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A fuzzy Delphi analytic hierarchy model to rank factors influencing public transit mode choice: A case study

Abstract

This study applied a decision-based model with uncertainty to identify factors in mode choice and to rank their influence in attracting riders to available public transit modes in the city of Tehran. The model integrates a fuzzy Delphi method and a fuzzy analytic hierarchy process with fuzzy set theory to process opinion uncertainties. The surveys found that from highest to lowest in influence, the service attribute rankings were safety, reliability, frequency, comfort, travel cost, information provision, and accessibility. Based on these attributes, subway ranked highest in passenger attraction potential, followed by ride-hailing, bus rapid transit, vans and taxis, then public bus services. These findings support the hypothesis that it is worthwhile for big cities to ramp investments in public transit improvements even as ride hailing services proliferate with the potential to attract users away from more throughput-efficient and lower-cost services.

Keywords: Fuzzy modelling; Fuzzy analytic hierarchy process; Fuzzy Delphi method; Public transit; Public transit service quality

1. Introduction

In recent years, Tehran has experienced huge population growth as well as expansion of its urban area. Today the estimated population of the City of Tehran is almost 8.5 million. However, daily commuting of people into the city boosts the population to more than 15 million (Gohari et al. 2015). The recent proliferation of shared mobility options has caused a rapid change in the transportation sector. Although public transportation services could meet the transportation needs of the growing population, users of those services are experiencing traffic congestion and overloaded vehicles during the peak hours. These issues lead to delays, longer waiting times, and higher inefficiencies. Consequently, these attributes discourage the use of public transportation modes and encourage a shift towards the use of private cars. This cycle leads to further congestion, higher pollution, and worsens the performance of some public transportation services (Nassereddine and Eskandari 2017). The situation also leads to inequity because residents who can afford private cars find them more comfortable, flexible, private, and faster in some situations (Bergstad et al. 2011). Although the importance of public transportation is increasing with the fast-paced growing population of Tehran, the public transit infrastructure is not meeting travel demands. This has led to severe traffic congestion and overloaded vehicles, which diminish the efficiency of public transit services. Although residents are inclined to use public transit services, the low quality of those services encourage a considerable portion of residents to use private cars (Nassereddine and Eskandari 2017).

A report from the municipality of Tehran found that public transit services handle approximately half of the daily trips (Nassereddine et al. 2017). The major public transit services in Tehran include bus, bus rapid transit (BRT), subway, vans/taxis, and app-based ride-hailing services that provides coverage to most of the regions in Tehran.

According to Ojo (2019), high vehicle ownership in developed countries reduces the demand for public transit whereas demand is higher in developing countries where ownership is low. The authors posit that the increasing trend in vehicle ownership in developing countries can gradually cause a reduction in public transit use rate. These findings suggest that it is useful to determine the changes needed in the quality attributes of public transit services to encourage a modal shift from private cars to public transit. Discouraging the use of private vehicles and encouraging a shift to public transportation services is a significant focus of large cities (Morton et al. 2016) and provision of quality public transit services facilitates the modal shifting process (Redman, Friman, Gärling, & Hartig, 2013). Therefore, informing policymaking requires identifying and evaluating the potential of available public transit modes to induce a shift away from private vehicles (dell'Olio et al. 2011). Besides, according to De Oña and De Oña (2015), assessment of service quality is an essential tool for transport planners and operators to retain passengers or attract more users, establish strategic goals, and to determine funding choices. The research questions of this study are:

(1) Which transportation quality attributes are most influential in attracting users to public transit?

(2) Which available public transit mode alternatives could be most effective in shifting users away from private cars?

The main **contribution** of this work is a demonstration of using the integrated models of FDM and FAHP in a case study that practitioners can replicate for other cities. The method assumes no preliminary judgments about the suitability of various modes based on the land-use setting. Agencies can use this work as a template to inform decisions about implementing new policies and appropriating funds to improve public transportation services in cities with a public transit structure like Tehran's. Moreover, public transit providers can use the template to reach a consensus about the ranked effectiveness of factors in attracting more users to their services. Unlike this study, previous studies did not compare ride hailing as a public transit mode.

To implement a successful policy or project in the transportation sector, it is critical to involve multiple stakeholders in the decision-making process (Macharis and Bernardini 2015). The **goal** of this research is to apply an appropriate Multi-criteria decision making (MCDM) model that uses the opinions of *experts* to rank the effectiveness of available public transit modes in Tehran in attracting users away from using private vehicles. The authors selected a combined fuzzy Delphi method (FDM) and fuzzy analytic hierarchy process (FAHP). This study takes an alternative approach to surveying *users* who may have a biased towards a given mode because of familiarity, experience, and frequency of use. Instead, the model processes the opinions of experts from the local government, university scholars, planners, and engineers in transportation science. The benefit of using experts is that they can provide a less-biased assessment of mode attributes, based on multi-modal knowledge and field experience.

The structure of the remainder of this paper is organized as follows—Section 2 describes in detail the theory and usage of the FDM and FAHP models. Section 3 provides a brief description of the questionnaires distributed for the survey of experts. Section 4 provides results of the FDM/FAHP calculations. Section 5 presents final remarks about the results and describes future work.

