There are not many suggestions that lead drivers into local streets, but there are many recommendations to take the shortest route in the highway. It might mean that taking the shortest route is faster than taking a much longer alternative route with local streets in this route.

The usage of local streets is 2.57 km in the route of 26.6km and 1.57 km in the route of 31.7km. The total local streets usage rate is 0.53 per cent in the peak hours. The ratio is the lowest in group 2 of commuting trips because there is only 12 time of suggestion of alternative routes with local streets.

Table 4.15. The number of observations by travel distance of the route C-F.

| Travel distance | Number of observations | |
|---|---|---|
| | Off-peak hours | Peak hours |
| 18.3 km | 193 | 41 |
| 24.7 km | 7 | 147 |
| 26.4 km | 0 | 6 |
| 31.7 km | 0 | 6 |
| Total | 200 | 200 |

The shortest route is suggested in the off-peak hours mainly (96.5 per cent), and it appears 41 times in the peak hour (20.5 per cent) (Table 4.15). The shortest route accounts for 20.5 per cent in the peak hours, while the route of 24.7 km is only 3.5 per cent in the off-peak hours.

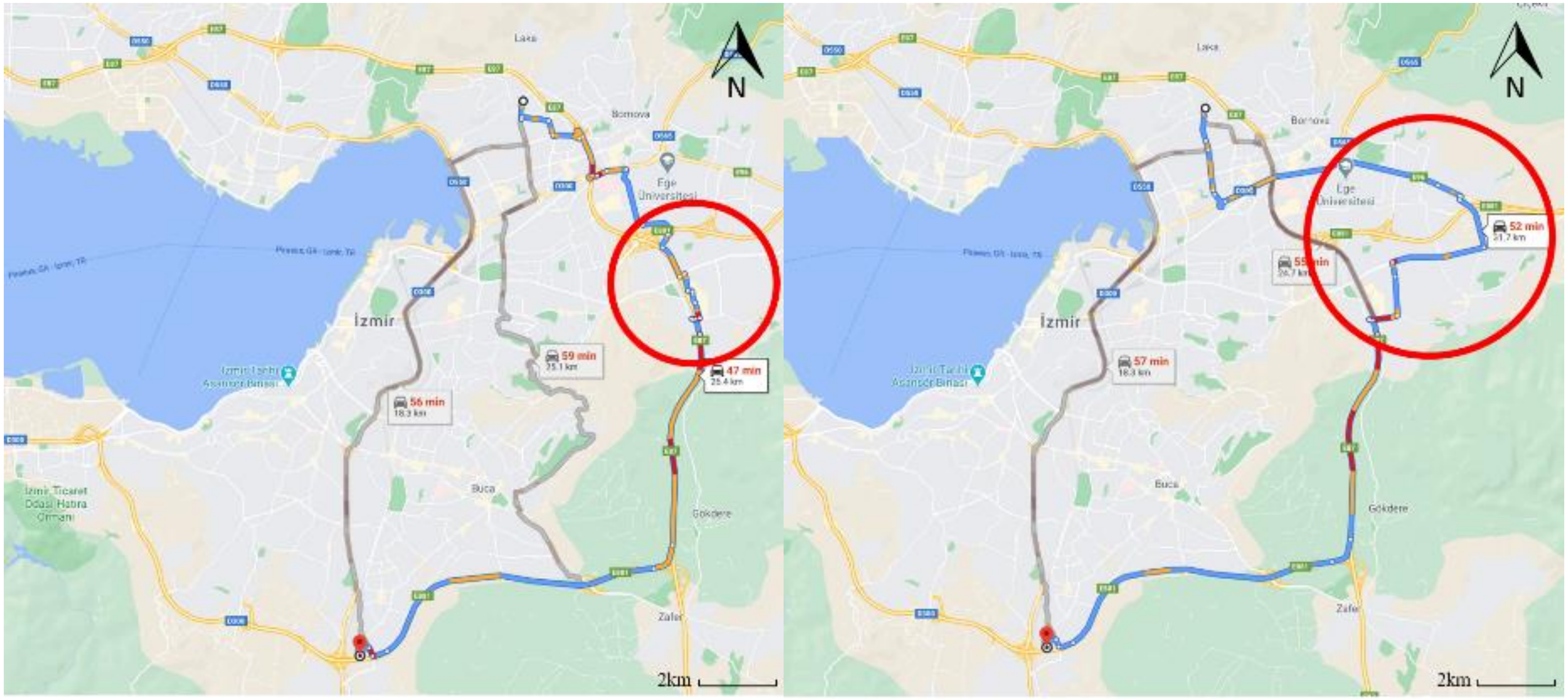


Figure 4.24. The alternative routes in the peak hours (left: 26.4 km and right: 31.7 km) of the route C-F

## 4.1.2.7. Route D-H

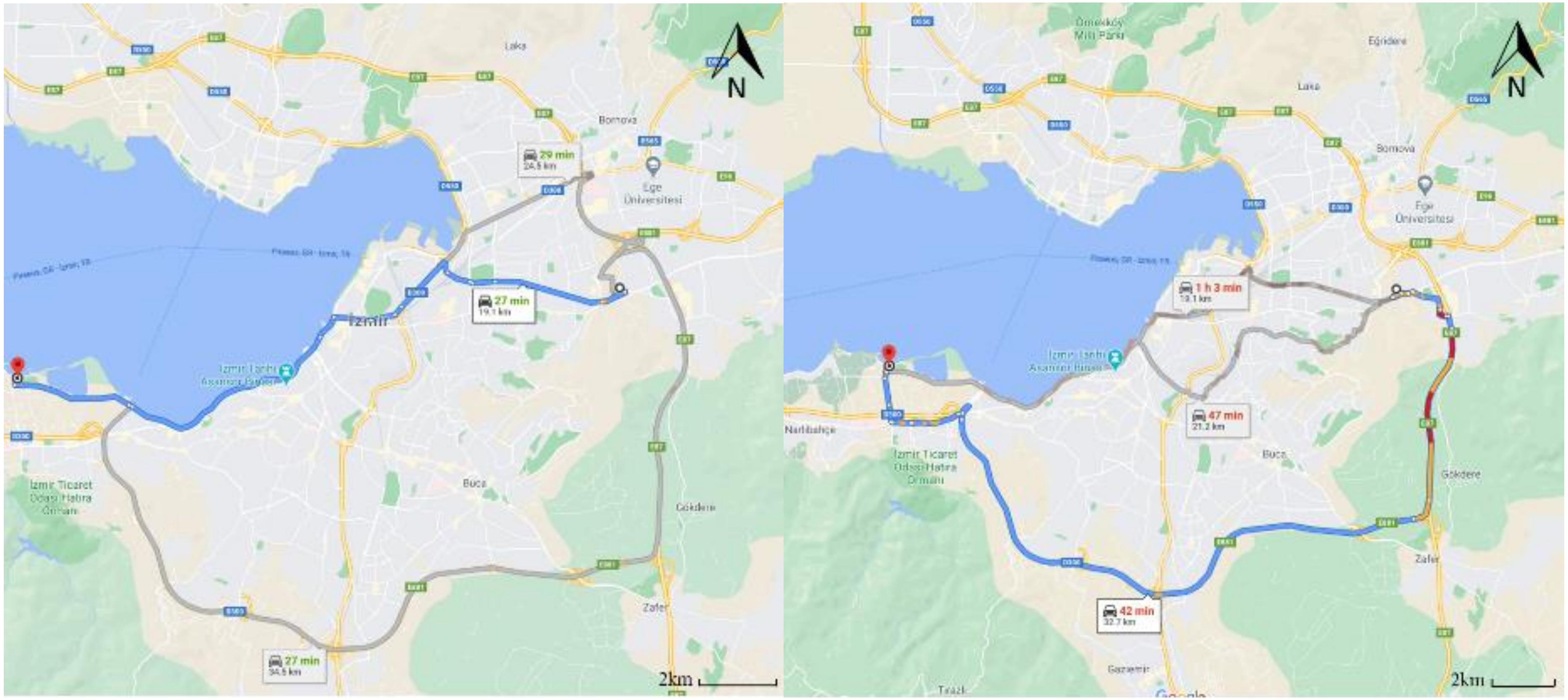


Figure 4.25. The most suggested route in the off-peak hours (left: 19.1 km) and the peak hours (right: 32.7 km) of the route D-H.

In the off-peak hours, the shortest route across the city center, using some of D-300 and boulevard is suggested, on the other hand, in the peak hours, the route using O-30 is recommended, evading congestion delays (Figure 4.25). GM suggests alternative routes sometimes, with a different path to get the highway or to leave it, but the general route is the same, mainly using O-30 (Figure 4.26). There are 4 different routes but none of them has local streets during the trip.

Table 4.16. The number of observations by the travel distance of the route D-H.

| Travel distance | Number of observations | |
|---|---|---|
| | Off-peak hours | Peak hours |
| 19.1 km | 200 | 0 |
| 32.4 km | 0 | 26 |
| 32.7 km | 0 | 114 |
| 34.5 km | 0 | 60 |
| Total | 200 | 200 |

In the off-peak hours, there is no variation, but only the shortest route is suggested over all observations. The alternative routes appear almost half of observation, 86 times (43 per cent) in the peak hours. The overall shape of the route is similar to the route C-H, but not like it, in the peak hours, the shortest route or the route crossing the city center is never recommended (Table 4.16). It means, there is severe congestion on the shortest route penetrate the city center. The overall pattern of the routes is similar to the route C-H. The two most suggested routes (32.7km and 34.5km) in the peak hours look similar to each other, but the way to access the highway is different.

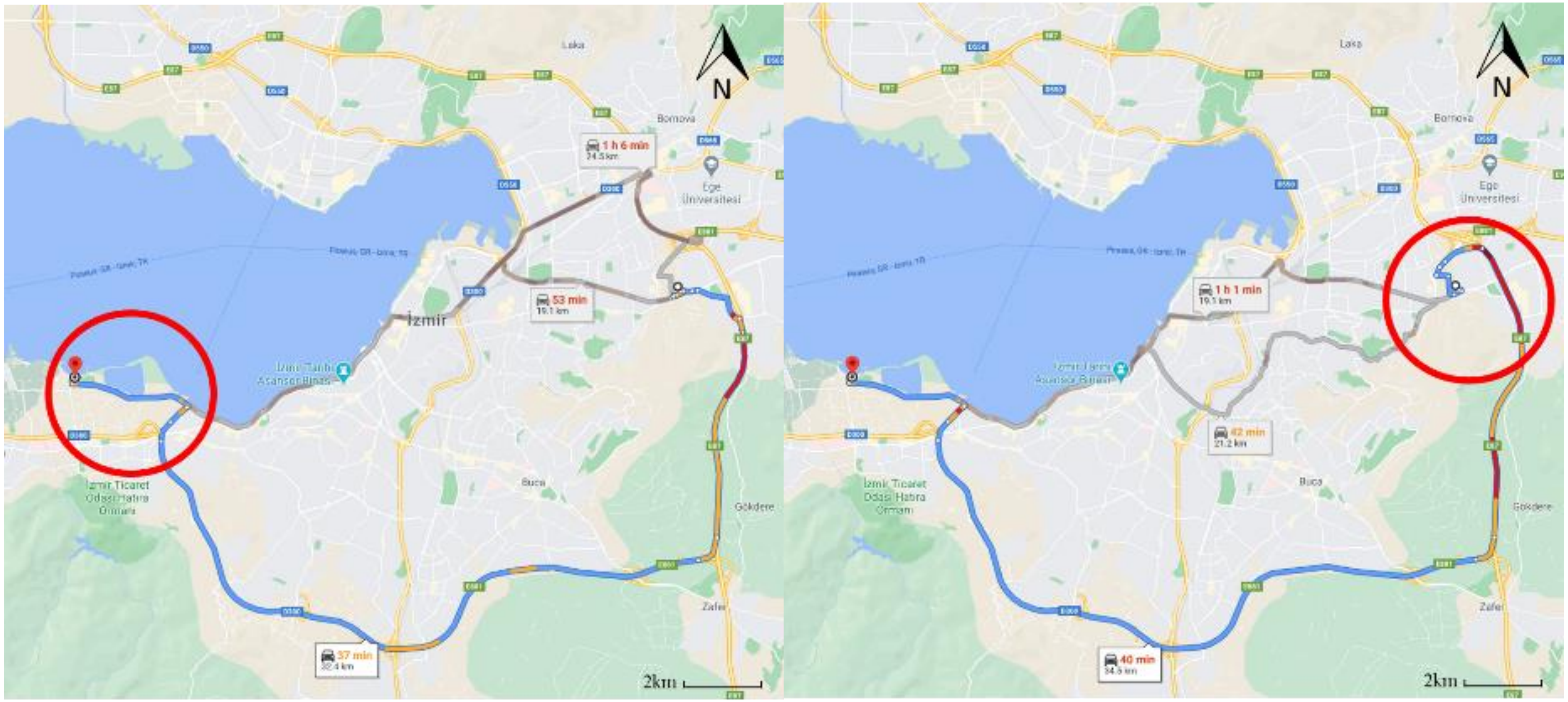


Figure 4.26. The alternative routes in the peak hours (left: 32.4 km and right: 34.5 km) of the route D-H.

## 4.2. Results of the Short Trips in CBD

There are variations of the results of each route. Like commuting trips in the overall city, there are two primary groups of results according to the travel distance as a result. In the first group, suggested routes of the peak hours and the off-peak hours are the same or similar. The travel time is longer in the peak hours because of congestion, but travel distance is the same. In the second group, there are significant differences of both the travel distance and the travel time between the peak hour and off-peak hour.

In the peak hours, GM suggests the routes with longer distances. It suggests arterial or local streets, where congestion is less. On the other hand, in the off-peak hours, the shortest route is suggested. There is no clear pattern, but the usage of local streets is higher in the peak hours. Compared to the result of commuting trips in the overall city, there are more alternatives of travel routes, and recommendations are sensitively changed even in the off-peak hours.

The average travel distance is around 4.6 km in the peak hours and 1.97 km in the off-peak hours. The average travel time of the route is approximately 10 minutes in the peak hours and 4 minutes in the off-peak hours. Overall, the travel distance and the time are both bigger at the peak hours.

The usage of local streets is relatively more compared to it of the commuting trips. There is only a small amount of local streets usage in the heavy congestion period in the commuting trips, on the contrary, in the case of the short trips within CBD, there is more usage of local streets without any pattern because there are more options to choose. The total travel distance over the 200 observations is 2,052 km in the off-peak hours and 2,194 km in the peak hours. The total length of local streets over the 200 observations is 298 km in the off-peak hours and 516 km in the peak hours. The ratio of usage of local streets is 14.55 per cent in the off-peak hours, and 23.54 per cent in the peak hours. It is 1.61 times more in the peak hours.

The travel time of each route is approximately 11 minutes in the peak hours and 7 minutes in the off-peak hours on average. The graphs show a similar trend between the peak hours and the off-peak hours overall (Figure 4.27). The difference is most noticeable in the route I-N and I-L. When total travel time in the peak hours is longer it tends to the travel time gap between the peak and the off-peak hours is bigger either. Excepting K-I and L-N, there is more than 3 minutes difference between the peak hours and the off-peak hours.

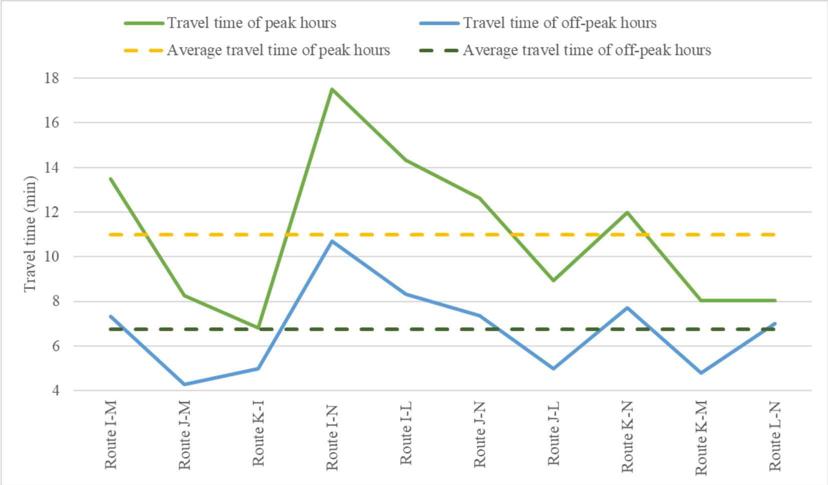


Figure 4.27. The travel time for each route in short trips in CBD.

The average length of each route is around 2.2 km in the peak hours, and 2 km in the off-peak hours. The patterns of the graphs are the exactly same to each other (Figure 4.28). Compared to the commuting group, the gap between the peak and the off-peak hours is subtle. Especially, there is almost no difference in the route I-M, J-M, K-I, and K-M. There is a striking gap in the travel distance in rout I-N, and other than that, there is only a delicate difference.


Figure 4.28. The travel distance for each route in short trips in CBD.

### 4.2.1. Group 1 of the Short Trips in CBD

The routes recommended by GM are way simpler than group 1 of the commuting trips in the overall city. Also, there is less difference of travel time because the total travel distance is short (Table 4.17). The travel distance of each route shows the same or almost similar distance, with less than 0.1 km difference, over all observation. The difference of the travel time is approximately 4 minutes and the one of travel distance is around 0.05 km in average.

Table 4.17. The average travel time and travel distance of group 1, short trip in CBD (n=200 in the peak hours and the off-peak hours each).

| | | Peak hours | | Off-peak hours | |
|---|---|---|---|---|---|
| | | Mean | SD | Mean | SD |
| Route I-M | Travel time (min) | 13.505 | 1.151785 | 7.345 | 0.497203 |
| | Travel distance (km) | 2.7045 | 0.282006 | 2.6 | 0 |
| Route J-M | Travel time (min) | 8.255 | 0.820574 | 4.28 | 0.450126 |
| | Travel distance (km) | 1.628 | 0.102315 | 1.6 | 0 |
| Route K-I | Travel time (min) | 6.835 | 0.721372 | 5 | 0 |
| | Travel distance (km) | 1.5 | 0 | 1.5 | 0 |
| Average | Travel time (min) | 9.531667 | 0.89791 | 5.541667 | 0.315776 |
| | Travel distance (km) | 1.944167 | 0.128107 | 1.9 | 0 |

In the case of the commuting trips, overall routes are similar over all alternatives, so that it is possible to show the ratio of the total length of local streets out of the total travel distance. On the other hand, in the case of the short trips in CBD, the whole route is different, so that simple comparison that used in the group of the commuting trip is impossible. The ratio of local streets usage in the off-peak hours divided by the one in the peak hours shows how many times more local streets are used in the peak hours. The route J-M and K-I have no impact on local streets, but in the case of the route J-M, drivers use local streets 1.52 times more in the peak hours (Table 4.18). In the average of group 1, 1.54 times more local streets are utilized in the peak hours with GM.

Table 4.18. The total travel length and the length of local streets of group 1, short trip in CBD.

| Route | Off-peak hours | | Peak hours | | Additional local streets usage ((C/D)/(A/B)) |
|---|---|---|---|---|---|
| | Length of local streets (km) (A) | Total travel distance (km) (B) | Length of local streets (km) (C) | Total travel distance (km) (D) | |
| Route I-M | 16.2 | 520 | 25.62 | 540.9 | 1.52 |
| Route J-M | 0 | 320 | 0 | 325.6 | - |
| Route K-I | 0 | 300 | 0 | 300 | - |
| Total | 16.2 | 1140 | 25.62 | 1166.5 | 1.54 |

There is no clear pattern of origin and destination of the route (Figure 4.29). The route I-M is one of the longest trips, crossing the center point, in contrast, route I-K is the shortest one, and the route I-M is middle of those two. Considering there is a relatively clear pattern of the routes in the commuting trips, total travel distance is not an important factor to decide alternative routes in a short trip.

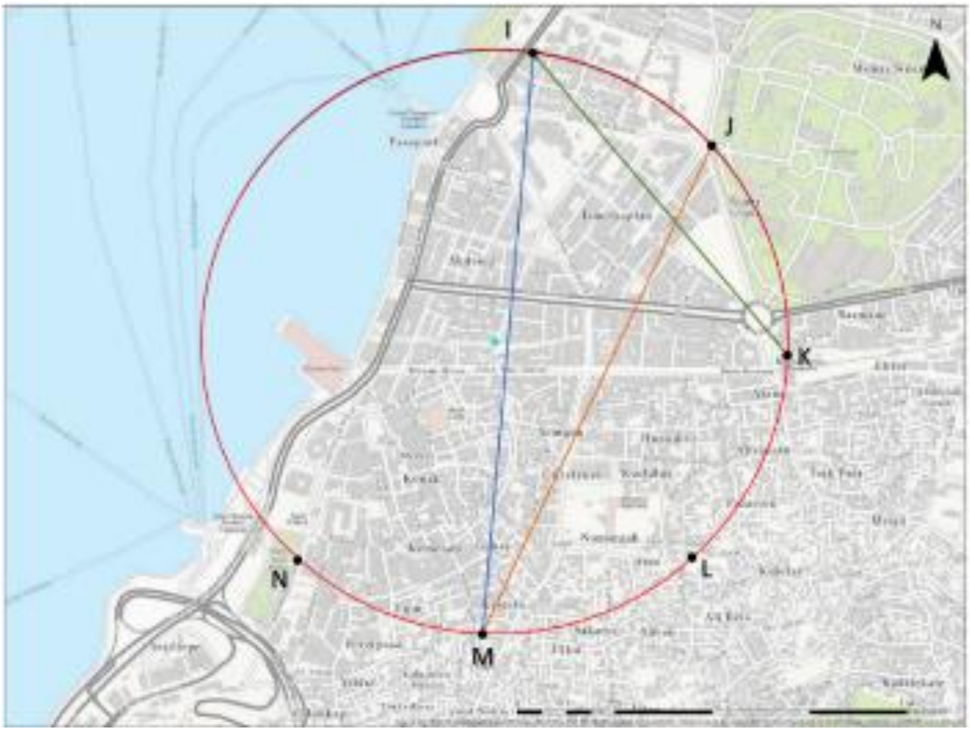


Figure 4.29. The routes of group 1, short trip in CBD.

### 4.2.1.1. Route I-M

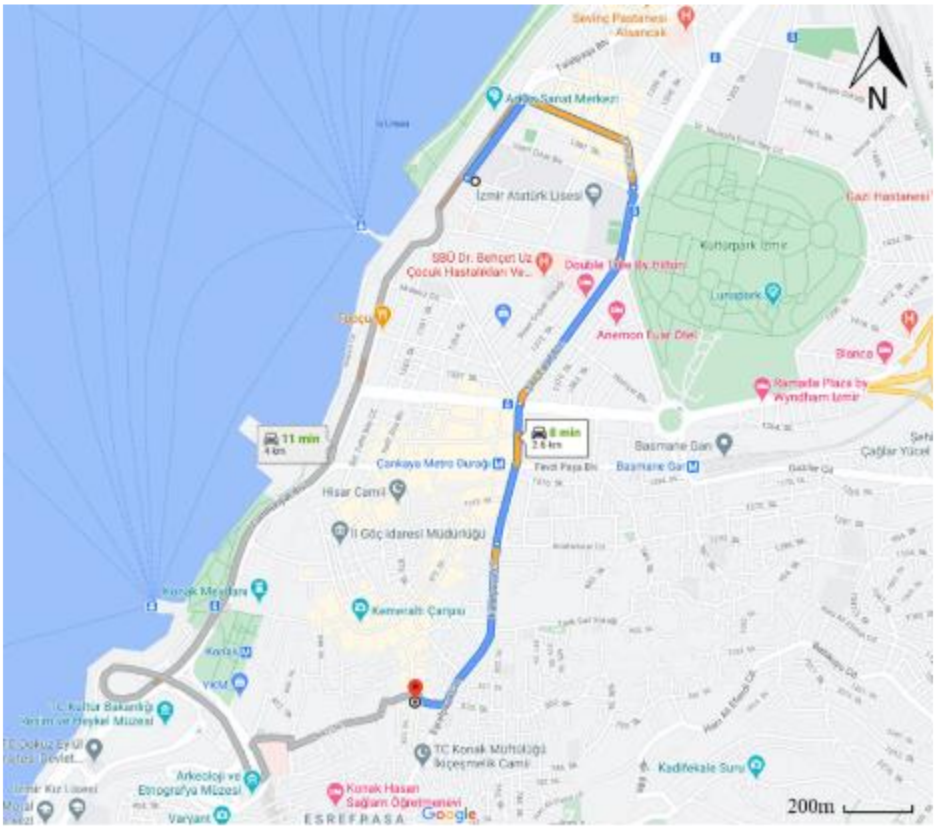


Figure 4.30. The most suggested route in the off-peak hours and the peak hours of the route I-M.

GM suggests the exact same route in the peak hours and the off-peak hours (Figure 4.30). There is no variation of the route suggestions in the off-peak hours, but there are some different options in the peak hours (Figure 4.31). In the case of 4km, it is recommended to use arterial along with the seaside, allowing access to destination in a reverse way compared to the most suggested route. In the Friday evening peak, when the congestion is the heaviest, GM sometimes shows a route of 3.1 km. The overall route is similar to the most suggested route, but it takes a bypass shortly near Kültürpark.

Regardless of the observed time, the shortest route, 2.6 km appears most (200 times in the off-peak hours and 169 times in the peak hours) (Table 4.19). In the peak hours, the shape of the routes becomes more complicated to avoid congestion. The alternative route appears 31 times in the peak hours (15.5 per cent). The longest route is recommended 6 times when only there is severe congestion on the network.

Table 4.19. The number of observations by the travel distance of the route I-M.

| Travel distance | Number of observations | |
|---|---|---|
| | Off-peak hours | Peak hours |
| 2.6 km | 200 | 169 |
| 3.1 km | 0 | 25 |
| 4 km | 0 | 6 |
| Total | 200 | 200 |

To see detailed usage of the local streets is shown in Table 4.20. The usage of local streets is 605m in the route of 4 km route, and 332 m in the route of 3.1 km, and 81m in the route of 2.6 km. The ratios of local streets usage are 4.73 per cent in the peak hours, and 3.11 per cent in the off-peak hours. The ratio of local streets usage is higher in alternative routes, more than 10 per cent in the route of 3.1 km. On the other hand, it is only 3 per cent in the most suggested route. The route with the highest usage of local streets is not suggested many times during the peak hours, but when congestion becomes heavier but there is no extra road infrastructure, usage of local streets would be increased. The total usage of local streets is 3.11 per cent in the off-peak hours, while it is 4.73 per cent in the peak hours.

Table 4.20. The comparison of the usage of local streets of the route I-M.

| Route | Off-peak hours | | | Peak hours | | |
|---|---|---|---|---|---|---|
| | Length of local streets (km) (A) | Total travel length (km) (B) | Ratio (%) (A/B) | Length of local streets (km) (C) | Total travel length (km) (D) | Ratio (%) (C/D) |
| 2.6 km | 16.2 | 520 | 3.11 | 13.69 | 439.4 | 3.11 |
| 3.1 km | - | - | - | 8.3 | 77.5 | 10.71 |
| 4 km | - | - | - | 3.63 | 24 | 15.12 |
| Total | 16.2 | 520 | 3.11 | 25.62 | 540.9 | 4.73 |

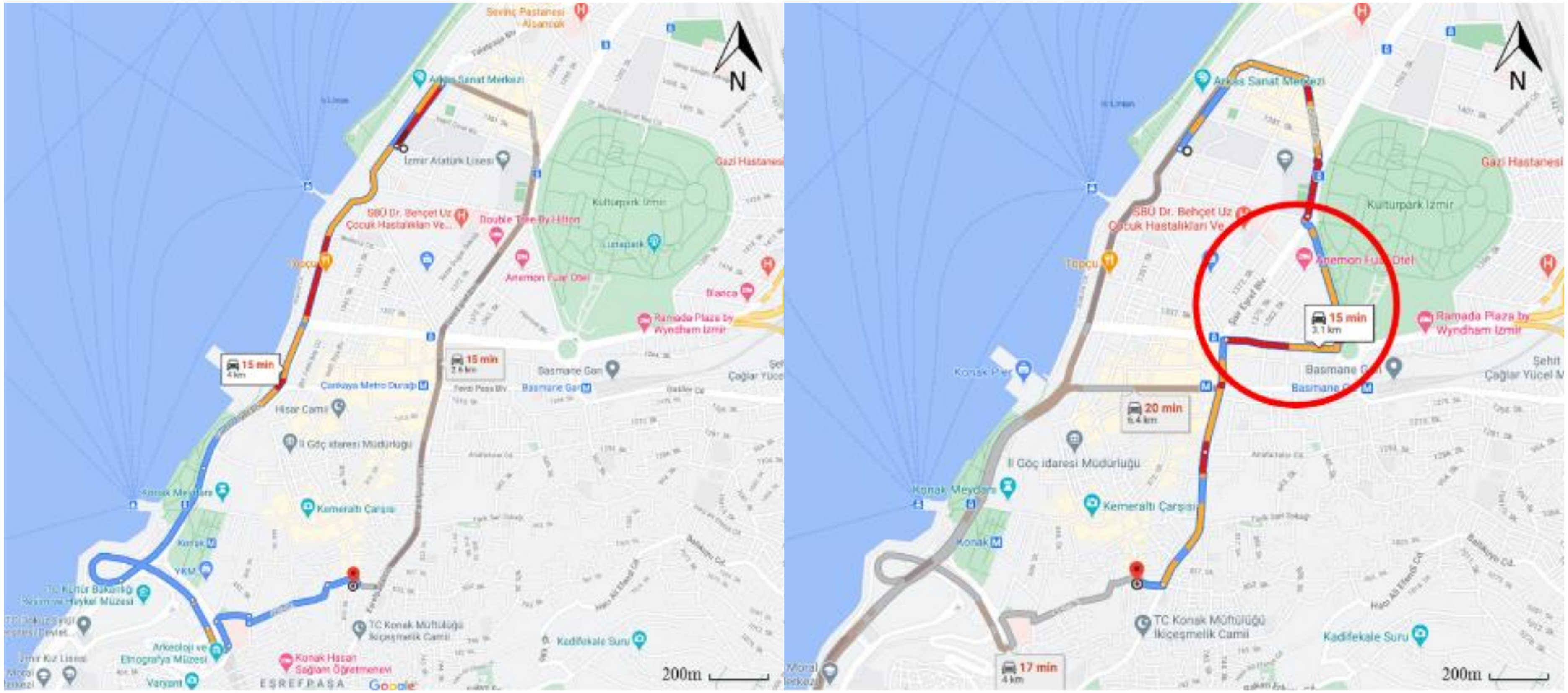


Figure 4.31. The alternative routes in the peak hours (left: 4 km and right: 3.1 km) of the route I-M.

### 4.2.1.2. Route J-M

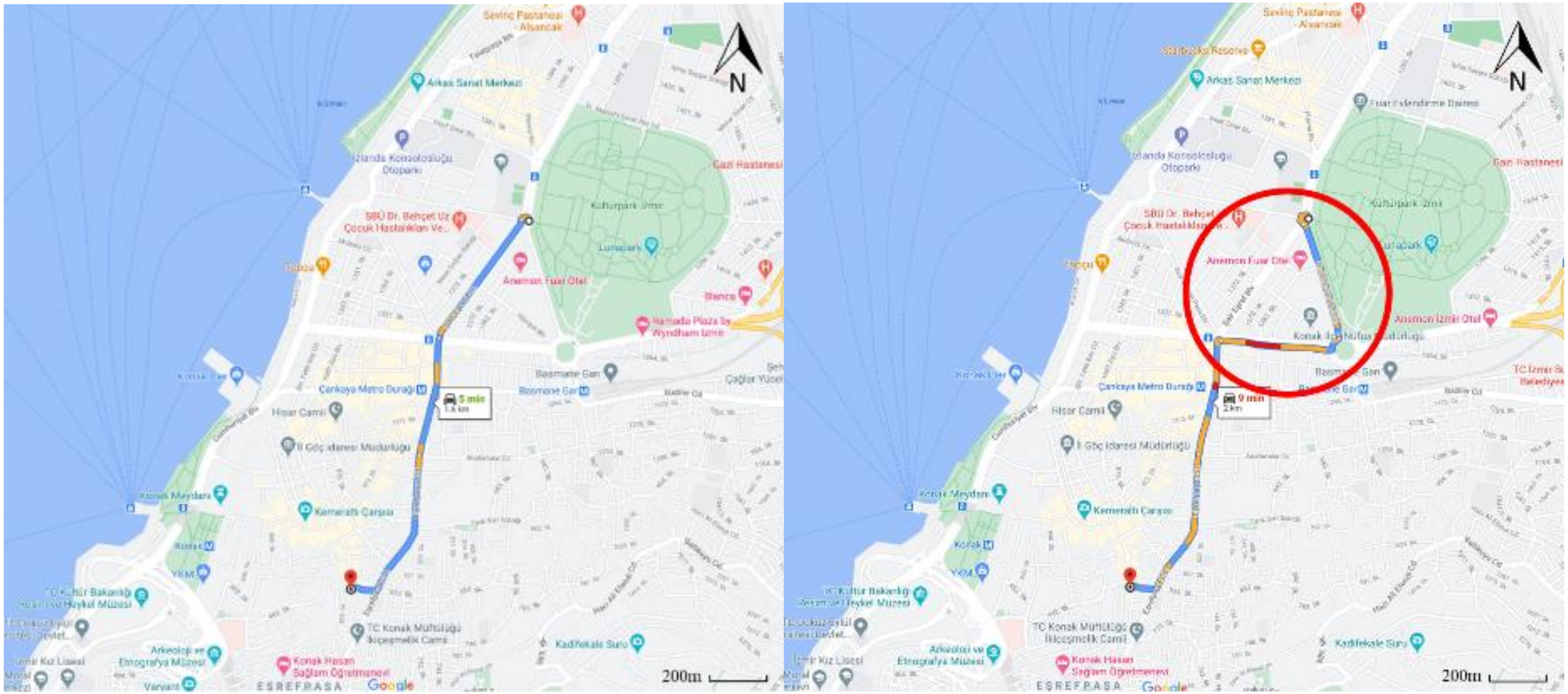


Figure 4.32. The most suggested route in the off-peak hours and the peak hours (left: 1.6 km) and the alternative routes in the peak hours (right: 2 km) of the route J-M

It is a quite simple route with less variation (Figure 4.32). The shortest straight-line shaped route without the usage of local streets is recommended, and there is no variation in the off-peak hours. In the peak hours, sometimes an alternative way is suggested for 14 times (7 per cent) (Table 4.21). It is slightly longer than the typical route, but it still uses only arterial, without local streets.

Table 4.21. The number of observations by the travel distance of the route J-M.

| Travel distance | Number of observations | |
|---|---|---|
| | Off-peak hours | Peak hours |
| 1.6 km | 200 | 186 |
| 2 km | 0 | 14 |
| Total | 200 | 200 |

#### 4.2.1.3. Route K-I

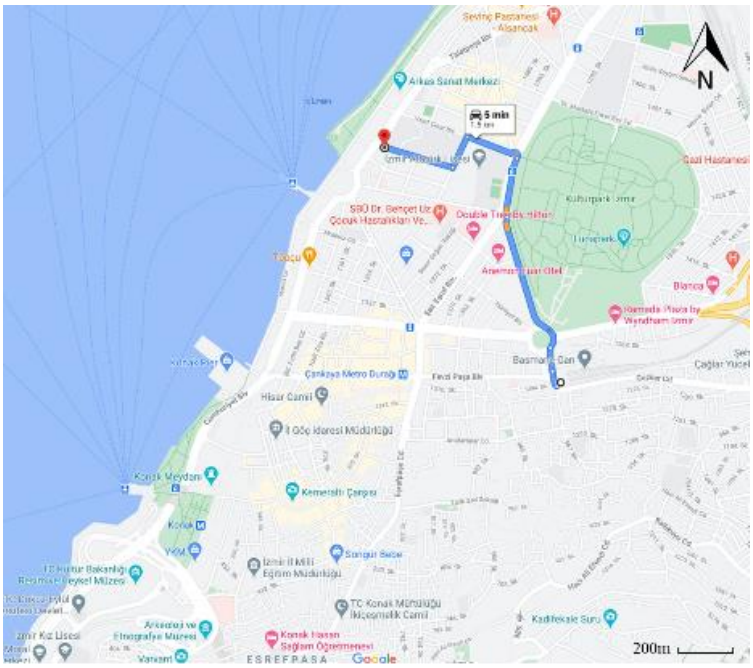


Figure 4.33. The most suggested route in the off-peak hours and the peak hours of the route K-I.

The result indicates the simplest route. Regardless of congestion on road, GM suggests the exact same route always (Figure 4.33). Throughout the observation, there are not any alternative routes (Table 4.22). There is some usage of local streets, However, it is essential usage to get the destination, so that the comparison of local streets is meaningless in this route.

Table 4.22. The number of observations by the travel distance of the route K-I.

| Travel distance | Number of observations | |
|---|---|---|
| | Off-peak hours | Peak hours |
| 1.5 km | 200 | 200 |
| Total | 200 | 200 |

### 4.2.2. Group 2 of the Short Trips in CBD

There are many alternative routes and those are completely distinguishable from each other in this group. In group 2 of the commuting trips in the overall city, there are various alternative routes during the peak hours, but they are mostly close to each other, with small bypass to avoid congestion in a specific region such as Konak or Bornova. On the other hand, in the short trip group, the whole route over the trip is different and alternative routes show mostly exact reverse direction compared to the most suggested route. The numeric value of each travel distance is similar to each other, however, the actual route on the road is quite different. The travel time between the off-peak hours and the peak hours is approximately 4 minutes, and the thing of travel distance is 0.2 km in average (Table 4.23).

Table 4.23. The average travel time and travel distance of group 2, short trip in CBD (n=200 in the peak hours and the off-peak hours each).

| | | Travel time | | Travel distance | |
|---|---|---|---|---|---|
| | | Mean | SD | Mean | SD |
| Route I-N | Travel time | 17.52 | 1.972066 | 10.695 | 0.568852 |
| | Travel distance | 3.9315 | 0.392592 | 3.077 | 0.18341 |
| Route I-L | Travel time | 14.315 | 1.000389 | 8.325 | 0.490487 |
| | Travel distance | 2.8805 | 0.194316 | 2.6 | 0 |
| Route J-N | Travel time | 12.63 | 1.285051 | 7.375 | 0.525123 |
| | Travel distance | 2.3465 | 0.17039 | 1.9 | 0 |
| Route J-L | Travel time | 8.935 | 0.716479 | 5.005 | 0.308953 |
| | Travel distance | 1.76 | 0.11518 | 1.6 | 0 |
| Route K-N | Travel time | 11.98 | 0.97692 | 7.73 | 0.555557 |
| | Travel distance | 2.427 | 0.08607 | 2.1 | 0 |
| Route K-M | Travel time | 8.03 | 0.75628 | 4.785 | 0.411853 |
| | Travel distance | 1.7 | 0 | 1.7 | 0 |
| Route L-N | Travel time | 8.025 | 0.18587 | 7.02 | 0.140351 |
| | Travel distance | 1.515 | 0.065548 | 1.4 | 0 |
| Average | Travel time | 10.6525 | 0.820165 | 6.706667 | 0.405387 |
| | Travel distance | 2.104833 | 0.105251 | 1.883333 | 0 |

About local streets use, excepting the route I-N, there is more usage of local streets in the peak hours (Table 4.24). It means the bypass suggested in the peak hours by GM is a complicated path with much local streets, without considering the hierarchy of roads. In the case of the route I-N, there is one of the main boulevards near origin and destination, GM recommends the route using it in the peak hours, so that usage of local streets is decreased in the peak hours. In the case of K-M, the additional usage of local streets in the peak hours is most remarkable, showing approximately 9.3 times more. Following that, the route I-L J-L, L-N and K-N shows additional usage of local streets in the peak hours. In average, usage of local streets is approximately 1.6 times more at the peak hours.

Table 4.24. The total travel length and the length of local streets of group 2, short trip in CBD.

| Route | Off-peak hours | | Peak hours | | Additional local streets usage ((C/D)/(A/B)) |
|---|---|---|---|---|---|
| | Length of local streets (km) (A) | Total travel distance (km) (B) | Length of local streets (km) (C) | Total travel distance (km) (D) | |
| Route I-N | 102.668 | 615.4 | 121.238 | 786.3 | 0.92 |
| Route I-L | 54.742 | 520 | 169.352 | 576.1 | 2.79 |
| Route J-N | 131.4 | 380 | 166.795 | 469.3 | 1.03 |
| Route J-L | 47.4 | 320 | 124.524 | 352 | 2.39 |
| Route K-N | 131.474 | 420 | 213.95 | 486 | 1.41 |
| Route K-M | 15.97 | 340 | 149.681 | 340 | 9.37 |
| Route L-N | 61.92 | 280 | 97.9419 | 303 | 1.46 |
| Total | 580.969 | 2964.7 | 1,008.087 | 3,223.4 | 1.6 |

There is no clear pattern of the route from the map again since there is no one in group 1 neither (Figure 4.34). Not only the longest one, the route I-N but also the shortest one, the route J-L, K-M, and L-N is included. It shows total travel distance and passing the center point is not an important factor in short trips.

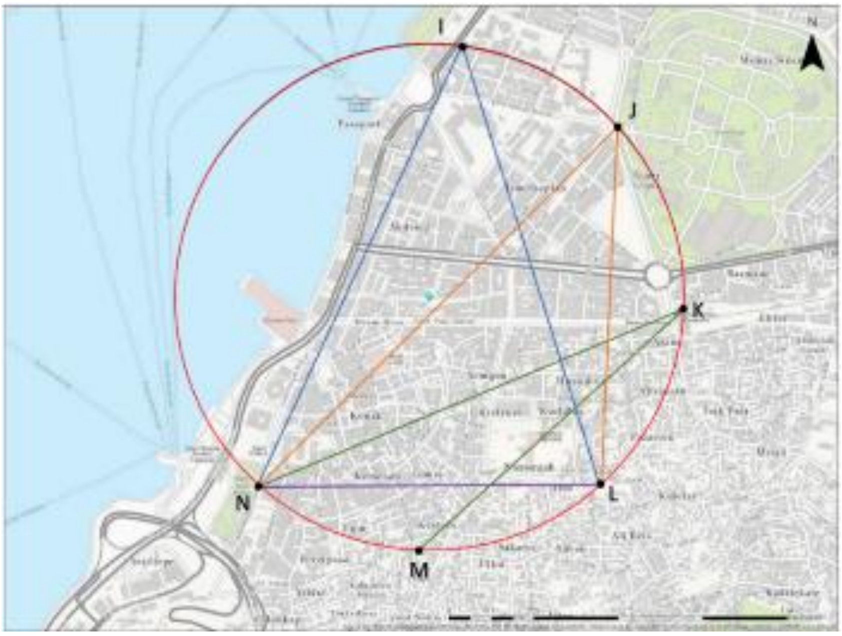


Figure 4.34. The routes of group 2, short trip in CBD.