2. Overview of public transit structure in Tehran

Currently, the public transit service in Tehran includes a regular bus transit system, bus rapid transit (BRT), subways, Taxis and Vans, and app-based ride-hailing services. The following sections explain these services in more detail and in the context of Tehran.

6.1 ***Public bus transit system***

The regular public bus transit system provides local access to various places within the city and benefits from dedicated lanes along very limited route portions. These buses are usually crowded and since they share the road with other vehicles, they exacerbate the congestion. Buses usually provide service along streets and have local access. Regular buses run from 6 am until 10 pm or 11 pm but may finish earlier through weekends and holidays. Waiting times can vary considerably based the traffic situation. Bus stations usually have a waiting area that seats but no surrounding structure to be equipped with air conditioners or information displays about routes or terminal times. This public transit system is managed by private sectors.

6.2 ***Bus Rapid Transit***

Bus Rapid Transit (BRT) is a service that utilizes dedicated lanes to travel faster than regular buses and avoid traffic. Tehran BRT includes ten rapid transit lines. The streets supporting BRT usually include more lanes and that makes it possible to provide them with excluded lanes. Buses travel in exclusive lanes which includes 62 miles. BRT usually follows certain time intervals for their waiting times which are shorter than the waiting times for regular buses. The information related to arrival and departure of the vehicles can also be accessed in waiting stations, inside the buses, and via the website of the service provider. BRTs are double sized compared to the regular buses and have one more door for boarding passengers. BRTs run 24/7. Bus Rapid Transit systems are managed by public sectors.

6.3 ***Subway***

Subway in Tehran plays an important role in transporting passengers and consists of 142 miles of metro-grade rail. Approximately 3 million passengers use the seven-line subway, Tehran Metro, daily. Tehran metro is owned and managed by a public sector called Tehran urban and sub-urban railway. Trains commute in a fixed and short time interval and stations are equipped with elevators or escalators if needed. The average speed for this subway is reported as 28 mph when the maximum speed is reported as 50 mph. They operate all days of a week from approximately 5:30 am to 23:00 pm. The trains consist of seven wagons where the capacity for seated and standing passengers is estimated by 1,300 passengers.

6.4 ***Taxis and vans***

Taxis and vans are usually shared in Tehran. There are taxi stations next to most of the main squares in the city and other spots that are usually crowded. Passengers also can hail taxis and vans from the streets. A regular Taxi can accommodate four passengers (one in the front seat and three on the back seat). Vans are another type of taxis which can accommodate nine to twelve passengers and, compared to taxis, are commonly used for longer trips in the city. Passengers can pay the fare with cash while some also pay through internet-based applications, recently. Taxis and vans are usually supposed to go through their fixed routes. Taxis and vans are owned by individuals but supervised and managed by Taxi Organization of Tehran which is a public sector. Taxis and vans move towards destinations from taxi stations whenever they are almost full of passengers. In some cases, the fare for taxis may be higher than vans while in the current study, the authors assume the same rate of fare for them.

6.5 ***App-based ride-hailing services***

Internet-based ride-hailing services provide door-to-door mobility in almost all regions of the city. Using cell phones and applications installed on them, passengers can request a trip from the two major car-hailing transit services in Tehran which are Snapp and Tap30 and are privately managed. Considering their reviews and rankings, passengers can choose between available derivers and vehicles, and the payments can be online or in cash.

3. Literature review

6.1 ***Public transit quality attributes***

Service quality is commonly defined as a measurement of the degree to which the service delivered meets to the customers' expectations (Bitner and Hubert 1994). Public transit service quality attributes are factors that can help evaluators assess the performance of a transit service. Assessing the service quality is the first step in improving the customer satisfaction and attracting more users to a system (Aydin, Celik, & Gumus, 2015). The assessment process includes evaluation of several criteria associated with service quality (Awasthi, Chauhan, Omrani, & Panahi, 2011).

To measure public transit service quality, previous studies proposed many quality attributes. The attributes to assess public transit service quality are taken from several methods such as literature review, survey of operators, statistical tests, and pilot user surveys (J. De Oña & De Oña, 2015). Lowering the number of attributes simplify the process of data collection. De Oña and De Oña (2015) states that there is no general agreement on the number of service quality dimensions and the attributes that must be selected with respect to each specific case study. However, due to the general importance of some service quality attributes such as service frequency, reliability, comfort, safety, information provision, fare and others, they are used often irrespective of the type of service and context considered.

In the current study, the authors conducted a comprehensive literature review to identify the most important public transit service quality attributes. The authors also discussed the attribute selection with public transit experts in Tehran to narrow the list towards context-specific attributes needed to assess the quality of public transit services. Although there were many attributes of service quality, the authors recognized overlaps and redundancies that allowed for a shorter list of attributes into 12 quality attributes, as shown in Table 1. The next sections explain each of the service quality attributes in detail.

5.3.1 Accessibility

According to (Celik, Bilisik, Erdogan, Gumus, & Baracli, 2013) accessibility is measured based on the distance suitability of regions to access the public transit services. Nathanail (2008) and many other studies (Eboli and Mazzulla, 2011; De Oña et al., 2014) consider accessibility as a very crucial attribute in evaluation of customer satisfaction for public transit services. Accessibility will measure how easy it will be for users to access public transit services.

5.3.2 Comfort

According to Aydin et al. (2015) and Jain et al. (2014), comfort can be related to the cleanliness of the transit service, noise level and vibration during a journey. Other comfort factors include the presence of air conditioning inside the public transit services, crowding, and seating availability.

5.3.3 Frequency

As Ojo (2019) states, public transit users appreciate a high-frequency transportation service. In a review study (Redman et al., 2013) also lists frequency of service as one of the most common service quality attributes addressed in evaluating public transit service quality. They used the concept of frequency and waiting time interchangeably when shorter waiting times results in higher frequency of receiving public transit services.

5.3.4 GHG emissions

Greenhouse gas (GHG) emissions is considered as an important quality attribute in a study conducted by Eboli and Mazzulla (2011). This attribute assessed environmental impact when considering the use of ecological vehicles and green technology. (Celik et al., 2013) also found that environmentally conscious vehicles are attractive attributes in public transit services. Keyvan-Ekbatani and Vaziri (2012) presented environmental impacts due to air pollution as an important factor.

5.3.5 Information provision

Information provision is one of the important factors addressed commonly by different studies (Eboli & Mazzulla, 2011). This attribute can include usage of modern equipment to access services, including screen displays to show schedules, vehicle departures and routes, the usage of modern equipment inside public transit services, such as, screen display for route map(s), announcements in stations during and after breakdowns, announcements in vehicles during and after breakdowns, timeliness and accuracy of the provided data and technologic advancements that the users demand (Carreira, Patrício, Natal Jorge, Magee, & Van Eikema Hommes, 2013).

5.3.6 Reliability

Based on the definition provided by Ojo, (2019), reliability is defined as an important quality attribute that represents how reliable public transit services are in delivering users to their destinations. A study by (Aydin et al., 2015) defines reliability as criterion based on passenger perceptions of the accuracy of the planned and practiced departure time, arrival time, journey time and waiting time.

5.3.7 Responsiveness

Responsiveness represents the service quality from staff in addressing customers' requests. It can include understanding users' needs and willingness, readiness, and the promptness of service provider responses concerns and needs (Chou et al., 2014; Awasthi et al., 2011).

5.3.8 Safety

According to Aydin et al. (2015), the authors measure safety of the public transit services through the process of reaching them and being inside their facilities. According to De Oña et al. (2014), travel safety and personal security on board is considered as the main criterion in defining public transit service quality. Likewise, in a study, Nathanail (2008) defined safety during a trip as the perception of passengers about how safe and secure they feel against the system itself and users with respect to crime inside public transit vehicles, and the risk of crashes.

5.3.9 Station comfort

Zhang et al. (2019) used the waiting environment at transit stations as an attribute to assess the public transit service quality. In this study, the authors also consider the availability of seats, air conditioner, safety, and noise as factors affecting station comfort.

5.3.10 Ticketing

According to the results from Nurul et al. (2013), ticketing or payment systems are important service quality attributes that can affect the loading time and eventually the travel time. In another study, Vuk (2005) identified functioning vending machines and similar kiosks as an important attribute in improving the satisfaction of public transit users.

5.3.11 Travel cost

Travel cost, commonly defined as the price to use public transit services, is a feature addressed repeatedly in the literature. Redman et al. (2013) states that users compare an existing fare to an expected reasonable price which is the perceived monetary value of the service they believe is provided.

5.3.12 Welcoming

According to De Oña et al. (2014), attitudes and behaviours of the personnel providing the services to users affect user perceptions about the quality of the service. Also, (Aydin et al., 2015) identified welcoming as one of the most important attributes in evaluating customer satisfaction in rail transit service.