## 4.2.2.1. Route I-N

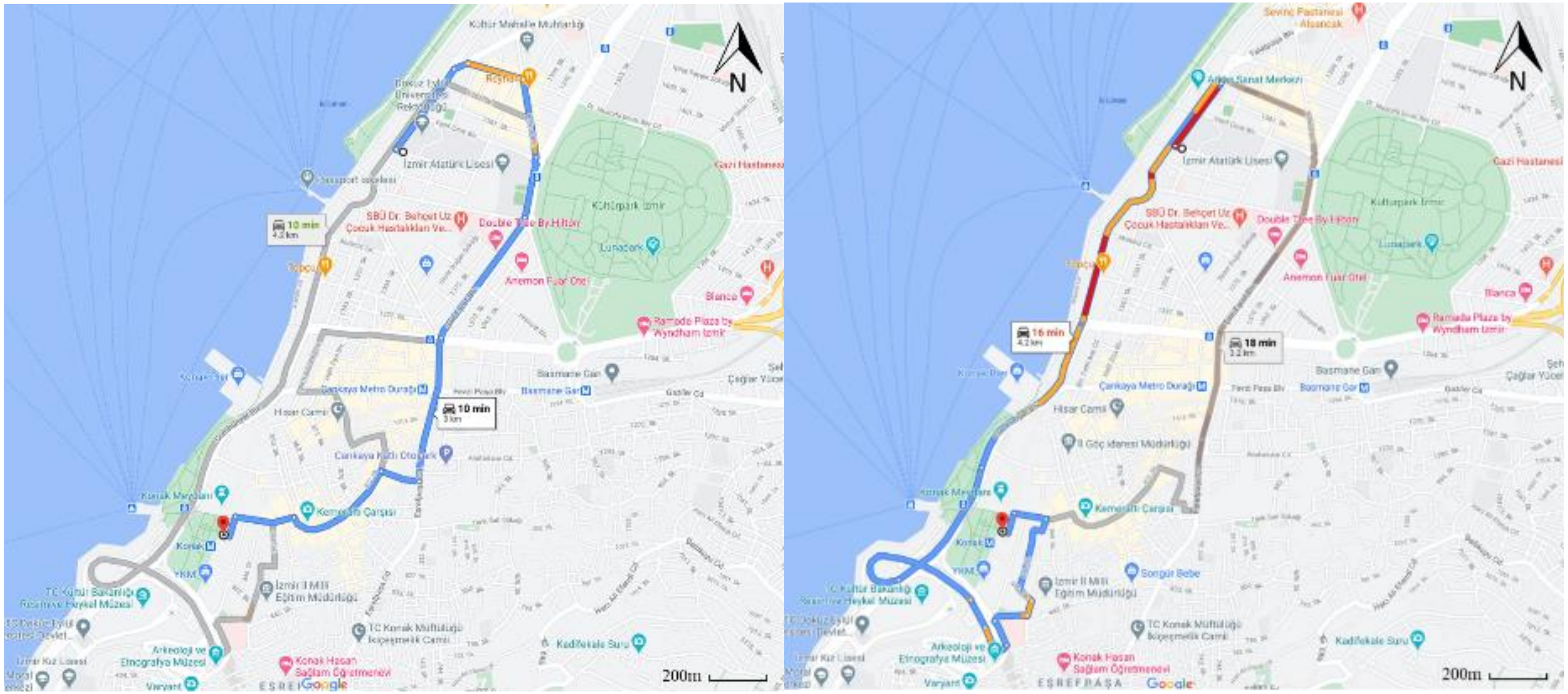


Figure 4.35. The most suggested route in the off-peak hours (left: 3 km) and the peak hours (right: 4.2 km) of the route I-N.

According to congestion, GM suggests exactly different routes. In the peak hours, to avoid congestion at the big crossroad near the metro station and tram stop, a longer bypass is recommended. In contrast, in the off-peak hours, the shortest route passing the central part of CBD is suggested (Figure 4.35).  Unlike the other route, there is an alternative route in the off-peak hours (Figure 4.36). In the peak hours, GM sometimes recommends alternative routes (Figure 4.37), and they are scattered throughout the observation. The routes appear without a pattern, responding to real-time congestion sensitively. It means the optimal route choice to minimize travel time is keep changing even in a relatively short time compared to the commuting trip.

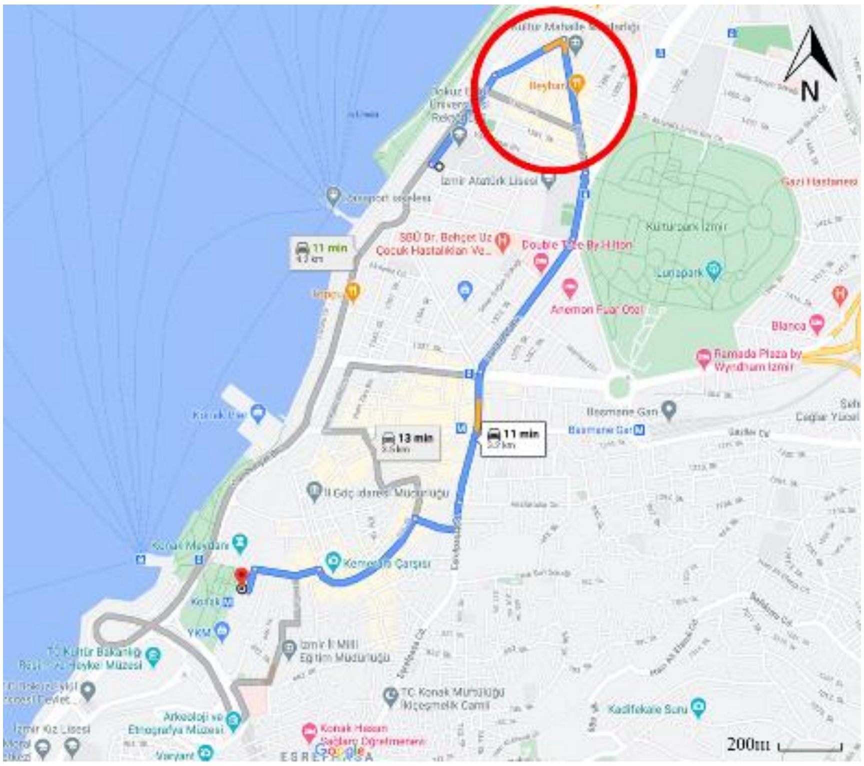


Figure 4.36. The alternative route in the off-peak hours (3.2 km (a)) of the route I-N.

The shortest route suggested 143 times in the off-peak hours (71.5 per cent), and it does not suggest at all during the peak hours, even total travel length is similar (Table 4.25). It means congestion is pretty heavier on the roads which are recommended in the off-peak hours. The most suggested route in the peak hours, is the longest one, 4.2 km, and it appears 134 times (67 per cent). The ratio of the alternative route is respectively 26.5 per cent in the off-peak hours, and 33 per cent in the peak hours.

Table 4.25. The number of observations by the travel distance of the route I-N.

| Travel distance | Number of observations | |
|---|---|---|
| | Off-peak hours | Peak hours |
| 3 km | 143 | 0 |
| 3.2 km (a) | 53 | 0 |
| 3.2 km (b) | 0 | 25 |
| 3.5 km | 0 | 41 |
| 4.2 km | 4 | 134 |
| Total | 200 | 200 |

The detailed usage of local streets is shown in Table 4.26. The lengths of local streets are 513m in the route of 3km, 700 m in the route of 3.2 km (b), 798 m in route 3.5 km, and 530 m in the route of 4.2 km. The length of the local streets is longer in the peak hours, but when we consider total travel together, the ratio is higher in the off-peak hours. This is because longer distance using arterial along with seaside is recommended in the peak hours to avoid congestion in local streets. Even though the shape of alternative routes in the peak hours is complicated, using local streets, usage of local streets is slight less in the peak hours (16.68 per cent in the off-peak hours and 15.49 per cent in the peak hours respectively).

Table 4.26. The comparison of the usage of local streets of the route I-N.

| Route | Off-peak hours | | | Peak hours | | |
|---|---|---|---|---|---|---|
| | Length of local streets (km) (A) | Total travel length (km) (B) | Ratio (%) (A/B) | Length of local streets (km) (C) | Total travel length (km) (D) | Ratio (%) (C/D) |
| 3 km | 73.359 | 429 | 17.1 | 0 | 0 | - |
| 3.2 km (a) | 27.189 | 169.6 | 16.03 | 0 | 0 | - |
| 3.2 km (b) | 0 | 0 | - | 17.5 | 80 | 21.88 |
| 3.5 km | 0 | 0 | - | 33.251 | 143.5 | 23.17 |
| 4.2 km | 2.120 | 16.8 | 12.62 | 71.02 | 562.8 | 12.62 |
| Total | 102.668 | 615.4 | 16.68 | 121.771 | 786.3 | 15.49 |

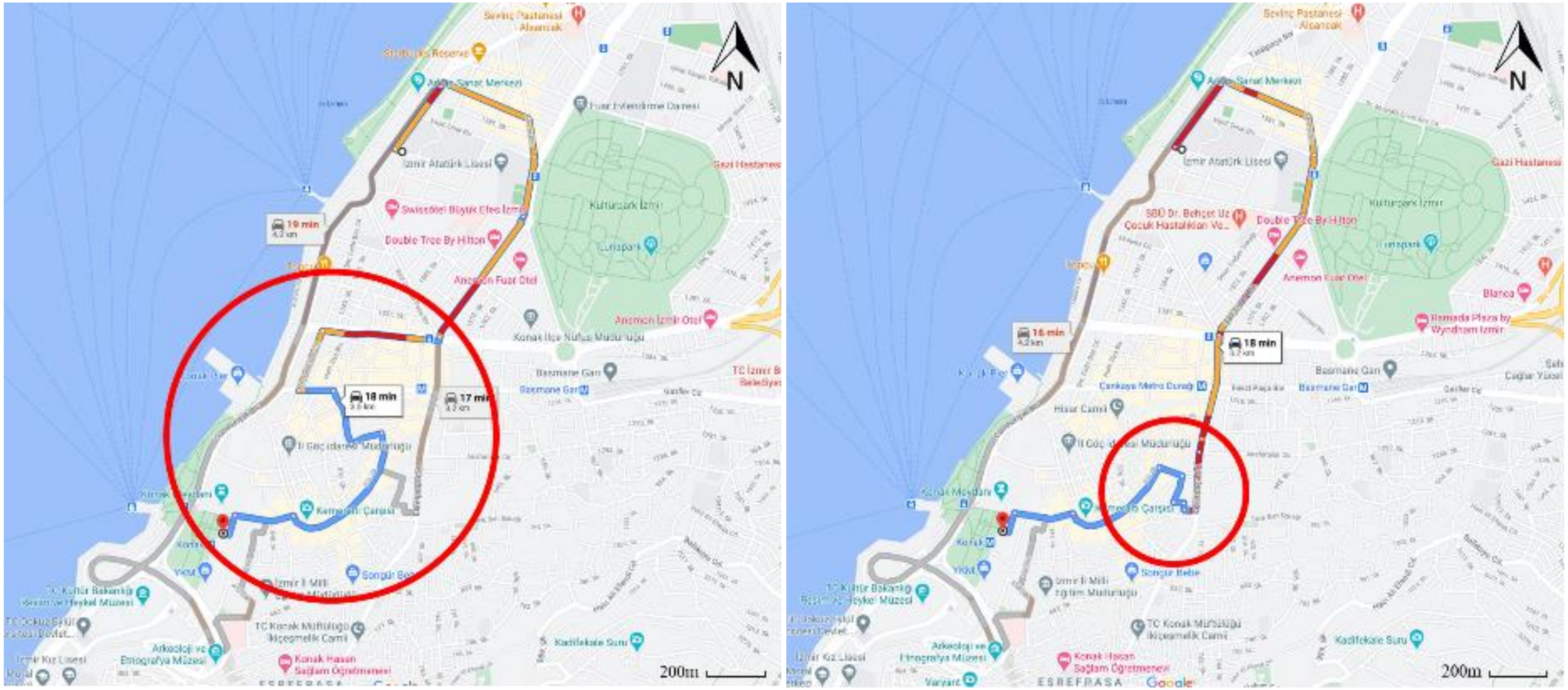


Figure 4.37. The alternative routes in the peak hours (left: 3.5 km and right: 3.2 km (b)) of the route I-N.

#### 4.2.2.2. Route I-L

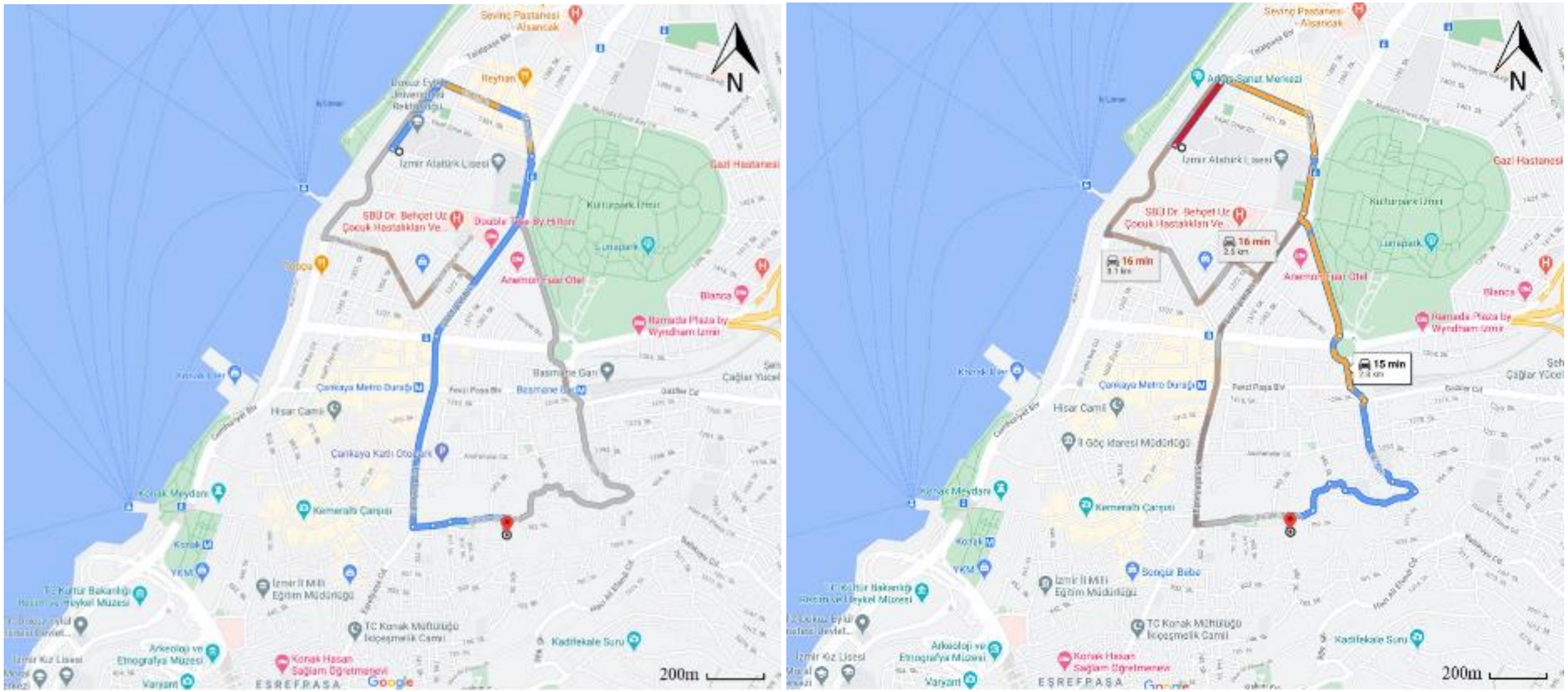


Figure 4.38. The most suggested route in the off-peak hours (left: 2.6 km) and in the peak hours (right: 2.8 km) of the route I-L.

The most suggested routes face the opposite direction, diverging near Kültürpark. In the off-peak hours, the route follows a straight line, whereas, in the peak hours, it shows meanderings of the path (Figure 4.38). The difference of travel distance is only 0.2 km (2.6km in the off-peak hours, and 2.8km in the peak hours), but the patterns of each route vary wildly. One of the alternative routes in the peak hours is similar to the route in the off-peak hours (route of 3.1 km in Figure 4.39). When congestion gets heavier, GM suggested the other alternative one, a more complex and stranger route (route of 3.5km in Figure 4.39).

Table 4.27. The number of observations by the travel distance of the route I-L.

| Travel distance | Number of observations | |
|---|---|---|
| | Off-peak hours | Peak hours |
| 2.6 km | 200 | 11 |
| 2.8 km | 0 | 144 |
| 3.1 km | 0 | 29 |
| 3.4 km | 0 | 16 |
| Total | 200 | 200 |

The number of observations is simple in the off-peak hours, without any alternatives (Table 4.27). In the peak hours, the route that is suggested in the off-peak hours sometimes appears without a clear pattern, but the frequency is not high. The route of 2.8 km is a majority in the peak hours (72 per cent), followed by the route of 3.1 km (14.5 per cent) and 3.4 km (8 per cent). The shape of the route of 3.1 km is similar to the one of the route of 2.6 km, but it never recommended in the off-peak hours. The shortest route is suggested in the peak hours 11 times (5.5 per cent).

In the off-peak hours, GM leads to the destination using the main road, with only 273 m of local streets. On the contrary, in the off-peak hours it leads drivers into a narrow alleyway instead of the wide road, using 983 m of local streets. There are alternative routes in the peak hours, route of 3.1 km contains only 296 m of local streets and the ratio of local streets is 9.57 per cent. On the other hand, it is almost 30 per cent in case of the route of 3.4km.

Table 4.28. The comparison of the usage of local streets of the route I-L.

| Route | Off-peak hours | | | Peak hours | | |
|---|---|---|---|---|---|---|
| | Length of local streets (km) (A) | Total travel length (km) (B) | Ratio (%) (A/B) | Length of local streets (km) (C) | Total travel length (km) (D) | Ratio (%) (C/D) |
| 2.6 km | 54.742 | 520 | 10.53 | 3.01081 | 28.6 | 10.53 |
| 2.8 km | 0 | 0 | - | 141.576 | 403.2 | 35.11 |
| 3.1 km | 0 | 0 | - | 8.6043 | 89.9 | 9.57 |
| 3.4 km | 0 | 0 | - | 16.16 | 54.4 | 29.7 |
| Total | 54.742 | 520 | 10.53 | 169.352 | 576.1 | 29.39 |

The route shows considerable usage of local streets during the peak hours. The most suggested route, 2.8 km, in the peak hours, indicates the most significant usage rate at 35.11 per cent (Table 4.28). Also, the route of 3.4 km, even though it is not recommended many times but it is focused on the heaviest congested time period, and still have significance at the usage of local streets. It is clear, that the route of 2.8 km and the route of 3.4 km use the narrowest alleyway in a residential area, thus there could negatively affect the hierarchy of the road system. The usage of local streets is 10.53 per cent in the off-peak hours, and 29.39 per cent in the peak hours.

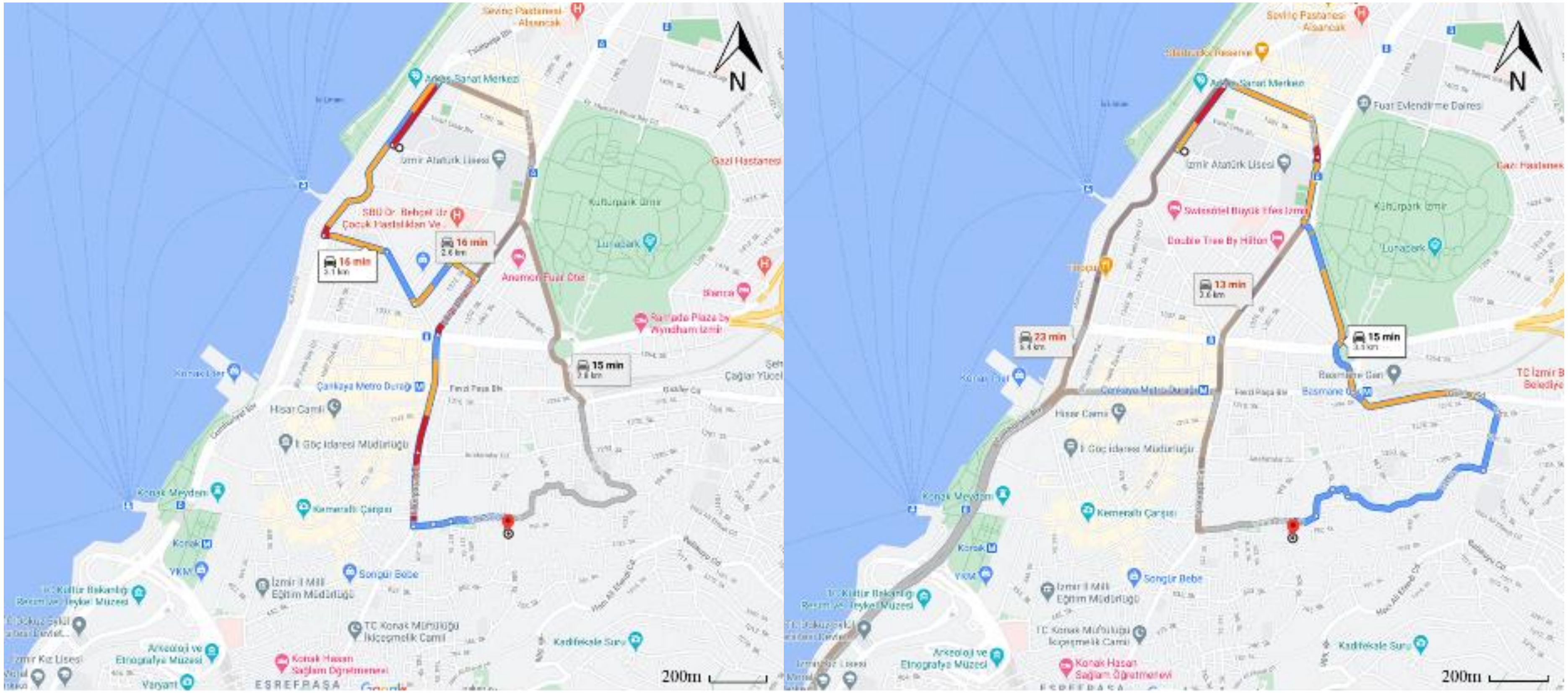


Figure 4.39. The alternative routes in the peak hours (left: 3.1 km and right: 3.5 km) of the route I-L.

## 4.2.2.3. Route J-N

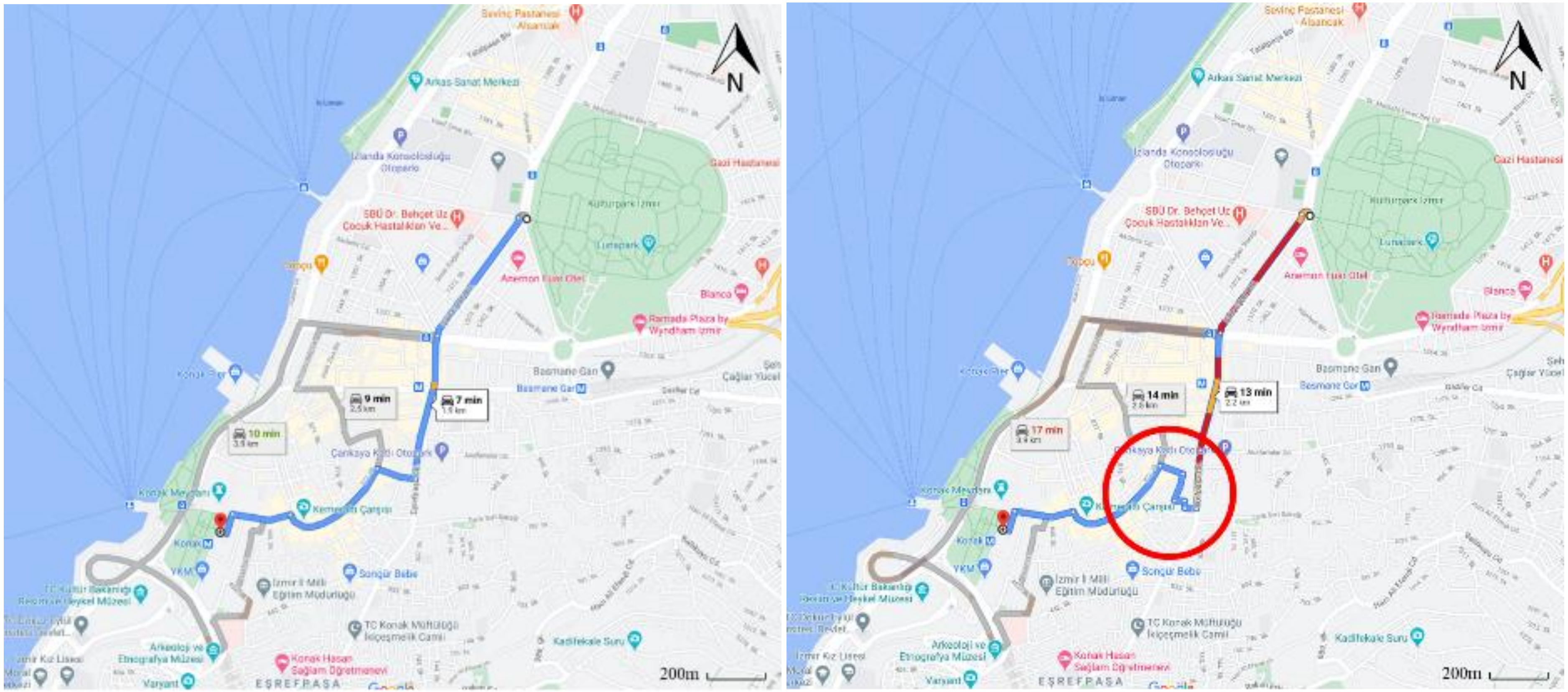


Figure 4.40. The most suggested route in the off-peak hours (left: 1.9 km) and the peak hours (right: 2.2 km) of the route J-N.

The most suggested route in the peak hours is the shortest route, 1.9 km, and it is the route of 2.2 km in the peak hours (Figure 4.40). The difference of length of them is only 0.3 km. The pattern of the alternative route is similar to the one in the commuting trips, rather than the other routes of the short trip within CBD; the overall route is similar over all alternatives, but there are a few variations, to avoid congestion in a specific area. The two most suggested are the almost same, but in the peak hours, GM suggests making a small detour. Also, there are two different alternative routes in peak hours, but the overall route is similar to the shortest route (Figure 4.41). Those two routes are recommended when traffic congestion gets more severe.

Table 4.29. The number of observations by the travel distance of the route J-N.

| Travel distance | Number of observations | |
|---|---|---|
| | Off-peak hours | Peak hours |
| 1.9 km | 200 | 0 |
| 2.2 km | 0 | 113 |
| 2.5 km | 0 | 55 |
| 2.6 km | 0 | 32 |
| Total | 200 | 200 |

There is only one route in the off-peak hours, which means the shortest path is the optimal option in the off-peak hours. But it is relatively evenly distributed in the peak hours (Table 4.29). Combining the two alternatives (the route of 2.5 km and 2.6 km), the number of observations is similar to the most suggested one (87 and 113 respectively). There is a clear pattern of the recommendation of the route of 2.5 km; it is suggested when congestion gets harder. On the other hand, the route of 2.6 km appears randomly over the observation.

Table 4.30. The comparison of the usage of local streets of the route J-N.

| Route | Off-peak hours | | | Peak hours | | |
|---|---|---|---|---|---|---|
| | Length of local streets (km) (A) | Total travel length (km) (B) | Ratio (%) (A/B) | Length of local streets (km) (C) | Total travel length (km) (D) | Ratio (%) (C/D) |
| 1.9 km | 131.4 | 380 | 34.58 | 0 | 0 | - |
| 2.2 km | 0 | 0 | - | 89.27 | 248.6 | 35.9 |
| 2.5 km | 0 | 0 | - | 52.2451 | 137.5 | 38 |
| 2.6 km | 0 | 0 | - | 25.28 | 83.2 | 30.38 |
| Total | 131.4 | 380 | 34.58 | 166.795 | 469.3 | 35.54 |

Looking closer to the usage of local streets, it is clear that local streets make up a sizable portion of the total trip (Table 4.30). Even though usage of local streets is high in the peak hours, the difference between the off-peak hours and the peak hours is low. However, the place that local streets are located is not a residential area, so that problem would be less than the other routes. There is more usage of local streets in the route of 2.5 km, around 950 m. In the case of 2.6 km, usage of local streets is the same as the route of 2.2 km, 790 m.

The proportion of local streets is 34.58 per cent in the off-peak hours, and 35.54 per cent in the peak hours. The ratio is even high in the off-peak hours, which means this trip is inevitably contained much local streets usage. The proportion is smaller in the peak hours due to total travel length is longer in the peak hours, however, the absolute number of usages of local streets is longer in the peak hours.

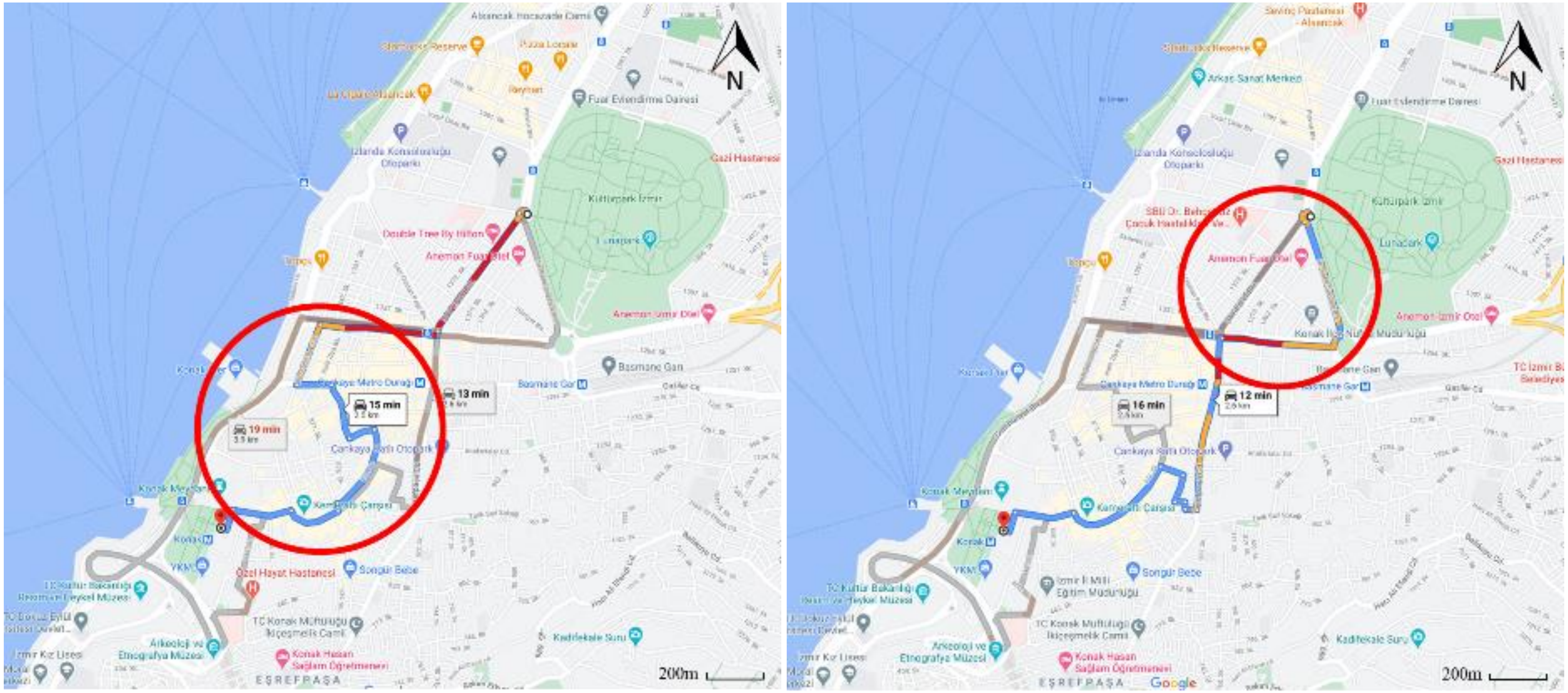


Figure 4.41. The alternative routes in the peak hours (left: 2.5 km and right: 2.6 km) of the route J-N.

### 4.2.2.4. Route J-L

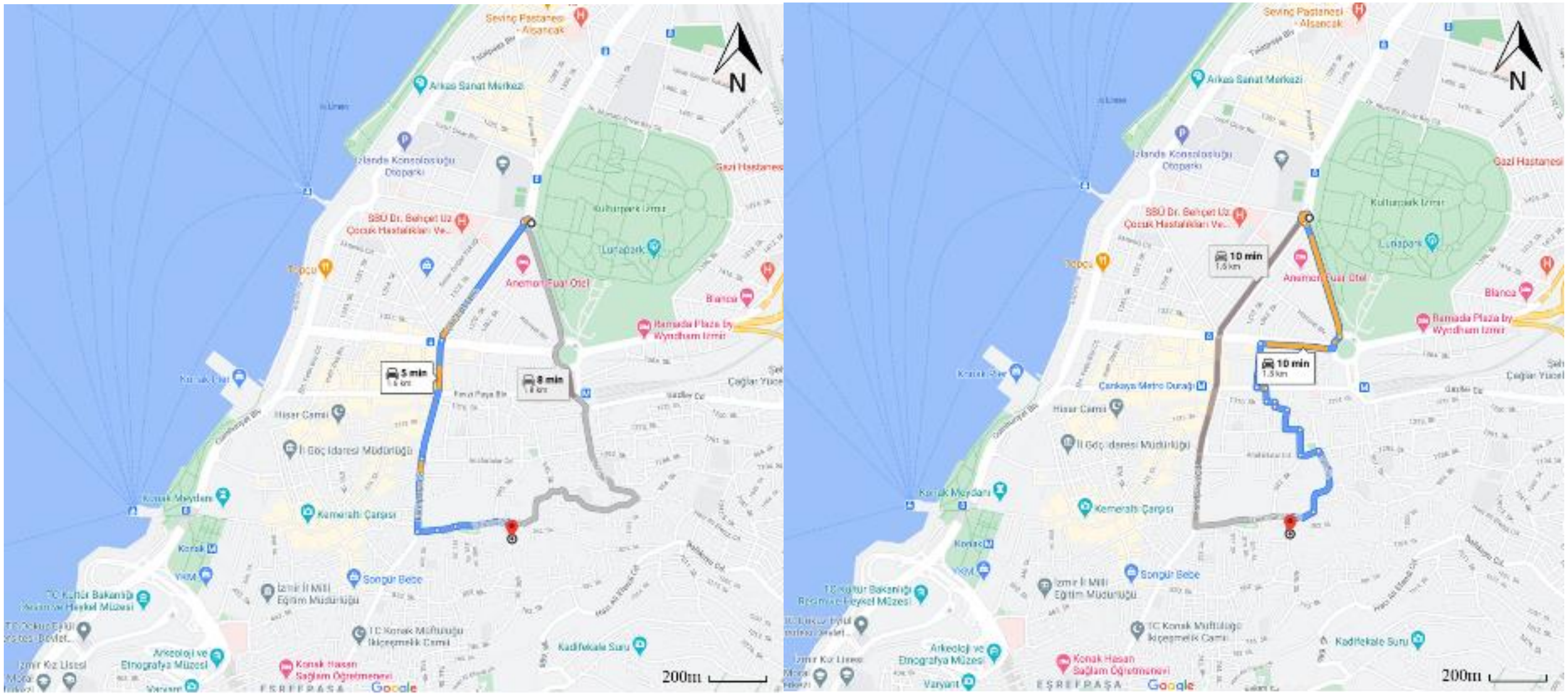


Figure 4.42. The most suggested route in the off-peak hours (left: 1.6 km) and the peak hours (right:1.8 km (a)) of the route J-L.

The suggested routes are overall similar to the route I-L since the destination is the same and origins are nearby (Figure 4.42). In the off-peak hours, it looks like a straight line along the main road. On the other hand, in the peak hours, it is quite tangled, so that it is hard to form an idea of the whole route without GM. To avoid congestion, the narrow alleyway is recommended. The other alternatives in the peak hours, the one shows the complicated shape of the route, and the other one is way simpler (Figure 4.43).

Table 4.31. The number of observations by the travel distance of the route J-L.

| Travel distance | Number of observations | |
|---|---|---|
| | Off-peak hours | Peak hours |
| 1.6 km | 200 | 57 |
| 1.8 km (a) | 0 | 76 |
| 1.8 km (b) | 0 | 50 |
| 2 km | 0 | 17 |
| Total | 200 | 200 |

In the peak hours, the number of observations is most evenly distributed among all routes (Table 4.31). The frequency of second and third most suggested routes in the off-peak hours is roughly alike (57 times and 50 times), while the most suggested one is 76 times. In the off-peak hours, there is no alternative route at all. On the contrary, in the peak hours, the recommended route is kept changing even within a short time. This is because the traffic condition of the main road is changed by the minute, and GM reacts to data sensitively.

Table 4.32. The comparison of the usage of local streets of the route J-L.

| Route | Off-peak hours | | | Peak hours | | |
|---|---|---|---|---|---|---|
| | Length of local streets (km) (A) | Total travel length (km) (B) | Ratio (%) (A/B) | Length of local streets (km) (C) | Total travel length (km) (D) | Ratio (%) (C/D) |
| 1.6 km | 47.4 | 320 | 14.81 | 13.509 | 91.2 | 14.81 |
| 1.8 km (a) | 0 | 0 | - | 57.836 | 136.8 | 42.28 |
| 1.8 km (b) | 0 | 0 | - | 49.15 | 90 | 54.61 |
| 2 km | 0 | 0 | - | 4.029 | 34 | 11.85 |
| Total | 47.4 | 320 | 14.81 | 124.524 | 352 | 35.38 |

The usage of local streets is much higher in the peak hours (Table 4.32). Especially, the route of 1.8 km (a) and 1.8 km (b) shows a high percentage (761m and 983m respectively), since they are shown complex-shaped on the map, with the usage of local streets and 237m in case of 1.6km and 2 km. Compared to the off-peak hours, the usage of local streets is more than twice at the peak hours (14.81 per cent in the off-peak hours and 35.38 per cent in the peak hours each). The alternative route of 2 km is the usage of local streets is the least with simpler shape than the general route in the off-peak hours, but the frequency of suggestion is less. Thus, it does not affect much total usage of local streets.

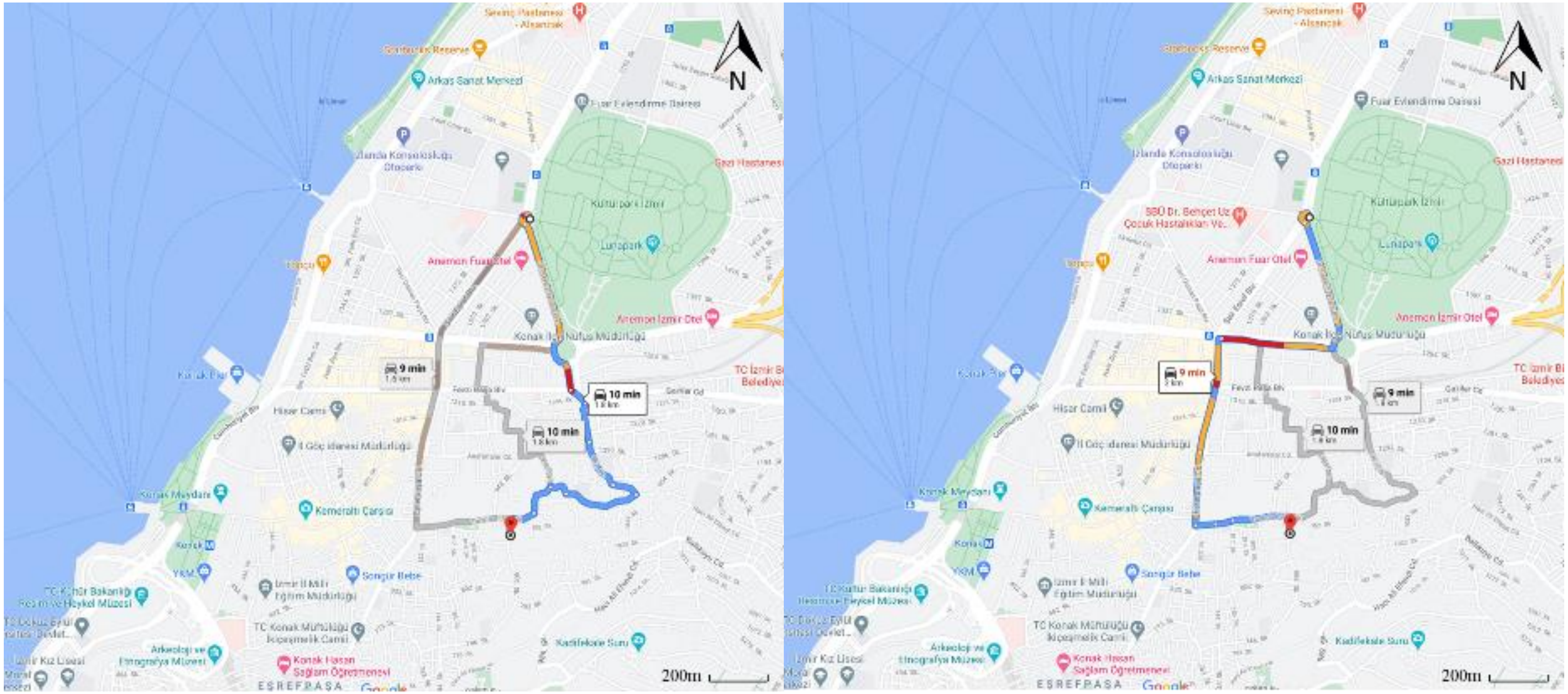


Figure 4.43. The alternative routes in the peak hours (left: 1.8 km (b) and right: 2 km) of the route J-L.

### 4.2.2.5. Route K-N

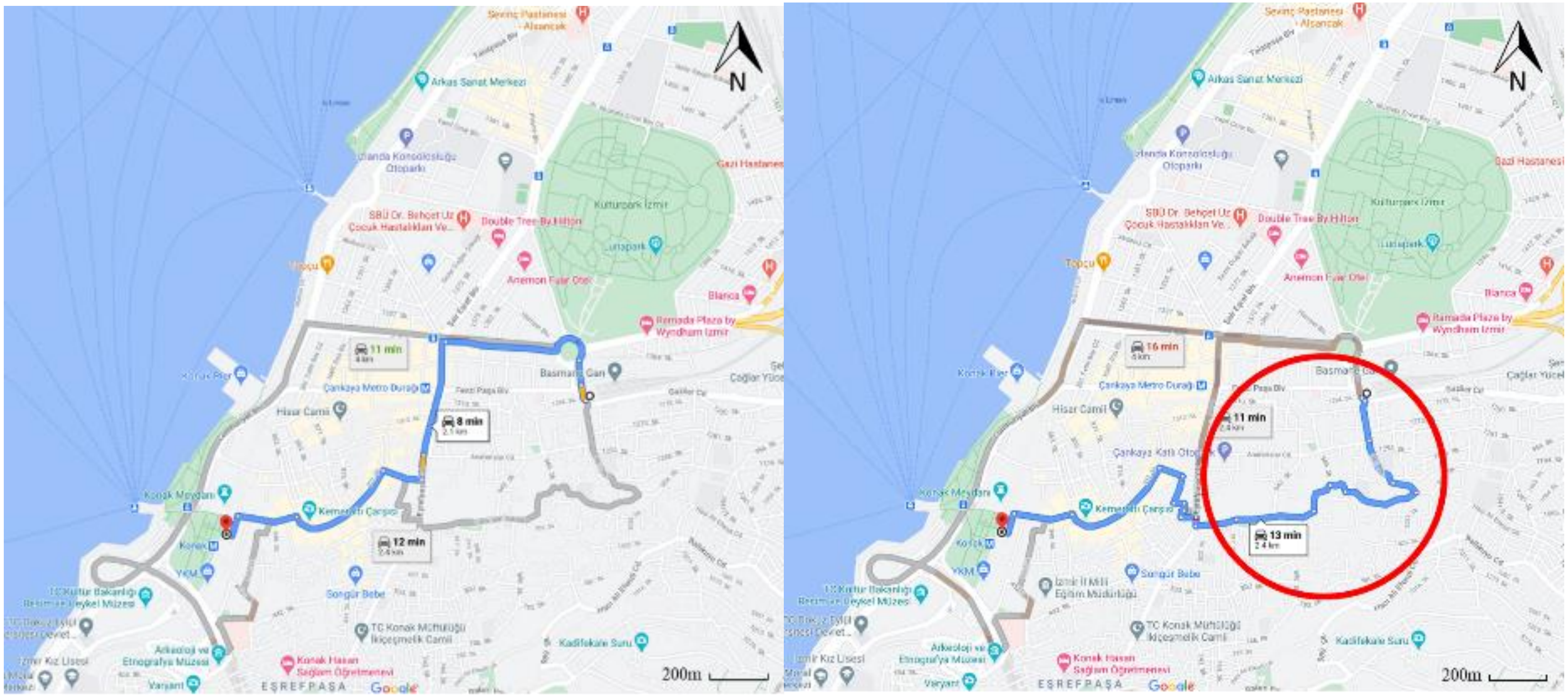


Figure 4.44. The most suggested route in the off-peak hours (left: 2.1 km) and the peak hours (right: 2.4 km (a)) of the route K-N.