Table 1 Public transit quality attributes

Public Transport Quality Attributes	References
Accessibility	(Redman et al., 2013), (Jain et al., 2014), (Keyvan-Ekbatani & Vaziri, 2012), (Güner, 2018), (Boujelbene & Derbel, 2015), (Barbosa et al., 2017), (Celik et al., 2013), (Calvo & Ferrer, 2018), (Nguyen-Phuoc, Su, Tran, Le, & Johnson, 2020), (Pedroso, Bermann, & Sanches-Pereira, 2018), (Camargo Pérez, Carrillo, & Montoya-Torres, 2014), (Eboli & Mazzulla, 2011), (Nassereddine & Eskandari, 2017),(J. de Oña, de Oña, & López, 2016), (Aydin et al., 2015), (Carreira et al., 2013)
Comfort	(Chou et al., 2014), (R. De Oña et al., 2014),(Zhang et al., 2019), (dell'Olio et al., 2011), (Nathanail, 2008), (Schiefelbusch, 2015), (Keyvan-Ekbatani & Vaziri, 2012), (Lee, 2018), (Pedroso et al., 2018), (Eboli & Mazzulla, 2015), (Mahmoud & Hine, 2016), (Barbosa et al., 2017), (Celik et al. 2013), (Güner, 2018), (Redman et al., 2013), (Eboli & Mazzulla, 2011), (J. de Oña et al., 2016), (Aydin et al., 2015), (Sam et al. 2018), (Carreira et al., 2013)
Frequency	(Redman et al., 2013), (Jain et al., 2014), (Eboli & Mazzulla, 2015), (Güner, 2018), (R. De Oña et al., 2014), (Carreira et al., 2013), (Chou et al., 2014), (Eboli & Mazzulla, 2011), (Celik et al., 2013), (dell'Olio et al., 2011), (Nathanail, 2008), (Nurul et al., 2013), (J. de Oña et al., 2016), (Calvo & Ferrer, 2018), (Mahmoud & Hine, 2016), (Zhang et al., 2019), (Keyvan-Ekbatani & Vaziri, 2012)
GHG emissions	(Keyvan-Ekbatani and Vaziri 2012), (Celik et al. 2013), (Eboli & Mazzulla, 2015), (Pedroso et al., 2018), (Camargo Pérez et al., 2014), (Eboli & Mazzulla, 2011), (Kumar et al., 2018), (Bilişik, Erdoğan, Kaya, & Baraçli, 2013), (Hsu, Lee, & Kreng, 2010), (Lee, 2018)
Information Provision	(Keyvan-Ekbatani and Vaziri 2012), (Redman et al. 2013), (dell'Olio et al. 2011), (Mahmoud and Hine 2016), (Celik et al. 2013), (Jain et al., 2014), (Calvo and Ferrer 2018), (Eboli & Mazzulla, 2011), (Morton, Caulfield, & Anable, 2016), (R. De Oña et al., 2014), (Carreira et al., 2013), (Aydin et al., 2015), (Nathanail, 2008), (J. de Oña et al., 2016)
Reliability	(Redman et al. 2013), (Keyvan-Ekbatani & Vaziri, 2012), (Bilişik et al. 2013), (Celik et al., 2013), (Jain et al., 2014), (Barbosa et al., 2017), (Zhang et al., 2019), (Sam et al., 2018), (Eboli & Mazzulla, 2015), (Kwong & Bai, 2003), (Huang, Tseng, & Hsu, 2016), (R. De Oña et al., 2014), (Chou et al., 2014), (Awasthi et al., 2011), (Eboli & Mazzulla, 2011), (Lee, 2018), (J. de Oña et al., 2016), (Mahmoud & Hine, 2016), (Eboli & Mazzulla, 2015), (Carreira et al., 2013),
Responsiveness	(Awasthi et al. 2011), (Bilişik et al. 2013), (Mahmoud and Hine 2016), (Barbosa et al., 2017), (Chou et al., 2014), (Sam et al., 2018), (Pedroso et al., 2018), (Morton et al., 2016)

Safety	(Redman et al., 2013), (Jain et al., 2014), (Zhang et al., 2019), (Mahmoud & Hine, 2016), (Calvo & Ferrer, 2018), (Irtema, Ismail, Borhan, Das, & Alshetwi, 2018), (R. De Oña et al., 2014), (Nathanail, 2008), (Chou et al., 2014), (Güner, 2018), (Nassereddine & Eskandari, 2017), (Awasthi et al., 2011), (Aydin et al., 2015), (Barbosa et al., 2017), (Eboli & Mazzulla, 2011), (Mahmoud & Hine, 2016), (Pedroso et al., 2018), (Hassan, Hawas, & Ahmed, 2013), (Morton et al., 2016), (Lee, 2018)
Station comfort	(Redman et al. 2013), (Jain et al., 2014), (Zhang et al. 2019), (Mahmoud and Hine 2016), (Shaygan and Testik 2019), (Celik et al. 2013), (Calvo and Ferrer 2018), (Barbosa et al., 2017), (Keyvan-Ekbatani & Vaziri, 2012), (Ojo, 2019), (Aydin et al., 2015), (Nathanail, 2008)
Ticketing	(Irtema et al. 2018), (Mahmoud and Hine 2016), (Bilişik et al. 2013), (Barbosa et al., 2017), (Chou et al., 2014), (Redman et al., 2013), (Ojo, 2019), (Aydin et al., 2015), (Chowdhury, Hadas, Gonzalez, & Schot, 2018), (Hassan et al., 2013), (Morton et al., 2016), (Nathanail, 2008), (Calvo & Ferrer, 2018),
Travel cost	(Redman et al. 2013), (Keyvan-Ekbatani and Vaziri 2012), (Bilişik et al. 2013), (Celik et al., 2013), (Jain et al., 2014), (Barbosa et al., 2017), (Lee, 2018), (Chou et al., 2014), (Güner, 2018), (Nassereddine & Eskandari, 2017), (Awasthi et al., 2011), (Aydin et al., 2015), (Eboli & Mazzulla, 2015), (Eboli & Mazzulla, 2011), (Mahmoud & Hine, 2016), (Chowdhury et al., 2018), (Pedroso et al., 2018), (Hassan et al., 2013), (Boujelbene & Derbel, 2015),
Welcoming	(dell'Olio et al. 2011), (Mahmoud and Hine 2016), (Celik et al. 2013), (Aydin et al., 2015)

6.2 *Literature review of evaluating public transit service quality using MCDM*

Multi-criteria decision making is a decision-making approach that combines various techniques to help decision-makers and stakeholders make decisions based on their preferences among two or more criteria (Chen et al. 2008). Camargo Pérez et al. (2014) affirm that MCDM is one of the most commonly used methods among decision-making methodologies. They stated that between 1982 and 2014, different researches applied 58 different MCDM methods to make decisions relating to public transit systems. In recent decades, the methodologies have become one of the most prominent techniques for making decisions about transit systems. Gerçek et al. (2004) evaluated three alternatives for a rail transit network in Istanbul by applying an analytical hierarchy process (AHP). This resulted in the creation of a new alternative that combined two closely competing alternatives in the rail transit networks. Awasthi et al. (2011) presented a hybrid framework that combined SERVQUAL and fuzzy TOPSIS models to evaluate the quality of metro transit service in Montreal, Canada. Nalan Bilişik et al. (2013) applied a combination of SERVQUAL, Delphi, and fuzzy analytic hierarchy process (FAHP) to classify services of the public transit organizations in Istanbul. Based on the views of experts, they identified the public transit company with the highest customer satisfaction level. Celik et al. (2013) evaluated the public transit system in Istanbul by applying customer satisfaction surveys. They provided a novel hybrid approach based on fuzzy TOPSIS and grey relational analysis (GRA) methods to rank public transit alternatives based on predefined quality attributes of the system.

Boujelbene and Derbel (2015) used AHP to rank the performance level of four transportation operators by considering quality measurements from the passengers' points of view. Jain et al. (2014) used AHP to prioritize the preference of urban commuters' shift from personal vehicles to public transit modes in Delhi, India. They found safety, reliability, cost, and comfort as factors that encourage a shift towards public transit. Barbosa et al. (2017) applied AHP to assess the objective and subjective quality service factors that determine user preference for public transit. Nassereddine and Eskandari (2017) performed an evaluation of public transit systems in Tehran. They used an integrated approach, including the Delphi method, group analytic hierarchy process (GAHP), and the preference ranking organization method (PROMETHEE), to evaluate user satisfaction levels of public transit in Tehran. Güner (2018) proposed an integrated two-stage approach of AHP-TOPSIS to measure the quality of a bus transit service. Based on experts' opinions, Pedroso et al. (2018) proposed an innovative assessment method that combined the functional unit concept and the AHP method to evaluate the performance BRT, light rail transit (LRT), and monorail transit (MNT) modes in a linear corridor of collective transportation systems in São Paulo City, Brazil.

4. Data collection

This study used a survey approach to collect data corresponding to the attributes affecting public transit service quality and prioritizing them based on experts' opinions. The experts responded to two sets of questionnaires. The first set led to ranking the most effective quality attributes based on the FDM method. The second set led to ranking the most effective public transit mode alternatives with respect to each of the quality attributes, using the FAHP method.

The authors looked for public transit experts to answer the surveys. The 32 selected participants in the survey were experts chosen from the Ministry of Roads and Transportation in Tehran who have been dealing with public transit in the city, knowledgeable scholars from universities who has been familiar with international and local public transit systems, and public transit planners and engineers from a research-based organization that had conducted several projects to improve public transit system in Tehran. To prevent the biasness of the opinions, the authors decided not to involve the direct operators of any of the studied public transit modes. In the next step, the authors identified the potential participants in the survey in each of the three organizations. The participants had to have university studies in transportation area (specifically public transportation) or work experience directly related to public transportation planning. Table 2 summarizes some demographics about the experts surveyed.

The questionnaires were sent to the survey participants including explanations about the goal of the survey and the ways they were compared. A sample of the questionnaire including the survey's questions is available in the Appendix. A concise description for each of the criteria was also attached to the survey, giving the responders enough information about the attributes based on which of the different transit modes would be compared.

Table 2 Demographics of the surveyed experts.

Demographic variables	Numbers observed	%
Gender		
Male	23	72
Female	9	28
Age		
21–30	8	25
31–40	11	34
41 and above	13	41
Education		
Bachelors' degree	5	16
Masters' degree	18	56
Ph.D.	9	28
Profession		
Administrator	4	13
Technical expert	16	50
Academic scholar	12	37
Years of experience		
Less than 5 years	6	19
Between 5 and 10 years	16	50
More than 10 years	10	31
Place of work		
Governmental organization	14	44
University	12	38
Private research center	6	18

5. Methodology

The integrated method has two layers. The first applies the FDM to the pool of experts to identify the most critical quality attributes in public transit mode choice. The second layer applies the FAHP approach to weigh and rank the effectiveness of each public transit mode in achieving the quality attributes to attract more users to the system.

6.1 ***Fuzzy triangular numbers***

In 1965, Zadeh (1965) first introduced the fuzzy set theory to deal with the vagueness and uncertainty of human responses. A fuzzy set is a class of items with a continuum of membership levels. A membership function characterizes the set by assigning to each object a degree of membership that ranges between zero and one. Fuzzy sets have become helpful mathematical tools for formulating decision problems in which the available information can be subjective or imprecise (Kahraman et al. 2003). Fuzzy set theory translates linguistic terms such as good, very good, poor, and very poor into fuzzy numbers (Awasthi et al. 2011). Analysts often use triangular fuzzy numbers (TFNs) as membership functions because of their computational simplicity. A fuzzy number $\tilde{a}$ [illegible] is a triangular fuzzy number (TFN) if its membership function is:

$$\mu_{\tilde{a}}(x) = \begin{cases} 0, & x \leq l \\ \frac{x-l}{m-l}, & l < x < m \\ \frac{u-x}{u-m}, & m < x < u \\ 0, & x > m \end{cases} \qquad (1)$$

From Eq. (1), l and u are the lower and upper values of the fuzzy number $\tilde{a}$ and m is the mean. Fig. 1 illustrates the TFN membership function.