The overall pattern of the route is similar to the route J-N in the off-peak hours, and it is similar to alternatives of the route J-L in the peak hours (Figure 4.44). In the off-peak hours, the only main road is used to make trips, with a small amount of usage of local streets to access the destination. On the contrary, the most suggested route in the peak hours is quite complex to be impossible to drive without GM. There are many turns within narrow paths near residential areas. When there is less congestion in the peak hours, there are some alternative routes, that have a little different path. The route of 2.4 km (b) is almost similar to the one of the off-peak hours, using less local streets. The route of 2.7 km has pretty high usage of local streets, but less than the route of 2.4 km (a) (Figure 4.45).

Table 4.33. The number of observations by the travel distance of the route K-N.

| Travel distance | Number of observations | |
|---|---|---|
| | Off-peak hours | Peak hours |
| 2.1 km | 200 | 0 |
| 2.4 km (a) | 0 | 125 |
| 2.4 km (b) | 0 | 55 |
| 2.7 km | 0 | 20 |
| Total | 200 | 200 |

In the off-peak hours, there are no alternative routes at all over the observation (Table 4.33). It means there is not much variable on the road in the off-peak hours. In the peak hours, the two alternative routes heading toward the exact opposite way compared to the most suggested route make up 37.5 per cent (55 times and 20 times respectively). Also, the most recommended route in the off-peak hours is never have recommended in the peak hours, and the opposite is the same as well.

Table 4.34. The comparison of the usage of local streets of the route K-N.

| Route | Off-peak hours | | | Peak hours | | |
|---|---|---|---|---|---|---|
| | Length of local streets (km) (A) | Total travel length (km) (B) | Ratio (%) (A/B) | Length of local streets (km) (C) | Total travel length (km) (D) | Ratio (%) (C/D) |
| 2.1 km | 131.474 | 420 | 31.3 | 0 | 0 | - |
| 2.4 km (a) | 0 | 0 | - | 148.271 | 300 | 49.42 |
| 2.4 km (b) | 0 | 0 | - | 43.450 | 132 | 32.92 |
| 2.7 km | 0 | 0 | - | 22.2284 | 54 | 41.46 |
| Total | 131.474 | 420 | 31.3 | 213.950 | 486 | 44.02 |

The usage of local streets is 657m (in case of 2.1 km), 1.19km (in case of 2.4 km (a)), 790m (in case of 2.4 km (b)), and 1.11km (in case of 2.7km). The ratio of local streets is 31.3 per cent in the off-peak hours. Considering it as the minimum per cent to make this trip, all suggested route in the peak hours has extra usage of local streets (Table 4.34). It is especially high at the route of 2.4 km (a) and 2.7 km. In the case of 2.7 km, the frequency of appearance is low, but the overall path of the route is different from any other suggestion in the route K-N with a pretty high proportion of local streets (41.46 per cent). The total usage of local streets is higher in the peak hours at 44.02 per cent. The shortest route, which contains the least usage of local streets is not suggested at all during the peak hours, and it makes the total usage of local streets higher in the peak hours.

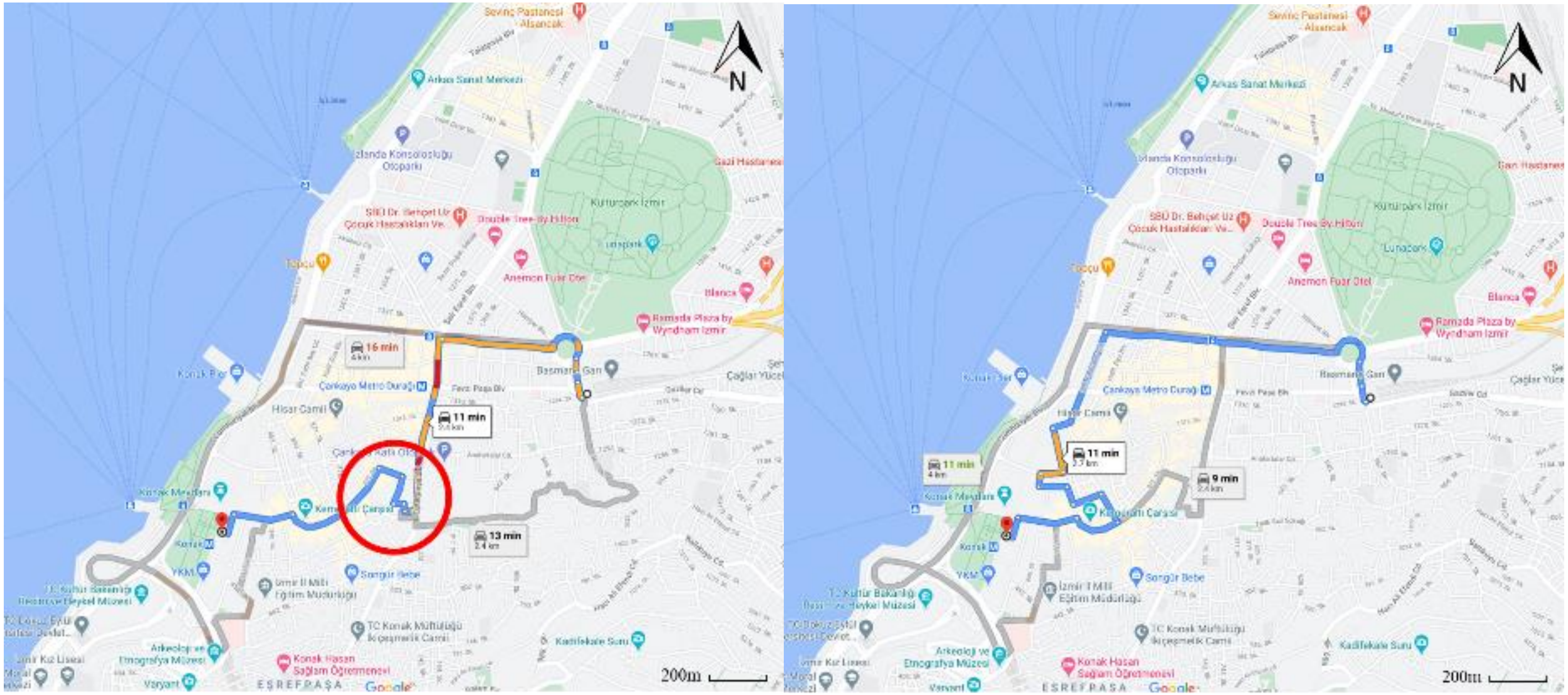


Figure 4.45. The alternative routes in the peak hours (left: 2.4 km (b) and right: 2.7 km) of the route K-N.

## 4.2.2.6. Route K-M

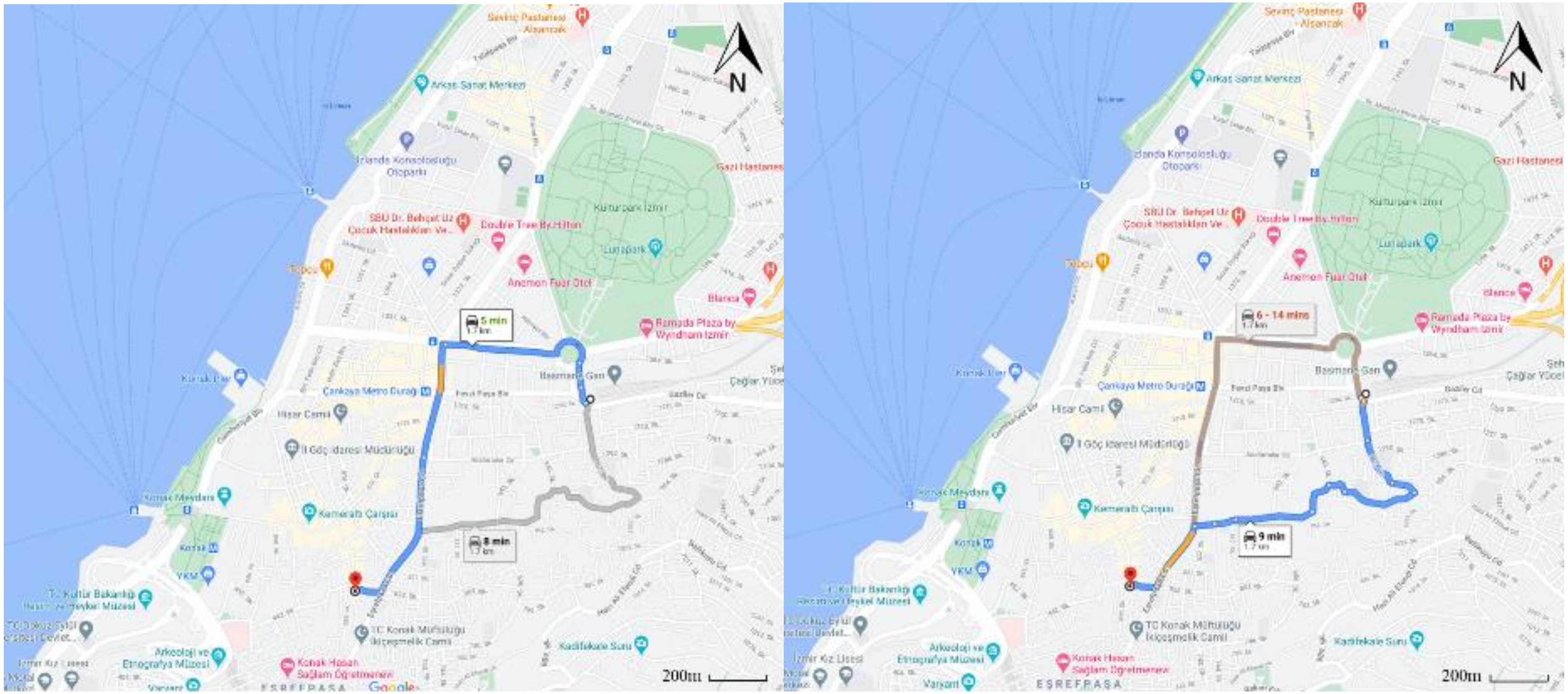


Figure 4.46. The most suggested route in the off-peak hours (left: 1.7 km (a)) hour and the peak hours (right: 1.7 km (b)) of the route K-M.

It shows a quite simple result, there is only 1 route in the off-peak hours, and in the peak hours, there are only 2 routes including one of the off-peak hours. GM makes drivers face the exact opposite direction from the departure point (Figure 4.46). The total travel length of the routes is the exactly same at 1.7 km, but the usage of local streets fairly distinct from each other.

Table 4.35. The number of observations by the travel distance of the route K-M.

| Travel distance | Number of observations | |
|---|---|---|
| | Off-peak hours | Peak hours |
| 1.7 km (a) | 200 | 64 |
| 1.7 km (b) | 0 | 136 |
| Total | 200 | 200 |

In the off-peak hours, there is no alternative route over all observation. In the peak hours, there is only 2 recommendation and one of them is one of the off-peak hours (Table 4.35). There is no appearance of the route of 1.7 km (b) in the off-peak hours, but there are 64 times of the route of 1.7km (a) in the peak hours.

The total length of each route is the exact same, but there is a huge difference in usage of local streets, 80m (in case of 1.7 km (a)) and 1.06km (in case of 1.7 km (b)) The total ratio of usage of local streets more than 9 times at the peak hours, compared to the off-peak hours (Table 4.36). The area in which the route of 1.7km (b) penetrates is a residential area and local streets is directly access to the entrance door of a house. There is no separation of roadway and pedestrian road so that the negative effect mention in chapter 2 is maximized in this route.

Table 4.36. The comparison of the usage of local streets of the route K-M.

| Route | Off-peak hours | | | Peak hours | | |
|---|---|---|---|---|---|---|
| | Length of local streets (km) (A) | Total travel length (km) (B) | Ratio (%) (A/B) | Length of local streets (km) (C) | Total travel length (km) (D) | Ratio (%) (C/D) |
| 1.7 km (a) | 15.970 | 340 | 4.7 | 5.1104 | 108.8 | 4.7 |
| 1.7 km (b) | 0 | 0 | - | 144.571 | 231.2 | 62.53 |
| Total | 15.970 | 340 | 4.7 | 149.681 | 340 | 44.02 |

### 4.2.2.7. Route L-N

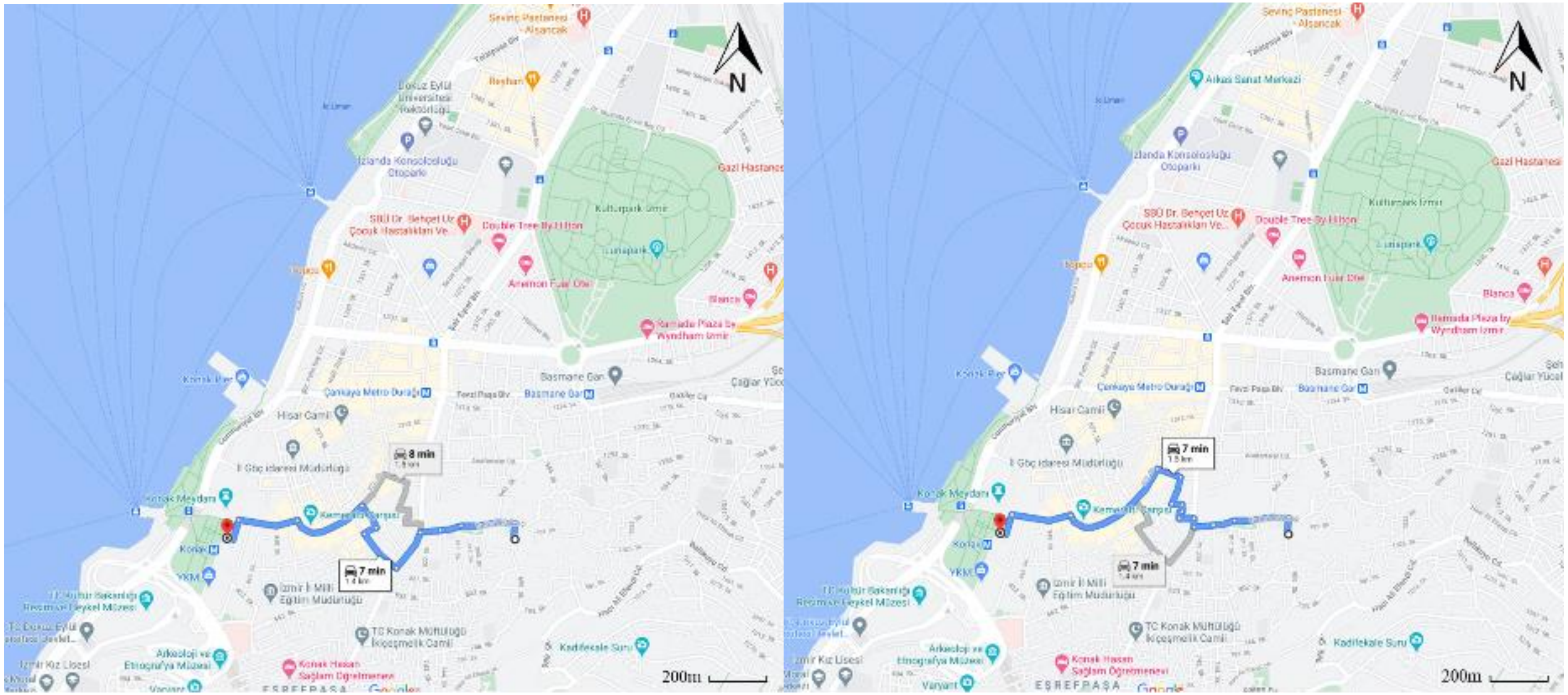


Figure 4.47. The most suggested route in off-peak hour (left: 1.4 km) and the peak hours (right: 1.5 km) of the route L-N.

There is only 0.1 km difference in total travel length between the off-peak hours and the peak hours, but it shows the different ways to access the destination. In the off-peak hours GM suggests arterial as much as it can, and then access to local streets. On the other hand, in the peak hours, the main road is relatively short and use local streets more (Figure 4.47). When there is serious congestion, GM suggests a much longer alternative route (Figure 4.48), but it does not appear often.

Table 4.37. The number of observations by the travel distance of the route L-N.

| Travel distance | Number of observations | |
|---|---|---|
| | Off-peak hours | Peak hours |
| 1.4 km | 200 | 0 |
| 1.5 km | 0 | 190 |
| 1.8 km | 0 | 10 |
| Total | 200 | 200 |

There is almost no alternative in both the off-peak hours and the peak hours (Table 4.37). In the off-peak hours, there is only one option, and in the peak hours, there are only 10 times different options is observed, other than that, it shows always show the same direction (95 pe cent

Table 4.38. The comparison of the usage of local streets of the route L-N.

| Route | Off-peak hours | | | Peak hours | | |
|---|---|---|---|---|---|---|
| | Length of local streets (km) (A) | Total travel length (km) (B) | Ratio (%) (A/B) | Length of local streets (km) (C) | Total travel length (km) (D) | Ratio (%) (C/D) |
| 1.4 km | 61.920 | 280 | 22.11 | 0 | 0 | - |
| 1.5 km | 0 | 0 | - | 90.8561 | 285 | 31.88 |
| 1.8 km | 0 | 0 | - | 7.0858 | 18 | 39.37 |
| Total | 61.92 | 280 | 22.11 | 97.9419 | 303 | 32.32 |

In a closer inspection of usage of local street usage, the percentage is higher at the peak hours (Table 4.38). This is because, in the off-peak hours, the main road is principally used, whereas, GM suggests more unstructured in the peak hours to avoid congestion, utilizing all types of roads. The length of the local streets of each route is 309.6m in case of 1.4 km, 478 m in case of 1.5km, and 708m in case of 1.8 km. The usage of local streets is 22.11 per cent in the off-peak hours, and 32.32 per cent in the peak hours. There are two routes that suggested in the peak hours, and all of them have a higher proportion of usage of local streets, compared to the general route in the off-peak hours (31.88 per cent and 39.32 per cent). The usage of local streets is highest at the route of 1.8 km, but it appears less over the observation.

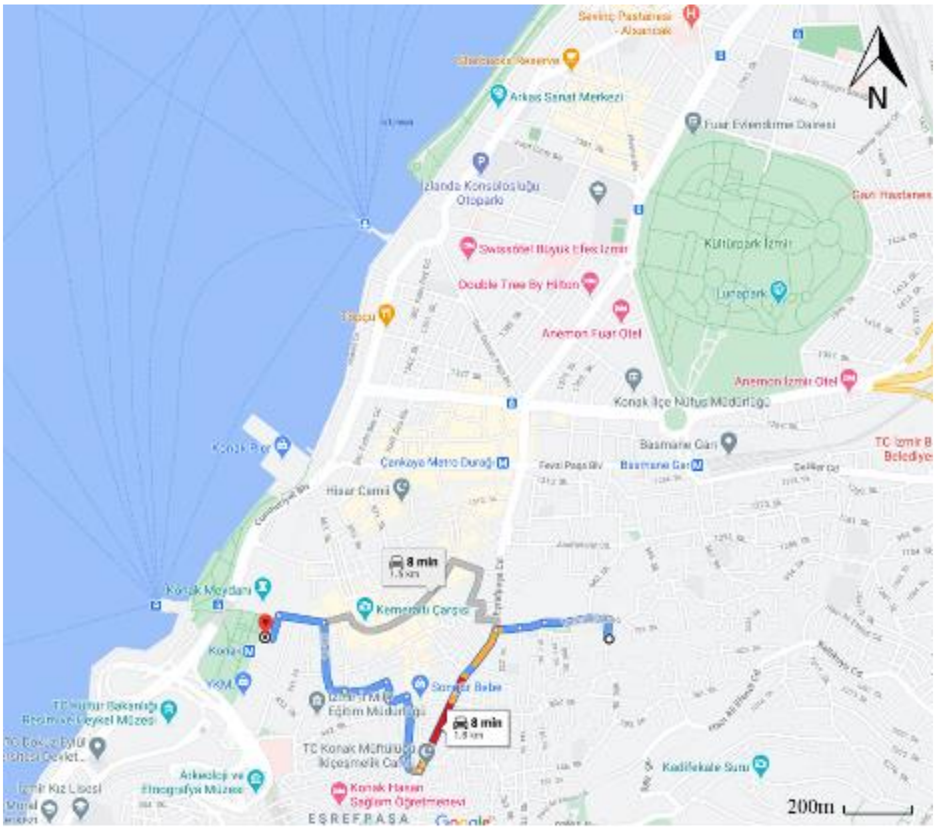


Figure 4.48. The alternative route (1.8 km) in the peak hours or the route L-N.

# CHAPTER 5

# DISCUSSION

We could clearly understand by data results; travel time and travel distance are mostly longer in the peak hours compared to the off-peak hours and usage of local streets are higher in the peak hours compared to the off-peak hours. The reason why it happens is that GM suggests a longer detour that using local streets in the peak hours to avoid congestion. Thus, the effect of using GM is that saving the travel time, making the longer travel distance, and allowing the higher usage of local streets.

The suggested route by Google map is the data gathered for the study, while the general choice is the assumption that when people drive without navigation systems, they would choose the shortest route or the same route of the off-peak hours (Table 5.1). Thus, the travel time with GM minus the travel time of general choice is saved time, and the travel distance of general choice minus the travel distance with GM is additional travel distance.

The saved travel time is around 8 minutes per trip in average. It is remarkable that saved time is more than 10 minutes in the route D-H, B-G, B-F, and C-F. The additional travel distance is approximately 5 km in average. There is more than 9 km of additional travel distance at the route D-H, A-F, B-G, and B-F. Mostly, when there is much saved travel time, there is more additional travel distance.

Table 5.1. The difference of travel time and travel distance caused by Google Maps in the peak hours of commuting trips in the overall city.

| | Suggested route by Google Maps | | General choice without navigation systems (the shortest route) | | Saved travel time (min) (C-A) | Additional travel distance (km) (B-D) |
|---|---|---|---|---|---|---|
| | Average travel time (min) (A) | Average travel distance (km) (B) | Average travel time (min) (C) | Travel distance (km) (D) | | |
| Route A-F | 48.2 | 35.92 | 57.5 | 26.2 | 9.3 | 9.72 |
| Route A-E | 41.39 | 30.92 | 45 | 30.6 | 3.61 | 0.32 |
| Route A-D | 23.98 | 20.59 | 24 | 20.8 | 0.02 | -0.21 |
| Route B-G | 48.02 | 38.98 | 61 | 29.5 | 12.98 | 9.48 |
| Route B-F | 44.03 | 32.47 | 57 | 23.6 | 12.97 | 8.87 |
| Route B-E | 38.01 | 26.76 | 40 | 26.2 | 1.99 | 0.56 |
| Route C-H | 46.29 | 28.35 | 52 | 19.9 | 5.71 | 8.45 |
| Route C-G | 43.74 | 30.28 | 52.5 | 24.2 | 8.76 | 6.08 |
| Route C-F | 39.89 | 23.65 | 50 | 18.3 | 10.11 | 5.35 |
| Route D-H | 39.27 | 33.2 | 60 | 19.1 | 20.73 | 14.1 |
| Route D-G | 32.47 | 25.85 | 42 | 25.1 | 9.53 | 0.75 |
| Route E-H | 20.56 | 21.9 | 22 | 21.8 | 1.44 | 0.1 |
| Average | 38.82 | 29.07 | 46.91 | 23.78 | 8.1 | 5.3 |

In table 5.2, we can see that the saved travel time and additional travel distance per vehicle. It means the time saving has happened only for one person. However, there is much more driver in İzmir. In some specific routes, the difference is not significant, but when we consider overall city scale, with the total number of drivers, it could show huge differences. With consideration of the population (Figure3.5) and the number of the vehicle (Figure 3.8) in İzmir, the number of drivers could be estimated at 781,738. The total estimated saved travel time caused by using GM is 75,945,846 minutes, approximately 1,265,764 hours (17 % of total estimated travel time) in commuting trips in the overall city (Table 5.2). Even though there is a regression in the route A-D, the estimated additional travel distance caused by using GM is 49,695,084 km (18 % of total estimated travel distance) in commuting trips in the overall city.

Table 5.2. The estimated saved travel time and the additional travel distance caused by Google Maps in the peak hours of commuting trips in the overall city.

| | Saved travel time per vehicle (min) | Additional travel distance per vehicle (km) | Estimated saved travel time of all vehicle (min) | Estimated additional travel distance of all vehicle (km) |
|---|---|---|---|---|
| Route A-F | 9.3 | 9.72 | 7,270,163 | 7,598,493 |
| Route A-E | 3.61 | 0.32 | 2,822,074 | 250,156 |
| Route A-D | 0.02 | -0.21 | 15,635 | -64,165 |
| Route B-G | 12.98 | 9.48 | 10,146,959 | 7,410,876 |
| Route B-F | 12.97 | 8.87 | 10,139,142 | 6,934,016 |
| Route B-E | 1.99 | 0.56 | 1,555,659 | 437,773 |
| Route C-H | 5.71 | 8.45 | 4,463,724 | 6,605,686 |
| Route C-G | 8.76 | 6.08 | 6,848,025 | 4,752,967 |
| Route C-F | 10.11 | 5.35 | 7,903,371 | 4,182,298 |
| Route D-H | 20.73 | 14.1 | 16,205,429 | 11,022,506 |
| Route D-G | 9.53 | 0.75 | 7,449,963 | 586,304 |
| Route E-H | 1.44 | 0.1 | 1,125,703 | 78,174 |
| Total | 97.15 | 63.57 | 75,945,846 | 49,695,084 |

The additional local streets usage is less than around 1.07 per cent overall (Figure 5.1). There is no usage of local streets in the route E-H and D-H, while, the other routes contain some usage of local streets, even though it is small. The total travel distance of commuting trips is 65,528 km and around 700 km of it is local streets.

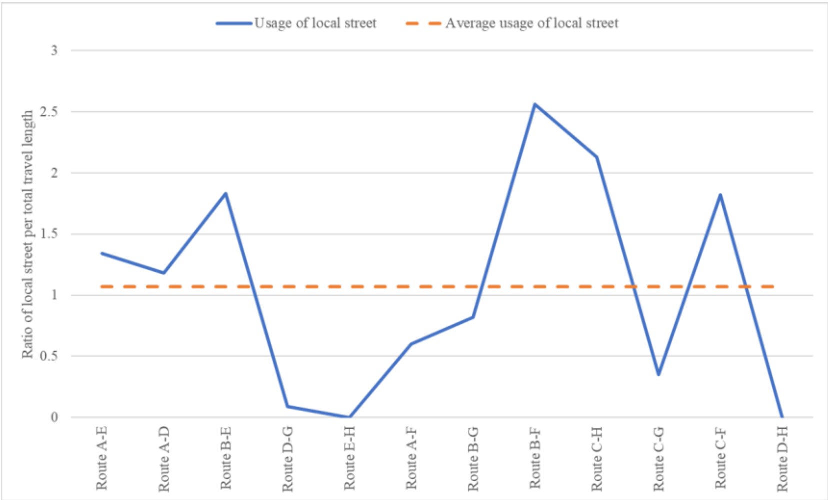


Figure 5.1. The additional usage of local streets in the peak hours of commuting trips in the overall city.

In the case of Short trips in CBD, the difference is smaller than the one of commuting trips, because the total scale of the travel time and the travel distance is smaller. However, there are still significant findings. The saved travel time is around 1 minute in average. The saved time of the route K-N, K-M, I-N, J-N, and J-L shows bigger than average. The additional travel distance is 0.15km in average (Table 5.3). It is prominent that the additional travel distance of the route I-N and I-L. Compared to commuting trips, there is no noticeable relationship between the saved time and the additional travel distance. It means regardless of the length of detour, there is chance that possible to save the travel time. For example, the additional travel distance is only 0.03 km in the route K-N, but the saved time is most among all route.

Table 5.3. The difference of travel time and travel distance caused by Google maps in the peak hours of short trips in CBD.

| | Suggested route by Google Maps | | General choice without navigation systems (the shortest route) | | Saved travel time (min) (C-A) | Additional travel distance (km) (B-D) |
|---|---|---|---|---|---|---|
| | Average travel time (min) (A) | Average travel distance (km) (B) | Average travel time (min) (C) | Travel distance (km) (D) | | |
| Route I-N | 17.52 | 3.93 | 19 | 3.2 | 1.48 | 0.73 |
| Route I-M | 13.5 | 2.7 | 14.5 | 2.6 | 1 | 0.1 |
| Route I-L | 14.32 | 2.88 | 15 | 2.6 | 0.68 | 0.28 |
| Route J-N | 12.63 | 2.35 | 14 | 2.2 | 1.37 | 0.15 |
| Route J-M | 8.26 | 1.63 | 8.6 | 1.6 | 0.34 | 0.03 |
| Route J-L | 8.94 | 1.76 | 10 | 1.6 | 1.06 | 0.16 |
| Route K-I | 6.84 | 1.5 | 7.5 | 1.5 | 0.66 | 0 |
| Route K-N | 11.98 | 2.43 | 14 | 2.4 | 2.02 | 0.03 |
| Route K-M | 8.03 | 1.7 | 10 | 1.7 | 1.97 | 0 |
| Route L-N | 8.03 | 1.52 | 9 | 1.5 | 0.97 | 0.02 |
| Average | 11.01 | 2.24 | 12.16 | 2.09 | 1.16 | 0.15 |

When it comes to city scale, the total estimated saved travel time is 9,029,073 minutes, around 150,485 hours (9.5 % of the total estimated travel time) in short trip in CBD, and the estimated additional travel distance caused by using GM is 1,172,607 km (6 % of the total estimated travel distance) in short trip in CBD (Table 5.4).

Table 5.4. The estimated saved travel time and the additional travel distance caused by Google Maps in the peak hours of commuting trips in Short trips in CBD.

| | Saved travel time per vehicle (min) | Additional travel distance per vehicle (km) | Estimated saved travel time of all vehicle (min) | Estimated additional travel distance of all vehicle (km) |
|---|---|---|---|---|
| Route I-N | 1.48 | 0.73 | 1,156,972 | 570,669 |
| Route I-M | 1 | 0.1 | 781,738 | 78,174 |
| Route I-L | 0.68 | 0.28 | 531,582 | 218,887 |
| Route J-N | 1.37 | 0.15 | 1,070,981 | 117,261 |
| Route J-M | 0.34 | 0.03 | 265,791 | 23,452 |
| Route J-L | 1.06 | 0.16 | 828,642 | 125,078 |
| Route K-I | 0.66 | 0 | 515,947 | 0 |
| Route K-N | 2.02 | 0.03 | 1,579,111 | 23,452 |
| Route K-M | 1.97 | 0 | 1,540,024 | 0 |
| Route L-N | 0.97 | 0.02 | 758,286 | 15,635 |
| Total | 11.55 | 1.5 | 9,029,073 | 1,172,607 |

The local streets usage is 1.7 times higher in the peak hours of short trips in CBD. It is noticeable that usage of local streets is more than 9 times in case of the route K-M. Total local streets length is 1069.102 km (23.87 % of the total travel distance) in the peak hours, while it is only 561.774 km (14 % of the total travel distance) in the off-peak hours.

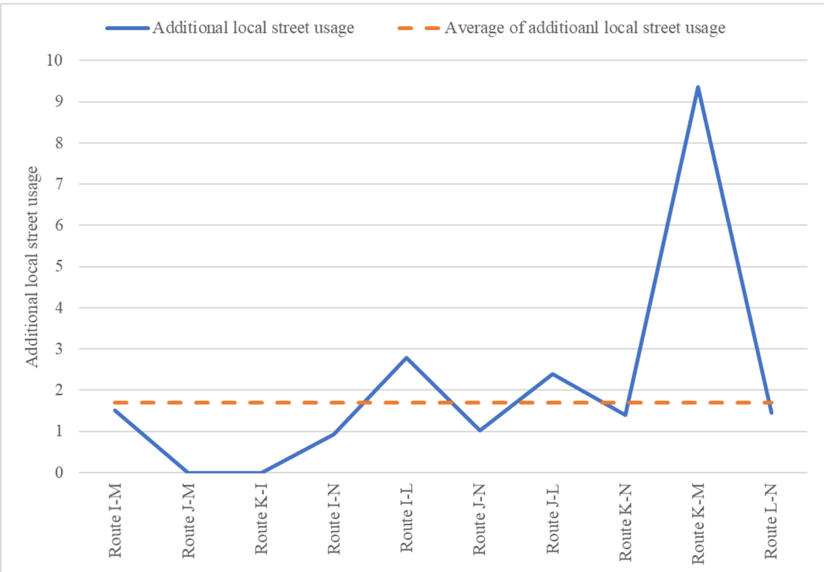


Figure 5.2. The additional usage of local streets of short trips in CBD.

Wardrop's equilibrium suggests the general idea rather than reflect the complicated the real-world exactly (Wardrop, 1952). Thus, it is hard to find an example of Wardrop's equilibrium in the real world. However, with navigation systems, it is expected to be realized by distributing the traffic evenly over the road network. Nonetheless, it is hard to say Wardrop's equilibrium is realized by GM in İzmir. The difference of travel time between the off-peak hours and the peak hours is compared to examine whether Wardrop's equilibrium is realized or not. In both cases, commuting trips and short trips, travel time is much longer in the peak hours even with help of navigation systems. The difference of time is the smallest at the route E-H (around 3 minutes), and L-N (around 1 minute) and it is the greatest at the route C-H (approximately 22 minutes) and I-N (approximately 7 minutes) (Table 5.5).

Even though the differences of travel time between off-peak and the peak hours are decreased by GM (Table 5.1), (Table 5.3) and there are some routes that show the subtle differences of travel time, it is hard to say Wardrop's equilibrium is realized, considering all routes.

Table 5.5. The average travel time of each route.

| Average travel time (min) | | | | | |
|---|---|---|---|---|---|
| Commuting trips in the overall city | | | Short trips in CBD | | |
| Route | Peak hours | Off-peak hours | Route | Peak hours | Off-peak hours |
| Route A-E | 41.385 | 23.72 | Route I-M | 13.505 | 7.345 |
| Route A-D | 23.98 | 19.12 | Route J-M | 8.255 | 4.28 |
| Route B-E | 38.025 | 21.13 | Route K-I | 6.835 | 5 |
| Route D-G | 32.465 | 22.205 | Route I-N | 17.52 | 10.695 |
| Route E-H | 20.555 | 17.575 | Route I-L | 14.315 | 8.325 |
| Route A-F | 48.2 | 29.27 | Route J-N | 12.63 | 7.375 |
| Route B-G | 48.02 | 30.89 | Route J-L | 8.935 | 5.005 |
| Route B-F | 44.03 | 27.78 | Route K-N | 11.98 | 7.73 |
| Route C-H | 46.285 | 24.16 | Route K-M | 8.03 | 4.785 |
| Route C-G | 43.74 | 26.265 | Route L-N | 8.025 | 7.02 |
| Route C-F | 39.89 | 24.2 | | | |
| Route D-H | 39.27 | 23.425 | | | |

There are two hypotheses in the study; (1) navigation systems affect road networks both positively and negatively, (2) navigation systems would realize Wardrop's equilibrium by distributing traffic evenly over the network. It is possible to say that the study proves the first one. GM leads drivers into alternative routes in the peak hours, so that the travel time is saved by using it. On the other hand, the total travel distance is increased in the peak hours, and along with it, usage of local streets is also raised. It would affect negatively the hierarchy of roads.

In contrast, there is no firm data that the second one is verified. Even if the travel time is saved over the whole route by GM, there is still a noticeable difference in the travel time between the off-peak and the peak hours. There are three possible reasons why Wardrop's equilibrium is not realized with GM. First, the usage rate of GM might be low in İzmir. Because when more people use navigation systems, the traffic distributes more evenly. It is necessary for a sufficient number of drivers uses navigation systems while driving. Second, there could be a lack of reliable road infrastructure. It means that despite the efficient utilization of the network, traffic congestion is not dissolved. Lastly, because of the inherent error, GM suggests the wrong path. It might make GM suggest the shortest route in the peak hours, or the longer detour in the off-peak hours.

# CHAPTER 6

# CONCLUSION

Traffic congestion is a crucial problem over the world. It is not a simple problem that could be solved by one solution, because the factors that affect the congestion are structurally intermingled and complicated. With the growth of traffic congestion, the ICT is developed concurrently. It could present a new type of solution for the traffic congestion by increasing the efficiency of road infrastructure. Without sharing information, each driver could never understand about the congestion on roads, resulting in more serious problems on the network. However, when drivers utilize the navigation systems, the equilibrium condition would probably be realized. Even though the travel distance of the suggested route by the navigation systems is longer, it could be faster in terms of travel time. The navigation systems calculate the optimal route at every moment, which human beings could not accomplish themselves. It is not necessary to invest in new road infrastructure, but using the current capacity of infrastructure, traffic congestion could be dissolved.

On the other hand, the navigation system could not understand the hierarchy of roads. In the case of local streets, it should be a pedestrian-friendly and low-speed environment. It is a tool to access destinations, not to deliver vehicles. A trip should start at a local street, and then vehicle access to arterial or highway to move faster. Afterward, it is off the arterial and takes a local street again to get closer to the destination with slow speed. Thus, through traffic should be appeared in local streets. It is not only the expectation of planners but also implicit consent among citizens, who share the spaces. No one expects a high-speed vehicle near their home, and a low-speed vehicle in the middle of a highway. However, when navigation systems try to find the shortest route regardless of the hierarchy of roads, the systems might guide drivers through the local streets in the middle of the trip. When a driver encounters the local streets while a destination is still far, they may recognize the local streets as part of arterial, driving fast.

The study is conducted to find out the effects of navigation systems based on real-time traffic data in the case of İzmir. GM, one of the navigation systems on smartphones and the web, is mainly used to collect data in the study. The study area is the urban area of İzmir with two different scales; (1) commuting trips in the overall city (16 km in a straight line) and (2) short trip in CBD (2 km in a straight line). We locate arbitrary nodes on the circle, and generate hypothetical trips from nodes to the other nodes, and gather the travel time and travel distance of the suggested routes by GM. Also, for the statistical robustness, we take 200 data for the same route in the same hours over the days.

It is clear from collected data that in the peak hours, GM mostly suggests the longer travel route with more usage of local streets in the peak hours compared to the off-peak hours. The differences of travel distance between the peak hours and the off-peak hours are greater in commuting trips, but the difference of usage of local streets is greater in short trips in CBD. In both commuting trips and short trips, travel time is shortened by using GM.

In the case of commuting trips in the overall city, the total percentage of the usage of local streets is not high. However, in most of the routes (the route A-E, B-E, A-F, B-G, B-F, C-G, and C-F), the pattern of alternative routes that pass the local streets are similar to each other. The usage of local streets is focused near an intersection in Bornova that two highways cross, where traffic congestion is severe. To avoid the area, GM guide drivers into local streets instead of the highway. The origins and destinations of each route are close to each other so that the pattern of recommended local streets might be similar. However, there is a chance that the shortest route that the algorithm calculated is the same over the routes. In other words, among several options of local streets, only one path is recommended over all routes. It may cause problems when lots of drivers use GM simultaneously, tons of traffic volume suddenly flow into the narrow alleyways. In addition, when the local streets become congested, the problem would be spread to the other narrow local streets in the future.

In the case of short trips within CBD, usage of local streets is more noticeable. The pattern of the usage of local streets is not that clear, compared to the commuting trips in the overall city, but GM leads traffic into the local streets without a specific preference, considering only the shorter travel time and reacting sensitively to real-time traffic flow. Especially, when there is heavy congestion in business and commercial area, GM suggests the detour passing the residential area near CBD. When the trip is short, there are more options to choose so that the function of the navigation systems, which is distribution traffic equally over all alternatives, could be more effective. Even though it varies with the location of origin and destination, the usage of local streets is overall 1.6 times more in the peak hours. It means when more people use GM while driving, local streets would be more crowded. In both, commuting trips and short trips, the shape of the route passing local streets is complicated. Even though drivers are familiar with the regions, it is impossible to think of the suggested route without supporting of the navigation systems. In other words, without navigation systems, drivers would not pass the local streets.

However, in terms of whether the navigation systems could function as Wardrop's principle or not, it is not well realized. Even though travel time is saved and travel distance is lengthened by GM, there is still a considerable gap of the travel time between the peak hours and the off-peak hours. There could be three reasons; (1) usage of GM is too low to realize the equilibrium condition, (2) physical infrastructure is not enough compared to traffic volume, and (3) internal program (GM) errors occur. The first one is related to the limitation of the study, the proportion of drivers who use navigation systems while driving is not a controlled variable. Thus, we could not be sure about the reason, but we can expect the usage rate of navigation is quite less in Turkey. In the U.S. around 50 per cent of smartphone users use navigation service while driving in 2018 (Kunst, 2020). Considering the population that has smartphones, around 38 per cent of the population use navigation systems while driving in the U.S. (Pew research center, 2019). Again, assuming the proportion of drivers, using data of the number of motor vehicle per 1,000 population in the U.S. (838 vehicles per 1,000 population (FHWA, 2020)), 31.84 per cent of drivers use navigation systems in the U.S. With cursory comparison, using the number of motor vehicle per 1,000 population in İzmir (179 vehicles per 1,000 population in İzmir (TURKSTAT, 2020)), only 6.8 per cent of drivers use navigation systems in İzmir. Yet this level of usage might not lead to the realization of Wardrop's equilibrium. The second possible reason is that the infrastructure is physically less so that even with the most efficient utilization of roads, traffic congestion is inevitable. The last one is caused by the error of GM itself. GM generates congested zones based on not only traffic sensors and historical data, but also the movement of users. Thus, when many drivers wait for the traffic light, it sometimes shows congestion, even though it is not. There is an experiment that when a walker carries 99 smartphones in a handcart and walks slowly, GM shows the traffic congestion (Ahlert, 2020). It might be the reason why GM does not distribute traffic more equally over all possible routes. The correct reason could be revealed by a future study with manipulating the usage of navigation systems under the same condition.

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# APPENDIX A

# RAW DATA

Table A.1. Raw data of the route A-F and A-E.

| Route A-F | | | | Route A-E | | | |
|---|---|---|---|---|---|---|---|
| Off-peak hours | | Peak hours | | Off-peak hours | | Peak hours | |
| Travel time (min) | Travel distance (km) | Travel time (min) | Travel distance (km) | Travel time (min) | Travel distance (km) | Travel time (min) | Travel distance (km) |
| 30 | 26.2 | 43 | 36.3 | 24 | 30.6 | 38 | 30.6 |
| 30 | 26.2 | 48 | 36.3 | 24 | 30.6 | 38 | 30.6 |
| 29 | 26.2 | 51 | 36.3 | 24 | 30.6 | 44 | 30.6 |
| 29 | 26.2 | 50 | 36.3 | 24 | 30.6 | 43 | 30.6 |
| 30 | 36.3 | 50 | 36.3 | 24 | 30.6 | 44 | 30.6 |
| 29 | 26.2 | 48 | 36.3 | 24 | 30.6 | 43 | 30.6 |
| 29 | 26.2 | 46 | 36.3 | 24 | 30.6 | 41 | 30.6 |
| 29 | 26.2 | 48 | 36.3 | 24 | 30.6 | 41 | 30.6 |
| 29 | 26.2 | 48 | 36.3 | 24 | 30.6 | 41 | 30.6 |
| 30 | 26.2 | 43 | 36.3 | 24 | 30.6 | 37 | 30.6 |
| 30 | 26.2 | 46 | 36.3 | 25 | 30.6 | 40 | 30.6 |
| 30 | 26.2 | 44 | 36.3 | 24 | 30.6 | 38 | 30.6 |
| 29 | 26.2 | 41 | 36.3 | 24 | 30.6 | 36 | 30.6 |
| 30 | 26.2 | 41 | 36.3 | 24 | 30.6 | 36 | 30.6 |
| 29 | 26.2 | 41 | 36.3 | 24 | 30.6 | 35 | 30.6 |
| 29 | 26.2 | 39 | 36.3 | 24 | 30.6 | 34 | 30.6 |
| 30 | 26.2 | 37 | 36.3 | 24 | 30.6 | 31 | 30.6 |
| 29 | 36.3 | 35 | 36.3 | 24 | 30.6 | 30 | 30.6 |
| 30 | 26.2 | 34 | 36.3 | 24 | 30.6 | 28 | 30.6 |
| 29 | 26.2 | 34 | 36.3 | 24 | 30.6 | 29 | 30.6 |
| 29 | 26.2 | 52 | 26.2 | 24 | 30.6 | 45 | 30.6 |
| 29 | 26.2 | 55 | 36.3 | 24 | 30.6 | 47 | 30.6 |
| 30 | 26.2 | 55 | 36.3 | 24 | 30.6 | 47 | 30.6 |
| 29 | 26.2 | 56 | 36.3 | 23 | 30.6 | 48 | 30.6 |
| 30 | 26.2 | 53 | 36.3 | 23 | 30.6 | 46 | 30.6 |
| 29 | 36.3 | 51 | 36.3 | 23 | 30.6 | 45 | 30.6 |
| 30 | 26.2 | 50 | 36.3 | 23 | 30.6 | 43 | 30.6 |
| 29 | 26.2 | 52 | 36.3 | 24 | 30.6 | 45 | 30.6 |
| 29 | 26.2 | 47 | 36.3 | 24 | 30.6 | 41 | 30.6 |
| 30 | 36.3 | 46 | 36.3 | 23 | 30.6 | 40 | 30.6 |
| 29 | 26.2 | 50 | 36.3 | 24 | 30.6 | 44 | 30.6 |
| 29 | 26.2 | 49 | 36.3 | 24 | 30.6 | 43 | 30.6 |
| 29 | 26.2 | 48 | 36.3 | 23 | 30.6 | 42 | 30.6 |
| 29 | 26.2 | 44 | 36.3 | 23 | 30.6 | 38 | 30.6 |
| 29 | 36.3 | 43 | 36.3 | 23 | 30.6 | 37 | 30.6 |
| 29 | 26.2 | 40 | 36.3 | 23 | 30.6 | 34 | 30.6 |
| 29 | 26.2 | 38 | 36.3 | 23 | 30.6 | 32 | 30.6 |
| 29 | 26.2 | 37 | 36.3 | 23 | 30.6 | 31 | 30.6 |
| 28 | 26.2 | 34 | 36.3 | 23 | 30.6 | 28 | 30.6 |
| 28 | 26.2 | 34 | 36.3 | 23 | 30.6 | 28 | 30.6 |
| 30 | 26.2 | 67 | 36.3 | 24 | 30.6 | 61 | 30.6 |
| 30 | 26.2 | 66 | 36.3 | 24 | 30.6 | 60 | 30.6 |
| 30 | 26.2 | 57 | 38.1 | 24 | 30.6 | 50 | 32.6 |
| 29 | 26.2 | 58 | 38.1 | 24 | 30.6 | 51 | 32.6 |
| 29 | 26.2 | 58 | 38.1 | 24 | 30.6 | 53 | 32.6 |
| 29 | 26.2 | 61 | 36.3 | 24 | 30.6 | 50 | 32.6 |

**(cont. on next page)**

**Table A.1 (cont.)**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 20 | 26.2 | 56 | 38.4 | 24 | 30.6 | 49 | 32.6 |
| 20 | 26.2 | 55 | 38.4 | 24 | 30.6 | 49 | 32.9 |
| 20 | 26.2 | 55 | 38.4 | 24 | 30.6 | 49 | 32.9 |
| 20 | 26.2 | 53 | 38.4 | 24 | 30.6 | 47 | 32.9 |
| 29 | 26.2 | 48 | 36.3 | 24 | 30.6 | 42 | 30.6 |
| 29 | 36.3 | 48 | 36.3 | 24 | 30.6 | 42 | 30.6 |
| 29 | 26.2 | 48 | 36.3 | 24 | 30.6 | 42 | 30.6 |
| 30 | 26.2 | 47 | 36.3 | 24 | 30.6 | 41 | 30.6 |
| 29 | 26.2 | 46 | 36.3 | 25 | 30.6 | 40 | 30.6 |
| 29 | 26.2 | 45 | 36.3 | 24 | 30.6 | 39 | 30.6 |
| 29 | 26.2 | 44 | 36.3 | 24 | 30.6 | 38 | 30.6 |
| 29 | 26.2 | 41 | 36.3 | 24 | 30.6 | 35 | 30.6 |
| 29 | 26.2 | 41 | 36.3 | 24 | 30.6 | 35 | 30.6 |
| 30 | 26.2 | 40 | 36.3 | 24 | 30.6 | 34 | 30.6 |
| 30 | 26.2 | 51 | 36.3 | 25 | 30.6 | 45 | 30.6 |
| 30 | 26.2 | 53 | 36.3 | 24 | 30.6 | 46 | 30.6 |
| 30 | 26.2 | 52 | 36.3 | 24 | 30.6 | 45 | 30.6 |
| 30 | 26.2 | 50 | 36.3 | 24 | 30.6 | 44 | 30.6 |
| 30 | 26.2 | 51 | 36.3 | 24 | 30.6 | 43 | 30.6 |
| 30 | 26.2 | 49 | 36.3 | 24 | 30.6 | 42 | 30.6 |
| 29 | 26.2 | 50 | 36.3 | 24 | 30.6 | 43 | 30.6 |
| 29 | 26.2 | 49 | 36.3 | 24 | 30.6 | 49 | 32.6 |
| 29 | 26.2 | 49 | 36.3 | 24 | 30.6 | 49 | 30.6 |
| 29 | 26.2 | 45 | 36.3 | 24 | 30.6 | 40 | 30.6 |
| 29 | 36.3 | 41 | 36.3 | 24 | 30.6 | 35 | 30.6 |
| 29 | 26.2 | 41 | 36.3 | 24 | 30.6 | 35 | 30.6 |
| 29 | 26.2 | 42 | 36.3 | 24 | 30.6 | 36 | 30.6 |
| 29 | 26.2 | 41 | 36.3 | 24 | 30.6 | 35 | 30.6 |
| 29 | 26.2 | 41 | 36.3 | 24 | 30.6 | 35 | 30.6 |
| 30 | 26.2 | 41 | 36.3 | 24 | 30.6 | 35 | 30.6 |
| 30 | 26.2 | 40 | 36.3 | 24 | 30.6 | 34 | 30.6 |
| 29 | 26.2 | 40 | 36.3 | 24 | 30.6 | 33 | 30.6 |
| 29 | 26.2 | 38 | 36.3 | 24 | 30.6 | 32 | 30.6 |
| 29 | 26.2 | 37 | 36.3 | 24 | 30.6 | 31 | 30.6 |
| 30 | 36.3 | 43 | 36.3 | 24 | 30.6 | 37 | 30.6 |
| 30 | 36.3 | 42 | 36.3 | 24 | 30.6 | 36 | 30.6 |
| 30 | 36.3 | 42 | 36.3 | 23 | 30.6 | 36 | 30.6 |
| 30 | 26.2 | 41 | 36.3 | 24 | 30.6 | 35 | 30.6 |
| 30 | 26.2 | 42 | 36.3 | 24 | 30.6 | 36 | 30.6 |
| 29 | 26.2 | 43 | 36.3 | 24 | 30.6 | 37 | 30.6 |
| 30 | 26.2 | 43 | 36.3 | 24 | 30.6 | 37 | 30.6 |
| 30 | 26.2 | 42 | 36.3 | 24 | 30.6 | 36 | 30.6 |
| 30 | 26.2 | 40 | 36.3 | 23 | 30.6 | 34 | 30.6 |
| 29 | 26.2 | 39 | 36.3 | 23 | 30.6 | 34 | 30.6 |
| 30 | 26.2 | 70 | 36.3 | 24 | 30.6 | 61 | 30.6 |
| 30 | 26.2 | 70 | 36.3 | 24 | 30.6 | 63 | 30.6 |
| 30 | 26.2 | 71 | 36.3 | 24 | 30.6 | 63 | 30.6 |
| 30 | 26.2 | 70 | 36.3 | 24 | 30.6 | 63 | 30.6 |
| 30 | 26.2 | 69 | 36.3 | 24 | 30.6 | 63 | 30.6 |
| 30 | 26.2 | 67 | 36.3 | 24 | 30.6 | 59 | 30.6 |
| 30 | 26.2 | 67 | 36.3 | 24 | 30.6 | 59 | 30.6 |
| 30 | 26.2 | 68 | 36.3 | 24 | 30.6 | 59 | 30.6 |
| 30 | 26.2 | 65 | 36.3 | 24 | 30.6 | 58 | 30.6 |
| 30 | 26.2 | 65 | 36.3 | 24 | 30.6 | 58 | 30.6 |
| 30 | 26.2 | 40 | 36.3 | 24 | 30.6 | 33 | 30.6 |
| 30 | 26.2 | 41 | 36.3 | 24 | 30.6 | 34 | 30.6 |
| 30 | 26.2 | 41 | 36.3 | 24 | 30.6 | 35 | 30.6 |
| 29 | 26.2 | 41 | 36.3 | 27 | 30.6 | 35 | 30.6 |
| 29 | 26.2 | 41 | 36.3 | 27 | 30.6 | 35 | 30.6 |
| 29 | 26.2 | 55 | 36.3 | 24 | 30.6 | 35 | 30.6 |
| 29 | 26.2 | 59 | 36.3 | 24 | 30.6 | 36 | 30.6 |

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**Table A.1 (cont.)**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 29 | 26.2 | 57 | 36.3 | 24 | 30.6 | 35 | 30.6 |
| 29 | 26.2 | 57 | 36.3 | 24 | 30.6 | 35 | 30.6 |
| 29 | 26.2 | 58 | 36.3 | 24 | 30.6 | 34 | 30.6 |
| 30 | 26.2 | 43 | 36.3 | 24 | 30.6 | 37 | 30.6 |
| 29 | 26.2 | 43 | 36.3 | 24 | 30.6 | 38 | 30.6 |
| 29 | 26.2 | 44 | 36.3 | 24 | 30.6 | 39 | 30.6 |
| 29 | 26.2 | 44 | 36.3 | 23 | 30.6 | 38 | 30.6 |
| 29 | 26.2 | 44 | 36.3 | 23 | 30.6 | 37 | 30.6 |
| 29 | 26.2 | 43 | 36.3 | 23 | 30.6 | 37 | 30.6 |
| 29 | 26.2 | 43 | 36.3 | 23 | 30.6 | 37 | 30.6 |
| 30 | 26.2 | 42 | 36.3 | 23 | 30.6 | 37 | 30.6 |
| 29 | 26.2 | 41 | 36.3 | 23 | 30.6 | 34 | 30.6 |
| 29 | 26.2 | 40 | 36.3 | 24 | 30.6 | 34 | 30.6 |
| 30 | 26.2 | 61 | 36.3 | 24 | 30.6 | 55 | 30.6 |
| 30 | 26.2 | 59 | 26.2 | 24 | 30.6 | 39 | 30.6 |
| 30 | 26.2 | 61 | 26.2 | 23 | 30.6 | 39 | 30.6 |
| 29 | 26.2 | 61 | 36.3 | 23 | 30.6 | 50 | 32.6 |
| 29 | 26.2 | 55 | 36.3 | 23 | 30.6 | 49 | 32.6 |
| 29 | 26.2 | 59 | 36.3 | 23 | 30.6 | 46 | 32.6 |
| 30 | 26.2 | 54 | 36.3 | 23 | 30.6 | 47 | 30.6 |
| 29 | 26.2 | 57 | 36.3 | 23 | 30.6 | 50 | 30.6 |
| 30 | 26.2 | 54 | 36.3 | 24 | 30.6 | 47 | 30.6 |
| 29 | 26.2 | 53 | 36.3 | 24 | 30.6 | 47 | 30.6 |
| 30 | 26.2 | 47 | 36.3 | 24 | 30.6 | 41 | 30.6 |
| 30 | 26.2 | 46 | 36.3 | 23 | 30.6 | 40 | 30.6 |
| 30 | 26.2 | 46 | 36.3 | 23 | 30.6 | 39 | 30.6 |
| 30 | 26.2 | 44 | 36.3 | 24 | 30.6 | 38 | 30.6 |
| 31 | 26.2 | 42 | 36.3 | 24 | 30.6 | 37 | 30.6 |
| 30 | 26.2 | 42 | 36.3 | 24 | 30.6 | 36 | 30.6 |
| 30 | 26.2 | 41 | 36.3 | 24 | 30.6 | 35 | 30.6 |
| 30 | 26.2 | 40 | 36.3 | 23 | 30.6 | 35 | 30.6 |
| 30 | 26.2 | 39 | 36.3 | 23 | 30.6 | 33 | 30.6 |
| 29 | 26.2 | 37 | 36.3 | 23 | 30.6 | 31 | 30.6 |
| 29 | 26.2 | 55 | 38.1 | 23 | 30.6 | 47 | 32.6 |
| 29 | 26.2 | 57 | 38.1 | 23 | 30.6 | 50 | 32.6 |
| 29 | 26.2 | 58 | 38.1 | 23 | 30.6 | 55 | 32.6 |
| 29 | 26.2 | 68 | 38.1 | 23 | 30.6 | 57 | 32.6 |
| 29 | 26.2 | 68 | 38.1 | 23 | 30.6 | 58 | 32.6 |
| 29 | 26.2 | 68 | 26.2 | 23 | 30.6 | 54 | 32.6 |
| 29 | 26.2 | 68 | 26.2 | 23 | 30.6 | 54 | 32.6 |
| 29 | 26.2 | 61 | 38.1 | 23 | 30.6 | 55 | 32.6 |
| 29 | 26.2 | 66 | 26.2 | 23 | 30.6 | 56 | 32.6 |
| 29 | 26.2 | 64 | 26.2 | 23 | 30.6 | 55 | 32.6 |
| 28 | 26.2 | 49 | 36.3 | 23 | 30.6 | 43 | 30.6 |
| 28 | 26.2 | 51 | 36.3 | 23 | 30.6 | 45 | 30.6 |
| 29 | 26.2 | 49 | 36.3 | 24 | 30.6 | 43 | 30.6 |
| 29 | 26.2 | 51 | 36.3 | 24 | 30.6 | 45 | 30.6 |
| 29 | 26.2 | 45 | 36.3 | 24 | 30.6 | 40 | 30.6 |
| 29 | 26.2 | 45 | 36.3 | 24 | 30.6 | 39 | 30.6 |
| 29 | 26.2 | 44 | 36.3 | 24 | 30.6 | 38 | 30.6 |
| 29 | 26.2 | 41 | 36.3 | 24 | 30.6 | 35 | 30.6 |
| 29 | 26.2 | 40 | 36.3 | 24 | 30.6 | 34 | 30.6 |
| 29 | 26.2 | 38 | 36.3 | 24 | 30.6 | 33 | 30.6 |
| 29 | 26.2 | 42 | 36.3 | 24 | 30.6 | 36 | 30.6 |
| 30 | 26.2 | 42 | 36.3 | 24 | 30.6 | 36 | 30.6 |
| 29 | 26.2 | 43 | 36.3 | 23 | 30.6 | 37 | 30.6 |
| 29 | 26.2 | 41 | 36.3 | 23 | 30.6 | 36 | 30.6 |
| 30 | 26.2 | 38 | 36.3 | 24 | 30.6 | 32 | 30.6 |
| 30 | 26.2 | 39 | 36.3 | 24 | 30.6 | 33 | 30.6 |
| 30 | 26.2 | 39 | 36.3 | 23 | 30.6 | 33 | 30.6 |
| 30 | 26.2 | 40 | 36.3 | 23 | 30.6 | 34 | 30.6 |

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**Table A.1 (cont.)**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 29 | 26.2 | 40 | 36.3 | 23 | 30.6 | 35 | 30.6 |
| 29 | 26.2 | 37 | 36.3 | 23 | 30.6 | 32 | 30.6 |
| 29 | 26.2 | 38 | 36.3 | 24 | 30.6 | 33 | 30.6 |
| 29 | 26.2 | 38 | 36.3 | 24 | 30.6 | 32 | 30.6 |
| 29 | 26.2 | 38 | 36.3 | 23 | 30.6 | 32 | 30.6 |
| 30 | 26.2 | 37 | 36.3 | 23 | 30.6 | 31 | 30.6 |
| 30 | 26.2 | 35 | 36.3 | 23 | 30.6 | 29 | 30.6 |
| 30 | 26.2 | 34 | 36.3 | 23 | 30.6 | 28 | 30.6 |
| 30 | 26.2 | 33 | 36.3 | 23 | 30.6 | 28 | 30.6 |
| 30 | 26.2 | 33 | 36.3 | 23 | 30.6 | 28 | 30.6 |
| 29 | 26.2 | 33 | 36.3 | 23 | 30.6 | 28 | 30.6 |
| 29 | 26.2 | 33 | 36.3 | 23 | 30.6 | 28 | 30.6 |
| 31 | 26.2 | 45 | 36.3 | 23 | 30.6 | 41 | 30.6 |
| 30 | 26.2 | 44 | 36.3 | 24 | 30.6 | 40 | 30.6 |
| 31 | 26.2 | 44 | 36.3 | 24 | 30.6 | 42 | 30.6 |
| 31 | 26.2 | 43 | 36.3 | 24 | 30.6 | 43 | 30.6 |
| 30 | 26.2 | 40 | 36.3 | 24 | 30.6 | 41 | 30.6 |
| 30 | 26.2 | 39 | 36.3 | 24 | 30.6 | 40 | 30.6 |
| 30 | 26.2 | 40 | 36.3 | 24 | 30.6 | 39 | 30.6 |
| 29 | 26.2 | 41 | 36.3 | 24 | 30.6 | 38 | 30.6 |
| 29 | 26.2 | 42 | 36.3 | 24 | 30.6 | 38 | 30.6 |
| 29 | 26.2 | 40 | 36.3 | 24 | 30.6 | 39 | 30.6 |
| 30 | 26.2 | 55 | 38.1 | 24 | 30.6 | 47 | 32.6 |
| 30 | 26.2 | 57 | 38.1 | 23 | 30.6 | 50 | 32.6 |
| 30 | 26.2 | 58 | 38.1 | 23 | 30.6 | 55 | 32.6 |
| 30 | 26.2 | 68 | 38.1 | 24 | 30.6 | 57 | 32.6 |
| 31 | 26.2 | 68 | 38.1 | 24 | 30.6 | 58 | 32.6 |
| 30 | 26.2 | 68 | 26.2 | 24 | 30.6 | 54 | 32.6 |
| 30 | 26.2 | 68 | 26.2 | 24 | 30.6 | 54 | 32.6 |
| 30 | 26.2 | 61 | 38.1 | 23 | 30.6 | 55 | 32.6 |
| 30 | 26.2 | 66 | 26.2 | 23 | 30.6 | 56 | 32.6 |
| 29 | 26.2 | 64 | 26.2 | 23 | 30.6 | 55 | 32.6 |

Table A.2. Raw data of the route A-D and B-G.

| Route A-D | | | | Route B-G | | | |
|---|---|---|---|---|---|---|---|
| Off-peak hours | | Peak hours | | Off-peak hours | | Peak hours | |
| Travel time (min) | Travel distance (km) | Travel time (min) | Travel distance (km) | Travel time (min) | Travel distance (km) | Travel time (min) | Travel distance (km) |
| 19 | 20.8 | 21 | 20.8 | 32 | 29.5 | 42 | 38.5 |
| 20 | 20.8 | 22 | 20.8 | 31 | 29.5 | 48 | 38.5 |
| 19 | 20.8 | 23 | 20.8 | 31 | 29.5 | 50 | 38.5 |
| 19 | 20.8 | 23 | 20.8 | 31 | 29.5 | 50 | 38.5 |
| 19 | 20.8 | 22 | 20.8 | 31 | 29.5 | 49 | 38.5 |
| 19 | 20.8 | 22 | 20.8 | 31 | 29.5 | 49 | 38.5 |
| 19 | 20.8 | 21 | 20.8 | 30 | 29.5 | 48 | 38.5 |
| 19 | 20.8 | 22 | 20.8 | 30 | 29.5 | 50 | 38.5 |
| 19 | 20.8 | 21 | 20.8 | 31 | 29.5 | 50 | 38.5 |
| 19 | 20.8 | 21 | 20.8 | 31 | 29.5 | 45 | 38.5 |
| 20 | 20.8 | 22 | 20.8 | 32 | 29.5 | 46 | 38.5 |
| 19 | 20.8 | 21 | 20.8 | 31 | 29.5 | 44 | 38.5 |
| 19 | 20.8 | 21 | 20.8 | 31 | 29.5 | 42 | 38.5 |
| 20 | 20.8 | 21 | 20.8 | 31 | 29.5 | 42 | 38.5 |
| 20 | 20.8 | 21 | 20.8 | 32 | 29.5 | 41 | 38.5 |
| 20 | 20.8 | 21 | 20.8 | 32 | 29.5 | 39 | 38.5 |
| 20 | 20.8 | 21 | 20.8 | 30 | 29.5 | 38 | 38.5 |
| 19 | 20.8 | 21 | 20.8 | 32 | 29.5 | 36 | 38.5 |
| 19 | 20.8 | 20 | 20.8 | 31 | 29.5 | 35 | 38.5 |
| 19 | 20.8 | 20 | 20.8 | 32 | 29.5 | 35 | 38.5 |

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**Table A.2 (cont.)**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 9 | 20.8 | 22 | 20.8 | 30 | 29.5 | 52 | 38.5 |
| 19 | 20.8 | 26 | 20.8 | 30 | 29.5 | 51 | 38.5 |
| 19 | 20.8 | 27 | 20.8 | 30 | 29.5 | 48 | 38.5 |
| 19 | 20.8 | 29 | 20.8 | 30 | 29.5 | 47 | 38.5 |
| 19 | 20.8 | 27 | 20.8 | 32 | 29.5 | 48 | 38.5 |
| 19 | 20.8 | 27 | 20.8 | 31 | 29.5 | 47 | 38.5 |
| 19 | 20.8 | 27 | 20.8 | 31 | 29.5 | 44 | 38.5 |
| 19 | 20.8 | 28 | 20.8 | 31 | 29.5 | 45 | 38.5 |
| 19 | 20.8 | 27 | 20.8 | 30 | 29.5 | 43 | 38.5 |
| 19 | 20.8 | 27 | 20.8 | 31 | 29.5 | 42 | 38.5 |
| 19 | 20.8 | 22 | 20.8 | 31 | 29.5 | 50 | 38.5 |
| 19 | 20.8 | 21 | 20.8 | 31 | 29.5 | 50 | 38.5 |
| 19 | 20.8 | 21 | 20.8 | 30 | 29.5 | 49 | 38.5 |
| 19 | 20.8 | 21 | 20.8 | 30 | 29.5 | 45 | 38.5 |
| 19 | 20.8 | 21 | 20.8 | 30 | 29.5 | 44 | 38.5 |
| 19 | 20.8 | 20 | 20.8 | 30 | 29.5 | 41 | 38.5 |
| 19 | 20.8 | 20 | 20.8 | 30 | 29.5 | 39 | 38.5 |
| 19 | 20.8 | 20 | 20.8 | 30 | 29.5 | 38 | 38.5 |
| 19 | 20.8 | 20 | 20.8 | 30 | 29.5 | 35 | 38.5 |
| 19 | 20.8 | 20 | 20.8 | 30 | 29.5 | 35 | 38.5 |
| 19 | 20.8 | 30 | 20.8 | 31 | 29.5 | 63 | 38.5 |
| 19 | 20.8 | 30 | 19.7 | 31 | 29.5 | 63 | 38.5 |
| 19 | 20.8 | 30 | 19.7 | 31 | 29.5 | 58 | 41 |
| 19 | 20.8 | 31 | 19.7 | 30 | 29.5 | 59 | 41 |
| 19 | 20.8 | 32 | 19.7 | 30 | 29.5 | 60 | 41 |
| 19 | 20.8 | 30 | 20.8 | 30 | 29.5 | 58 | 41 |
| 19 | 20.8 | 28 | 20.8 | 31 | 29.5 | 58 | 41 |
| 19 | 20.8 | 28 | 20.8 | 31 | 29.5 | 58 | 41.3 |
| 19 | 20.8 | 27 | 19.7 | 31 | 29.5 | 57 | 41.3 |
| 19 | 20.8 | 27 | 19.7 | 31 | 29.5 | 56 | 41.3 |
| 20 | 20.8 | 22 | 20.8 | 31 | 29.5 | 49 | 38.5 |
| 19 | 20.8 | 21 | 20.8 | 30 | 38.5 | 48 | 38.5 |
| 19 | 20.8 | 21 | 20.8 | 31 | 29.5 | 48 | 38.5 |
| 19 | 20.8 | 21 | 20.8 | 31 | 29.5 | 47 | 38.5 |
| 19 | 20.8 | 21 | 20.8 | 31 | 29.5 | 45 | 38.5 |
| 19 | 20.8 | 21 | 20.8 | 31 | 29.5 | 46 | 38.5 |
| 19 | 20.8 | 21 | 20.8 | 31 | 29.5 | 45 | 38.5 |
| 19 | 20.8 | 20 | 20.8 | 31 | 29.5 | 42 | 38.5 |
| 19 | 20.8 | 20 | 20.8 | 31 | 29.5 | 42 | 38.5 |
| 19 | 20.8 | 20 | 20.8 | 31 | 29.5 | 41 | 38.5 |
| 20 | 20.8 | 22 | 20.8 | 31 | 29.5 | 52 | 38.5 |
| 20 | 20.8 | 23 | 20.8 | 31 | 29.5 | 52 | 38.5 |
| 19 | 20.8 | 23 | 20.8 | 31 | 29.5 | 50 | 38.5 |
| 20 | 20.8 | 22 | 20.8 | 31 | 29.5 | 49 | 38.5 |
| 19 | 20.8 | 22 | 20.8 | 31 | 29.5 | 49 | 38.5 |
| 19 | 20.8 | 22 | 20.8 | 31 | 29.5 | 50 | 38.5 |
| 19 | 20.8 | 21 | 20.8 | 31 | 29.5 | 51 | 38.5 |
| 19 | 20.8 | 21 | 20.8 | 31 | 29.5 | 50 | 38.5 |
| 19 | 20.8 | 21 | 20.8 | 31 | 29.5 | 49 | 38.5 |
| 19 | 20.8 | 21 | 20.8 | 31 | 29.5 | 46 | 38.5 |
| 20 | 20.8 | 22 | 20.8 | 30 | 38.5 | 41 | 38.5 |
| 19 | 20.8 | 22 | 20.8 | 30 | 38.5 | 41 | 38.5 |
| 20 | 20.8 | 22 | 20.8 | 30 | 38.5 | 42 | 38.5 |
| 19 | 20.8 | 22 | 20.8 | 30 | 29.5 | 42 | 38.5 |
| 19 | 20.8 | 22 | 20.8 | 31 | 29.5 | 41 | 38.5 |
| 19 | 20.8 | 22 | 20.8 | 31 | 29.5 | 41 | 38.5 |
| 19 | 20.8 | 22 | 20.8 | 31 | 29.5 | 40 | 38.5 |
| 19 | 20.8 | 21 | 20.8 | 31 | 29.5 | 40 | 38.5 |
| 19 | 20.8 | 21 | 20.8 | 31 | 29.5 | 39 | 38.5 |
| 19 | 20.8 | 21 | 20.8 | 31 | 29.5 | 38 | 38.5 |
| 20 | 20.8 | 22 | 20.8 | 32 | 29.5 | 42 | 38.5 |

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**Table A.2 (cont.)**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 19 | 20.8 | 22 | 20.8 | 31 | 29.5 | 42 | 38.5 |
| 19 | 20.8 | 22 | 20.8 | 31 | 29.5 | 42 | 38.5 |
| 19 | 20.8 | 21 | 20.8 | 31 | 29.5 | 42 | 38.5 |
| 19 | 20.8 | 21 | 20.8 | 31 | 29.5 | 42 | 38.5 |
| 19 | 20.8 | 22 | 20.8 | 31 | 29.5 | 44 | 38.5 |
| 19 | 20.8 | 22 | 20.8 | 31 | 29.5 | 44 | 38.5 |
| 19 | 20.8 | 21 | 20.8 | 32 | 29.5 | 43 | 38.5 |
| 19 | 20.8 | 21 | 20.8 | 32 | 29.5 | 41 | 38.5 |
| 19 | 20.8 | 21 | 20.8 | 31 | 29.5 | 40 | 38.5 |
| 19 | 20.8 | 33 | 19.7 | 31 | 29.5 | 63 | 41 |
| 19 | 20.8 | 34 | 19.7 | 31 | 29.5 | 70 | 41 |
| 19 | 20.8 | 38 | 19.7 | 31 | 29.5 | 70 | 41 |
| 19 | 20.8 | 38 | 19.7 | 31 | 29.5 | 72 | 41 |
| 19 | 20.8 | 40 | 19.7 | 31 | 29.5 | 71 | 41 |
| 20 | 20.8 | 41 | 19.7 | 31 | 29.5 | 69 | 38.5 |
| 20 | 20.8 | 40 | 19.7 | 31 | 29.5 | 69 | 38.5 |
| 19 | 20.8 | 43 | 20.8 | 31 | 29.5 | 70 | 38.5 |
| 19 | 20.8 | 40 | 20.8 | 31 | 29.5 | 70 | 38.5 |
| 19 | 20.8 | 35 | 20.8 | 31 | 29.5 | 71 | 38.5 |
| 19 | 20.8 | 21 | 20.8 | 31 | 29.5 | 39 | 38.5 |
| 20 | 20.8 | 22 | 20.8 | 32 | 29.5 | 40 | 38.5 |
| 19 | 20.8 | 22 | 20.8 | 31 | 29.5 | 41 | 38.5 |
| 19 | 20.8 | 22 | 20.8 | 30 | 29.5 | 41 | 38.5 |
| 19 | 20.8 | 22 | 20.8 | 31 | 29.5 | 41 | 38.5 |
| 19 | 20.8 | 21 | 20.8 | 31 | 29.5 | 34 | 38.5 |
| 19 | 20.8 | 21 | 20.8 | 31 | 29.5 | 33 | 38.5 |
| 19 | 20.8 | 21 | 20.8 | 30 | 29.5 | 31 | 38.5 |
| 19 | 20.8 | 21 | 20.8 | 30 | 29.5 | 32 | 38.5 |
| 19 | 20.8 | 21 | 20.8 | 30 | 29.5 | 32 | 38.5 |
| 19 | 20.8 | 23 | 20.8 | 31 | 29.5 | 42 | 38.5 |
| 19 | 20.8 | 23 | 20.8 | 31 | 29.5 | 42 | 38.5 |
| 19 | 20.8 | 23 | 20.8 | 31 | 29.5 | 43 | 38.5 |
| 19 | 20.8 | 23 | 20.8 | 31 | 29.5 | 42 | 38.5 |
| 19 | 20.8 | 23 | 20.8 | 32 | 29.5 | 42 | 38.5 |
| 19 | 20.8 | 22 | 20.8 | 31 | 29.5 | 43 | 38.5 |
| 19 | 20.8 | 22 | 20.8 | 31 | 29.5 | 43 | 38.5 |
| 19 | 20.8 | 22 | 20.8 | 31 | 29.5 | 43 | 38.5 |
| 19 | 20.8 | 21 | 20.8 | 31 | 29.5 | 41 | 38.5 |
| 19 | 20.8 | 22 | 20.8 | 31 | 29.5 | 41 | 38.5 |
| 19 | 20.8 | 25 | 19.7 | 32 | 29.5 | 58 | 41 |
| 19 | 20.8 | 27 | 19.7 | 31 | 29.5 | 59 | 41 |
| 19 | 20.8 | 27 | 19.7 | 31 | 29.5 | 58 | 41 |
| 19 | 20.8 | 27 | 19.7 | 31 | 29.5 | 58 | 41 |
| 19 | 20.8 | 26 | 19.7 | 31 | 29.5 | 57 | 41 |
| 19 | 20.8 | 26 | 19.7 | 30 | 29.5 | 46 | 38.5 |
| 19 | 20.8 | 26 | 19.7 | 30 | 29.5 | 53 | 38.5 |
| 19 | 20.8 | 27 | 20.8 | 30 | 29.5 | 58 | 38.5 |
| 19 | 20.8 | 26 | 20.8 | 30 | 29.5 | 55 | 38.5 |
| 19 | 20.8 | 26 | 20.8 | 30 | 29.5 | 54 | 38.5 |
| 19 | 20.8 | 22 | 20.8 | 30 | 29.5 | 46 | 38.5 |
| 19 | 20.8 | 22 | 20.8 | 30 | 29.5 | 46 | 38.5 |
| 19 | 20.8 | 23 | 20.8 | 30 | 29.5 | 45 | 38.5 |
| 19 | 20.8 | 23 | 20.8 | 31 | 29.5 | 43 | 38.5 |
| 20 | 20.8 | 22 | 20.8 | 30 | 29.5 | 44 | 38.5 |
| 20 | 20.8 | 21 | 20.8 | 30 | 29.5 | 42 | 38.5 |
| 19 | 20.8 | 21 | 20.8 | 30 | 29.5 | 42 | 38.5 |
| 19 | 20.8 | 21 | 20.8 | 31 | 29.5 | 41 | 38.5 |
| 19 | 20.8 | 21 | 20.8 | 31 | 29.5 | 40 | 38.5 |
| 19 | 20.8 | 20 | 20.8 | 30 | 29.5 | 38 | 38.5 |
| 19 | 20.8 | 23 | 19.7 | 32 | 29.5 | 65 | 41 |
| 19 | 20.8 | 25 | 19.7 | 31 | 29.5 | 58 | 41 |

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**Table A.2 (cont.)**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 19 | 20.8 | 29 | 19.7 | 31 | 29.5 | 66 | 41 |
| 19 | 20.8 | 29 | 19.7 | 31 | 29.5 | 66 | 41 |
| 19 | 20.8 | 28 | 19.7 | 31 | 29.5 | 69 | 41 |
| 19 | 20.8 | 30 | 19.7 | 31 | 29.5 | 69 | 41 |
| 19 | 20.8 | 32 | 19.7 | 31 | 29.5 | 68 | 41 |
| 19 | 20.8 | 34 | 19.7 | 31 | 29.5 | 68 | 41 |
| 19 | 20.8 | 34 | 20.8 | 31 | 29.5 | 67 | 41 |
| 19 | 20.8 | 33 | 19.7 | 32 | 29.5 | 66 | 41 |
| 19 | 20.8 | 22 | 20.8 | 31 | 29.5 | 48 | 38.5 |
| 19 | 20.8 | 23 | 20.8 | 30 | 29.5 | 50 | 38.5 |
| 19 | 20.8 | 23 | 20.8 | 30 | 29.5 | 49 | 38.5 |
| 20 | 20.8 | 26 | 20.8 | 30 | 29.5 | 52 | 38.5 |
| 19 | 20.8 | 22 | 20.8 | 31 | 29.5 | 46 | 38.5 |
| 19 | 20.8 | 21 | 20.8 | 31 | 29.5 | 46 | 38.5 |
| 19 | 20.8 | 21 | 20.8 | 31 | 29.5 | 45 | 38.5 |
| 19 | 20.8 | 21 | 20.8 | 31 | 29.5 | 42 | 38.5 |
| 19 | 20.8 | 20 | 20.8 | 30 | 29.5 | 40 | 38.5 |
| 19 | 20.8 | 20 | 20.8 | 30 | 29.5 | 39 | 38.5 |
| 20 | 20.8 | 23 | 20.8 | 31 | 29.5 | 41 | 38.5 |
| 20 | 20.8 | 23 | 20.8 | 31 | 29.5 | 41 | 38.5 |
| 19 | 20.8 | 23 | 20.8 | 31 | 29.5 | 41 | 38.5 |
| 19 | 20.8 | 22 | 20.8 | 31 | 29.5 | 40 | 38.5 |
| 19 | 20.8 | 22 | 20.8 | 32 | 29.5 | 38 | 38.5 |
| 19 | 20.8 | 22 | 20.8 | 32 | 29.5 | 39 | 38.5 |
| 19 | 20.8 | 22 | 20.8 | 32 | 29.5 | 39 | 38.5 |
| 19 | 20.8 | 21 | 20.8 | 32 | 29.5 | 40 | 38.5 |
| 19 | 20.8 | 21 | 20.8 | 31 | 29.5 | 41 | 38.5 |
| 19 | 20.8 | 20 | 20.8 | 31 | 29.5 | 38 | 38.5 |
| 20 | 20.8 | 21 | 20.8 | 31 | 29.5 | 39 | 38.5 |
| 19 | 20.8 | 20 | 20.8 | 31 | 29.5 | 39 | 38.5 |
| 19 | 20.8 | 21 | 20.8 | 32 | 29.5 | 38 | 38.5 |
| 19 | 20.8 | 21 | 20.8 | 32 | 29.5 | 38 | 38.5 |
| 19 | 20.8 | 20 | 20.8 | 31 | 29.5 | 36 | 38.5 |
| 19 | 20.8 | 20 | 20.8 | 31 | 29.5 | 36 | 38.5 |
| 19 | 20.8 | 20 | 20.8 | 31 | 29.5 | 36 | 38.5 |
| 19 | 20.8 | 20 | 20.8 | 31 | 29.5 | 36 | 38.5 |
| 19 | 20.8 | 20 | 20.8 | 31 | 29.5 | 36 | 38.5 |
| 19 | 20.8 | 20 | 20.8 | 31 | 29.5 | 36 | 38.5 |
| 19 | 20.8 | 20 | 20.8 | 32 | 29.5 | 46 | 38.5 |
| 19 | 20.8 | 21 | 20.8 | 32 | 29.5 | 46 | 38.5 |
| 19 | 20.8 | 22 | 20.8 | 32 | 29.5 | 45 | 38.5 |
| 19 | 20.8 | 22 | 20.8 | 32 | 29.5 | 45 | 38.5 |
| 19 | 20.8 | 22 | 20.8 | 32 | 29.5 | 46 | 38.5 |
| 19 | 20.8 | 22 | 20.8 | 32 | 29.5 | 47 | 38.5 |
| 19 | 20.8 | 20 | 20.8 | 32 | 29.5 | 45 | 38.5 |
| 19 | 20.8 | 21 | 20.8 | 32 | 29.5 | 44 | 38.5 |
| 19 | 20.8 | 20 | 20.8 | 31 | 29.5 | 44 | 38.5 |
| 19 | 20.8 | 21 | 20.8 | 32 | 29.5 | 43 | 38.5 |
| 19 | 20.8 | 23 | 19.7 | 30 | 29.5 | 65 | 41 |
| 19 | 20.8 | 25 | 19.7 | 30 | 29.5 | 58 | 41 |
| 19 | 20.8 | 29 | 19.7 | 30 | 29.5 | 66 | 41 |
| 19 | 20.8 | 29 | 19.7 | 31 | 29.5 | 66 | 41 |
| 20 | 20.8 | 28 | 19.7 | 30 | 29.5 | 69 | 41 |
| 20 | 20.8 | 30 | 19.7 | 30 | 29.5 | 69 | 41 |
| 19 | 20.8 | 32 | 19.7 | 30 | 29.5 | 68 | 41 |
| 19 | 20.8 | 34 | 19.7 | 31 | 29.5 | 68 | 41 |
| 19 | 20.8 | 34 | 20.8 | 31 | 29.5 | 67 | 41 |
| 19 | 20.8 | 33 | 19.7 | 30 | 29.5 | 66 | 41 |

Table A.3. Raw data of the route B-F and B-E.