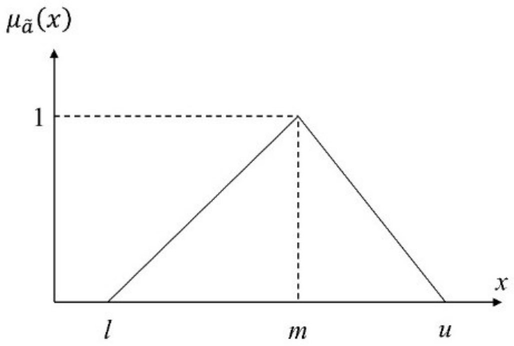

Fig. 1 TFN membership function of $\tilde{a}$

Mathematical operations on fuzzy numbers $\tilde{a}_1$ and $\tilde{a}_2$ are defined as:

$$\tilde{a}_1 = (l_1, m_1, u_1) \tag{2}$$

$$\tilde{a}_2 = (l_2, m_2, u_2) \tag{3}$$

$$\tilde{a}_1 \oplus \tilde{a}_2 = (l_1 + l_2, m_1 + m_2, u_1 + u_2) \tag{4}$$

$$\tilde{a}_1 \otimes \tilde{a}_2 = (l_1 l_2, m_1 m_2, u_1 u_2) \tag{5}$$

$$\tilde{a}_1{}^{-1} = \left(\frac{1}{u_1}, \frac{1}{m_1}, \frac{1}{l_1}\right) \tag{6}$$

$$\frac{\tilde{a}_1}{\tilde{a}_2} = \left(\frac{l_1}{u_2}, \frac{m_1}{m_2}, \frac{u_1}{l_2}\right) \tag{7}$$

Fuzzy set theory mimics human reasoning that uses uncertain information to make decisions. The integrated Delphi and AHP methods of this study apply fuzzy sets to deal with the uncertainties in human judgments.

6.2 *Fuzzy Delphi method*

Researchers use the Delphi method to drive consensus among experts. Ishikawa et al. (1993) first proposed the fuzzy Delphi method (FDM) derived from the traditional Delphi technique and fuzzy set theory. Noorderhaven (1995) proved that integrating the fuzzy set theory into the Delphi method could solve the problem of fuzziness in the common understanding of opinions from experts. This study uses FDM to rank public transit quality attributes that can affect mode choice in Tehran.

The four steps of the FDM method are:

- Collect data from experts.
- Establish fuzzy triangular numbers and their aggregation.

- Defuzzify the data.
- Screen evaluation indexes

5.3.1 Collect opinions

The questionnaires use linguistic variables to determine the experts' evaluation score for the importance of each quality attribute. The linguistic levels are “extremely agree,” “agree,” “neutral,” “disagree,” and “extremely disagree.” The authors provided questionnaires to experts in transportation planning and business development to collect their opinions about the effectiveness of the quality attributes, irrespective of the transportation mode alternative.

5.3.2 Triangular fuzzy numbers and aggregation

The procedure converts the linguistic evaluations into triangular fuzzy numbers. Chang et al. (2015) found that the best approach is to use a five-point triangular fuzzy set as summarized in Table 3. For example, if an expert selects “extremely agree,” then the TFN is $(0.7,0.9,1)$. The next step in the procedure follows the Hsu et al. (2010) approach to FDM. The aggregated opinions are then:

$$\tilde{a}_j = \left(\min_i\{l_{ij}\}, \frac{1}{n}\sum_{i=1}^{n} m_i, \max_i\{u_{ij}\}\right) = \left(l_j, m_j, u_j\right); i = 1,2,\ldots,k; j = 1,2,\ldots,n. \quad (8)$$

where l_j, m_j, and u_j are the lowest value, arithmetic mean, and the highest values of the elements of the fuzzy numbers. The indices *i* and *j* enumerate the experts and the quality attributes, respectively.

Table 3 Linguistic terms and corresponding TFNs for the importance weight of criteria (Tseng 2011)

Linguistic term	Corresponding TFN
Extremely agree	(0.7, 0.9, 1.0)
Agree	(0.5, 0.7, 0.9)
Neutral	(0.3, 0.5, 0.7)
Disagree	(0.1, 0.3, 0.5)
Extremely disagree	(0.0, 0.1, 0.3)

5.3.3 Defuzzification

There are several sophisticated methods for defuzzification. One of the simplest methods is the centre of gravity method such that:

$$a_j = \frac{l_j+m_j+u_j}{3}, j = 1,2, \ldots, k \quad (9)$$

for each TFN $\tilde{a}_j = (l_j, m_j, u_j)$. Hence, a_j is a defuzzified (crisp) number that quantifies the aggregated opinion of all the experts about the effectiveness of a quality attribute.

5.3.4 Screening the criteria

To normalize the fuzzy numbers, the process finds the difference between the average of an individual expert's opinion and the average of opinions across all the experts. The moderator then sends the results back to each expert for an opportunity to modify their previous comments or to make new opinions based on the deviations of their average opinion from the overall average opinion about an attribute. After defuzzification, the following logic selects the final quality attributes such that:

- If $a_j \geq \alpha$, then factor j is added as a quality attribute for the next stage.
- If $a_j < \alpha$, then factor j is omitted.

The Cronbach threshold of $\alpha = 0.7$ is selected. That is, if the crisp number of each quality attribute is greater than or equal to 0.7 then it qualifies as an evaluation factor and will be omitted otherwise. The iterations continue until the difference between the average of each quality attribute's value and the value from the previous iteration is less than or equal to 0.1.

6.3 ***Fuzzy analytic hierarchy process (FAHP)***

Analytic hierarchy process (AHP) is a popular method for solving complicated decision problems. AHP has been applied extensively by professionals and academics in many different engineering and management applications (Pedroso et al. 2018). The method decomposes each complex problem into several sub-problems such that each hierarchy represents a set of criteria related to a sub-problem. In traditional AHP, a nine-point scale establishes the pairwise comparisons between criteria and sub-criteria. However, the method has been generally criticized because the discrete scale cannot handle uncertainty and ambiguity (Chan and Kumar 2007). Assigning a TFN to each linguistic scale, as summarized in Table 4, provides a resolution.

Table 4 Linguistic scale (Hsu et al. 2010)

Linguistic scale for the importance	Crisp Value	Fuzzy Number
Equally important	1	(1,1,1)
Judgment values between equally and moderately	2	(1,2,3)
Moderately more important	3	(2,3,4)
Judgment values between moderately and strongly	4	(3,4,5)
Strongly more important	5	(4,5,6)
Judgment values between strongly and very strongly	6	(5,6,7)
Very strongly more important	7	(6,7,8)
Judgment values between very strongly and extremely	8	(7,8,9)
Extremely more important	9	(8,9,9)

FAHP adds fuzzy logic to the AHP method to deal with the impreciseness of opinions from the experts. In this research, the authors use the extent analysis method proposed by Chang, D. Y. (1996) to implement the fuzzy AHP method. The method uses pairwise comparisons to evaluate the importance of criteria concerning the main goal, and the alternatives concerning each criterion. In this study, the *criteria* are the quality attributes when using a specified public transit mode, and the *alternatives* are the individual public transit modes available. The following are the five steps of the FAHP method:

(1) Problem definition

(2) Hierarchy structure setup

(3) Pair-wise comparisons

(4) Fuzzy weight determination per criterion

(5) Evaluate the weights of the criteria and the alternatives

5.3.1 Problem definition

The goal is to identify and rank public transportation mode alternatives in Tehran with respect to quality attributes that can spur a mode shift towards public transit and away from private vehicles.

5.3.2 Hierarchy structure

As shown in Fig 2, the hierarchy structure consists of three levels. The top level states the final goal of the problem. The middle layer contains the quality attributes of the public transit system, which are the outputs from the Delphi method. The bottom layer contains the available public transit mode alternatives.

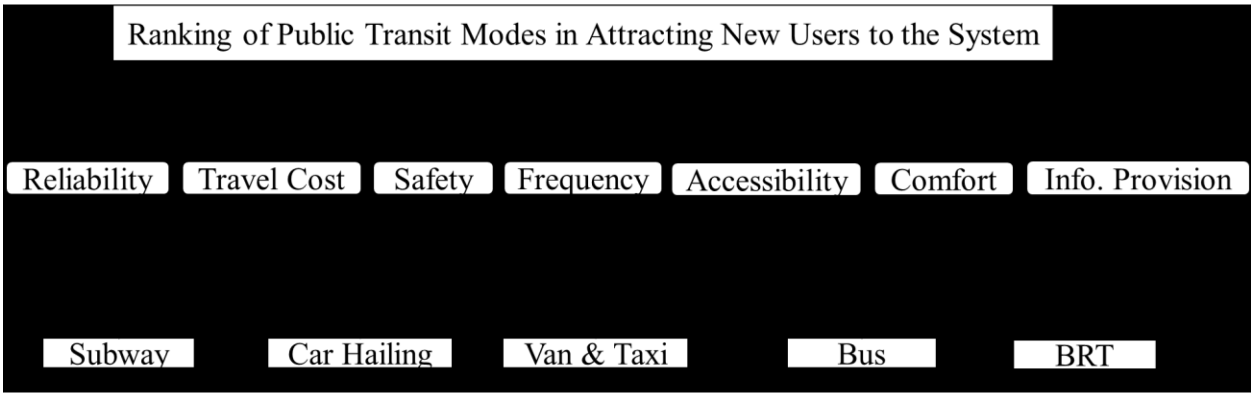

Fig. 2 Hierarchy of the fuzzy framework.