| Route B-F | | | | Route B-E | | | |
|---|---|---|---|---|---|---|---|
| Off-peak hours | | Peak hours | | Off-peak hours | | Peak hours | |
| Travel time (min) | Travel distance (km) | Travel time (min) | Travel distance (km) | Travel time (min) | Travel distance (km) | Travel time (min) | Travel distance (km) |
| 29 | 23.6 | 40 | 31.9 | 22 | 26.2 | 34 | 26.2 |
| 27 | 23.6 | 44 | 31.9 | 22 | 26.2 | 38 | 26.2 |
| 27 | 23.6 | 46 | 31.9 | 22 | 26.2 | 40 | 26.2 |
| 27 | 23.6 | 45 | 31.9 | 21 | 26.2 | 39 | 26.2 |
| 29 | 23.6 | 45 | 31.9 | 22 | 26.2 | 38 | 26.2 |
| 27 | 23.6 | 44 | 31.9 | 22 | 26.2 | 38 | 26.2 |
| 27 | 23.6 | 43 | 31.9 | 21 | 26.2 | 37 | 26.2 |
| 27 | 23.6 | 45 | 31.9 | 21 | 26.2 | 39 | 26.2 |
| 27 | 31.9 | 44 | 31.9 | 22 | 26.2 | 38 | 26.2 |
| 27 | 23.6 | 40 | 31.9 | 22 | 26.2 | 34 | 26.2 |
| 27 | 23.6 | 42 | 31.9 | 22 | 26.2 | 36 | 26.2 |
| 27 | 23.6 | 40 | 31.9 | 21 | 26.2 | 34 | 26.2 |
| 27 | 23.6 | 38 | 31.9 | 21 | 26.2 | 32 | 26.2 |
| 27 | 23.6 | 38 | 31.9 | 21 | 26.2 | 32 | 26.2 |
| 27 | 23.6 | 38 | 31.9 | 21 | 26.2 | 31 | 26.2 |
| 28 | 23.6 | 36 | 31.9 | 21 | 26.2 | 30 | 26.2 |
| 29 | 23.6 | 34 | 31.9 | 21 | 26.2 | 29 | 26.2 |
| 27 | 23.6 | 32 | 31.9 | 21 | 26.2 | 27 | 26.2 |
| 27 | 31.9 | 31 | 31.9 | 21 | 26.2 | 25 | 26.2 |
| 26 | 31.9 | 32 | 31.9 | 21 | 26.2 | 26 | 26.2 |
| 26 | 23.6 | 47 | 31.9 | 21 | 26.2 | 40 | 26.2 |
| 26 | 23.6 | 46 | 31.9 | 21 | 26.2 | 40 | 26.2 |
| 26 | 23.6 | 44 | 31.9 | 21 | 26.2 | 38 | 26.2 |
| 26 | 23.6 | 43 | 31.9 | 21 | 26.2 | 37 | 26.2 |
| 26 | 23.6 | 44 | 31.9 | 21 | 26.2 | 38 | 26.2 |
| 27 | 23.6 | 43 | 31.9 | 21 | 26.2 | 37 | 26.2 |
| 27 | 23.6 | 40 | 31.9 | 21 | 26.2 | 35 | 26.2 |
| 27 | 23.6 | 41 | 31.9 | 21 | 26.2 | 35 | 26.2 |
| 28 | 23.6 | 39 | 31.9 | 21 | 26.2 | 33 | 26.2 |
| 28 | 23.6 | 38 | 31.9 | 21 | 26.2 | 32 | 26.2 |
| 28 | 23.6 | 46 | 31.9 | 21 | 26.2 | 39 | 26.2 |
| 28 | 23.6 | 45 | 31.9 | 21 | 26.2 | 39 | 26.2 |
| 27 | 23.6 | 44 | 31.9 | 21 | 26.2 | 38 | 26.2 |
| 27 | 23.6 | 40 | 31.9 | 21 | 26.2 | 34 | 26.2 |
| 26 | 23.6 | 41 | 31.9 | 21 | 26.2 | 35 | 26.2 |
| 26 | 23.6 | 37 | 31.9 | 21 | 26.2 | 31 | 26.2 |
| 26 | 23.6 | 35 | 31.9 | 21 | 26.2 | 29 | 26.2 |
| 26 | 23.6 | 34 | 31.9 | 21 | 26.2 | 28 | 26.2 |
| 26 | 23.6 | 31 | 31.9 | 21 | 26.2 | 28 | 26.2 |
| 26 | 23.6 | 31 | 31.9 | 21 | 26.2 | 28 | 26.2 |
| 26 | 23.6 | 59 | 31.9 | 21 | 26.2 | 53 | 26.2 |
| 26 | 23.6 | 58 | 31.9 | 21 | 26.2 | 46 | 28.9 |
| 26 | 23.6 | 53 | 34.5 | 21 | 26.2 | 47 | 28.9 |
| 26 | 31.9 | 53 | 34.5 | 21 | 26.2 | 47 | 28.9 |
| 26 | 31.9 | 58 | 34.5 | 21 | 26.2 | 50 | 28.9 |
| 26 | 31.9 | 54 | 34.5 | 21 | 26.2 | 47 | 29.2 |
| 26 | 23.6 | 53 | 34.7 | 21 | 26.2 | 46 | 29.2 |
| 26 | 23.6 | 53 | 34.7 | 21 | 26.2 | 47 | 29.2 |
| 26 | 23.6 | 52 | 34.7 | 21 | 26.2 | 47 | 26.2 |
| 26 | 23.6 | 51 | 34.7 | 21 | 26.2 | 45 | 29.2 |
| 27 | 31.9 | 44 | 31.9 | 21 | 26.2 | 38 | 26.2 |
| 29 | 23.6 | 43 | 31.9 | 21 | 26.2 | 38 | 26.2 |
| 27 | 31.9 | 44 | 31.9 | 21 | 26.2 | 38 | 26.2 |
| 28 | 23.6 | 43 | 31.9 | 22 | 26.2 | 37 | 26.2 |
| 28 | 23.6 | 41 | 31.9 | 21 | 26.2 | 35 | 26.2 |
| 28 | 23.6 | 42 | 31.9 | 21 | 26.2 | 35 | 26.2 |

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**Table A.3 (cont.)**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 28 | 23.6 | 41 | 31.9 | 22 | 26.2 | 35 | 26.2 |
| 28 | 23.6 | 38 | 31.9 | 22 | 26.2 | 33 | 26.2 |
| 28 | 23.6 | 38 | 31.9 | 22 | 26.2 | 32 | 26.2 |
| 28 | 23.6 | 37 | 31.9 | 21 | 26.2 | 31 | 26.2 |
| 29 | 23.6 | 47 | 31.9 | 22 | 26.2 | 41 | 26.2 |
| 29 | 23.6 | 47 | 31.9 | 22 | 26.2 | 41 | 26.2 |
| 28 | 23.6 | 47 | 31.9 | 21 | 26.2 | 40 | 26.2 |
| 29 | 23.6 | 45 | 31.9 | 21 | 26.2 | 39 | 26.2 |
| 27 | 31.9 | 45 | 31.9 | 21 | 26.2 | 39 | 26.2 |
| 27 | 31.9 | 46 | 31.9 | 22 | 26.2 | 39 | 26.2 |
| 28 | 23.6 | 46 | 31.9 | 21 | 26.2 | 40 | 26.2 |
| 28 | 23.6 | 45 | 31.9 | 21 | 26.2 | 39 | 26.2 |
| 28 | 23.6 | 45 | 31.9 | 21 | 26.2 | 39 | 26.2 |
| 27 | 31.9 | 42 | 31.9 | 21 | 26.2 | 36 | 26.2 |
| 27 | 31.9 | 37 | 31.9 | 21 | 26.2 | 32 | 26.2 |
| 26 | 31.9 | 37 | 31.9 | 21 | 26.2 | 31 | 26.2 |
| 27 | 31.9 | 38 | 31.9 | 21 | 26.2 | 32 | 26.2 |
| 27 | 23.6 | 38 | 31.9 | 21 | 26.2 | 32 | 26.2 |
| 29 | 23.6 | 37 | 31.9 | 21 | 26.2 | 31 | 26.2 |
| 29 | 23.6 | 37 | 31.9 | 21 | 26.2 | 31 | 26.2 |
| 27 | 23.6 | 36 | 31.9 | 21 | 26.2 | 30 | 26.2 |
| 29 | 23.6 | 36 | 31.9 | 21 | 26.2 | 30 | 26.2 |
| 28 | 23.6 | 35 | 31.9 | 21 | 26.2 | 29 | 26.2 |
| 28 | 23.6 | 34 | 31.9 | 21 | 26.2 | 28 | 26.2 |
| 29 | 23.6 | 38 | 31.9 | 22 | 26.2 | 32 | 26.2 |
| 27 | 31.9 | 38 | 31.9 | 21 | 26.2 | 32 | 26.2 |
| 27 | 31.9 | 38 | 31.9 | 21 | 26.2 | 32 | 26.2 |
| 29 | 23.6 | 38 | 31.9 | 21 | 26.2 | 32 | 26.2 |
| 28 | 23.6 | 38 | 31.9 | 21 | 26.2 | 32 | 26.2 |
| 28 | 23.6 | 40 | 31.9 | 21 | 26.2 | 34 | 26.2 |
| 28 | 23.6 | 40 | 31.9 | 21 | 26.2 | 34 | 26.2 |
| 29 | 23.6 | 39 | 31.9 | 21 | 26.2 | 33 | 26.2 |
| 28 | 23.6 | 37 | 31.9 | 21 | 26.2 | 31 | 26.2 |
| 28 | 23.6 | 36 | 31.9 | 21 | 26.2 | 31 | 26.2 |
| 29 | 23.6 | 68 | 34.5 | 21 | 26.2 | 53 | 28.9 |
| 29 | 23.6 | 68 | 34.5 | 21 | 26.2 | 54 | 28.9 |
| 29 | 23.6 | 68 | 34.5 | 21 | 26.2 | 57 | 28.9 |
| 29 | 23.6 | 69 | 34.5 | 21 | 26.2 | 57 | 28.9 |
| 29 | 23.6 | 69 | 34.5 | 21 | 26.2 | 57 | 28.9 |
| 29 | 23.6 | 68 | 34.5 | 22 | 26.2 | 58 | 28.9 |
| 29 | 23.6 | 66 | 34.5 | 22 | 26.2 | 58 | 28.9 |
| 29 | 23.6 | 67 | 34.5 | 21 | 26.2 | 59 | 26.2 |
| 27 | 23.6 | 67 | 34.5 | 21 | 26.2 | 59 | 26.2 |
| 27 | 23.6 | 66 | 31.9 | 22 | 26.2 | 59 | 28.9 |
| 29 | 23.6 | 35 | 31.9 | 21 | 26.2 | 29 | 26.2 |
| 29 | 23.6 | 36 | 31.9 | 22 | 26.2 | 30 | 26.2 |
| 28 | 23.6 | 37 | 31.9 | 21 | 26.2 | 30 | 26.2 |
| 28 | 23.6 | 37 | 31.9 | 21 | 26.2 | 30 | 26.2 |
| 28 | 23.6 | 37 | 31.9 | 21 | 26.2 | 31 | 26.2 |
| 28 | 23.6 | 37 | 31.9 | 21 | 26.2 | 30 | 26.2 |
| 28 | 23.6 | 37 | 31.9 | 21 | 26.2 | 31 | 26.2 |
| 28 | 23.6 | 39 | 31.9 | 21 | 26.2 | 32 | 26.2 |
| 28 | 23.6 | 37 | 31.9 | 21 | 26.2 | 31 | 26.2 |
| 28 | 23.6 | 36 | 31.9 | 21 | 26.2 | 30 | 26.2 |
| 28 | 23.6 | 38 | 31.9 | 21 | 26.2 | 32 | 26.2 |
| 28 | 23.6 | 38 | 31.9 | 21 | 26.2 | 32 | 26.2 |
| 29 | 23.6 | 39 | 31.9 | 21 | 26.2 | 33 | 26.2 |
| 28 | 23.6 | 38 | 31.9 | 21 | 26.2 | 33 | 26.2 |
| 28 | 23.6 | 39 | 31.9 | 21 | 26.2 | 33 | 26.2 |
| 28 | 23.6 | 39 | 31.9 | 21 | 26.2 | 33 | 26.2 |
| 29 | 23.6 | 39 | 31.9 | 21 | 26.2 | 33 | 26.2 |

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**Table A.3 (cont.)**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 29 | 23.6 | 39 | 31.9 | 21 | 26.2 | 32 | 26.2 |
| 28 | 23.6 | 37 | 31.9 | 21 | 26.2 | 31 | 26.2 |
| 28 | 23.6 | 36 | 31.9 | 21 | 26.2 | 30 | 26.2 |
| 29 | 23.6 | 56 | 31.9 | 21 | 26.2 | 63 | 29.2 |
| 29 | 23.6 | 56 | 31.9 | 21 | 26.2 | 62 | 26.2 |
| 29 | 23.6 | 56 | 31.9 | 21 | 26.2 | 63 | 26.2 |
| 29 | 23.6 | 56 | 31.9 | 21 | 26.2 | 64 | 26.2 |
| 29 | 23.6 | 56 | 34.5 | 21 | 26.2 | 46 | 28.9 |
| 28 | 23.6 | 48 | 34.7 | 21 | 26.2 | 43 | 28.9 |
| 26 | 23.6 | 48 | 34.7 | 21 | 26.2 | 43 | 28.9 |
| 26 | 23.6 | 51 | 34.7 | 21 | 26.2 | 47 | 26.2 |
| 26 | 23.6 | 61 | 34.7 | 21 | 26.2 | 55 | 28.9 |
| 26 | 23.6 | 50 | 31.9 | 21 | 26.2 | 43 | 26.2 |
| 29 | 23.6 | 42 | 31.9 | 21 | 26.2 | 35 | 26.2 |
| 29 | 23.6 | 42 | 31.9 | 21 | 26.2 | 36 | 26.2 |
| 29 | 23.6 | 41 | 31.9 | 21 | 26.2 | 34 | 26.2 |
| 29 | 23.6 | 39 | 31.9 | 21 | 26.2 | 33 | 26.2 |
| 29 | 23.6 | 40 | 31.9 | 21 | 26.2 | 34 | 26.2 |
| 29 | 23.6 | 38 | 31.9 | 21 | 26.2 | 32 | 26.2 |
| 28 | 23.6 | 38 | 31.9 | 21 | 26.2 | 32 | 26.2 |
| 28 | 23.6 | 37 | 31.9 | 21 | 26.2 | 32 | 26.2 |
| 28 | 23.6 | 36 | 31.9 | 21 | 26.2 | 30 | 26.2 |
| 28 | 23.6 | 35 | 31.9 | 21 | 26.2 | 28 | 26.2 |
| 29 | 23.6 | 64 | 34.5 | 21 | 26.2 | 44 | 28.9 |
| 29 | 23.6 | 55 | 34.7 | 21 | 26.2 | 47 | 28.9 |
| 29 | 23.6 | 59 | 34.7 | 21 | 26.2 | 50 | 28.9 |
| 28 | 23.6 | 56 | 34.7 | 21 | 26.2 | 49 | 28.9 |
| 28 | 23.6 | 56 | 34.7 | 21 | 26.2 | 49 | 28.9 |
| 29 | 23.6 | 55 | 34.7 | 21 | 26.2 | 55 | 28.9 |
| 29 | 23.6 | 55 | 34.7 | 21 | 26.2 | 49 | 28.9 |
| 29 | 23.6 | 64 | 34.5 | 21 | 26.2 | 50 | 28.9 |
| 29 | 23.6 | 56 | 34.7 | 21 | 26.2 | 49 | 28.9 |
| 29 | 23.6 | 62 | 34.5 | 21 | 26.2 | 49 | 28.9 |
| 28 | 23.6 | 45 | 31.9 | 21 | 26.2 | 39 | 26.2 |
| 28 | 23.6 | 45 | 31.9 | 21 | 26.2 | 39 | 26.2 |
| 28 | 23.6 | 45 | 31.9 | 22 | 26.2 | 39 | 26.2 |
| 28 | 23.6 | 48 | 31.9 | 22 | 26.2 | 42 | 26.2 |
| 28 | 23.6 | 42 | 31.9 | 21 | 26.2 | 36 | 26.2 |
| 28 | 23.6 | 41 | 31.9 | 21 | 26.2 | 36 | 26.2 |
| 28 | 23.6 | 40 | 31.9 | 21 | 26.2 | 35 | 26.2 |
| 28 | 23.6 | 39 | 31.9 | 21 | 26.2 | 33 | 26.2 |
| 28 | 23.6 | 36 | 31.9 | 21 | 26.2 | 31 | 26.2 |
| 28 | 23.6 | 36 | 31.9 | 21 | 26.2 | 30 | 26.2 |
| 29 | 23.6 | 37 | 31.9 | 21 | 26.2 | 32 | 26.2 |
| 29 | 23.6 | 38 | 31.9 | 21 | 26.2 | 32 | 26.2 |
| 29 | 23.6 | 38 | 31.9 | 21 | 26.2 | 32 | 26.2 |
| 29 | 23.6 | 36 | 31.9 | 21 | 26.2 | 30 | 26.2 |
| 29 | 23.6 | 35 | 31.9 | 21 | 26.2 | 29 | 26.2 |
| 29 | 23.6 | 36 | 31.9 | 21 | 26.2 | 30 | 26.2 |
| 29 | 23.6 | 36 | 31.9 | 21 | 26.2 | 30 | 26.2 |
| 29 | 23.6 | 36 | 31.9 | 21 | 26.2 | 30 | 26.2 |
| 29 | 23.6 | 36 | 31.9 | 21 | 26.2 | 32 | 26.2 |
| 29 | 23.6 | 34 | 31.9 | 21 | 26.2 | 28 | 26.2 |
| 27 | 23.6 | 35 | 31.9 | 21 | 26.2 | 29 | 26.2 |
| 27 | 23.6 | 35 | 31.9 | 21 | 26.2 | 29 | 26.2 |
| 26 | 23.6 | 35 | 31.9 | 21 | 26.2 | 29 | 26.2 |
| 26 | 23.6 | 34 | 31.9 | 21 | 26.2 | 28 | 26.2 |
| 26 | 23.6 | 32 | 31.9 | 21 | 26.2 | 28 | 26.2 |
| 26 | 23.6 | 32 | 31.9 | 21 | 26.2 | 28 | 26.2 |
| 26 | 23.6 | 32 | 31.9 | 21 | 26.2 | 28 | 26.2 |
| 26 | 23.6 | 32 | 31.9 | 21 | 26.2 | 28 | 26.2 |

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**Table A.3 (cont.)**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 26 | 23.6 | 32 | 31.9 | 21 | 26.2 | 28 | 26.2 |
| 26 | 23.6 | 32 | 31.9 | 21 | 26.2 | 28 | 26.2 |
| 26 | 23.6 | 45 | 31.9 | 21 | 26.2 | 43 | 26.2 |
| 27 | 23.6 | 44 | 31.9 | 21 | 26.2 | 43 | 26.2 |
| 28 | 23.6 | 43 | 31.9 | 22 | 26.2 | 42 | 26.2 |
| 27 | 23.6 | 44 | 31.9 | 21 | 26.2 | 40 | 26.2 |
| 29 | 23.6 | 43 | 31.9 | 21 | 26.2 | 40 | 26.2 |
| 29 | 23.6 | 42 | 31.9 | 21 | 26.2 | 41 | 26.2 |
| 29 | 23.6 | 41 | 31.9 | 22 | 26.2 | 39 | 26.2 |
| 27 | 23.6 | 40 | 31.9 | 22 | 26.2 | 39 | 26.2 |
| 29 | 23.6 | 38 | 31.9 | 22 | 26.2 | 38 | 26.2 |
| 29 | 23.6 | 37 | 31.9 | 21 | 26.2 | 38 | 26.2 |
| 29 | 23.6 | 64 | 34.5 | 21 | 26.2 | 44 | 28.9 |
| 29 | 23.6 | 55 | 34.7 | 21 | 26.2 | 47 | 28.9 |
| 29 | 23.6 | 59 | 34.7 | 21 | 26.2 | 50 | 28.9 |
| 29 | 23.6 | 56 | 34.7 | 21 | 26.2 | 49 | 28.9 |
| 29 | 23.6 | 56 | 34.7 | 21 | 26.2 | 49 | 28.9 |
| 29 | 23.6 | 55 | 34.7 | 21 | 26.2 | 55 | 28.9 |
| 28 | 23.6 | 55 | 34.7 | 21 | 26.2 | 49 | 28.9 |
| 28 | 23.6 | 64 | 34.5 | 21 | 26.2 | 50 | 28.9 |
| 28 | 23.6 | 56 | 34.7 | 21 | 26.2 | 49 | 28.9 |
| 28 | 23.6 | 62 | 34.5 | 21 | 26.2 | 49 | 28.9 |

Table A.4. Raw data of the route C-H and C-G.

| Route C-H | | | | Route C-G | | | |
|---|---|---|---|---|---|---|---|
| Off-peak hours | | Peak hours | | Off-peak hours | | Peak hours | |
| Travel time (min) | Travel distance (km) | Travel time (min) | Travel distance (km) | Travel time (min) | Travel distance (km) | Travel time (min) | Travel distance (km) |
| 27 | 19.9 | 47 | 19.9 | 27 | 24.2 | 42 | 31.2 |
| 26 | 19.9 | 47 | 19.9 | 27 | 24.2 | 42 | 31.2 |
| 23 | 19.9 | 47 | 19.9 | 25 | 24.2 | 47 | 31.2 |
| 24 | 19.9 | 45 | 20.2 | 26 | 24.2 | 48 | 31.2 |
| 24 | 19.9 | 46 | 20.2 | 26 | 24.2 | 48 | 31.2 |
| 24 | 19.9 | 43 | 20.2 | 26 | 24.2 | 46 | 31.2 |
| 24 | 19.9 | 43 | 20.2 | 26 | 24.2 | 46 | 31.2 |
| 24 | 19.9 | 44 | 20.2 | 26 | 24.2 | 46 | 31.2 |
| 24 | 19.9 | 44 | 20.2 | 26 | 24.2 | 47 | 31.2 |
| 24 | 19.9 | 42 | 20.2 | 26 | 24.2 | 42 | 31.2 |
| 26 | 19.9 | 48 | 38.5 | 27 | 24.2 | 43 | 31.2 |
| 25 | 19.9 | 43 | 20.2 | 27 | 24.2 | 42 | 31.2 |
| 25 | 19.9 | 42 | 38.5 | 27 | 24.2 | 40 | 31.2 |
| 26 | 19.9 | 46 | 38.5 | 27 | 24.2 | 40 | 31.2 |
| 25 | 19.9 | 46 | 38.5 | 27 | 24.2 | 39 | 31.2 |
| 25 | 19.9 | 43 | 38.5 | 27 | 24.2 | 38 | 31.2 |
| 25 | 19.9 | 44 | 38.5 | 27 | 24.2 | 38 | 31.2 |
| 25 | 19.9 | 42 | 19.9 | 27 | 24.2 | 35 | 31.2 |
| 25 | 19.9 | 39 | 38.5 | 27 | 24.2 | 34 | 31.2 |
| 25 | 19.9 | 40 | 38.5 | 27 | 24.2 | 33 | 31.2 |
| 25 | 19.9 | 45 | 20.2 | 27 | 24.2 | 49 | 31.2 |
| 25 | 19.9 | 44 | 20.2 | 27 | 24.2 | 49 | 31.2 |
| 25 | 19.9 | 47 | 20.2 | 27 | 24.2 | 46 | 31.2 |
| 25 | 19.9 | 49 | 20.2 | 26 | 24.2 | 45 | 31.2 |
| 24 | 19.9 | 50 | 20.2 | 26 | 24.2 | 46 | 31.2 |
| 24 | 19.9 | 49 | 20.2 | 27 | 24.2 | 44 | 31.2 |
| 24 | 19.9 | 45 | 20.2 | 26 | 24.2 | 41 | 31.2 |
| 24 | 19.9 | 45 | 20.2 | 26 | 24.2 | 42 | 31.2 |
| 24 | 19.9 | 44 | 20.2 | 27 | 24.2 | 41 | 31.2 |
| 24 | 19.9 | 42 | 19.9 | 26 | 24.2 | 39 | 31.2 |

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**Table A.4 (cont.)**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 23 | 19.9 | 44 | 38.5 | 26 | 24.2 | 47 | 31.2 |
| 23 | 19.9 | 43 | 20.5 | 26 | 24.2 | 46 | 31.2 |
| 23 | 19.9 | 43 | 19.9 | 26 | 24.2 | 45 | 31.2 |
| 23 | 19.9 | 47 | 38.5 | 26 | 24.2 | 41 | 31.2 |
| 23 | 19.9 | 47 | 38.5 | 26 | 24.2 | 41 | 31.2 |
| 23 | 19.9 | 44 | 38.5 | 26 | 24.2 | 38 | 31.2 |
| 23 | 19.9 | 42 | 38.5 | 26 | 24.2 | 36 | 31.2 |
| 23 | 19.9 | 41 | 38.5 | 26 | 24.2 | 35 | 31.2 |
| 23 | 19.9 | 38 | 38.5 | 26 | 24.2 | 32 | 31.2 |
| 23 | 19.9 | 38 | 38.5 | 26 | 24.2 | 32 | 31.2 |
| 25 | 19.9 | 55 | 19.9 | 27 | 24.2 | 51 | 33.5 |
| 25 | 19.9 | 57 | 19.9 | 27 | 24.2 | 53 | 33.5 |
| 25 | 19.9 | 55 | 20.5 | 27 | 24.2 | 53 | 33.5 |
| 24 | 19.9 | 56 | 20.5 | 27 | 24.2 | 57 | 38.3 |
| 24 | 19.9 | 56 | 20.5 | 27 | 24.2 | 57 | 38.3 |
| 24 | 19.9 | 58 | 20.5 | 27 | 24.2 | 53 | 33.5 |
| 24 | 19.9 | 54 | 20.5 | 26 | 24.2 | 53 | 33.5 |
| 24 | 19.9 | 51 | 20.5 | 26 | 24.2 | 54 | 33.5 |
| 24 | 19.9 | 48 | 20.5 | 26 | 24.2 | 55 | 38.3 |
| 24 | 19.9 | 48 | 20.5 | 26 | 24.2 | 51 | 33.5 |
| 25 | 19.9 | 50 | 38.5 | 26 | 24.2 | 45 | 31.2 |
| 25 | 19.9 | 45 | 20.5 | 26 | 24.2 | 45 | 31.2 |
| 25 | 19.9 | 45 | 20.5 | 26 | 24.2 | 46 | 31.2 |
| 25 | 19.9 | 46 | 20.5 | 26 | 24.2 | 45 | 31.2 |
| 24 | 19.9 | 47 | 19.9 | 26 | 24.2 | 44 | 31.2 |
| 24 | 19.9 | 46 | 19.9 | 26 | 24.2 | 44 | 31.2 |
| 24 | 19.9 | 44 | 19.9 | 26 | 24.2 | 42 | 31.2 |
| 24 | 19.9 | 47 | 38.5 | 26 | 24.2 | 40 | 31.2 |
| 24 | 19.9 | 46 | 38.5 | 26 | 24.2 | 40 | 31.2 |
| 23 | 19.9 | 45 | 38.5 | 26 | 24.2 | 38 | 31.2 |
| 25 | 19.9 | 48 | 19.9 | 26 | 24.2 | 47 | 31.2 |
| 24 | 19.9 | 48 | 19.9 | 27 | 24.2 | 49 | 31.2 |
| 24 | 19.9 | 50 | 38.5 | 26 | 24.2 | 47 | 31.2 |
| 24 | 19.9 | 50 | 38.5 | 26 | 24.2 | 46 | 31.2 |
| 24 | 19.9 | 48 | 20.2 | 26 | 24.2 | 46 | 31.2 |
| 24 | 19.9 | 48 | 20.2 | 26 | 24.2 | 46 | 31.2 |
| 24 | 19.9 | 48 | 38.5 | 26 | 24.2 | 48 | 31.2 |
| 24 | 19.9 | 44 | 38.5 | 27 | 24.2 | 48 | 31.2 |
| 24 | 19.9 | 45 | 38.5 | 26 | 24.2 | 47 | 31.2 |
| 24 | 19.9 | 44 | 38.5 | 26 | 24.2 | 44 | 31.2 |
| 25 | 19.9 | 47 | 38.5 | 27 | 24.2 | 38 | 31.2 |
| 25 | 19.9 | 47 | 38.5 | 26 | 24.2 | 38 | 31.2 |
| 25 | 19.9 | 48 | 38.5 | 26 | 24.2 | 39 | 31.2 |
| 25 | 19.9 | 47 | 38.5 | 26 | 24.2 | 39 | 31.2 |
| 25 | 19.9 | 47 | 38.5 | 26 | 24.2 | 38 | 31.2 |
| 25 | 19.9 | 47 | 38.5 | 26 | 24.2 | 38 | 31.2 |
| 25 | 19.9 | 46 | 38.5 | 26 | 24.2 | 37 | 31.2 |
| 25 | 19.9 | 45 | 38.5 | 26 | 24.2 | 37 | 31.2 |
| 25 | 19.9 | 42 | 19.9 | 26 | 24.2 | 36 | 31.2 |
| 24 | 19.9 | 45 | 38.5 | 26 | 24.2 | 36 | 31.2 |
| 25 | 19.9 | 44 | 38.5 | 27 | 24.2 | 38 | 31.2 |
| 25 | 19.9 | 43 | 20.2 | 26 | 24.2 | 39 | 31.2 |
| 25 | 19.9 | 44 | 38.5 | 26 | 24.2 | 38 | 31.2 |
| 25 | 19.9 | 43 | 38.5 | 26 | 24.2 | 39 | 31.2 |
| 25 | 19.9 | 43 | 38.5 | 26 | 24.2 | 40 | 31.2 |
| 24 | 19.9 | 45 | 38.5 | 26 | 24.2 | 37 | 31.2 |
| 24 | 19.9 | 45 | 38.5 | 27 | 24.2 | 37 | 31.2 |
| 25 | 19.9 | 44 | 20.2 | 27 | 24.2 | 40 | 31.2 |
| 25 | 19.9 | 45 | 20.2 | 27 | 24.2 | 39 | 31.2 |
| 24 | 19.9 | 45 | 20.2 | 27 | 24.2 | 40 | 31.2 |
| 24 | 19.9 | 49 | 19.9 | 26 | 24.2 | 54 | 31.2 |

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**Table A.4 (cont.)**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 25 | 19.9 | 52 | 20.5 | 26 | 24.2 | 58 | 31.2 |
| 25 | 19.9 | 29 | 20.5 | 26 | 24.2 | 57 | 31.2 |
| 25 | 19.9 | 53 | 20.5 | 26 | 24.2 | 56 | 31.2 |
| 25 | 19.9 | 53 | 20.5 | 26 | 24.2 | 54 | 31.2 |
| 25 | 19.9 | 50 | 20.5 | 27 | 24.2 | 44 | 33.5 |
| 25 | 19.9 | 53 | 20.2 | 26 | 24.2 | 54 | 38.3 |
| 25 | 19.9 | 55 | 20.2 | 27 | 24.2 | 56 | 38.3 |
| 25 | 19.9 | 55 | 20.2 | 26 | 24.2 | 54 | 31.2 |
| 25 | 19.9 | 55 | 20.2 | 26 | 24.2 | 54 | 31.2 |
| 25 | 19.9 | 43 | 20.2 | 26 | 24.2 | 36 | 31.2 |
| 24 | 19.9 | 44 | 20.2 | 26 | 24.2 | 37 | 31.2 |
| 24 | 19.9 | 44 | 20.2 | 25 | 24.2 | 38 | 31.2 |
| 24 | 19.9 | 46 | 20.2 | 25 | 24.2 | 38 | 31.2 |
| 24 | 19.9 | 43 | 20.2 | 25 | 24.2 | 38 | 31.2 |
| 24 | 19.9 | 47 | 38.5 | 26 | 24.2 | 38 | 31.2 |
| 24 | 19.9 | 47 | 38.5 | 25 | 24.2 | 38 | 31.2 |
| 24 | 19.9 | 47 | 38.5 | 25 | 24.2 | 39 | 31.2 |
| 24 | 19.9 | 48 | 38.5 | 25 | 24.2 | 38 | 31.2 |
| 24 | 19.9 | 45 | 38.5 | 25 | 24.2 | 37 | 31.2 |
| 25 | 19.9 | 48 | 38.5 | 26 | 24.2 | 40 | 31.2 |
| 25 | 19.9 | 50 | 38.5 | 26 | 24.2 | 42 | 31.2 |
| 25 | 19.9 | 54 | 38.5 | 27 | 24.2 | 41 | 31.2 |
| 24 | 19.9 | 52 | 38.5 | 26 | 24.2 | 41 | 31.2 |
| 24 | 19.9 | 55 | 38.5 | 26 | 24.2 | 41 | 31.2 |
| 24 | 19.9 | 54 | 38.5 | 26 | 24.2 | 42 | 31.2 |
| 24 | 19.9 | 54 | 38.5 | 26 | 24.2 | 41 | 31.2 |
| 24 | 19.9 | 54 | 38.5 | 26 | 24.2 | 41 | 31.2 |
| 24 | 19.9 | 50 | 38.5 | 26 | 24.2 | 39 | 31.2 |
| 24 | 19.9 | 49 | 38.5 | 26 | 24.2 | 38 | 24.2 |
| 25 | 19.9 | 58 | 38.5 | 27 | 24.2 | 45 | 24.2 |
| 24 | 19.9 | 61 | 38.5 | 26 | 24.2 | 47 | 24.2 |
| 24 | 19.9 | 61 | 38.5 | 26 | 24.2 | 48 | 24.2 |
| 24 | 19.9 | 62 | 38.5 | 26 | 24.2 | 47 | 24.2 |
| 24 | 19.9 | 46 | 19.9 | 26 | 24.2 | 47 | 24.2 |
| 24 | 19.9 | 47 | 19.9 | 25 | 24.2 | 45 | 24.2 |
| 24 | 19.9 | 46 | 20.2 | 26 | 24.2 | 46 | 24.2 |
| 24 | 19.9 | 43 | 20.2 | 26 | 24.2 | 47 | 24.2 |
| 24 | 19.9 | 45 | 20.2 | 25 | 24.2 | 47 | 24.2 |
| 24 | 19.9 | 45 | 19.9 | 25 | 24.2 | 48 | 24.2 |
| 25 | 19.9 | 47 | 19.9 | 27 | 24.2 | 49 | 24.2 |
| 24 | 19.9 | 47 | 19.9 | 27 | 24.2 | 48 | 24.2 |
| 24 | 19.9 | 46 | 20.5 | 26 | 24.2 | 48 | 24.2 |
| 24 | 19.9 | 47 | 20.5 | 26 | 24.2 | 48 | 24.2 |
| 24 | 19.9 | 45 | 19.9 | 27 | 24.2 | 50 | 24.2 |
| 24 | 19.9 | 46 | 20.5 | 27 | 24.2 | 49 | 24.2 |
| 24 | 19.9 | 44 | 20.5 | 27 | 24.2 | 52 | 24.2 |
| 24 | 19.9 | 45 | 38.5 | 29 | 24.2 | 49 | 24.2 |
| 24 | 19.9 | 43 | 38.5 | 27 | 24.2 | 49 | 24.2 |
| 24 | 19.9 | 42 | 38.5 | 27 | 24.2 | 48 | 24.2 |
| 25 | 19.9 | 51 | 19.9 | 26 | 24.2 | 51 | 24.2 |
| 25 | 19.9 | 51 | 20.5 | 26 | 24.2 | 53 | 24.2 |
| 25 | 19.9 | 54 | 19.9 | 27 | 24.2 | 53 | 24.2 |
| 25 | 19.9 | 54 | 19.9 | 26 | 24.2 | 56 | 24.2 |
| 25 | 19.9 | 56 | 20.5 | 26 | 24.2 | 54 | 24.2 |
| 25 | 19.9 | 58 | 20.5 | 26 | 24.2 | 55 | 24.2 |
| 24 | 19.9 | 55 | 20.5 | 26 | 24.2 | 54 | 24.2 |
| 24 | 19.9 | 53 | 20.5 | 26 | 24.2 | 55 | 24.2 |
| 24 | 19.9 | 56 | 20.2 | 26 | 24.2 | 53 | 38.3 |
| 23 | 19.9 | 56 | 19.9 | 26 | 24.2 | 53 | 38.3 |
| 24 | 19.9 | 44 | 19.9 | 26 | 24.2 | 43 | 24.2 |
| 24 | 19.9 | 45 | 19.9 | 25 | 24.2 | 46 | 31.2 |

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**Table A.4 (cont.)**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 24 | 19.9 | 45 | 19.9 | 25 | 24.2 | 45 | 31.2 |
| 24 | 19.9 | 45 | 20.5 | 26 | 24.2 | 45 | 31.2 |
| 24 | 19.9 | 45 | 20.5 | 26 | 24.2 | 42 | 31.2 |
| 24 | 19.9 | 44 | 20.5 | 26 | 24.2 | 42 | 31.2 |
| 23 | 19.9 | 41 | 20.5 | 26 | 24.2 | 42 | 31.2 |
| 23 | 19.9 | 41 | 20.5 | 26 | 24.2 | 30 | 31.2 |
| 23 | 19.9 | 39 | 20.5 | 25 | 24.2 | 38 | 31.2 |
| 23 | 19.9 | 36 | 20.2 | 25 | 24.2 | 37 | 31.2 |
| 24 | 19.9 | 41 | 19.9 | 25 | 24.2 | 41 | 31.2 |
| 24 | 19.9 | 43 | 19.9 | 25 | 24.2 | 40 | 31.2 |
| 24 | 19.9 | 44 | 19.9 | 27 | 24.2 | 40 | 31.2 |
| 24 | 19.9 | 46 | 20.5 | 25 | 24.2 | 38 | 31.2 |
| 24 | 19.9 | 45 | 38.5 | 26 | 24.2 | 36 | 31.2 |
| 24 | 19.9 | 44 | 38.5 | 26 | 24.2 | 37 | 31.2 |
| 24 | 19.9 | 45 | 38.5 | 26 | 24.2 | 38 | 31.2 |
| 24 | 19.9 | 44 | 38.5 | 26 | 24.2 | 38 | 31.2 |
| 23 | 19.9 | 44 | 38.5 | 27 | 24.2 | 39 | 31.2 |
| 23 | 19.9 | 42 | 38.5 | 27 | 24.2 | 37 | 31.2 |
| 24 | 19.9 | 33 | 38.5 | 27 | 24.2 | 36 | 31.2 |
| 24 | 19.9 | 33 | 38.5 | 26 | 24.2 | 36 | 31.2 |
| 24 | 19.9 | 31 | 38.5 | 27 | 24.2 | 36 | 31.2 |
| 24 | 19.9 | 30 | 38.5 | 26 | 24.2 | 35 | 31.2 |
| 24 | 19.9 | 31 | 38.5 | 26 | 24.2 | 34 | 31.2 |
| 24 | 19.9 | 31 | 38.5 | 26 | 24.2 | 33 | 31.2 |
| 24 | 19.9 | 33 | 38.5 | 27 | 24.2 | 32 | 31.2 |
| 24 | 19.9 | 33 | 38.5 | 26 | 24.2 | 32 | 31.2 |
| 24 | 19.9 | 33 | 38.5 | 26 | 24.2 | 31 | 31.2 |
| 24 | 19.9 | 32 | 38.5 | 26 | 24.2 | 30 | 31.2 |
| 26 | 19.9 | 42 | 38.5 | 27 | 24.2 | 40 | 31.2 |
| 26 | 19.9 | 42 | 38.5 | 27 | 24.2 | 41 | 31.2 |
| 25 | 19.9 | 41 | 38.5 | 28 | 24.2 | 40 | 31.2 |
| 25 | 19.9 | 40 | 38.5 | 27 | 24.2 | 40 | 31.2 |
| 24 | 19.9 | 39 | 38.5 | 27 | 24.2 | 40 | 31.2 |
| 24 | 19.9 | 39 | 38.5 | 27 | 24.2 | 39 | 31.2 |
| 24 | 19.9 | 38 | 38.5 | 27 | 24.2 | 39 | 31.2 |
| 24 | 19.9 | 39 | 38.5 | 27 | 24.2 | 38 | 31.2 |
| 24 | 19.9 | 40 | 38.5 | 26 | 24.2 | 39 | 31.2 |
| 24 | 19.9 | 40 | 38.5 | 26 | 24.2 | 40 | 31.2 |
| 25 | 19.9 | 51 | 19.9 | 27 | 24.2 | 51 | 24.2 |
| 24 | 19.9 | 51 | 20.5 | 27 | 24.2 | 53 | 24.2 |
| 24 | 19.9 | 54 | 19.9 | 26 | 24.2 | 53 | 24.2 |
| 24 | 19.9 | 54 | 19.9 | 26 | 24.2 | 56 | 24.2 |
| 24 | 19.9 | 56 | 20.5 | 27 | 24.2 | 54 | 24.2 |
| 24 | 19.9 | 58 | 20.5 | 27 | 24.2 | 55 | 24.2 |
| 24 | 19.9 | 55 | 20.5 | 27 | 24.2 | 54 | 24.2 |
| 24 | 19.9 | 53 | 20.5 | 29 | 24.2 | 55 | 24.2 |
| 24 | 19.9 | 56 | 20.5 | 27 | 24.2 | 53 | 38.3 |
| 24 | 19.9 | 56 | 19.9 | 27 | 24.2 | 53 | 38.3 |

Table A.5. Raw data of the route C-F and D-H.

| Route C-F | | | | Route D-H | | | |
|---|---|---|---|---|---|---|---|
| Off-peak hours | | Peak hours | | Off-peak hours | | Peak hours | |
| Travel time (min) | Travel distance (km) | Travel time (min) | Travel distance (km) | Travel time (min) | Travel distance (km) | Travel time (min) | Travel distance (km) |
| 23 | 18.3 | 38 | 24.7 | 29 | 19.1 | 40 | 34.5 |
| 24 | 18.3 | 41 | 24.7 | 29 | 19.1 | 41 | 34.5 |
| 23 | 18.3 | 43 | 24.7 | 25 | 19.1 | 42 | 32.7 |
| 23 | 18.3 | 43 | 24.7 | 24 | 19.1 | 41 | 32.7 |

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**Table A.5 (cont.)**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 23 | 18.3 | 43 | 24.7 | 25 | 19.1 | 43 | 32.7 |
| 23 | 18.3 | 42 | 24.7 | 24 | 19.1 | 41 | 32.7 |
| 23 | 18.3 | 42 | 24.7 | 25 | 19.1 | 40 | 32.7 |
| 23 | 18.3 | 43 | 24.7 | 25 | 19.1 | 41 | 32.7 |
| 23 | 18.3 | 42 | 24.7 | 24 | 19.1 | 40 | 32.7 |
| 23 | 18.3 | 38 | 24.7 | 25 | 19.1 | 37 | 32.4 |
| 25 | 18.3 | 40 | 24.7 | 26 | 19.1 | 38 | 32.4 |
| 24 | 18.3 | 38 | 24.7 | 26 | 19.1 | 39 | 32.7 |
| 23 | 18.3 | 36 | 24.7 | 26 | 19.1 | 39 | 34.5 |
| 24 | 18.3 | 36 | 24.7 | 26 | 19.1 | 38 | 32.4 |
| 24 | 18.3 | 36 | 24.7 | 26 | 19.1 | 38 | 32.7 |
| 24 | 18.3 | 35 | 24.7 | 26 | 19.1 | 38 | 34.5 |
| 24 | 18.3 | 34 | 24.7 | 26 | 19.1 | 36 | 34.5 |
| 23 | 18.3 | 31 | 24.7 | 26 | 19.1 | 35 | 34.5 |
| 24 | 18.3 | 30 | 24.7 | 26 | 19.1 | 34 | 34.5 |
| 23 | 18.3 | 29 | 24.7 | 26 | 19.1 | 34 | 34.5 |
| 24 | 18.3 | 44 | 24.7 | 26 | 19.1 | 42 | 32.7 |
| 24 | 18.3 | 44 | 24.7 | 26 | 19.1 | 41 | 32.7 |
| 24 | 18.3 | 42 | 24.7 | 26 | 19.1 | 42 | 32.7 |
| 23 | 18.3 | 41 | 24.7 | 26 | 19.1 | 39 | 32.7 |
| 23 | 18.3 | 42 | 24.7 | 25 | 19.1 | 39 | 32.7 |
| 23 | 18.3 | 40 | 24.7 | 26 | 19.1 | 39 | 32.7 |
| 23 | 18.3 | 38 | 24.7 | 26 | 19.1 | 39 | 32.7 |
| 23 | 18.3 | 38 | 24.7 | 25 | 19.1 | 39 | 32.7 |
| 23 | 18.3 | 37 | 24.7 | 25 | 19.1 | 39 | 32.7 |
| 23 | 18.3 | 35 | 24.7 | 25 | 19.1 | 39 | 32.7 |
| 23 | 18.3 | 42 | 24.7 | 25 | 19.1 | 40 | 32.7 |
| 23 | 18.3 | 42 | 24.7 | 25 | 19.1 | 39 | 32.7 |
| 23 | 18.3 | 41 | 24.7 | 25 | 19.1 | 39 | 32.7 |
| 23 | 18.3 | 37 | 24.7 | 25 | 19.1 | 37 | 32.4 |
| 22 | 18.3 | 37 | 24.7 | 25 | 19.1 | 38 | 32.4 |
| 22 | 18.3 | 34 | 24.7 | 25 | 19.1 | 37 | 32.4 |
| 23 | 18.3 | 32 | 24.7 | 25 | 19.1 | 37 | 34.5 |
| 23 | 18.3 | 31 | 24.7 | 25 | 19.1 | 36 | 34.5 |
| 22 | 18.3 | 28 | 24.7 | 25 | 19.1 | 33 | 34.5 |
| 22 | 18.3 | 28 | 24.7 | 25 | 19.1 | 33 | 34.5 |
| 24 | 18.3 | 47 | 24.7 | 26 | 19.1 | 41 | 32.7 |
| 24 | 18.3 | 47 | 26.4 | 26 | 19.1 | 41 | 32.7 |
| 24 | 18.3 | 47 | 26.4 | 26 | 19.1 | 41 | 32.7 |
| 23 | 18.3 | 48 | 26.4 | 26 | 19.1 | 41 | 32.7 |
| 23 | 18.3 | 52 | 31.7 | 26 | 19.1 | 41 | 32.7 |
| 23 | 18.3 | 53 | 31.7 | 26 | 19.1 | 41 | 32.7 |
| 23 | 18.3 | 46 | 26.4 | 26 | 19.1 | 41 | 32.7 |
| 23 | 18.3 | 48 | 26.4 | 26 | 19.1 | 43 | 32.7 |
| 23 | 18.3 | 49 | 31.7 | 26 | 19.1 | 40 | 32.7 |
| 23 | 18.3 | 46 | 26.4 | 26 | 19.1 | 39 | 32.7 |
| 23 | 24.7 | 41 | 24.7 | 26 | 19.1 | 45 | 34.5 |
| 23 | 18.3 | 41 | 24.7 | 26 | 19.1 | 42 | 32.7 |
| 23 | 18.3 | 42 | 24.7 | 26 | 19.1 | 41 | 32.7 |
| 23 | 18.3 | 41 | 24.7 | 26 | 19.1 | 40 | 32.7 |
| 23 | 24.7 | 40 | 24.7 | 25 | 19.1 | 39 | 32.7 |
| 23 | 18.3 | 39 | 24.7 | 25 | 19.1 | 37 | 32.4 |
| 23 | 18.3 | 39 | 24.7 | 25 | 19.1 | 38 | 32.4 |
| 23 | 18.3 | 36 | 24.7 | 26 | 19.1 | 37 | 32.4 |
| 23 | 18.3 | 36 | 24.7 | 26 | 19.1 | 37 | 32.4 |
| 23 | 18.3 | 35 | 24.7 | 24 | 19.1 | 36 | 32.4 |
| 24 | 18.3 | 45 | 24.7 | 26 | 19.1 | 41 | 32.7 |
| 23 | 18.3 | 45 | 24.7 | 26 | 19.1 | 43 | 32.7 |
| 23 | 18.3 | 43 | 24.7 | 26 | 19.1 | 41 | 34.5 |
| 23 | 18.3 | 42 | 24.7 | 26 | 19.1 | 41 | 32.7 |
| 23 | 18.3 | 42 | 24.7 | 25 | 19.1 | 40 | 32.7 |

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Table A.5 (cont.)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 23 | 18.3 | 42 | 24.7 | 25 | 19.1 | 40 | 32.7 |
| 23 | 18.3 | 44 | 24.7 | 25 | 19.1 | 42 | 32.7 |
| 23 | 18.3 | 41 | 24.7 | 25 | 19.1 | 41 | 32.7 |
| 23 | 18.3 | 39 | 24.7 | 25 | 19.1 | 39 | 32.7 |
| 23 | 18.3 | 38 | 24.7 | 25 | 19.1 | 38 | 32.7 |
| 23 | 24.7 | 34 | 24.7 | 27 | 19.1 | 38 | 34.5 |
| 23 | 18.3 | 35 | 24.7 | 26 | 19.1 | 39 | 34.5 |
| 23 | 24.7 | 35 | 24.7 | 26 | 19.1 | 40 | 34.5 |
| 23 | 24.7 | 35 | 24.7 | 26 | 19.1 | 38 | 34.5 |
| 23 | 18.3 | 34 | 24.7 | 26 | 19.1 | 37 | 32.7 |
| 24 | 18.3 | 34 | 24.7 | 26 | 19.1 | 37 | 32.7 |
| 23 | 18.3 | 34 | 24.7 | 26 | 19.1 | 38 | 32.7 |
| 23 | 18.3 | 33 | 24.7 | 27 | 19.1 | 37 | 32.7 |
| 23 | 18.3 | 32 | 24.7 | 26 | 19.1 | 37 | 32.7 |
| 23 | 18.3 | 32 | 24.7 | 26 | 19.1 | 36 | 32.7 |
| 24 | 18.3 | 34 | 24.7 | 26 | 19.1 | 38 | 34.5 |
| 24 | 18.3 | 35 | 24.7 | 26 | 19.1 | 39 | 34.5 |
| 24 | 18.3 | 34 | 24.7 | 26 | 19.1 | 39 | 34.5 |
| 24 | 18.3 | 35 | 24.7 | 26 | 19.1 | 41 | 34.5 |
| 24 | 18.3 | 36 | 24.7 | 26 | 19.1 | 41 | 34.5 |
| 24 | 18.3 | 38 | 24.7 | 26 | 19.1 | 38 | 32.7 |
| 23 | 18.3 | 38 | 24.7 | 26 | 19.1 | 38 | 32.7 |
| 23 | 24.7 | 36 | 24.7 | 25 | 19.1 | 37 | 32.7 |
| 23 | 18.3 | 35 | 24.7 | 25 | 19.1 | 38 | 32.7 |
| 23 | 24.7 | 36 | 24.7 | 26 | 19.1 | 38 | 32.7 |
| 24 | 18.3 | 50 | 24.7 | 27 | 19.1 | 41 | 32.7 |
| 24 | 18.3 | 50 | 24.7 | 27 | 19.1 | 41 | 32.7 |
| 24 | 18.3 | 53 | 24.7 | 27 | 19.1 | 43 | 32.7 |
| 24 | 18.3 | 51 | 24.7 | 27 | 19.1 | 43 | 32.7 |
| 24 | 18.3 | 50 | 24.7 | 27 | 19.1 | 41 | 32.7 |
| 24 | 18.3 | 50 | 24.7 | 27 | 19.1 | 41 | 32.7 |
| 24 | 18.3 | 50 | 24.7 | 27 | 19.1 | 41 | 32.7 |
| 24 | 18.3 | 50 | 31.7 | 27 | 19.1 | 41 | 32.7 |
| 24 | 18.3 | 49 | 31.7 | 27 | 19.1 | 42 | 32.7 |
| 24 | 18.3 | 49 | 31.7 | 26 | 19.1 | 41 | 32.7 |
| 23 | 18.3 | 33 | 24.7 | 26 | 19.1 | 36 | 34.5 |
| 23 | 18.3 | 33 | 24.7 | 25 | 19.1 | 38 | 34.5 |
| 23 | 18.3 | 34 | 24.7 | 25 | 19.1 | 39 | 34.5 |
| 23 | 18.3 | 34 | 24.7 | 26 | 19.1 | 39 | 34.5 |
| 23 | 18.3 | 35 | 24.7 | 25 | 19.1 | 39 | 34.5 |
| 23 | 18.3 | 34 | 24.7 | 26 | 19.1 | 39 | 34.5 |
| 23 | 18.3 | 34 | 24.7 | 26 | 19.1 | 39 | 34.5 |
| 23 | 18.3 | 35 | 24.7 | 26 | 19.1 | 38 | 32.7 |
| 23 | 18.3 | 34 | 24.7 | 26 | 19.1 | 37 | 32.7 |
| 23 | 18.3 | 33 | 24.7 | 26 | 19.1 | 37 | 32.7 |
| 23 | 18.3 | 37 | 24.7 | 26 | 19.1 | 38 | 32.7 |
| 23 | 18.3 | 38 | 24.7 | 26 | 19.1 | 39 | 32.7 |
| 23 | 18.3 | 37 | 24.7 | 26 | 19.1 | 40 | 32.7 |
| 23 | 18.3 | 38 | 24.7 | 26 | 19.1 | 40 | 32.7 |
| 23 | 18.3 | 37 | 24.7 | 26 | 19.1 | 38 | 32.7 |
| 23 | 18.3 | 38 | 24.7 | 26 | 19.1 | 38 | 32.7 |
| 23 | 18.3 | 38 | 24.7 | 25 | 19.1 | 38 | 32.7 |
| 23 | 18.3 | 37 | 24.7 | 25 | 19.1 | 38 | 32.7 |
| 23 | 18.3 | 36 | 24.7 | 25 | 19.1 | 38 | 32.7 |
| 23 | 18.3 | 34 | 24.7 | 25 | 19.1 | 38 | 32.7 |
| 24 | 18.3 | 43 | 18.3 | 27 | 19.1 | 41 | 32.7 |
| 23 | 18.3 | 46 | 18.3 | 26 | 19.1 | 40 | 32.7 |
| 23 | 18.3 | 46 | 18.3 | 26 | 19.1 | 41 | 32.7 |
| 23 | 18.3 | 46 | 18.3 | 27 | 19.1 | 40 | 32.7 |
| 23 | 18.3 | 45 | 18.3 | 27 | 19.1 | 40 | 32.7 |
| 23 | 18.3 | 47 | 18.3 | 27 | 19.1 | 39 | 32.7 |

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**Table A.5 (cont.)**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 23 | 18.3 | 44 | 18.3 | 25 | 19.1 | 40 | 32.7 |
| 23 | 18.3 | 44 | 18.3 | 25 | 19.1 | 39 | 32.7 |
| 23 | 18.3 | 44 | 18.3 | 25 | 19.1 | 40 | 32.7 |
| 23 | 18.3 | 44 | 18.3 | 25 | 19.1 | 40 | 32.7 |
| 25 | 18.3 | 39 | 18.3 | 26 | 19.1 | 39 | 32.7 |
| 25 | 18.3 | 40 | 18.3 | 26 | 19.1 | 41 | 32.4 |
| 24 | 18.3 | 38 | 18.3 | 26 | 19.1 | 49 | 32.7 |
| 24 | 18.3 | 37 | 18.3 | 25 | 19.1 | 38 | 32.7 |
| 24 | 18.3 | 37 | 18.3 | 25 | 19.1 | 37 | 32.7 |
| 24 | 18.3 | 35 | 18.3 | 25 | 19.1 | 37 | 32.4 |
| 24 | 18.3 | 36 | 18.3 | 25 | 19.1 | 38 | 32.4 |
| 24 | 18.3 | 35 | 18.3 | 25 | 19.1 | 37 | 32.4 |
| 24 | 18.3 | 33 | 18.3 | 26 | 19.1 | 36 | 32.4 |
| 24 | 18.3 | 32 | 18.3 | 26 | 19.1 | 36 | 32.4 |
| 24 | 18.3 | 49 | 18.3 | 27 | 19.1 | 42 | 32.7 |
| 24 | 18.3 | 51 | 18.3 | 27 | 19.1 | 43 | 32.7 |
| 24 | 18.3 | 50 | 18.3 | 27 | 19.1 | 44 | 32.7 |
| 24 | 18.3 | 50 | 18.3 | 27 | 19.1 | 46 | 32.7 |
| 24 | 18.3 | 51 | 18.3 | 27 | 19.1 | 45 | 32.7 |
| 24 | 18.3 | 49 | 18.3 | 26 | 19.1 | 44 | 32.7 |
| 23 | 18.3 | 49 | 18.3 | 26 | 19.1 | 42 | 32.7 |
| 24 | 18.3 | 50 | 18.3 | 26 | 19.1 | 41 | 32.7 |
| 23 | 18.3 | 48 | 18.3 | 25 | 19.1 | 42 | 32.7 |
| 23 | 18.3 | 50 | 18.3 | 25 | 19.1 | 41 | 32.7 |
| 23 | 18.3 | 42 | 18.3 | 26 | 19.1 | 42 | 32.7 |
| 23 | 18.3 | 42 | 24.7 | 25 | 19.1 | 41 | 32.4 |
| 23 | 18.3 | 41 | 24.7 | 25 | 19.1 | 40 | 32.4 |
| 24 | 18.3 | 41 | 24.7 | 25 | 19.1 | 39 | 32.4 |
| 23 | 18.3 | 39 | 24.7 | 26 | 19.1 | 39 | 32.4 |
| 23 | 18.3 | 38 | 24.7 | 25 | 19.1 | 38 | 32.4 |
| 23 | 18.3 | 38 | 24.7 | 25 | 19.1 | 37 | 32.4 |
| 23 | 18.3 | 36 | 24.7 | 24 | 19.1 | 36 | 32.4 |
| 23 | 18.3 | 35 | 24.7 | 24 | 19.1 | 37 | 32.4 |
| 23 | 18.3 | 33 | 24.7 | 24 | 19.1 | 36 | 32.4 |
| 23 | 18.3 | 36 | 24.7 | 25 | 19.1 | 38 | 34.5 |
| 23 | 18.3 | 36 | 24.7 | 25 | 19.1 | 40 | 34.5 |
| 23 | 18.3 | 37 | 24.7 | 25 | 19.1 | 40 | 34.5 |
| 23 | 18.3 | 34 | 24.7 | 26 | 19.1 | 38 | 34.5 |
| 23 | 18.3 | 33 | 24.7 | 26 | 19.1 | 38 | 34.5 |
| 24 | 18.3 | 34 | 24.7 | 26 | 19.1 | 39 | 34.5 |
| 24 | 18.3 | 34 | 24.7 | 26 | 19.1 | 40 | 34.5 |
| 24 | 18.3 | 34 | 24.7 | 25 | 19.1 | 40 | 34.5 |
| 23 | 18.3 | 36 | 24.7 | 25 | 19.1 | 40 | 34.5 |
| 23 | 18.3 | 33 | 24.7 | 25 | 19.1 | 38 | 34.5 |
| 24 | 18.3 | 32 | 24.7 | 26 | 19.1 | 35 | 34.5 |
| 24 | 18.3 | 32 | 24.7 | 26 | 19.1 | 35 | 34.5 |
| 24 | 18.3 | 32 | 24.7 | 25 | 19.1 | 35 | 34.5 |
| 24 | 18.3 | 31 | 24.7 | 25 | 19.1 | 34 | 34.5 |
| 24 | 18.3 | 30 | 24.7 | 25 | 19.1 | 33 | 34.5 |
| 24 | 18.3 | 30 | 24.7 | 25 | 19.1 | 33 | 34.5 |
| 24 | 18.3 | 30 | 24.7 | 25 | 19.1 | 32 | 34.5 |
| 24 | 18.3 | 30 | 24.7 | 25 | 19.1 | 31 | 34.5 |
| 24 | 18.3 | 30 | 24.7 | 26 | 19.1 | 31 | 34.5 |
| 23 | 18.3 | 30 | 24.7 | 26 | 19.1 | 30 | 34.5 |
| 25 | 18.3 | 43 | 24.7 | 26 | 19.1 | 40 | 34.5 |
| 25 | 18.3 | 43 | 24.7 | 26 | 19.1 | 40 | 34.5 |
| 25 | 18.3 | 42 | 24.7 | 26 | 19.1 | 41 | 34.5 |
| 25 | 18.3 | 40 | 24.7 | 26 | 19.1 | 42 | 34.5 |
| 24 | 18.3 | 41 | 24.7 | 26 | 19.1 | 44 | 34.5 |
| 24 | 18.3 | 41 | 24.7 | 26 | 19.1 | 39 | 34.5 |
| 24 | 18.3 | 41 | 24.7 | 25 | 19.1 | 40 | 34.5 |

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**Table A.5 (cont.)**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 23 | 18.3 | 42 | 24.7 | 25 | 19.1 | 41 | 34.5 |
| 23 | 18.3 | 44 | 24.7 | 25 | 19.1 | 40 | 34.5 |
| 23 | 18.3 | 44 | 24.7 | 25 | 19.1 | 40 | 34.5 |
| 25 | 18.3 | 49 | 18.3 | 26 | 19.1 | 42 | 32.7 |
| 25 | 18.3 | 51 | 18.3 | 26 | 19.1 | 43 | 32.7 |
| 24 | 18.3 | 50 | 18.3 | 26 | 19.1 | 44 | 32.7 |
| 24 | 18.3 | 50 | 18.3 | 25 | 19.1 | 46 | 32.7 |
| 24 | 18.3 | 51 | 18.3 | 25 | 19.1 | 45 | 32.7 |
| 24 | 18.3 | 49 | 18.3 | 25 | 19.1 | 44 | 32.7 |
| 24 | 18.3 | 49 | 18.3 | 25 | 19.1 | 42 | 32.7 |
| 24 | 18.3 | 50 | 18.3 | 25 | 19.1 | 41 | 32.7 |
| 24 | 18.3 | 48 | 18.3 | 26 | 19.1 | 42 | 32.7 |
| 24 | 18.3 | 50 | 18.3 | 26 | 19.1 | 41 | 32.7 |

Table A.6. Raw data of the route D-G and E-H.

| Route D-G | | | | Route E-H | | | |
|---|---|---|---|---|---|---|---|
| Off-peak hours | | Peak hours | | Off-peak hours | | Peak hours | |
| Travel time (min) | Travel distance (km) | Travel time (min) | Travel distance (km) | Travel time (min) | Travel distance (km) | Travel time (min) | Travel distance (km) |
| 23 | 27.2 | 32 | 25.1 | 20 | 21.8 | 19 | 21.8 |
| 22 | 27.2 | 34 | 27.2 | 19 | 21.8 | 20 | 21.8 |
| 23 | 27.2 | 36 | 25.1 | 17 | 21.8 | 23 | 21.8 |
| 23 | 27.2 | 37 | 27.2 | 17 | 21.8 | 22 | 21.8 |
| 23 | 27.2 | 36 | 25.1 | 17 | 21.8 | 22 | 21.8 |
| 23 | 27.2 | 34 | 25.1 | 17 | 21.8 | 21 | 21.8 |
| 23 | 27.2 | 33 | 25.1 | 17 | 21.8 | 20 | 21.8 |
| 22 | 27.2 | 33 | 25.1 | 17 | 21.8 | 22 | 21.8 |
| 22 | 27.2 | 33 | 25.1 | 17 | 21.8 | 21 | 21.8 |
| 22 | 27.2 | 33 | 25.1 | 17 | 21.8 | 20 | 21.8 |
| 22 | 27.2 | 32 | 25.1 | 18 | 21.8 | 17 | 21.8 |
| 22 | 27.2 | 34 | 27.2 | 18 | 21.8 | 21 | 21.8 |
| 22 | 27.2 | 33 | 27.2 | 18 | 21.8 | 20 | 21.8 |
| 22 | 27.2 | 31 | 25.1 | 18 | 21.8 | 20 | 21.8 |
| 22 | 27.2 | 31 | 25.1 | 18 | 21.8 | 21 | 21.8 |
| 22 | 27.2 | 31 | 27.2 | 18 | 21.8 | 21 | 21.8 |
| 22 | 27.2 | 30 | 27.2 | 18 | 21.8 | 20 | 21.8 |
| 22 | 27.2 | 29 | 27.2 | 17 | 21.8 | 20 | 21.8 |
| 22 | 27.2 | 28 | 27.2 | 17 | 21.8 | 20 | 21.8 |
| 22 | 27.2 | 28 | 27.2 | 17 | 21.8 | 20 | 21.8 |
| 22 | 27.2 | 34 | 25.1 | 18 | 21.8 | 21 | 21.8 |
| 22 | 27.2 | 35 | 25.2 | 18 | 21.8 | 21 | 22.1 |
| 22 | 27.2 | 35 | 25.1 | 18 | 21.8 | 21 | 22.1 |
| 22 | 27.2 | 32 | 25.1 | 18 | 21.8 | 21 | 22.1 |
| 22 | 27.2 | 32 | 25.1 | 18 | 21.8 | 21 | 22.1 |
| 22 | 27.2 | 32 | 25.1 | 18 | 21.8 | 21 | 22.1 |
| 22 | 27.2 | 32 | 25.1 | 18 | 21.8 | 21 | 22.1 |
| 23 | 27.2 | 32 | 25.1 | 18 | 21.8 | 21 | 22.1 |
| 22 | 27.2 | 32 | 25.1 | 18 | 21.8 | 21 | 22.1 |
| 22 | 27.2 | 32 | 25.1 | 18 | 21.8 | 21 | 21.8 |
| 22 | 27.2 | 33 | 25.1 | 17 | 21.8 | 21 | 21.8 |
| 22 | 27.2 | 33 | 25.1 | 17 | 21.8 | 20 | 21.8 |
| 22 | 27.2 | 32 | 25.1 | 17 | 21.8 | 20 | 21.8 |
| 22 | 27.2 | 31 | 25.1 | 17 | 21.8 | 20 | 21.8 |
| 22 | 27.2 | 32 | 25.1 | 18 | 21.8 | 20 | 21.8 |
| 22 | 27.2 | 33 | 27.2 | 18 | 21.8 | 20 | 21.8 |
| 22 | 27.2 | 31 | 27.2 | 18 | 21.8 | 20 | 21.8 |
| 22 | 27.2 | 30 | 27.2 | 18 | 21.8 | 20 | 21.8 |
| 22 | 27.2 | 27 | 27.2 | 18 | 21.8 | 20 | 21.8 |

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Table A.6 (cont.)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 22 | 27.2 | 27 | 27.2 | 18 | 21.8 | 20 | 21.8 |
| 22 | 27.2 | 34 | 25.1 | 17 | 21.8 | 21 | 22.1 |
| 22 | 27.2 | 34 | 25.1 | 17 | 21.8 | 21 | 22.1 |
| 22 | 27.2 | 34 | 25.1 | 17 | 21.8 | 22 | 22.1 |
| 22 | 27.2 | 34 | 25.1 | 17 | 21.8 | 22 | 22.1 |
| 22 | 27.2 | 34 | 25.1 | 17 | 21.8 | 22 | 22.1 |
| 22 | 27.2 | 34 | 25.1 | 17 | 21.8 | 21 | 22.1 |
| 22 | 27.2 | 34 | 25.1 | 18 | 21.8 | 21 | 22.1 |
| 22 | 27.2 | 34 | 25.1 | 18 | 21.8 | 21 | 22.1 |
| 22 | 27.2 | 33 | 25.1 | 18 | 21.8 | 22 | 21.8 |
| 22 | 27.2 | 33 | 25.1 | 18 | 21.8 | 22 | 21.8 |
| 22 | 27.2 | 38 | 27.2 | 18 | 21.8 | 21 | 21.8 |
| 23 | 27.2 | 38 | 27.2 | 18 | 21.8 | 21 | 21.8 |
| 22 | 27.2 | 34 | 25.1 | 17 | 21.8 | 21 | 21.8 |
| 22 | 27.2 | 33 | 25.1 | 17 | 21.8 | 20 | 21.8 |
| 22 | 27.2 | 32 | 25.1 | 18 | 21.8 | 20 | 21.8 |
| 24 | 27.2 | 31 | 25.1 | 18 | 21.8 | 20 | 21.8 |
| 22 | 27.2 | 32 | 25.1 | 17 | 21.8 | 20 | 21.8 |
| 23 | 27.2 | 31 | 25.1 | 18 | 21.8 | 20 | 21.8 |
| 23 | 27.2 | 31 | 25.1 | 18 | 21.8 | 20 | 21.8 |
| 23 | 27.2 | 30 | 25.1 | 18 | 21.8 | 20 | 21.8 |
| 23 | 27.2 | 34 | 25.1 | 18 | 21.8 | 20 | 21.8 |
| 23 | 27.2 | 38 | 25.1 | 18 | 21.8 | 20 | 21.8 |
| 23 | 27.2 | 38 | 25.1 | 18 | 21.8 | 20 | 21.8 |
| 23 | 27.2 | 34 | 25.1 | 18 | 21.8 | 20 | 21.8 |
| 23 | 27.2 | 34 | 25.1 | 18 | 21.8 | 20 | 21.8 |
| 23 | 27.2 | 34 | 25.1 | 18 | 21.8 | 21 | 21.8 |
| 22 | 27.2 | 35 | 25.1 | 18 | 21.8 | 21 | 21.8 |
| 22 | 27.2 | 35 | 25.2 | 17 | 21.8 | 20 | 21.8 |
| 23 | 27.2 | 33 | 25.2 | 17 | 21.8 | 20 | 21.8 |
| 23 | 27.2 | 33 | 25.2 | 17 | 21.8 | 20 | 21.8 |
| 22 | 27.2 | 32 | 27.2 | 18 | 21.8 | 21 | 22.1 |
| 22 | 27.2 | 32 | 27.2 | 18 | 21.8 | 21 | 22.1 |
| 22 | 27.2 | 33 | 27.2 | 17 | 21.8 | 21 | 22.1 |
| 22 | 27.2 | 32 | 27.2 | 18 | 21.8 | 21 | 22.1 |
| 22 | 27.2 | 32 | 27.2 | 17 | 21.8 | 21 | 22.1 |
| 22 | 27.2 | 31 | 25.1 | 18 | 21.8 | 21 | 22.1 |
| 22 | 27.2 | 31 | 27.2 | 18 | 21.8 | 21 | 22.1 |
| 22 | 27.2 | 31 | 27.2 | 17 | 21.8 | 21 | 22.1 |
| 22 | 27.2 | 30 | 27.2 | 18 | 21.8 | 21 | 22.1 |
| 22 | 27.2 | 29 | 27.2 | 18 | 21.8 | 21 | 22.1 |
| 22 | 27.2 | 31 | 27.2 | 17 | 21.8 | 21 | 22.1 |
| 22 | 27.2 | 32 | 27.2 | 17 | 21.8 | 21 | 22.1 |
| 22 | 27.2 | 32 | 27.2 | 17 | 21.8 | 21 | 22.1 |
| 22 | 27.2 | 34 | 27.2 | 17 | 21.8 | 21 | 22.1 |
| 22 | 27.2 | 32 | 25.1 | 17 | 21.8 | 21 | 22.1 |
| 22 | 27.2 | 31 | 25.1 | 17 | 21.8 | 21 | 22.1 |
| 22 | 27.2 | 31 | 25.1 | 17 | 21.8 | 21 | 22.1 |
| 23 | 27.2 | 31 | 25.1 | 17 | 21.8 | 21 | 22.1 |
| 22 | 27.2 | 31 | 25.1 | 17 | 21.8 | 21 | 22.1 |
| 22 | 27.2 | 31 | 25.1 | 17 | 21.8 | 21 | 22.1 |
| 22 | 27.2 | 35 | 25.1 | 18 | 21.8 | 21 | 21.8 |
| 22 | 27.2 | 34 | 25.1 | 18 | 21.8 | 20 | 21.8 |
| 22 | 27.2 | 35 | 25.1 | 18 | 21.8 | 21 | 21.8 |
| 22 | 27.2 | 35 | 25.1 | 18 | 21.8 | 22 | 21.8 |
| 22 | 27.2 | 35 | 25.1 | 18 | 21.8 | 21 | 21.8 |
| 22 | 27.2 | 34 | 25.1 | 18 | 21.8 | 22 | 21.8 |
| 22 | 27.2 | 35 | 25.1 | 17 | 21.8 | 21 | 22.1 |
| 22 | 27.2 | 35 | 25.1 | 17 | 21.8 | 21 | 22.1 |
| 22 | 27.2 | 35 | 25.1 | 17 | 21.8 | 21 | 21.8 |
| 22 | 27.2 | 35 | 25.1 | 17 | 21.8 | 22 | 22.1 |

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**Table A.6 (cont.)**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 22 | 27.2 | 29 | 27.2 | 17 | 21.8 | 21 | 22.1 |
| 22 | 27.2 | 31 | 27.2 | 18 | 21.8 | 21 | 22.1 |
| 22 | 27.2 | 32 | 27.2 | 17 | 21.8 | 21 | 22.1 |
| 22 | 27.2 | 32 | 27.2 | 17 | 21.8 | 21 | 22.1 |
| 22 | 27.2 | 31 | 27.2 | 18 | 21.8 | 21 | 22.1 |
| 23 | 27.2 | 32 | 27.2 | 17 | 21.8 | 21 | 21.8 |
| 22 | 27.2 | 32 | 27.2 | 17 | 21.8 | 21 | 22.1 |
| 22 | 27.2 | 30 | 25.1 | 17 | 21.8 | 21 | 22.1 |
| 22 | 27.2 | 30 | 25.1 | 17 | 21.8 | 21 | 22.1 |
| 22 | 27.2 | 30 | 25.1 | 17 | 21.8 | 21 | 22.1 |
| 22 | 27.2 | 21 | 27.2 | 18 | 21.8 | 20 | 22.1 |
| 22 | 27.2 | 32 | 27.2 | 18 | 21.8 | 21 | 22.1 |
| 23 | 27.2 | 34 | 27.2 | 19 | 21.8 | 21 | 22.1 |
| 22 | 27.2 | 33 | 27.2 | 18 | 21.8 | 21 | 22.1 |
| 22 | 27.2 | 32 | 25.1 | 18 | 21.8 | 21 | 22.1 |
| 22 | 27.2 | 32 | 25.1 | 18 | 21.8 | 21 | 21.8 |
| 22 | 27.2 | 31 | 25.1 | 17 | 21.8 | 21 | 21.8 |
| 22 | 27.2 | 32 | 25.1 | 17 | 21.8 | 21 | 21.8 |
| 22 | 27.2 | 31 | 25.1 | 17 | 21.8 | 21 | 21.8 |
| 22 | 27.2 | 30 | 25.1 | 17 | 21.8 | 21 | 21.8 |
| 22 | 27.2 | 34 | 25.1 | 18 | 21.8 | 20 | 22.1 |
| 22 | 27.2 | 34 | 25.1 | 18 | 21.8 | 20 | 22.1 |
| 22 | 27.2 | 35 | 25.1 | 17 | 21.8 | 20 | 22.1 |
| 22 | 27.2 | 34 | 25.1 | 17 | 21.8 | 20 | 22.1 |
| 22 | 27.2 | 33 | 25.1 | 18 | 21.8 | 21 | 21.8 |
| 22 | 27.2 | 33 | 25.1 | 18 | 21.8 | 21 | 21.8 |
| 22 | 27.2 | 32 | 25.1 | 18 | 21.8 | 21 | 21.8 |
| 22 | 27.2 | 32 | 25.1 | 18 | 21.8 | 21 | 21.8 |
| 22 | 27.2 | 33 | 25.1 | 17 | 21.8 | 21 | 21.8 |
| 22 | 27.2 | 33 | 25.1 | 18 | 21.8 | 21 | 21.8 |
| 22 | 27.2 | 32 | 25.1 | 18 | 21.8 | 20 | 21.8 |
| 22 | 27.2 | 34 | 25.1 | 18 | 21.8 | 20 | 21.8 |
| 22 | 27.2 | 33 | 25.1 | 17 | 21.8 | 20 | 21.8 |
| 23 | 27.2 | 31 | 25.1 | 18 | 21.8 | 20 | 21.8 |
| 23 | 27.2 | 31 | 25.1 | 18 | 21.8 | 21 | 21.8 |
| 22 | 27.2 | 31 | 25.1 | 17 | 21.8 | 21 | 21.8 |
| 22 | 27.2 | 32 | 25.1 | 18 | 21.8 | 21 | 21.8 |
| 24 | 27.2 | 31 | 25.1 | 19 | 21.8 | 21 | 21.8 |
| 23 | 27.2 | 29 | 25.1 | 18 | 21.8 | 21 | 21.8 |
| 23 | 27.2 | 29 | 25.1 | 18 | 21.8 | 21 | 21.8 |
| 22 | 27.2 | 35 | 25.1 | 18 | 21.8 | 20 | 21.8 |
| 22 | 27.2 | 37 | 25.1 | 17 | 21.8 | 20 | 21.8 |
| 22 | 27.2 | 38 | 25.1 | 17 | 21.8 | 20 | 21.8 |
| 22 | 27.2 | 40 | 25.1 | 17 | 21.8 | 20 | 21.8 |
| 22 | 27.2 | 39 | 25.1 | 17 | 21.8 | 20 | 21.8 |
| 22 | 27.2 | 37 | 25.1 | 17 | 21.8 | 20 | 21.8 |
| 22 | 27.2 | 35 | 25.1 | 17 | 21.8 | 20 | 21.8 |
| 22 | 27.2 | 34 | 25.1 | 17 | 21.8 | 21 | 21.8 |
| 22 | 27.2 | 34 | 25.1 | 17 | 21.8 | 21 | 21.8 |
| 22 | 27.2 | 34 | 25.1 | 17 | 21.8 | 20 | 21.8 |
| 22 | 27.2 | 35 | 25.1 | 17 | 21.8 | 19 | 21.8 |
| 22 | 27.2 | 35 | 25.1 | 17 | 21.8 | 19 | 21.8 |
| 22 | 27.2 | 34 | 25.1 | 17 | 21.8 | 19 | 21.8 |
| 22 | 27.2 | 33 | 25.1 | 17 | 21.8 | 20 | 21.8 |
| 22 | 27.2 | 33 | 25.1 | 17 | 21.8 | 19 | 21.8 |
| 22 | 27.2 | 33 | 25.1 | 18 | 21.8 | 19 | 21.8 |
| 22 | 27.2 | 32 | 25.1 | 18 | 21.8 | 19 | 21.8 |
| 23 | 27.2 | 31 | 25.1 | 18 | 21.8 | 19 | 21.8 |
| 22 | 27.2 | 32 | 25.1 | 18 | 21.8 | 20 | 21.8 |
| 22 | 27.2 | 32 | 27.2 | 18 | 21.8 | 19 | 21.8 |
| 22 | 27.2 | 32 | 27.2 | 18 | 21.8 | 21 | 22.1 |

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**Table A.6 (cont.)**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 22 | 27.2 | 32 | 27.2 | 17 | 21.8 | 21 | 22.1 |
| 22 | 27.2 | 32 | 27.2 | 18 | 21.8 | 21 | 22.1 |
| 22 | 27.2 | 31 | 27.2 | 18 | 21.8 | 21 | 22.1 |
| 22 | 27.2 | 31 | 27.2 | 17 | 21.8 | 21 | 22.1 |
| 22 | 27.2 | 32 | 27.2 | 17 | 21.8 | 21 | 22.1 |
| 22 | 27.2 | 32 | 27.2 | 18 | 21.8 | 21 | 22.1 |
| 22 | 27.2 | 32 | 27.2 | 17 | 21.8 | 21 | 22.1 |
| 22 | 27.2 | 32 | 27.2 | 17 | 21.8 | 22 | 22.1 |
| 22 | 27.2 | 31 | 27.2 | 17 | 21.8 | 22 | 21.8 |
| 22 | 27.2 | 30 | 27.2 | 18 | 21.8 | 19 | 21.8 |
| 22 | 27.2 | 29 | 27.2 | 18 | 21.8 | 19 | 21.8 |
| 22 | 27.2 | 29 | 27.2 | 18 | 21.8 | 20 | 21.8 |
| 22 | 27.2 | 28 | 27.2 | 18 | 21.8 | 20 | 21.8 |
| 22 | 27.2 | 27 | 27.2 | 18 | 21.8 | 20 | 21.8 |
| 22 | 27.2 | 27 | 27.2 | 18 | 21.8 | 20 | 21.8 |
| 22 | 27.2 | 27 | 27.2 | 18 | 21.8 | 20 | 21.8 |
| 22 | 27.2 | 27 | 27.2 | 18 | 21.8 | 20 | 21.8 |
| 22 | 27.2 | 27 | 27.2 | 18 | 21.8 | 20 | 21.8 |
| 22 | 27.2 | 27 | 27.2 | 18 | 21.8 | 20 | 21.8 |
| 22 | 27.2 | 30 | 27.2 | 18 | 21.8 | 22 | 21.8 |
| 22 | 27.2 | 31 | 27.2 | 18 | 21.8 | 21 | 21.8 |
| 23 | 27.2 | 30 | 27.2 | 17 | 21.8 | 20 | 21.8 |
| 22 | 27.2 | 30 | 27.2 | 17 | 21.8 | 19 | 21.8 |
| 22 | 27.2 | 31 | 27.2 | 17 | 21.8 | 20 | 21.8 |
| 22 | 27.2 | 30 | 27.2 | 17 | 21.8 | 20 | 21.8 |
| 23 | 27.2 | 29 | 27.2 | 17 | 21.8 | 21 | 21.8 |
| 23 | 27.2 | 29 | 27.2 | 17 | 21.8 | 20 | 21.8 |
| 23 | 27.2 | 30 | 27.2 | 17 | 21.8 | 19 | 21.8 |
| 22 | 27.2 | 31 | 27.2 | 17 | 21.8 | 19 | 21.8 |
| 22 | 27.2 | 35 | 25.1 | 18 | 21.8 | 20 | 21.8 |
| 22 | 27.2 | 37 | 25.1 | 18 | 21.8 | 20 | 21.8 |
| 22 | 27.2 | 38 | 25.1 | 17 | 21.8 | 20 | 21.8 |
| 23 | 27.2 | 40 | 25.1 | 18 | 21.8 | 20 | 21.8 |
| 23 | 27.2 | 39 | 25.1 | 18 | 21.8 | 20 | 21.8 |
| 22 | 27.2 | 37 | 25.1 | 17 | 21.8 | 20 | 21.8 |
| 22 | 27.2 | 35 | 25.1 | 18 | 21.8 | 20 | 21.8 |
| 24 | 27.2 | 34 | 25.1 | 19 | 21.8 | 21 | 21.8 |
| 23 | 27.2 | 34 | 25.1 | 18 | 21.8 | 21 | 21.8 |
| 23 | 27.2 | 34 | 25.1 | 18 | 21.8 | 20 | 21.8 |

Table A.7. Raw data of the route I-N and I-M.

| Route I-N | | | | Route I-M | | | |
|---|---|---|---|---|---|---|---|
| Off-peak hours | | Peak hours | | Off-peak hours | | Peak hours | |
| Travel time (min) | Travel distance (km) | Travel time (min) | Travel distance (km) | Travel time (min) | Travel distance (km) | Travel time (min) | Travel distance (km) |
| 10 | 3.2 (a) | 17 | 3.2 (b) | 7 | 2.6 | 13 | 2.6 |
| 10 | 3.2 (a) | 18 | 4.2 | 7 | 2.6 | 15 | 2.6 |
| 10 | 3.2 (a) | 17 | 4.2 | 7 | 2.6 | 14 | 2.6 |
| 11 | 3.2 (a) | 16 | 4.2 | 7 | 2.6 | 15 | 2.6 |
| 10 | 3.2 (a) | 17 | 4.2 | 7 | 2.6 | 14 | 2.6 |
| 10 | 3.2 (a) | 17 | 4.2 | 7 | 2.6 | 13 | 2.6 |
| 11 | 3.2 (a) | 17 | 4.2 | 7 | 2.6 | 12 | 2.6 |
| 10 | 3.2 (a) | 16 | 4.2 | 7 | 2.6 | 14 | 2.6 |
| 10 | 3.2 (a) | 16 | 4.2 | 7 | 2.6 | 16 | 2.6 |
| 10 | 3.2 (a) | 15 | 3.2 (b) | 7 | 2.6 | 15 | 2.6 |
| 11 | 3.2 (a) | 15 | 3.2 (b) | 8 | 2.6 | 15 | 4 |
| 11 | 3.2 (a) | 15 | 3.2 (b) | 8 | 2.6 | 15 | 4 |
| 11 | 3.2 (a) | 16 | 4.2 | 8 | 2.6 | 15 | 4 |

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**Table A.7 (cont.)**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 11 | 3.2 (a) | 17 | 4.2 | 8 | 2.6 | 15 | 3.1 |
| 11 | 3.2 (a) | 19 | 4.2 | 8 | 2.6 | 15 | 3.1 |
| 11 | 3.2 (a) | 17 | 4.2 | 8 | 2.6 | 14 | 3.1 |
| 11 | 3.2 (a) | 17 | 4.2 | 8 | 2.6 | 15 | 3.1 |
| 11 | 3.2 (a) | 15 | 3.2 (b) | 8 | 2.6 | 14 | 3.1 |
| 11 | 3.2 (a) | 15 | 3.2 (b) | 7 | 2.6 | 14 | 3.1 |
| 11 | 3.2 (a) | 15 | 3.2 (b) | 7 | 2.6 | 14 | 3.1 |
| 11 | 3.2 (a) | 17 | 4.2 | 7 | 2.6 | 15 | 4 |
| 11 | 3.2 (a) | 17 | 4.2 | 7 | 2.6 | 14 | 2.6 |
| 11 | 3.2 (a) | 17 | 4.2 | 7 | 2.6 | 15 | 4 |
| 11 | 3.2 (a) | 16 | 4.2 | 7 | 2.6 | 15 | 4 |
| 11 | 3.2 (a) | 18 | 4.2 | 7 | 2.6 | 14 | 2.6 |
| 11 | 3.2 (a) | 16 | 4.2 | 8 | 2.6 | 14 | 2.6 |
| 11 | 3.2 (a) | 16 | 3.2 (b) | 8 | 2.6 | 12 | 2.6 |
| 11 | 3.2 (a) | 16 | 4.2 | 8 | 2.6 | 13 | 2.6 |
| 11 | 3.2 (a) | 15 | 3.2 (b) | 8 | 2.6 | 13 | 2.6 |
| 11 | 3.2 (a) | 16 | 4.2 | 8 | 2.6 | 13 | 2.6 |
| 10 | 3 | 19 | 4.2 | 7 | 2.6 | 15 | 3.1 |
| 10 | 3 | 18 | 3.2 (b) | 7 | 2.6 | 15 | 3.1 |
| 11 | 3.2 (a) | 17 | 4.2 | 7 | 2.6 | 14 | 2.6 |
| 11 | 3.2 (a) | 17 | 3.2 (b) | 7 | 2.6 | 14 | 2.6 |
| 10 | 3.2 (a) | 19 | 4.2 | 7 | 2.6 | 14 | 2.6 |
| 10 | 3.2 (a) | 19 | 4.2 | 7 | 2.6 | 14 | 2.6 |
| 10 | 3.2 (a) | 16 | 3.2 (b) | 7 | 2.6 | 13 | 2.6 |
| 10 | 3.2 (a) | 19 | 4.2 | 7 | 2.6 | 13 | 2.6 |
| 11 | 3.2 (a) | 18 | 4.2 | 7 | 2.6 | 13 | 2.6 |
| 11 | 3.2 (a) | 18 | 4.2 | 7 | 2.6 | 13 | 2.6 |
| 10 | 3.2 (a) | 21 | 4.2 | 7 | 2.6 | 16 | 2.6 |
| 10 | 3.2 (a) | 21 | 3.2 (b) | 7 | 2.6 | 16 | 2.6 |
| 10 | 3.2 (a) | 22 | 3.2 (b) | 7 | 2.6 | 15 | 2.6 |
| 10 | 3.2 (a) | 19 | 4.2 | 7 | 2.6 | 14 | 2.6 |
| 10 | 3.2 (a) | 20 | 3.2 (b) | 7 | 2.6 | 14 | 2.6 |
| 10 | 3.2 (a) | 19 | 3.2 (b) | 7 | 2.6 | 14 | 2.6 |
| 10 | 3.2 (a) | 19 | 3.2 (b) | 7 | 2.6 | 14 | 2.6 |
| 10 | 3.2 (a) | 18 | 3.2 (b) | 7 | 2.6 | 14 | 2.6 |
| 10 | 3.2 (a) | 17 | 3.2 (b) | 7 | 2.6 | 13 | 2.6 |
| 10 | 3.2 (a) | 17 | 3.2 (b) | 7 | 2.6 | 14 | 2.6 |
| 10 | 3.2 (a) | 16 | 3.2 (b) | 7 | 2.6 | 12 | 2.6 |
| 10 | 3.2 (a) | 16 | 3.2 (b) | 7 | 2.6 | 13 | 2.6 |
| 10 | 3.2 (a) | 16 | 3.2 (b) | 7 | 2.6 | 12 | 2.6 |
| 10 | 3 | 20 | 4.2 | 7 | 2.6 | 13 | 2.6 |
| 10 | 3 | 18 | 4.2 | 7 | 2.6 | 13 | 2.6 |
| 10 | 3 | 17 | 4.2 | 7 | 2.6 | 13 | 2.6 |
| 10 | 3 | 17 | 4.2 | 7 | 2.6 | 13 | 2.6 |
| 10 | 3 | 16 | 4.2 | 7 | 2.6 | 13 | 2.6 |
| 10 | 3.2 (a) | 16 | 4.2 | 7 | 2.6 | 12 | 2.6 |
| 10 | 3.2 (a) | 16 | 4.2 | 7 | 2.6 | 12 | 2.6 |
| 11 | 4.2 | 16 | 3.2 (b) | 8 | 2.6 | 13 | 2.6 |
| 11 | 4.2 | 17 | 4.2 | 7 | 2.6 | 13 | 2.6 |
| 10 | 3 | 17 | 4.2 | 8 | 2.6 | 12 | 2.6 |
| 10 | 3 | 15 | 4.2 | 8 | 2.6 | 12 | 2.6 |
| 10 | 3 | 14 | 4.2 | 7 | 2.6 | 12 | 2.6 |
| 10 | 3 | 15 | 4.2 | 7 | 2.6 | 12 | 2.6 |
| 10 | 3 | 15 | 4.2 | 8 | 2.6 | 11 | 2.6 |
| 10 | 3 | 14 | 4.2 | 8 | 2.6 | 12 | 2.6 |
| 10 | 3 | 13 | 4.2 | 8 | 2.6 | 11 | 2.6 |
| 10 | 3 | 14 | 4.2 | 7 | 2.6 | 11 | 2.6 |
| 11 | 3 | 19 | 4.2 | 7 | 2.6 | 14 | 2.6 |
| 11 | 3 | 19 | 4.2 | 7 | 2.6 | 13 | 2.6 |
| 11 | 3 | 18 | 4.2 | 7 | 2.6 | 14 | 2.6 |
| 11 | 3 | 20 | 4.2 | 7 | 2.6 | 14 | 2.6 |

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**Table A.7 (cont.)**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 11 | 3 | 18 | 4.2 | 7 | 2.6 | 14 | 2.6 |
| 11 | 3 | 19 | 4.2 | 7 | 2.6 | 13 | 2.6 |
| 11 | 3 | 17 | 4.2 | 8 | 2.6 | 12 | 2.6 |
| 11 | 3 | 17 | 4.2 | 8 | 2.6 | 13 | 2.6 |
| 11 | 3 | 19 | 4.2 | 8 | 2.6 | 13 | 2.6 |
| 11 | 3 | 18 | 4.2 | 7 | 2.6 | 13 | 2.6 |
| 11 | 3 | 16 | 4.2 | 8 | 2.6 | 15 | 2.6 |
| 11 | 3 | 16 | 4.2 | 8 | 2.6 | 15 | 2.6 |
| 11 | 3 | 17 | 4.2 | 8 | 2.6 | 15 | 2.6 |
| 11 | 3 | 16 | 4.2 | 8 | 2.6 | 15 | 2.6 |
| 11 | 3 | 16 | 4.2 | 8 | 2.6 | 15 | 2.6 |
| 11 | 3 | 16 | 4.2 | 7 | 2.6 | 14 | 2.6 |
| 11 | 3 | 16 | 4.2 | 7 | 2.6 | 14 | 2.6 |
| 11 | 3 | 16 | 4.2 | 7 | 2.6 | 15 | 2.6 |
| 11 | 3 | 17 | 3.2 (b) | 7 | 2.6 | 13 | 2.6 |
| 11 | 3 | 18 | 4.2 | 7 | 2.6 | 14 | 2.6 |
| 10 | 3 | 17 | 4.2 | 7 | 2.6 | 15 | 2.6 |
| 10 | 3 | 19 | 4.2 | 7 | 2.6 | 14 | 2.6 |
| 11 | 3 | 17 | 4.2 | 7 | 2.6 | 14 | 2.6 |
| 11 | 3 | 17 | 4.2 | 7 | 2.6 | 15 | 2.6 |
| 10 | 3 | 18 | 4.2 | 7 | 2.6 | 15 | 3.1 |
| 10 | 3 | 17 | 4.2 | 7 | 2.6 | 14 | 3.1 |
| 10 | 3 | 16 | 4.2 | 7 | 2.6 | 14 | 3.1 |
| 11 | 3 | 17 | 4.2 | 7 | 2.6 | 15 | 2.6 |
| 11 | 3 | 19 | 4.2 | 7 | 2.6 | 14 | 2.6 |
| 10 | 3 | 19 | 4.2 | 7 | 2.6 | 13 | 2.6 |
| 10 | 3 | 16 | 4.2 | 7 | 2.6 | 12 | 2.6 |
| 10 | 3 | 16 | 4.2 | 7 | 2.6 | 13 | 2.6 |
| 10 | 3 | 17 | 4.2 | 7 | 2.6 | 13 | 2.6 |
| 10 | 3 | 16 | 4.2 | 7 | 2.6 | 13 | 2.6 |
| 10 | 3 | 16 | 4.2 | 7 | 2.6 | 13 | 2.6 |
| 10 | 3 | 18 | 4.2 | 7 | 2.6 | 14 | 2.6 |
| 10 | 3 | 18 | 4.2 | 7 | 2.6 | 14 | 2.6 |
| 10 | 3 | 17 | 4.2 | 7 | 2.6 | 14 | 2.6 |
| 10 | 3 | 18 | 4.2 | 7 | 2.6 | 14 | 2.6 |
| 10 | 3 | 16 | 4.2 | 7 | 2.6 | 14 | 2.6 |
| 11 | 3 | 18 | 3.5 | 8 | 2.6 | 13 | 2.6 |
| 11 | 3 | 18 | 3.5 | 7 | 2.6 | 13 | 2.6 |
| 11 | 3 | 18 | 3.5 | 7 | 2.6 | 12 | 2.6 |
| 11 | 3 | 18 | 3.5 | 8 | 2.6 | 13 | 2.6 |
| 11 | 3 | 17 | 3.5 | 8 | 2.6 | 12 | 2.6 |
| 11 | 3 | 18 | 3.5 | 8 | 2.6 | 13 | 2.6 |
| 11 | 3 | 17 | 3.5 | 8 | 2.6 | 14 | 2.6 |
| 11 | 3 | 17 | 3.5 | 8 | 2.6 | 13 | 2.6 |
| 11 | 3 | 18 | 3.5 | 8 | 2.6 | 13 | 2.6 |
| 11 | 3 | 18 | 3.5 | 8 | 2.6 | 13 | 2.6 |
| 11 | 3 | 18 | 3.5 | 7 | 2.6 | 13 | 2.6 |
| 10 | 3 | 29 | 3.5 | 7 | 2.6 | 13 | 2.6 |
| 10 | 3 | 29 | 4.2 | 7 | 2.6 | 15 | 2.6 |
| 10 | 3 | 17 | 4.2 | 7 | 2.6 | 12 | 3.1 |
| 10 | 3 | 17 | 3.5 | 7 | 2.6 | 13 | 2.6 |
| 11 | 3 | 17 | 3.5 | 7 | 2.6 | 13 | 3.1 |
| 11 | 3 | 17 | 3.5 | 7 | 2.6 | 14 | 3.1 |
| 11 | 3 | 16 | 4.2 | 7 | 2.6 | 13 | 3.1 |
| 10 | 3 | 15 | 4.2 | 7 | 2.6 | 13 | 3.1 |
| 10 | 3 | 17 | 4.2 | 7 | 2.6 | 14 | 3.1 |
| 11 | 3 | 18 | 4.2 | 8 | 2.6 | 13 | 2.6 |
| 11 | 3 | 17 | 4.2 | 7 | 2.6 | 13 | 2.6 |
| 11 | 3 | 19 | 4.2 | 8 | 2.6 | 13 | 2.6 |
| 11 | 3 | 19 | 4.2 | 8 | 2.6 | 13 | 2.6 |
| 11 | 3 | 18 | 3.5 | 7 | 2.6 | 13 | 2.6 |

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**Table A.7 (cont.)**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 11 | 3 | 18 | 3.5 | 7 | 2.6 | 12 | 2.6 |
| 11 | 3 | 17 | 3.5 | 7 | 2.6 | 11 | 2.6 |
| 11 | 3 | 17 | 3.5 | 7 | 2.6 | 12 | 2.6 |
| 11 | 3 | 17 | 3.5 | 7 | 2.6 | 12 | 2.6 |
| 11 | 3 | 17 | 3.5 | 7 | 2.6 | 12 | 2.6 |
| 11 | 3 | 20 | 4.2 | 7 | 2.6 | 13 | 2.6 |
| 11 | 3 | 19 | 3.5 | 7 | 2.6 | 13 | 2.6 |
| 11 | 3 | 21 | 3.5 | 7 | 2.6 | 14 | 2.6 |
| 11 | 3 | 20 | 4.2 | 8 | 2.6 | 15 | 2.6 |
| 11 | 3 | 19 | 4.2 | 7 | 2.6 | 14 | 2.6 |
| 11 | 3 | 19 | 4.2 | 7 | 2.6 | 13 | 2.6 |
| 11 | 3 | 18 | 4.2 | 7 | 2.6 | 13 | 2.6 |
| 11 | 3 | 18 | 4.2 | 7 | 2.6 | 13 | 3.1 |
| 11 | 3 | 20 | 4.2 | 7 | 2.6 | 14 | 3.1 |
| 11 | 3 | 20 | 4.2 | 7 | 2.6 | 15 | 2.6 |
| 11 | 3 | 17 | 4.2 | 7 | 2.6 | 13 | 2.6 |
| 11 | 3 | 18 | 4.2 | 7 | 2.6 | 13 | 2.6 |
| 11 | 3 | 18 | 3.5 | 7 | 2.6 | 12 | 2.6 |
| 11 | 3 | 18 | 3.5 | 7 | 2.6 | 13 | 2.6 |
| 11 | 3 | 18 | 3.5 | 7 | 2.6 | 12 | 2.6 |
| 11 | 3 | 19 | 3.5 | 7 | 2.6 | 12 | 2.6 |
| 11 | 3 | 17 | 3.5 | 7 | 2.6 | 11 | 2.6 |
| 11 | 3 | 17 | 3.5 | 7 | 2.6 | 13 | 2.6 |
| 11 | 3 | 17 | 4.2 | 7 | 2.6 | 12 | 2.6 |
| 11 | 3 | 16 | 4.2 | 7 | 2.6 | 12 | 2.6 |
| 11 | 3 | 14 | 4.2 | 8 | 2.6 | 15 | 2.6 |
| 11 | 3 | 15 | 4.2 | 8 | 2.6 | 15 | 2.6 |
| 12 | 3 | 19 | 4.2 | 8 | 2.6 | 15 | 2.6 |
| 11 | 4.2 | 19 | 4.2 | 9 | 2.6 | 15 | 2.6 |
| 12 | 3 | 20 | 4.2 | 9 | 2.6 | 16 | 2.6 |
| 12 | 3 | 20 | 3.5 | 8 | 2.6 | 15 | 2.6 |
| 11 | 3 | 20 | 3.5 | 8 | 2.6 | 14 | 2.6 |
| 12 | 3 | 19 | 3.5 | 8 | 2.6 | 15 | 2.6 |
| 12 | 3 | 18 | 3.5 | 8 | 2.6 | 14 | 2.6 |
| 12 | 3 | 18 | 3.5 | 8 | 2.6 | 14 | 2.6 |
| 11 | 3 | 19 | 4.2 | 8 | 2.6 | 12 | 2.6 |
| 11 | 3 | 19 | 4.2 | 8 | 2.6 | 11 | 2.6 |
| 11 | 3 | 17 | 4.2 | 8 | 2.6 | 12 | 2.6 |
| 12 | 3 | 16 | 4.2 | 8 | 2.6 | 14 | 2.6 |
| 12 | 3 | 18 | 4.2 | 8 | 2.6 | 15 | 2.6 |
| 12 | 3 | 18 | 4.2 | 8 | 2.6 | 15 | 2.6 |
| 11 | 3 | 18 | 4.2 | 8 | 2.6 | 15 | 2.6 |
| 12 | 3 | 18 | 4.2 | 8 | 2.6 | 14 | 2.6 |
| 12 | 3 | 15 | 4.2 | 8 | 2.6 | 15 | 2.6 |
| 11 | 3 | 15 | 4.2 | 8 | 2.6 | 16 | 2.6 |
| 11 | 3 | 17 | 4.2 | 8 | 2.6 | 12 | 2.6 |
| 11 | 3 | 17 | 4.2 | 8 | 2.6 | 12 | 2.6 |
| 11 | 3 | 18 | 3.5 | 8 | 2.6 | 13 | 2.6 |
| 10 | 4.2 | 18 | 3.5 | 8 | 2.6 | 12 | 2.6 |
| 11 | 3 | 17 | 3.5 | 8 | 2.6 | 11 | 2.6 |
| 11 | 3 | 16 | 4.2 | 8 | 2.6 | 12 | 2.6 |
| 11 | 3 | 15 | 4.2 | 8 | 2.6 | 13 | 2.6 |
| 11 | 3 | 15 | 4.2 | 8 | 2.6 | 13 | 2.6 |
| 10 | 3 | 16 | 4.2 | 7 | 2.6 | 13 | 2.6 |
| 11 | 3 | 15 | 4.2 | 7 | 2.6 | 13 | 2.6 |
| 10 | 3 | 20 | 4.2 | 7 | 2.6 | 13 | 2.6 |
| 10 | 3 | 19 | 3.5 | 7 | 2.6 | 13 | 3.1 |
| 11 | 3 | 21 | 3.5 | 7 | 2.6 | 14 | 3.1 |
| 11 | 3 | 21 | 3.5 | 7 | 2.6 | 15 | 3.1 |
| 10 | 3 | 20 | 3.5 | 7 | 2.6 | 14 | 2.6 |
| 10 | 3 | 19 | 4.2 | 7 | 2.6 | 13 | 2.6 |

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**Table A.7 (cont.)**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 10 | 3 | 18 | 4.2 | 7 | 2.6 | 13 | 2.6 |
| 11 | 3 | 18 | 4.2 | 7 | 2.6 | 13 | 3.1 |
| 11 | 3 | 20 | 4.2 | 7 | 2.6 | 14 | 3.1 |
| 10 | 3 | 20 | 4.2 | 7 | 2.6 | 15 | 2.6 |

Table A.8. Raw data of the route I-L and J-N.

| Route I-L | | | | Route J-N | | | |
|---|---|---|---|---|---|---|---|
| Off-peak hours | | Peak hours | | Off-peak hours | | Peak hours | |
| Travel time (min) | Travel distance (km) | Travel time (min) | Travel distance (km) | Travel time (min) | Travel distance (km) | Travel time (min) | Travel distance (km) |
| 8 | 2.6 | 14 | 3.1 | 7 | 1.9 | 12 | 2.2 |
| 8 | 2.6 | 16 | 3.1 | 7 | 1.9 | 13 | 2.2 |
| 8 | 2.6 | 15 | 3.1 | 7 | 1.9 | 12 | 2.2 |
| 9 | 2.6 | 15 | 3.1 | 7 | 1.9 | 13 | 2.2 |
| 8 | 2.6 | 14 | 3.1 | 7 | 1.9 | 13 | 2.2 |
| 8 | 2.6 | 14 | 3.1 | 7 | 1.9 | 12 | 2.2 |
| 8 | 2.6 | 14 | 3.1 | 7 | 1.9 | 13 | 2.2 |
| 8 | 2.6 | 15 | 3.1 | 7 | 1.9 | 13 | 2.2 |
| 9 | 2.6 | 17 | 3.1 | 7 | 1.9 | 14 | 2.2 |
| 8 | 2.6 | 15 | 3.1 | 7 | 1.9 | 13 | 2.2 |
| 9 | 2.6 | 14 | 2.8 | 7 | 1.9 | 12 | 2.2 |
| 9 | 2.6 | 14 | 2.8 | 7 | 1.9 | 14 | 2.2 |
| 8 | 2.6 | 16 | 3.1 | 7 | 1.9 | 12 | 2.6 |
| 9 | 2.6 | 16 | 3.4 | 7 | 1.9 | 12 | 2.6 |
| 9 | 2.6 | 15 | 3.4 | 7 | 1.9 | 12 | 2.6 |
| 9 | 2.6 | 15 | 3.4 | 7 | 1.9 | 12 | 2.6 |
| 9 | 2.6 | 15 | 2.8 | 7 | 1.9 | 12 | 2.6 |
| 9 | 2.6 | 14 | 3.4 | 7 | 1.9 | 13 | 2.5 |
| 8 | 2.6 | 14 | 3.4 | 7 | 1.9 | 12 | 2.6 |
| 8 | 2.6 | 15 | 3.4 | 7 | 1.9 | 13 | 2.5 |
| 8 | 2.6 | 14 | 2.8 | 7 | 1.9 | 13 | 2.2 |
| 8 | 2.6 | 14 | 2.8 | 7 | 1.9 | 14 | 2.2 |
| 8 | 2.6 | 15 | 2.8 | 7 | 1.9 | 14 | 2.2 |
| 8 | 2.6 | 16 | 2.8 | 7 | 1.9 | 14 | 2.2 |
| 8 | 2.6 | 15 | 2.8 | 7 | 1.9 | 13 | 2.2 |
| 9 | 2.6 | 14 | 2.8 | 7 | 1.9 | 12 | 2.2 |
| 9 | 2.6 | 13 | 2.8 | 7 | 1.9 | 8 | 2.2 |
| 9 | 2.6 | 13 | 2.8 | 7 | 1.9 | 12 | 2.2 |
| 8 | 2.6 | 13 | 2.8 | 7 | 1.9 | 12 | 2.2 |
| 8 | 2.6 | 13 | 2.8 | 7 | 1.9 | 12 | 2.2 |
| 8 | 2.6 | 16 | 2.8 | 7 | 1.9 | 12 | 2.6 |
| 8 | 2.6 | 16 | 2.8 | 7 | 1.9 | 12 | 2.6 |
| 8 | 2.6 | 14 | 2.8 | 7 | 1.9 | 12 | 2.2 |
| 8 | 2.6 | 14 | 2.8 | 7 | 1.9 | 12 | 2.2 |
| 8 | 2.6 | 14 | 2.8 | 7 | 1.9 | 12 | 2.2 |
| 8 | 2.6 | 14 | 2.8 | 7 | 1.9 | 12 | 2.2 |
| 8 | 2.6 | 13 | 2.8 | 7 | 1.9 | 12 | 2.2 |
| 8 | 2.6 | 13 | 2.8 | 7 | 1.9 | 12 | 2.2 |
| 8 | 2.6 | 14 | 2.8 | 7 | 1.9 | 12 | 2.2 |
| 8 | 2.6 | 14 | 2.8 | 7 | 1.9 | 12 | 2.2 |
| 8 | 2.6 | 16 | 2.8 | 7 | 1.9 | 13 | 2.2 |
| 8 | 2.6 | 15 | 2.8 | 7 | 1.9 | 14 | 2.2 |
| 8 | 2.6 | 15 | 2.8 | 7 | 1.9 | 12 | 2.6 |
| 8 | 2.6 | 14 | 2.8 | 7 | 1.9 | 12 | 2.2 |
| 8 | 2.6 | 14 | 2.8 | 7 | 1.9 | 13 | 2.2 |
| 8 | 2.6 | 14 | 2.8 | 7 | 1.9 | 13 | 2.2 |
| 8 | 2.6 | 14 | 2.8 | 7 | 1.9 | 12 | 2.2 |
| 8 | 2.6 | 14 | 2.8 | 7 | 1.9 | 13 | 2.2 |

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**Table A.8 (cont.)**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 8 | 2.6 | 14 | 2.8 | 7 | 1.9 | 13 | 2.2 |
| 8 | 2.6 | 13 | 2.8 | 7 | 1.9 | 13 | 2.2 |
| 8 | 2.6 | 13 | 2.6 | 7 | 1.9 | 11 | 2.2 |
| 8 | 2.6 | 13 | 2.6 | 7 | 1.9 | 11 | 2.2 |
| 8 | 2.6 | 14 | 2.8 | 7 | 1.9 | 11 | 2.2 |
| 8 | 2.6 | 14 | 2.8 | 7 | 1.9 | 12 | 2.2 |
| 8 | 2.6 | 14 | 2.8 | 7 | 1.9 | 12 | 2.2 |
| 8 | 2.6 | 14 | 2.8 | 7 | 1.9 | 12 | 2.2 |
| 8 | 2.6 | 14 | 2.8 | 7 | 1.9 | 11 | 2.2 |
| 8 | 2.6 | 13 | 2.6 | 7 | 1.9 | 12 | 2.2 |
| 8 | 2.6 | 14 | 2.8 | 7 | 1.9 | 11 | 2.2 |
| 8 | 2.6 | 14 | 2.8 | 7 | 1.9 | 11 | 2.2 |
| 9 | 2.6 | 13 | 2.6 | 7 | 1.9 | 11 | 2.2 |
| 8 | 2.6 | 13 | 2.6 | 7 | 1.9 | 12 | 2.2 |
| 9 | 2.6 | 15 | 2.8 | 7 | 1.9 | 11 | 2.2 |
| 9 | 2.6 | 13 | 2.6 | 7 | 1.9 | 11 | 2.2 |
| 8 | 2.6 | 14 | 2.8 | 7 | 1.9 | 11 | 2.2 |
| 8 | 2.6 | 14 | 2.8 | 7 | 1.9 | 11 | 2.2 |
| 8 | 2.6 | 12 | 2.6 | 7 | 1.9 | 10 | 2.2 |
| 8 | 2.6 | 14 | 2.8 | 7 | 1.9 | 11 | 2.2 |
| 8 | 2.6 | 13 | 2.8 | 7 | 1.9 | 11 | 2.2 |
| 8 | 2.6 | 13 | 2.8 | 7 | 1.9 | 10 | 2.2 |
| 8 | 2.6 | 14 | 2.8 | 7 | 1.9 | 13 | 2.2 |
| 8 | 2.6 | 14 | 2.8 | 7 | 1.9 | 13 | 2.2 |
| 8 | 2.6 | 14 | 2.8 | 7 | 1.9 | 12 | 2.2 |
| 8 | 2.6 | 14 | 2.8 | 7 | 1.9 | 13 | 2.2 |
| 8 | 2.6 | 14 | 2.8 | 7 | 1.9 | 13 | 2.2 |
| 8 | 2.6 | 13 | 2.6 | 7 | 1.9 | 12 | 2.2 |
| 9 | 2.6 | 13 | 2.8 | 7 | 1.9 | 12 | 2.2 |
| 9 | 2.6 | 13 | 2.8 | 7 | 1.9 | 12 | 2.2 |
| 9 | 2.6 | 14 | 2.8 | 7 | 1.9 | 12 | 2.2 |
| 8 | 2.6 | 13 | 2.8 | 7 | 1.9 | 12 | 2.2 |
| 9 | 2.6 | 15 | 2.8 | 8 | 1.9 | 12 | 2.2 |
| 9 | 2.6 | 16 | 3.1 | 8 | 1.9 | 13 | 2.2 |
| 9 | 2.6 | 16 | 2.8 | 8 | 1.9 | 12 | 2.2 |
| 9 | 2.6 | 16 | 2.8 | 8 | 1.9 | 13 | 2.2 |
| 8 | 2.6 | 15 | 2.8 | 8 | 1.9 | 11 | 2.6 |
| 8 | 2.6 | 15 | 2.8 | 8 | 1.9 | 12 | 2.2 |
| 8 | 2.6 | 15 | 2.8 | 7 | 1.9 | 12 | 2.2 |
| 8 | 2.6 | 15 | 2.8 | 7 | 1.9 | 12 | 2.2 |
| 8 | 2.6 | 14 | 2.6 | 7 | 1.9 | 11 | 2.2 |
| 8 | 2.6 | 14 | 2.6 | 7 | 1.9 | 11 | 2.2 |
| 8 | 2.6 | 16 | 2.8 | 7 | 1.9 | 14 | 2.5 |
| 8 | 2.6 | 16 | 2.8 | 7 | 1.9 | 13 | 2.5 |
| 8 | 2.6 | 15 | 2.8 | 8 | 1.9 | 14 | 2.5 |
| 8 | 2.6 | 16 | 2.8 | 8 | 1.9 | 16 | 2.5 |
| 8 | 2.6 | 16 | 2.8 | 7 | 1.9 | 16 | 2.5 |
| 8 | 2.6 | 15 | 2.8 | 7 | 1.9 | 16 | 2.5 |
| 8 | 2.6 | 15 | 2.8 | 7 | 1.9 | 16 | 2.5 |
| 8 | 2.6 | 15 | 2.8 | 7 | 1.9 | 16 | 2.5 |
| 8 | 2.6 | 14 | 2.8 | 8 | 1.9 | 15 | 2.5 |
| 8 | 2.6 | 14 | 2.8 | 8 | 1.9 | 15 | 2.5 |
| 8 | 2.6 | 14 | 2.8 | 7 | 1.9 | 12 | 2.5 |
| 8 | 2.6 | 14 | 2.8 | 7 | 1.9 | 12 | 2.5 |
| 8 | 2.6 | 15 | 2.8 | 7 | 1.9 | 11 | 2.5 |
| 8 | 2.6 | 15 | 2.8 | 7 | 1.9 | 12 | 2.2 |
| 8 | 2.6 | 15 | 2.8 | 7 | 1.9 | 12 | 2.2 |
| 8 | 2.6 | 14 | 2.8 | 7 | 1.9 | 13 | 2.2 |
| 8 | 2.6 | 14 | 2.8 | 7 | 1.9 | 12 | 2.2 |
| 8 | 2.6 | 14 | 2.8 | 7 | 1.9 | 12 | 2.2 |
| 8 | 2.6 | 14 | 2.8 | 7 | 1.9 | 12 | 2.2 |

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**Table A.8 (cont.)**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 8 | 2.6 | 14 | 2.8 | 7 | 1.9 | 12 | 2.2 |
| 9 | 2.6 | 14 | 3.4 | 7 | 1.9 | 12 | 2.2 |
| 9 | 2.6 | 13 | 3.4 | 7 | 1.9 | 11 | 2.2 |
| 9 | 2.6 | 13 | 3.4 | 7 | 1.9 | 11 | 2.2 |
| 9 | 2.6 | 13 | 3.4 | 8 | 1.9 | 11 | 2.2 |
| 9 | 2.6 | 13 | 3.4 | 8 | 1.9 | 11 | 2.2 |
| 9 | 2.6 | 14 | 3.4 | 7 | 1.9 | 11 | 2.2 |
| 9 | 2.6 | 14 | 3.4 | 7 | 1.9 | 12 | 2.2 |
| 9 | 2.6 | 13 | 3.4 | 7 | 1.9 | 12 | 2.2 |
| 9 | 2.6 | 14 | 3.4 | 7 | 1.9 | 12 | 2.2 |
| 9 | 2.6 | 14 | 3.4 | 7 | 1.9 | 12 | 2.2 |
| 8 | 2.6 | 14 | 2.8 | 7 | 1.9 | 12 | 2.2 |
| 8 | 2.6 | 14 | 3.1 | 8 | 1.9 | 11 | 2.6 |
| 8 | 2.6 | 14 | 3.1 | 7 | 1.9 | 11 | 2.6 |
| 8 | 2.6 | 14 | 3.1 | 7 | 1.9 | 11 | 2.6 |
| 8 | 2.6 | 13 | 3.1 | 7 | 1.9 | 13 | 2.2 |
| 8 | 2.6 | 14 | 2.8 | 7 | 1.9 | 12 | 2.6 |
| 8 | 2.6 | 14 | 2.8 | 7 | 1.9 | 12 | 2.6 |
| 8 | 2.6 | 14 | 2.8 | 7 | 1.9 | 12 | 2.6 |
| 8 | 2.6 | 14 | 2.8 | 7 | 1.9 | 12 | 2.6 |
| 8 | 2.6 | 14 | 3.1 | 7 | 1.9 | 12 | 2.6 |
| 8 | 2.6 | 14 | 3.1 | 8 | 1.9 | 14 | 2.6 |
| 8 | 2.6 | 14 | 3.1 | 8 | 1.9 | 14 | 2.6 |
| 9 | 2.6 | 14 | 3.1 | 8 | 1.9 | 14 | 2.6 |
| 9 | 2.6 | 14 | 3.1 | 8 | 1.9 | 13 | 2.6 |
| 8 | 2.6 | 13 | 3.1 | 8 | 1.9 | 14 | 2.6 |
| 8 | 2.6 | 12 | 3.1 | 8 | 1.9 | 12 | 2.6 |
| 8 | 2.6 | 12 | 3.1 | 8 | 1.9 | 13 | 2.6 |
| 8 | 2.6 | 12 | 3.1 | 8 | 1.9 | 12 | 2.6 |
| 8 | 2.6 | 13 | 3.1 | 8 | 1.9 | 13 | 2.6 |
| 8 | 2.6 | 13 | 3.1 | 8 | 1.9 | 12 | 2.6 |
| 8 | 2.6 | 14 | 2.8 | 8 | 1.9 | 13 | 2.2 |
| 8 | 2.6 | 14 | 2.8 | 8 | 1.9 | 12 | 2.2 |
| 8 | 2.6 | 15 | 2.8 | 8 | 1.9 | 12 | 2.2 |
| 8 | 2.6 | 15 | 2.8 | 8 | 1.9 | 12 | 2.2 |
| 8 | 2.6 | 14 | 2.8 | 8 | 1.9 | 12 | 2.2 |
| 8 | 2.6 | 14 | 2.8 | 8 | 1.9 | 13 | 2.2 |
| 8 | 2.6 | 14 | 2.8 | 8 | 1.9 | 12 | 2.2 |
| 8 | 2.6 | 14 | 3.1 | 8 | 1.9 | 14 | 2.2 |
| 8 | 2.6 | 14 | 3.1 | 8 | 1.9 | 12 | 2.6 |
| 8 | 2.6 | 16 | 2.8 | 8 | 1.9 | 12 | 2.6 |
| 9 | 2.6 | 15 | 2.8 | 8 | 1.9 | 13 | 2.5 |
| 8 | 2.6 | 15 | 2.8 | 7 | 1.9 | 13 | 2.5 |
| 8 | 2.6 | 15 | 2.8 | 7 | 1.9 | 13 | 2.5 |
| 8 | 2.6 | 14 | 2.8 | 7 | 1.9 | 14 | 2.5 |
| 8 | 2.6 | 14 | 2.8 | 8 | 1.9 | 14 | 2.5 |
| 8 | 2.6 | 14 | 2.8 | 8 | 1.9 | 15 | 2.5 |
| 8 | 2.6 | 14 | 2.8 | 8 | 1.9 | 13 | 2.5 |
| 8 | 2.6 | 14 | 2.8 | 7 | 1.9 | 13 | 2.5 |
| 8 | 2.6 | 14 | 2.8 | 8 | 1.9 | 12 | 2.5 |
| 8 | 2.6 | 13 | 2.8 | 8 | 1.9 | 13 | 2.5 |
| 9 | 2.6 | 17 | 2.8 | 8 | 1.9 | 15 | 2.5 |
| 9 | 2.6 | 15 | 2.6 | 8 | 1.9 | 15 | 2.5 |
| 9 | 2.6 | 17 | 2.8 | 8 | 1.9 | 15 | 2.5 |
| 10 | 2.6 | 17 | 2.8 | 8 | 1.9 | 15 | 2.5 |
| 10 | 2.6 | 17 | 2.8 | 8 | 1.9 | 15 | 2.5 |
| 9 | 2.6 | 16 | 2.8 | 8 | 1.9 | 15 | 2.5 |
| 9 | 2.6 | 15 | 2.8 | 8 | 1.9 | 15 | 2.5 |
| 9 | 2.6 | 15 | 2.8 | 8 | 1.9 | 13 | 2.5 |
| 9 | 2.6 | 15 | 2.8 | 8 | 1.9 | 13 | 2.5 |
| 9 | 2.6 | 14 | 2.8 | 8 | 1.9 | 14 | 2.5 |

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**Table A.8 (cont.)**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 9 | 2.6 | 14 | 2.8 | 8 | 1.9 | 13 | 2.5 |
| 9 | 2.6 | 14 | 2.8 | 8 | 1.9 | 15 | 2.5 |
| 9 | 2.6 | 14 | 2.8 | 8 | 1.9 | 15 | 2.5 |
| 9 | 2.6 | 15 | 2.8 | 8 | 1.9 | 15 | 2.5 |
| 9 | 2.6 | 15 | 2.8 | 8 | 1.9 | 15 | 2.5 |
| 9 | 2.6 | 14 | 2.8 | 8 | 1.9 | 15 | 2.5 |
| 9 | 2.6 | 16 | 2.8 | 8 | 1.9 | 13 | 2.5 |
| 9 | 2.6 | 15 | 2.8 | 8 | 1.9 | 14 | 2.5 |
| 9 | 2.6 | 17 | 2.8 | 8 | 1.9 | 14 | 2.5 |
| 9 | 2.6 | 15 | 2.8 | 8 | 1.9 | 13 | 2.5 |
| 9 | 2.6 | 14 | 2.8 | 9 | 1.9 | 12 | 2.5 |
| 9 | 2.6 | 14 | 2.8 | 8 | 1.9 | 12 | 2.5 |
| 9 | 2.6 | 15 | 2.8 | 8 | 1.9 | 13 | 2.5 |
| 9 | 2.6 | 15 | 2.8 | 9 | 1.9 | 14 | 2.5 |
| 9 | 2.6 | 16 | 2.8 | 9 | 1.9 | 13 | 2.5 |
| 9 | 2.6 | 15 | 2.8 | 9 | 1.9 | 14 | 2.5 |
| 9 | 2.6 | 14 | 2.8 | 8 | 1.9 | 13 | 2.5 |
| 9 | 2.6 | 14 | 2.8 | 8 | 1.9 | 13 | 2.5 |
| 8 | 2.6 | 14 | 2.8 | 7 | 1.9 | 14 | 2.5 |
| 8 | 2.6 | 15 | 2.8 | 7 | 1.9 | 15 | 2.5 |
| 8 | 2.6 | 14 | 2.8 | 7 | 1.9 | 13 | 2.2 |
| 8 | 2.6 | 14 | 2.8 | 7 | 1.9 | 12 | 2.2 |
| 8 | 2.6 | 15 | 2.8 | 8 | 1.9 | 12 | 2.2 |
| 8 | 2.6 | 15 | 2.8 | 8 | 1.9 | 12 | 2.2 |
| 8 | 2.6 | 14 | 2.8 | 7 | 1.9 | 12 | 2.2 |
| 8 | 2.6 | 14 | 2.8 | 7 | 1.9 | 13 | 2.2 |
| 8 | 2.6 | 14 | 2.8 | 7 | 1.9 | 12 | 2.2 |
| 8 | 2.6 | 14 | 2.8 | 7 | 1.9 | 14 | 2.2 |
| 8 | 2.6 | 14 | 2.8 | 8 | 1.9 | 12 | 2.6 |
| 8 | 2.6 | 16 | 2.8 | 8 | 1.9 | 12 | 2.6 |

Table A.9. Raw data of the route J-M and J-L.

| Route J-M | | | | Route J-L | | | |
|---|---|---|---|---|---|---|---|
| Off-peak hours | | Peak hours | | Off-peak hours | | Peak hours | |
| Travel time (min) | Travel distance (km) | Travel time (min) | Travel distance (km) | Travel time (min) | Travel distance (km) | Travel time (min) | Travel distance (km) |
| 4 | 1.6 | 8 | 1.6 | 5 | 1.6 | 9 | 1.6 |
| 4 | 1.6 | 9 | 1.6 | 5 | 1.6 | 10 | 1.6 |
| 4 | 1.6 | 8 | 1.6 | 5 | 1.6 | 9 | 1.8 (a) |
| 4 | 1.6 | 9 | 1.6 | 5 | 1.6 | 10 | 1.8 (a) |
| 4 | 1.6 | 9 | 1.6 | 5 | 1.6 | 10 | 1.8 (a) |
| 4 | 1.6 | 8 | 1.6 | 5 | 1.6 | 9 | 1.8 (a) |
| 4 | 1.6 | 8 | 1.6 | 5 | 1.6 | 9 | 1.8 (a) |
| 4 | 1.6 | 9 | 1.6 | 5 | 1.6 | 10 | 1.8 (a) |
| 4 | 1.6 | 10 | 1.6 | 5 | 1.6 | 11 | 1.8 (b) |
| 4 | 1.6 | 9 | 1.6 | 5 | 1.6 | 10 | 1.8 (b) |
| 5 | 1.6 | 8 | 1.6 | 5 | 1.6 | 9 | 1.8 (b) |
| 5 | 1.6 | 10 | 1.6 | 5 | 1.6 | 9 | 1.8 (b) |
| 4 | 1.6 | 9 | 1.6 | 5 | 1.6 | 9 | 1.8 (b) |
| 4 | 1.6 | 8 | 2 | 5 | 1.6 | 9 | 2 |
| 4 | 1.6 | 9 | 1.6 | 5 | 1.6 | 9 | 1.8 (b) |
| 4 | 1.6 | 8 | 2 | 5 | 1.6 | 9 | 2 |
| 4 | 1.6 | 8 | 2 | 5 | 1.6 | 9 | 2 |
| 4 | 1.6 | 8 | 1.6 | 5 | 1.6 | 9 | 1.6 |
| 4 | 1.6 | 7 | 2 | 5 | 1.6 | 8 | 2 |
| 4 | 1.6 | 9 | 1.6 | 5 | 1.6 | 9 | 1.8 (a) |
| 5 | 1.6 | 9 | 1.6 | 5 | 1.6 | 9 | 1.8 (a) |
| 4 | 1.6 | 10 | 1.6 | 5 | 1.6 | 10 | 1.8 (b) |

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**Table A.9 (cont.)**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 4 | 1.6 | 10 | 1.6 | 5 | 1.6 | 10 | 1.8 (b) |
| 5 | 1.6 | 10 | 1.6 | 5 | 1.6 | 10 | 1.8 (a) |
| 5 | 1.6 | 9 | 1.6 | 5 | 1.6 | 9 | 1.8 (a) |
| 5 | 1.6 | 9 | 1.6 | 5 | 1.6 | 9 | 1.8 (a) |
| 4 | 1.6 | 9 | 1.6 | 5 | 1.6 | 9 | 1.8 (b) |
| 4 | 1.6 | 8 | 1.6 | 5 | 1.6 | 9 | 1.8 (a) |
| 4 | 1.6 | 8 | 1.6 | 5 | 1.6 | 8 | 1.8 (a) |
| 4 | 1.6 | 9 | 1.6 | 5 | 1.6 | 8 | 1.8 (b) |
| 4 | 1.6 | 4 | 1.6 | 5 | 1.6 | 9 | 1.8 (a) |
| 4 | 1.6 | 8 | 2 | 5 | 1.6 | 9 | 2 |
| 4 | 1.6 | 8 | 1.6 | 5 | 1.6 | 9 | 1.6 |
| 4 | 1.6 | 8 | 1.6 | 5 | 1.6 | 9 | 1.6 |
| 4 | 1.6 | 8 | 1.6 | 5 | 1.6 | 9 | 1.6 |
| 4 | 1.6 | 8 | 1.6 | 5 | 1.6 | 9 | 1.6 |
| 5 | 1.6 | 8 | 1.6 | 5 | 1.6 | 9 | 1.6 |
| 5 | 1.6 | 8 | 1.6 | 5 | 1.6 | 9 | 1.6 |
| 5 | 1.6 | 8 | 1.6 | 5 | 1.6 | 9 | 1.6 |
| 5 | 1.6 | 8 | 1.6 | 5 | 1.6 | 9 | 1.6 |
| 4 | 1.6 | 10 | 1.6 | 5 | 1.6 | 11 | 1.8 (b) |
| 4 | 1.6 | 10 | 1.6 | 5 | 1.6 | 10 | 1.8 (b) |
| 4 | 1.6 | 8 | 1.6 | 5 | 1.6 | 9 | 2 |
| 4 | 1.6 | 9 | 1.6 | 5 | 1.6 | 9 | 1.6 |
| 4 | 1.6 | 9 | 1.6 | 5 | 1.6 | 10 | 1.8 (b) |
| 4 | 1.6 | 9 | 1.6 | 5 | 1.6 | 10 | 1.8 (a) |
| 4 | 1.6 | 9 | 1.6 | 5 | 1.6 | 9 | 1.8 (a) |
| 4 | 1.6 | 9 | 1.6 | 5 | 1.6 | 9 | 1.8 (a) |
| 4 | 1.6 | 8 | 1.6 | 5 | 1.6 | 9 | 1.8 (b) |
| 4 | 1.6 | 9 | 1.6 | 5 | 1.6 | 9 | 1.8 (b) |
| 4 | 1.6 | 8 | 1.6 | 5 | 1.6 | 8 | 1.6 |
| 4 | 1.6 | 8 | 1.6 | 5 | 1.6 | 8 | 1.6 |
| 4 | 1.6 | 7 | 1.6 | 5 | 1.6 | 8 | 1.6 |
| 4 | 1.6 | 8 | 1.6 | 5 | 1.6 | 9 | 1.6 |
| 4 | 1.6 | 8 | 1.6 | 5 | 1.6 | 10 | 1.8 (a) |
| 4 | 1.6 | 8 | 1.6 | 5 | 1.6 | 9 | 1.8 (a) |
| 4 | 1.6 | 8 | 1.6 | 5 | 1.6 | 9 | 1.8 (a) |
| 4 | 1.6 | 8 | 1.6 | 5 | 1.6 | 9 | 1.8 (a) |
| 4 | 1.6 | 7 | 1.6 | 5 | 1.6 | 8 | 1.8 (a) |
| 4 | 1.6 | 7 | 1.6 | 5 | 1.6 | 9 | 1.8 (a) |
| 4 | 1.6 | 8 | 1.6 | 5 | 1.6 | 8 | 1.8 (a) |
| 4 | 1.6 | 8 | 1.6 | 5 | 1.6 | 9 | 1.8 (a) |
| 4 | 1.6 | 7 | 1.6 | 5 | 1.6 | 8 | 1.8 (a) |
| 4 | 1.6 | 8 | 1.6 | 5 | 1.6 | 8 | 1.8 (a) |
| 4 | 1.6 | 7 | 1.6 | 5 | 1.6 | 8 | 1.8 (a) |
| 4 | 1.6 | 7 | 1.6 | 5 | 1.6 | 8 | 1.8 (a) |
| 4 | 1.6 | 7 | 1.6 | 5 | 1.6 | 7 | 1.8 (a) |
| 5 | 1.6 | 8 | 1.6 | 5 | 1.6 | 8 | 1.8 (a) |
| 4 | 1.6 | 7 | 1.6 | 5 | 1.6 | 7 | 1.8 (a) |
| 4 | 1.6 | 8 | 1.6 | 5 | 1.6 | 8 | 1.8 (a) |
| 4 | 1.6 | 9 | 1.6 | 5 | 1.6 | 9 | 1.8 (a) |
| 4 | 1.6 | 9 | 1.6 | 5 | 1.6 | 9 | 1.8 (b) |
| 4 | 1.6 | 9 | 1.6 | 5 | 1.6 | 9 | 1.8 (b) |
| 5 | 1.6 | 9 | 1.6 | 5 | 1.6 | 9 | 1.8 (b) |
| 5 | 1.6 | 9 | 1.6 | 5 | 1.6 | 9 | 1.8 (b) |
| 5 | 1.6 | 8 | 1.6 | 5 | 1.6 | 9 | 1.8 (b) |
| 5 | 1.6 | 8 | 1.6 | 5 | 1.6 | 9 | 1.6 |
| 5 | 1.6 | 9 | 1.6 | 5 | 1.6 | 9 | 1.6 |
| 5 | 1.6 | 8 | 1.6 | 5 | 1.6 | 9 | 1.8 (b) |
| 5 | 1.6 | 8 | 1.6 | 5 | 1.6 | 9 | 1.8 (b) |
| 4 | 1.6 | 9 | 1.6 | 5 | 1.6 | 9 | 1.6 |
| 4 | 1.6 | 9 | 1.6 | 5 | 1.6 | 10 | 1.8 (b) |
| 4 | 1.6 | 8 | 1.6 | 5 | 1.6 | 9 | 1.6 |

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**Table A.9 (cont.)**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 4 | 1.6 | 9 | 1.6 | 5 | 1.6 | 10 | 1.8 (b) |
| 4 | 1.6 | 8 | 1.6 | 5 | 1.6 | 9 | 1.8 (b) |
| 4 | 1.6 | 8 | 1.6 | 5 | 1.6 | 9 | 1.6 |
| 4 | 1.6 | 8 | 1.6 | 5 | 1.6 | 9 | 1.8 (b) |
| 4 | 1.6 | 8 | 1.6 | 5 | 1.6 | 9 | 1.8 (b) |
| 4 | 1.6 | 7 | 1.6 | 5 | 1.6 | 8 | 1.8 (b) |
| 4 | 1.6 | 8 | 1.6 | 5 | 1.6 | 8 | 1.6 |
| 5 | 1.6 | 8 | 1.6 | 5 | 1.6 | 9 | 1.8 (b) |
| 4 | 1.6 | 8 | 1.6 | 5 | 1.6 | 10 | 1.8 (b) |
| 5 | 1.6 | 8 | 1.6 | 5 | 1.6 | 9 | 1.8 (b) |
| 5 | 1.6 | 9 | 1.6 | 5 | 1.6 | 9 | 1.8 (a) |
| 5 | 1.6 | 9 | 1.6 | 6 | 1.6 | 9 | 1.8 (a) |
| 4 | 1.6 | 9 | 1.6 | 5 | 1.6 | 9 | 1.8 (a) |
| 4 | 1.6 | 9 | 2 | 5 | 1.6 | 9 | 1.8 (a) |
| 5 | 1.6 | 9 | 1.6 | 5 | 1.6 | 9 | 1.8 (a) |
| 5 | 1.6 | 9 | 1.6 | 6 | 1.6 | 9 | 1.8 (b) |
| 5 | 1.6 | 8 | 2 | 5 | 1.6 | 9 | 1.8 (b) |
| 4 | 1.6 | 8 | 1.6 | 5 | 1.6 | 8 | 1.6 |
| 4 | 1.6 | 8 | 1.6 | 5 | 1.6 | 9 | 1.6 |
| 4 | 1.6 | 8 | 1.6 | 5 | 1.6 | 8 | 1.8 (a) |
| 4 | 1.6 | 8 | 1.6 | 5 | 1.6 | 9 | 1.8 (a) |
| 4 | 1.6 | 8 | 1.6 | 5 | 1.6 | 9 | 1.8 (a) |
| 4 | 1.6 | 9 | 1.6 | 5 | 1.6 | 10 | 1.8 (a) |
| 4 | 1.6 | 9 | 1.6 | 5 | 1.6 | 9 | 1.8 (a) |
| 4 | 1.6 | 8 | 1.6 | 5 | 1.6 | 9 | 1.8 (a) |
| 4 | 1.6 | 8 | 1.6 | 5 | 1.6 | 9 | 1.8 (a) |
| 4 | 1.6 | 8 | 1.6 | 5 | 1.6 | 9 | 1.8 (a) |
| 5 | 1.6 | 8 | 1.6 | 5 | 1.6 | 9 | 1.8 (a) |
| 4 | 1.6 | 7 | 1.6 | 5 | 1.6 | 8 | 1.8 (a) |
| 4 | 1.6 | 7 | 1.6 | 5 | 1.6 | 8 | 1.8 (a) |
| 5 | 1.6 | 7 | 1.6 | 5 | 1.6 | 8 | 1.8 (a) |
| 4 | 1.6 | 7 | 1.6 | 5 | 1.6 | 8 | 1.8 (a) |
| 4 | 1.6 | 7 | 1.6 | 5 | 1.6 | 8 | 1.8 (a) |
| 4 | 1.6 | 8 | 1.6 | 5 | 1.6 | 8 | 1.8 (b) |
| 4 | 1.6 | 8 | 1.6 | 5 | 1.6 | 9 | 1.8 (b) |
| 4 | 1.6 | 8 | 1.6 | 5 | 1.6 | 9 | 1.8 (b) |
| 4 | 1.6 | 8 | 1.6 | 5 | 1.6 | 9 | 1.8 (b) |
| 5 | 1.6 | 8 | 1.6 | 5 | 1.6 | 9 | 1.6 |
| 4 | 1.6 | 9 | 1.6 | 5 | 1.6 | 9 | 1.6 |
| 4 | 1.6 | 8 | 2 | 5 | 1.6 | 8 | 2 |
| 4 | 1.6 | 7 | 2 | 5 | 1.6 | 8 | 2 |
| 4 | 1.6 | 9 | 1.6 | 5 | 1.6 | 9 | 2 |
| 4 | 1.6 | 9 | 1.6 | 5 | 1.6 | 10 | 1.6 |
| 4 | 1.6 | 8 | 2 | 5 | 1.6 | 9 | 2 |
| 4 | 1.6 | 9 | 1.6 | 5 | 1.6 | 10 | 1.6 |
| 4 | 1.6 | 8 | 2 | 5 | 1.6 | 9 | 2 |
| 4 | 1.6 | 8 | 2 | 5 | 1.6 | 9 | 2 |
| 4 | 1.6 | 8 | 1.6 | 5 | 1.6 | 8 | 1.6 |
| 4 | 1.6 | 8 | 1.6 | 5 | 1.6 | 9 | 1.6 |
| 4 | 1.6 | 8 | 1.6 | 5 | 1.6 | 9 | 1.6 |
| 4 | 1.6 | 8 | 1.6 | 5 | 1.6 | 8 | 1.6 |
| 4 | 1.6 | 8 | 1.6 | 5 | 1.6 | 9 | 1.8 (b) |
| 4 | 1.6 | 7 | 1.6 | 5 | 1.6 | 8 | 1.8 (b) |
| 4 | 1.6 | 7 | 1.6 | 5 | 1.6 | 8 | 1.8 (b) |
| 4 | 1.6 | 7 | 1.6 | 5 | 1.6 | 8 | 1.8 (b) |
| 4 | 1.6 | 8 | 1.6 | 5 | 1.6 | 8 | 1.8 (b) |
| 4 | 1.6 | 7 | 1.6 | 5 | 1.6 | 8 | 1.8 (b) |
| 4 | 1.6 | 9 | 1.6 | 5 | 1.6 | 9 | 1.6 |
| 4 | 1.6 | 8 | 1.6 | 5 | 1.6 | 9 | 1.6 |
| 4 | 1.6 | 9 | 1.6 | 5 | 1.6 | 10 | 1.8 (b) |
| 5 | 1.6 | 8 | 1.6 | 5 | 1.6 | 9 | 1.8 (b) |
| 5 | 1.6 | 8 | 1.6 | 5 | 1.6 | 9 | 1.8 (b) |
| 4 | 1.6 | 8 | 1.6 | 5 | 1.6 | 9 | 1.8 (a) |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 4 | 1.6 | 9 | 1.6 | 5 | 1.6 | 9 | 1.8 (b) |
| 4 | 1.6 | 9 | 1.6 | 5 | 1.6 | 9 | 1.8 (b) |
| 4 | 1.6 | 8 | 2 | 5 | 1.6 | 9 | 2 |
| 4 | 1.6 | 9 | 1.6 | 5 | 1.6 | 8 | 2 |
| 5 | 1.6 | 8 | 1.6 | 5 | 1.6 | 9 | 1.6 |
| 4 | 1.6 | 8 | 1.6 | 4 | 1.6 | 9 | 1.6 |
| 4 | 1.6 | 8 | 1.6 | 4 | 1.6 | 8 | 1.6 |
| 4 | 1.6 | 7 | 1.6 | 4 | 1.6 | 8 | 1.6 |
| 4 | 1.6 | 7 | 1.6 | 4 | 1.6 | 8 | 1.6 |
| 4 | 1.6 | 8 | 1.6 | 4 | 1.6 | 8 | 1.6 |
| 4 | 1.6 | 7 | 1.6 | 4 | 1.6 | 8 | 1.6 |
| 4 | 1.6 | 8 | 1.6 | 4 | 1.6 | 9 | 1.6 |
| 4 | 1.6 | 8 | 1.6 | 4 | 1.6 | 8 | 1.6 |
| 4 | 1.6 | 8 | 1.6 | 4 | 1.6 | 8 | 1.8 (b) |
| 4 | 1.6 | 9 | 1.6 | 5 | 1.6 | 10 | 1.8 (b) |
| 4 | 1.6 | 8 | 1.6 | 5 | 1.6 | 9 | 1.8 (a) |
| 5 | 1.6 | 9 | 1.6 | 5 | 1.6 | 10 | 1.8 (a) |
| 5 | 1.6 | 10 | 1.6 | 5 | 1.6 | 11 | 1.8 (a) |
| 5 | 1.6 | 10 | 1.6 | 5 | 1.6 | 11 | 1.8 (a) |
| 5 | 1.6 | 10 | 1.6 | 5 | 1.6 | 10 | 1.6 |
| 4 | 1.6 | 10 | 1.6 | 5 | 1.6 | 10 | 1.6 |
| 5 | 1.6 | 10 | 1.6 | 5 | 1.6 | 11 | 1.6 |
| 5 | 1.6 | 9 | 1.6 | 5 | 1.6 | 10 | 1.6 |
| 4 | 1.6 | 8 | 1.6 | 5 | 1.6 | 9 | 1.6 |
| 4 | 1.6 | 8 | 1.6 | 5 | 1.6 | 8 | 1.6 |
| 4 | 1.6 | 8 | 1.6 | 5 | 1.6 | 9 | 1.6 |
| 4 | 1.6 | 7 | 1.6 | 5 | 1.6 | 8 | 1.6 |
| 5 | 1.6 | 7 | 1.6 | 5 | 1.6 | 9 | 1.6 |
| 5 | 1.6 | 8 | 1.6 | 6 | 1.6 | 9 | 1.6 |
| 5 | 1.6 | 7 | 1.6 | 6 | 1.6 | 9 | 1.6 |
| 5 | 1.6 | 8 | 1.6 | 6 | 1.6 | 9 | 1.6 |
| 5 | 1.6 | 8 | 1.6 | 6 | 1.6 | 9 | 1.8 (a) |
| 5 | 1.6 | 8 | 1.6 | 6 | 1.6 | 8 | 1.8 (a) |
| 5 | 1.6 | 8 | 1.6 | 6 | 1.6 | 8 | 1.8 (a) |
| 5 | 1.6 | 8 | 1.6 | 5 | 1.6 | 9 | 1.8 (a) |
| 4 | 1.6 | 8 | 1.6 | 5 | 1.6 | 9 | 1.8 (a) |
| 4 | 1.6 | 8 | 1.6 | 5 | 1.6 | 9 | 1.8 (a) |
| 5 | 1.6 | 9 | 1.6 | 5 | 1.6 | 10 | 1.8 (a) |
| 5 | 1.6 | 9 | 1.6 | 5 | 1.6 | 10 | 1.8 (a) |
| 5 | 1.6 | 9 | 1.6 | 5 | 1.6 | 10 | 1.8 (a) |
| 5 | 1.6 | 9 | 1.6 | 5 | 1.6 | 9 | 1.8 (a) |
| 4 | 1.6 | 8 | 1.6 | 5 | 1.6 | 8 | 1.8 (a) |
| 4 | 1.6 | 8 | 1.6 | 5 | 1.6 | 9 | 1.8 (a) |
| 4 | 1.6 | 8 | 1.6 | 5 | 1.6 | 9 | 1.8 (a) |
| 5 | 1.6 | 9 | 1.6 | 5 | 1.6 | 9 | 1.8 (a) |
| 4 | 1.6 | 8 | 1.6 | 5 | 1.6 | 9 | 1.8 (a) |
| 5 | 1.6 | 9 | 1.6 | 5 | 1.6 | 10 | 1.8 (a) |
| 5 | 1.6 | 8 | 1.6 | 5 | 1.6 | 9 | 1.8 (a) |
| 5 | 1.6 | 8 | 1.6 | 6 | 1.6 | 9 | 1.8 (a) |
| 4 | 1.6 | 8 | 1.6 | 5 | 1.6 | 9 | 1.6 |
| 4 | 1.6 | 9 | 1.6 | 5 | 1.6 | 9 | 1.6 |
| 5 | 1.6 | 9 | 1.6 | 5 | 1.6 | 9 | 2 |
| 5 | 1.6 | 8 | 2 | 6 | 1.6 | 9 | 2 |
| 5 | 1.6 | 9 | 1.6 | 5 | 1.6 | 8 | 2 |

Table A.10. Raw data of the route K-I and K-N.

| Route K-I | | | | Route K-N | | | |
|---|---|---|---|---|---|---|---|
| Off-peak hours | | Peak hours | | Off-peak hours | | Peak hours | |
| Travel time (min) | Travel distance (km) | Travel time (min) | Travel distance (km) | Travel time (min) | Travel distance (km) | Travel time (min) | Travel distance (km) |
| 5 | 1.5 | 7 | 1.5 | 8 | 2.1 | 12 | 2.4 (b) |
| 5 | 1.5 | 7 | 1.5 | 8 | 2.1 | 12 | 2.4 (a) |
| 5 | 1.5 | 7 | 1.5 | 8 | 2.1 | 12 | 2.4 (b) |
| 5 | 1.5 | 7 | 1.5 | 8 | 2.1 | 12 | 2.4 (b) |
| 5 | 1.5 | 7 | 1.5 | 8 | 2.1 | 11 | 2.4 (b) |
| 5 | 1.5 | 7 | 1.5 | 8 | 2.1 | 12 | 2.4 (b) |
| 5 | 1.5 | 7 | 1.5 | 8 | 2.1 | 13 | 2.4 (a) |
| 5 | 1.5 | 7 | 1.5 | 8 | 2.1 | 13 | 2.4 (a) |
| 5 | 1.5 | 7 | 1.5 | 8 | 2.1 | 14 | 2.4 (a) |
| 5 | 1.5 | 6 | 1.5 | 8 | 2.1 | 13 | 2.4 (a) |
| 5 | 1.5 | 6 | 1.5 | 7 | 2.1 | 13 | 2.4 (a) |
| 5 | 1.5 | 7 | 1.5 | 7 | 2.1 | 13 | 2.4 (a) |
| 5 | 1.5 | 6 | 1.5 | 8 | 2.1 | 11 | 2.4 (b) |
| 5 | 1.5 | 6 | 1.5 | 7 | 2.1 | 12 | 2.4 (a) |
| 5 | 1.5 | 6 | 1.5 | 7 | 2.1 | 12 | 2.4 (a) |
| 5 | 1.5 | 6 | 1.5 | 8 | 2.1 | 12 | 2.7 |
| 5 | 1.5 | 6 | 1.5 | 8 | 2.1 | 11 | 2.4 (a) |
| 5 | 1.5 | 6 | 1.5 | 8 | 2.1 | 12 | 2.4 (a) |
| 5 | 1.5 | 6 | 1.5 | 8 | 2.1 | 12 | 2.7 |
| 5 | 1.5 | 7 | 1.5 | 7 | 2.1 | 12 | 2.7 |
| 5 | 1.5 | 7 | 1.5 | 8 | 2.1 | 13 | 2.4 (a) |
| 5 | 1.5 | 7 | 1.5 | 8 | 2.1 | 13 | 2.4 (a) |
| 5 | 1.5 | 7 | 1.5 | 7 | 2.1 | 13 | 2.4 (a) |
| 5 | 1.5 | 6 | 1.5 | 7 | 2.1 | 13 | 2.4 (a) |
| 5 | 1.5 | 6 | 1.5 | 8 | 2.1 | 13 | 2.4 (a) |
| 5 | 1.5 | 7 | 1.5 | 8 | 2.1 | 13 | 2.4 (a) |
| 5 | 1.5 | 7 | 1.5 | 8 | 2.1 | 12 | 2.4 (b) |
| 5 | 1.5 | 6 | 1.5 | 8 | 2.1 | 12 | 2.4 (a) |
| 5 | 1.5 | 7 | 1.5 | 7 | 2.1 | 13 | 2.4 (a) |
| 5 | 1.5 | 6 | 1.5 | 7 | 2.1 | 13 | 2.4 (a) |
| 5 | 1.5 | 9 | 1.5 | 7 | 2.1 | 12 | 2.4 (a) |
| 5 | 1.5 | 8 | 1.5 | 7 | 2.1 | 12 | 2.4 (a) |
| 5 | 1.5 | 8 | 1.5 | 7 | 2.1 | 12 | 2.4 (a) |
| 5 | 1.5 | 8 | 1.5 | 7 | 2.1 | 11 | 2.4 (b) |
| 5 | 1.5 | 7 | 1.5 | 7 | 2.1 | 12 | 2.4 (a) |
| 5 | 1.5 | 7 | 1.5 | 7 | 2.1 | 12 | 2.4 (a) |
| 5 | 1.5 | 6 | 1.5 | 7 | 2.1 | 11 | 2.4 (b) |
| 5 | 1.5 | 7 | 1.5 | 7 | 2.1 | 11 | 2.4 (b) |
| 5 | 1.5 | 6 | 1.5 | 7 | 2.1 | 11 | 2.4 (b) |
| 5 | 1.5 | 6 | 1.5 | 7 | 2.1 | 11 | 2.4 (b) |
| 5 | 1.5 | 8 | 1.5 | 7 | 2.1 | 13 | 2.4 (a) |
| 5 | 1.5 | 7 | 1.5 | 7 | 2.1 | 13 | 2.4 (a) |
| 5 | 1.5 | 7 | 1.5 | 7 | 2.1 | 13 | 2.4 (a) |
| 5 | 1.5 | 7 | 1.5 | 7 | 2.1 | 12 | 2.4 (a) |
| 5 | 1.5 | 7 | 1.5 | 7 | 2.1 | 12 | 2.4 (a) |
| 5 | 1.5 | 7 | 1.5 | 7 | 2.1 | 12 | 2.4 (a) |
| 5 | 1.5 | 7 | 1.5 | 7 | 2.1 | 11 | 2.4 (a) |
| 5 | 1.5 | 6 | 1.5 | 7 | 2.1 | 11 | 2.4 (a) |
| 5 | 1.5 | 6 | 1.5 | 7 | 2.1 | 11 | 2.4 (b) |
| 5 | 1.5 | 6 | 1.5 | 7 | 2.1 | 12 | 2.4 (b) |
| 5 | 1.5 | 7 | 1.5 | 7 | 2.1 | 11 | 2.4 (b) |
| 5 | 1.5 | 7 | 1.5 | 7 | 2.1 | 11 | 2.4 (b) |

**(cont. on next page)**

**Table A.10 (cont.)**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 5 | 1.5 | 7 | 1.5 | 7 | 2.1 | 11 | 2.4 (b) |
| 5 | 1.5 | 6 | 1.5 | 7 | 2.1 | 12 | 2.4 (b) |
| 5 | 1.5 | 6 | 1.5 | 7 | 2.1 | 11 | 2.4 (b) |
| 5 | 1.5 | 6 | 1.5 | 7 | 2.1 | 11 | 2.4 (b) |
| 5 | 1.5 | 7 | 1.5 | 7 | 2.1 | 11 | 2.4 (b) |
| 5 | 1.5 | 6 | 1.5 | 7 | 2.1 | 11 | 2.4 (b) |
| 5 | 1.5 | 6 | 1.5 | 7 | 2.1 | 11 | 2.4 (b) |
| 5 | 1.5 | 6 | 1.5 | 7 | 2.1 | 11 | 2.4 (b) |
| 5 | 1.5 | 7 | 1.5 | 8 | 2.1 | 12 | 2.4 (b) |
| 5 | 1.5 | 8 | 1.5 | 7 | 2.1 | 11 | 2.4 (b) |
| 5 | 1.5 | 7 | 1.5 | 7 | 2.1 | 11 | 2.4 (b) |
| 5 | 1.5 | 7 | 1.5 | 8 | 2.1 | 12 | 2.4 (b) |
| 5 | 1.5 | 6 | 1.5 | 8 | 2.1 | 11 | 2.4 (b) |
| 5 | 1.5 | 6 | 1.5 | 8 | 2.1 | 11 | 2.4 (b) |
| 5 | 1.5 | 6 | 1.5 | 8 | 2.1 | 11 | 2.4 (b) |
| 5 | 1.5 | 6 | 1.5 | 8 | 2.1 | 11 | 2.4 (b) |
| 5 | 1.5 | 6 | 1.5 | 7 | 2.1 | 11 | 2.4 (b) |
| 5 | 1.5 | 6 | 1.5 | 7 | 2.1 | 11 | 2.4 (b) |
| 5 | 1.5 | 7 | 1.5 | 8 | 2.1 | 12 | 2.4 (a) |
| 5 | 1.5 | 7 | 1.5 | 7 | 2.1 | 11 | 2.4 (a) |
| 5 | 1.5 | 6 | 1.5 | 7 | 2.1 | 11 | 2.4 (a) |
| 5 | 1.5 | 6 | 1.5 | 7 | 2.1 | 11 | 2.4 (a) |
| 5 | 1.5 | 6 | 1.5 | 7 | 2.1 | 12 | 2.4 (a) |
| 5 | 1.5 | 6 | 1.5 | 7 | 2.1 | 11 | 2.4 (a) |
| 5 | 1.5 | 6 | 1.5 | 7 | 2.1 | 11 | 2.4 (a) |
| 5 | 1.5 | 6 | 1.5 | 7 | 2.1 | 11 | 2.4 (a) |
| 5 | 1.5 | 6 | 1.5 | 7 | 2.1 | 11 | 2.4 (a) |
| 5 | 1.5 | 7 | 1.5 | 7 | 2.1 | 11 | 2.4 (a) |
| 5 | 1.5 | 7 | 1.5 | 8 | 2.1 | 12 | 2.4 (a) |
| 5 | 1.5 | 7 | 1.5 | 8 | 2.1 | 11 | 2.4 (a) |
| 5 | 1.5 | 7 | 1.5 | 8 | 2.1 | 11 | 2.4 (a) |
| 5 | 1.5 | 7 | 1.5 | 8 | 2.1 | 12 | 2.4 (a) |
| 5 | 1.5 | 7 | 1.5 | 8 | 2.1 | 11 | 2.4 (a) |
| 5 | 1.5 | 7 | 1.5 | 8 | 2.1 | 11 | 2.4 (a) |
| 5 | 1.5 | 7 | 1.5 | 8 | 2.1 | 11 | 2.4 (a) |
| 5 | 1.5 | 7 | 1.5 | 8 | 2.1 | 12 | 2.4 (a) |
| 5 | 1.5 | 7 | 1.5 | 8 | 2.1 | 11 | 2.4 (a) |
| 5 | 1.5 | 6 | 1.5 | 8 | 2.1 | 12 | 2.4 (a) |
| 5 | 1.5 | 7 | 1.5 | 8 | 2.1 | 11 | 2.4 (a) |
| 5 | 1.5 | 7 | 1.5 | 8 | 2.1 | 12 | 2.4 (a) |
| 5 | 1.5 | 7 | 1.5 | 8 | 2.1 | 11 | 2.4 (a) |
| 5 | 1.5 | 7 | 1.5 | 8 | 2.1 | 11 | 2.4 (a) |
| 5 | 1.5 | 7 | 1.5 | 9 | 2.1 | 12 | 2.4 (a) |
| 5 | 1.5 | 6 | 1.5 | 8 | 2.1 | 12 | 2.4 (a) |
| 5 | 1.5 | 6 | 1.5 | 8 | 2.1 | 12 | 2.4 (a) |
| 5 | 1.5 | 6 | 1.5 | 8 | 2.1 | 12 | 2.4 (a) |
| 5 | 1.5 | 7 | 1.5 | 8 | 2.1 | 12 | 2.4 (a) |
| 5 | 1.5 | 6 | 1.5 | 8 | 2.1 | 11 | 2.4 (a) |
| 5 | 1.5 | 7 | 1.5 | 7 | 2.1 | 12 | 2.4 (b) |
| 5 | 1.5 | 7 | 1.5 | 7 | 2.1 | 12 | 2.4 (b) |
| 5 | 1.5 | 7 | 1.5 | 7 | 2.1 | 12 | 2.4 (b) |
| 5 | 1.5 | 7 | 1.5 | 7 | 2.1 | 12 | 2.4 (b) |
| 5 | 1.5 | 7 | 1.5 | 7 | 2.1 | 12 | 2.4 (b) |
| 5 | 1.5 | 7 | 1.5 | 7 | 2.1 | 12 | 2.4 (b) |
| 5 | 1.5 | 7 | 1.5 | 7 | 2.1 | 12 | 2.4 (b) |
| 5 | 1.5 | 6 | 1.5 | 7 | 2.1 | 12 | 2.4 (b) |
| 5 | 1.5 | 6 | 1.5 | 7 | 2.1 | 11 | 2.4 (b) |
| 5 | 1.5 | 7 | 1.5 | 7 | 2.1 | 11 | 2.4 (b) |
| 5 | 1.5 | 7 | 1.5 | 8 | 2.1 | 11 | 2.4 (b) |
| 5 | 1.5 | 7 | 1.5 | 8 | 2.1 | 11 | 2.4 (b) |

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**Table A.10 (cont.)**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 5 | 1.5 | 6 | 1.5 | 8 | 2.1 | 11 | 2.4 (b) |
| 5 | 1.5 | 7 | 1.5 | 8 | 2.1 | 12 | 2.7 |
| 5 | 1.5 | 7 | 1.5 | 8 | 2.1 | 12 | 2.7 |
| 5 | 1.5 | 7 | 1.5 | 8 | 2.1 | 12 | 2.7 |
| 5 | 1.5 | 6 | 1.5 | 8 | 2.1 | 12 | 2.7 |
| 5 | 1.5 | 6 | 1.5 | 8 | 2.1 | 12 | 2.7 |
| 5 | 1.5 | 6 | 1.5 | 8 | 2.1 | 12 | 2.7 |
| 5 | 1.5 | 6 | 1.5 | 8 | 2.1 | 12 | 2.7 |
| 5 | 1.5 | 7 | 1.5 | 8 | 2.1 | 11 | 2.4 (b) |
| 5 | 1.5 | 7 | 1.5 | 8 | 2.1 | 11 | 2.4 (b) |
| 5 | 1.5 | 7 | 1.5 | 7 | 2.1 | 11 | 2.4 (b) |
| 5 | 1.5 | 7 | 1.5 | 8 | 2.1 | 11 | 2.4 (b) |
| 5 | 1.5 | 7 | 1.5 | 7 | 2.1 | 11 | 2.4 (a) |
| 5 | 1.5 | 6 | 1.5 | 8 | 2.1 | 11 | 2.4 (b) |
| 5 | 1.5 | 6 | 1.5 | 8 | 2.1 | 11 | 2.4 (a) |
| 5 | 1.5 | 6 | 1.5 | 8 | 2.1 | 11 | 2.4 (b) |
| 5 | 1.5 | 6 | 1.5 | 8 | 2.1 | 11 | 2.4 (b) |
| 5 | 1.5 | 6 | 1.5 | 7 | 2.1 | 11 | 2.4 (b) |
| 5 | 1.5 | 7 | 1.5 | 8 | 2.1 | 11 | 2.7 |
| 5 | 1.5 | 8 | 1.5 | 8 | 2.1 | 11 | 2.7 |
| 5 | 1.5 | 7 | 1.5 | 8 | 2.1 | 11 | 2.7 |
| 5 | 1.5 | 7 | 1.5 | 8 | 2.1 | 13 | 2.4 (a) |
| 5 | 1.5 | 6 | 1.5 | 8 | 2.1 | 13 | 2.4 (a) |
| 5 | 1.5 | 6 | 1.5 | 8 | 2.1 | 11 | 2.7 |
| 5 | 1.5 | 6 | 1.5 | 8 | 2.1 | 11 | 2.7 |
| 5 | 1.5 | 6 | 1.5 | 8 | 2.1 | 13 | 2.4 (a) |
| 5 | 1.5 | 6 | 1.5 | 8 | 2.1 | 11 | 2.7 |
| 5 | 1.5 | 6 | 1.5 | 8 | 2.1 | 13 | 2.4 (a) |
| 5 | 1.5 | 7 | 1.5 | 8 | 2.1 | 12 | 2.4 (a) |
| 5 | 1.5 | 7 | 1.5 | 8 | 2.1 | 12 | 2.4 (a) |
| 5 | 1.5 | 7 | 1.5 | 8 | 2.1 | 11 | 2.4 (a) |
| 5 | 1.5 | 7 | 1.5 | 8 | 2.1 | 12 | 2.4 (a) |
| 5 | 1.5 | 7 | 1.5 | 8 | 2.1 | 12 | 2.4 (a) |
| 5 | 1.5 | 7 | 1.5 | 8 | 2.1 | 12 | 2.4 (a) |
| 5 | 1.5 | 7 | 1.5 | 8 | 2.1 | 12 | 2.4 (a) |
| 5 | 1.5 | 7 | 1.5 | 8 | 2.1 | 12 | 2.4 (a) |
| 5 | 1.5 | 7 | 1.5 | 8 | 2.1 | 12 | 2.4 (a) |
| 5 | 1.5 | 7 | 1.5 | 8 | 2.1 | 12 | 2.4 (a) |
| 5 | 1.5 | 7 | 1.5 | 8 | 2.1 | 13 | 2.4 (a) |
| 5 | 1.5 | 7 | 1.5 | 8 | 2.1 | 12 | 2.4 (a) |
| 5 | 1.5 | 7 | 1.5 | 8 | 2.1 | 12 | 2.4 (a) |
| 5 | 1.5 | 7 | 1.5 | 8 | 2.1 | 12 | 2.4 (a) |
| 5 | 1.5 | 7 | 1.5 | 8 | 2.1 | 12 | 2.4 (a) |
| 5 | 1.5 | 7 | 1.5 | 8 | 2.1 | 12 | 2.4 (a) |
| 5 | 1.5 | 7 | 1.5 | 8 | 2.1 | 12 | 2.4 (a) |
| 5 | 1.5 | 7 | 1.5 | 8 | 2.1 | 12 | 2.4 (a) |
| 5 | 1.5 | 7 | 1.5 | 8 | 2.1 | 11 | 2.4 (a) |
| 5 | 1.5 | 7 | 1.5 | 8 | 2.1 | 11 | 2.4 (a) |
| 5 | 1.5 | 8 | 1.5 | 8 | 2.1 | 14 | 2.4 (a) |
| 5 | 1.5 | 9 | 1.5 | 8 | 2.1 | 15 | 2.4 (a) |
| 5 | 1.5 | 10 | 1.5 | 8 | 2.1 | 15 | 2.4 (a) |
| 5 | 1.5 | 9 | 1.5 | 8 | 2.1 | 15 | 2.4 (a) |
| 5 | 1.5 | 9 | 1.5 | 9 | 2.1 | 15 | 2.4 (a) |
| 5 | 1.5 | 9 | 1.5 | 9 | 2.1 | 14 | 2.4 (a) |
| 5 | 1.5 | 8 | 1.5 | 8 | 2.1 | 14 | 2.4 (a) |
| 5 | 1.5 | 8 | 1.5 | 8 | 2.1 | 14 | 2.4 (a) |
| 5 | 1.5 | 8 | 1.5 | 8 | 2.1 | 14 | 2.7 |
| 5 | 1.5 | 8 | 1.5 | 8 | 2.1 | 14 | 2.7 |
| 5 | 1.5 | 8 | 1.5 | 8 | 2.1 | 13 | 2.4 (a) |
| 5 | 1.5 | 8 | 1.5 | 8 | 2.1 | 13 | 2.4 (a) |
| 5 | 1.5 | 8 | 1.5 | 8 | 2.1 | 14 | 2.4 (a) |

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**Table A.10 (cont.)**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 5 | 1.5 | 8 | 1.5 | 9 | 2.1 | 14 | 2.4 (a) |
| 5 | 1.5 | 8 | 1.5 | 9 | 2.1 | 14 | 2.4 (a) |
| 5 | 1.5 | 7 | 1.5 | 9 | 2.1 | 13 | 2.4 (a) |
| 5 | 1.5 | 7 | 1.5 | 9 | 2.1 | 12 | 2.4 (a) |
| 5 | 1.5 | 7 | 1.5 | 9 | 2.1 | 12 | 2.4 (a) |
| 5 | 1.5 | 8 | 1.5 | 9 | 2.1 | 11 | 2.4 (a) |
| 5 | 1.5 | 7 | 1.5 | 9 | 2.1 | 12 | 2.4 (a) |
| 5 | 1.5 | 7 | 1.5 | 8 | 2.1 | 14 | 2.4 (a) |
| 5 | 1.5 | 7 | 1.5 | 8 | 2.1 | 14 | 2.4 (a) |
| 5 | 1.5 | 7 | 1.5 | 8 | 2.1 | 13 | 2.7 |
| 5 | 1.5 | 7 | 1.5 | 8 | 2.1 | 13 | 2.4 (a) |
| 5 | 1.5 | 7 | 1.5 | 8 | 2.1 | 13 | 2.4 (a) |
| 5 | 1.5 | 6 | 1.5 | 8 | 2.1 | 14 | 2.4 (a) |
| 5 | 1.5 | 6 | 1.5 | 8 | 2.1 | 12 | 2.7 |
| 5 | 1.5 | 7 | 1.5 | 8 | 2.1 | 13 | 2.4 (a) |
| 5 | 1.5 | 7 | 1.5 | 8 | 2.1 | 13 | 2.4 (a) |
| 5 | 1.5 | 7 | 1.5 | 8 | 2.1 | 13 | 2.4 (a) |
| 5 | 1.5 | 7 | 1.5 | 8 | 2.1 | 12 | 2.4 (a) |
| 5 | 1.5 | 7 | 1.5 | 8 | 2.1 | 12 | 2.4 (a) |
| 5 | 1.5 | 7 | 1.5 | 8 | 2.1 | 11 | 2.4 (a) |
| 5 | 1.5 | 7 | 1.5 | 8 | 2.1 | 12 | 2.4 (a) |
| 5 | 1.5 | 7 | 1.5 | 9 | 2.1 | 12 | 2.4 (a) |
| 5 | 1.5 | 7 | 1.5 | 8 | 2.1 | 12 | 2.4 (a) |
| 5 | 1.5 | 7 | 1.5 | 8 | 2.1 | 12 | 2.4 (a) |
| 5 | 1.5 | 7 | 1.5 | 8 | 2.1 | 12 | 2.4 (a) |
| 5 | 1.5 | 7 | 1.5 | 8 | 2.1 | 12 | 2.4 (a) |
| 5 | 1.5 | 7 | 1.5 | 8 | 2.1 | 12 | 2.4 (a) |

Table A.11. Raw data of the route K-M and L-N.

| Route K-M | | | | Route L-N | | | |
|---|---|---|---|---|---|---|---|
| Off-peak hours | | Peak hours | | Off-peak hours | | Peak hours | |
| Travel time (min) | Travel distance (km) | Travel time (min) | Travel distance (km) | Travel time (min) | Travel distance (km) | Travel time (min) | Travel distance (km) |
| 5 | 1.7 (a) | 9 | 1.7 (a) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 8 | 1.7 (a) | 7 | 1.4 | 9 | 1.5 |
| 5 | 1.7 (a) | 8 | 1.7 (a) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 8 | 1.7 (a) | 8 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 7 | 1.7 (a) | 8 | 1.4 | 8 | 1.5 |
| 4 | 1.7 (a) | 8 | 1.7 (a) | 8 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 9 | 1.7 (a) | 8 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 8 | 1.7 (a) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 10 | 1.7 (a) | 7 | 1.4 | 8 | 1.5 |
| 4 | 1.7 (a) | 8 | 1.7 (a) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 9 | 1.7 (b) | 7 | 1.4 | 7 | 1.5 |
| 5 | 1.7 (a) | 8 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 7 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 8 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 8 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 8 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 8 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 4 | 1.7 (a) | 7 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 4 | 1.7 (a) | 7 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 4 | 1.7 (a) | 8 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 9 | 1.7 (a) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 9 | 1.7 (a) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 12 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 10 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 9 | 1.7 (a) | 7 | 1.4 | 8 | 1.5 |

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**Table A.11 (cont.)**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 5 | 1.7 (a) | 9 | 1.7 (a) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 9 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 8 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 9 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 9 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 8 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 8 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 8 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 7 | 1.7 (a) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 8 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 8 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 8 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 8 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 8 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 8 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 4 | 1.7 (a) | 9 | 1.7 (a) | 7 | 1.4 | 8 | 1.5 |
| 4 | 1.7 (a) | 9 | 1.7 (a) | 7 | 1.4 | 8 | 1.5 |
| 4 | 1.7 (a) | 8 | 1.7 (a) | 7 | 1.4 | 8 | 1.5 |
| 4 | 1.7 (a) | 8 | 1.7 (a) | 7 | 1.4 | 8 | 1.5 |
| 4 | 1.7 (a) | 8 | 1.7 (a) | 7 | 1.4 | 8 | 1.5 |
| 4 | 1.7 (a) | 8 | 1.7 (a) | 7 | 1.4 | 8 | 1.5 |
| 4 | 1.7 (a) | 8 | 1.7 (a) | 7 | 1.4 | 8 | 1.5 |
| 4 | 1.7 (a) | 8 | 1.7 (a) | 7 | 1.4 | 8 | 1.5 |
| 4 | 1.7 (a) | 7 | 1.7 (a) | 7 | 1.4 | 8 | 1.5 |
| 4 | 1.7 (a) | 8 | 1.7 (a) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 8 | 1.7 (a) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 8 | 1.7 (a) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 7 | 1.7 (a) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 8 | 1.7 (a) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 8 | 1.7 (a) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 8 | 1.7 (a) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 7 | 1.7 (a) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 8 | 1.7 (a) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 7 | 1.7 (a) | 7 | 1.4 | 8 | 1.5 |
| 4 | 1.7 (a) | 7 | 1.7 (a) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 8 | 1.7 (a) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 8 | 1.7 (a) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 7 | 1.7 (a) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 8 | 1.7 (a) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 7 | 1.7 (a) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 7 | 1.7 (a) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 7 | 1.7 (a) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 7 | 1.7 (a) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 7 | 1.7 (a) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 7 | 1.7 (a) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 8 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 8 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 8 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 8 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 8 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 9 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 7 | 1.7 (a) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 9 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 9 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 8 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 9 | 1.7 (a) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 8 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 7 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 8 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 7 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 7 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |

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**Table A.11 (cont.)**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 5 | 1.7 (a) | 7 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 8 | 1.7 (a) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 8 | 1.7 (a) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 8 | 1.7 (a) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 8 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 8 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 8 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 7 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 8 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 8 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 8 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 8 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 8 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 4 | 1.7 (a) | 7 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 8 | 1.7 (a) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 9 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 4 | 1.7 (a) | 8 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 8 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 4 | 1.7 (a) | 8 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 4 | 1.7 (a) | 8 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 4 | 1.7 (a) | 8 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 4 | 1.7 (a) | 8 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 4 | 1.7 (a) | 8 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 4 | 1.7 (a) | 8 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 8 | 1.7 (b) | 7 | 1.4 | 8 | 1.8 |
| 5 | 1.7 (a) | 7 | 1.7 (b) | 7 | 1.4 | 9 | 1.8 |
| 5 | 1.7 (a) | 7 | 1.7 (b) | 7 | 1.4 | 8 | 1.8 |
| 5 | 1.7 (a) | 7 | 1.7 (b) | 7 | 1.4 | 8 | 1.8 |
| 5 | 1.7 (a) | 7 | 1.7 (b) | 7 | 1.4 | 8 | 1.8 |
| 5 | 1.7 (a) | 8 | 1.7 (b) | 7 | 1.4 | 8 | 1.8 |
| 5 | 1.7 (a) | 9 | 1.7 (b) | 7 | 1.4 | 8 | 1.8 |
| 5 | 1.7 (a) | 8 | 1.7 (b) | 7 | 1.4 | 8 | 1.8 |
| 5 | 1.7 (a) | 8 | 1.7 (b) | 7 | 1.4 | 8 | 1.8 |
| 5 | 1.7 (a) | 8 | 1.7 (b) | 7 | 1.4 | 8 | 1.8 |
| 5 | 1.7 (a) | 8 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 8 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 4 | 1.7 (a) | 8 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 4 | 1.7 (a) | 8 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 4 | 1.7 (a) | 8 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 4 | 1.7 (a) | 8 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 4 | 1.7 (a) | 8 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 8 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 8 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 4 | 1.7 (a) | 8 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 4 | 1.7 (a) | 7 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 4 | 1.7 (a) | 7 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 7 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 4 | 1.7 (a) | 7 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 7 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 7 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 7 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 7 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 7 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 7 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 4 | 1.7 (a) | 8 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 4 | 1.7 (a) | 7 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 7 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 8 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 9 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 8 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 8 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |

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**Table A.11 (cont.)**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 5 | 1.7 (a) | 7 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 8 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 7 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 8 | 1.7 (a) | 7 | 1.4 | 9 | 1.5 |
| 4 | 1.7 (a) | 8 | 1.7 (a) | 7 | 1.4 | 9 | 1.5 |
| 5 | 1.7 (a) | 8 | 1.7 (a) | 7 | 1.4 | 9 | 1.5 |
| 5 | 1.7 (a) | 8 | 1.7 (a) | 7 | 1.4 | 8 | 1.5 |
| 4 | 1.7 (a) | 8 | 1.7 (a) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 8 | 1.7 (a) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 8 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 4 | 1.7 (a) | 8 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 4 | 1.7 (a) | 8 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 4 | 1.7 (a) | 8 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 9 | 1.7 (b) | 7 | 1.4 | 9 | 1.5 |
| 4 | 1.7 (a) | 9 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 9 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 9 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 9 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 9 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 9 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 9 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 9 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 9 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 9 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 9 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 9 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 9 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 9 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 9 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 9 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 9 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 9 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 9 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 8 | 1.7 (a) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 8 | 1.7 (a) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 8 | 1.7 (a) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 8 | 1.7 (a) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 8 | 1.7 (a) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 8 | 1.7 (a) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 9 | 1.7 (a) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 9 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 9 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 4 | 1.7 (a) | 9 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 8 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 7 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 7 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 8 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 9 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 8 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 8 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 7 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 5 | 1.7 (a) | 8 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |
| 4 | 1.7 (a) | 7 | 1.7 (b) | 7 | 1.4 | 8 | 1.5 |