5.3.3 Pairwise comparisons

The pairwise comparisons involve a linguistic response where experts, based on their knowledge and experience, decide on the relative importance of one item over another. First, conducting each pairwise comparison compares the quality attributes with respect to the main goal. The process then pairwise compares the public transit mode alternatives with respect to each of the quality attributes. Table 3 defines the linguistic scales and the associated fuzzy numbers. An expert pairwise comparison matrix then organizes the linguistic variables after their conversion into TFNs such that:

$$\widetilde{M}^k = \begin{bmatrix} \widetilde{M}_{11}^k & \widetilde{M}_{12}^k & \dots & \widetilde{M}_{1n}^k \\ \widetilde{M}_{21}^k & \widetilde{M}_{22}^k & \dots & \widetilde{M}_{2n}^k \\ \vdots & & & \vdots \\ \widetilde{M}_{n1}^k & \widetilde{M}_{n2}^k & \dots & \widetilde{M}_{nn}^k \end{bmatrix} \quad (10)$$

where the cells represent the k^{th} decision maker's relative preference of the i^{th} quality attribute over the j^{th} quality attribute. For *n* quality attribute and *m* decision-makers, the indices are $i, j = 1, \dots, n$, and $k = 1, \dots, m$, where l_{ij}, m_{ij}, u_{ij} are real numbers with the constraint that $l_{ij} \leq m_{ij} \leq u_{ij}$.

Calculate the average of preferences on each factor using the geometric mean such that:

$$\widetilde{M}_{ij} = \left(\prod_{k=1}^{m} \widetilde{M}_{ij}^k\right)^{1/k} \quad (11)$$

Subsequently, the integrated fuzzy comparison matrix becomes:

$$\widetilde{M} = \begin{bmatrix} \widetilde{M}_{11} & \cdots & \widetilde{M}_{1n} \\ \vdots & \ddots & \vdots \\ \widetilde{M}_{n1} & \cdots & \widetilde{M}_{nn} \end{bmatrix} \quad (12)$$

5.3.4 Consistency of pairwise comparisons

Priorities make sense only if extracted from consistent matrices. Consistency means that the pairwise comparisons are closer to logical selections than to random selections. This analysis selects the consistency index (CI) proposed by Saaty (2004) that stems from the eigenvalue method. This is combined with the method proposed by Gogus and Boucher (1998) to calculate a consistency ratio of fuzzy pairwise comparisons. The steps of the process are:

Step 1: Convert a triangular fuzzy matrix into two independent matrices where the TFN is presented as follows:

$$A_{ij} = (l_{ij}, m_{ij}, u_{ij}) \quad (13)$$

Middle numbers of the triangular fuzzy matrix generate the first matrix such that:

$$A_m = [m_{ij}] \quad (14)$$

The geometric mean (GM) of the upper and lower bounds of the triangular fuzzy matrix generates the second matrix such that:

$$A_g = [\sqrt{u_{ij} \times l_{ij}}] \quad (15)$$

Step 2: Compute the weight vector of each matrix (w^m and w^g) and calculate their corresponding largest eigenvalues (λ^m_{max} and λ^g_{max}) as follows:

$$M \times w^m = \lambda^m_{max} \times w^m \quad (16)$$

$$M \times w^g = \lambda^g_{max} \times w^g \quad (17)$$

Therefore, the solution for the largest eigenvalues is:

$$\lambda^m_{max} = \frac{1}{n} \sum_{i=1}^{n} \sum_{j=1}^{n} m_{ij} \, (w^m_j / w^m_i) \quad (18)$$

$$\lambda^g_{max} = \frac{1}{n} \sum_{i=1}^{n} \sum_{j=1}^{n} \sqrt{u_{ij} \times l_{ij}} (w^g_j / w^g_i) \quad (19)$$

Step 3: Calculate the consistency index ($CI_m$and CI_g) for each matrix as follows:

$$CI_m = \frac{\lambda^m_{max} - n}{n-1} \quad (20)$$

$$CI_g = \frac{\lambda^g_{max} - n}{n-1} \quad (21)$$

Where n is the dimension of the matrix.

Step 4: Calculate the consistency ratio (CR) of the matrices as a function of the CI and a random index (RI) such that:

$$CR_m = CI_m/RI_m \tag{22}$$

$$CR_g = CI_g/RI_g \tag{23}$$

The method from Gogus and Boucher (1998) produce random indices (Table 5) with a sample size of 400.

Table 5 Random index

Size of the matrix	RI^m	RI^g
1	0	0
2	0	0
3	0.4890	0.1796
4	0.7937	0.2627
5	1.0720	0.3597
6	1.1996	0.3818
7	1.2874	0.4090
8	1.3410	0.4164
9	1.3793	0.4348
10	1.4095	0.4455
11	1.4181	0.4536
12	1.4462	0.4776
13	1.4555	0.4691
14	1.4913	0.4804
15	1.4986	0.4880

If the values of CR_m and CR_g are less than 0.1, then the matrices of the judgments are consistent. Subjective judgments can yield consistency ratios exceeding 10% (Saaty, 2004).

5.3.5 Fuzzy weight determination

In this study, an extent analysis method is used to determine weights based on TFNs for each of the quality attributes with regard the final goal, and for each mode alternative with respect to each quality attribute. This method, first proposed by Chang (1996), defines $X = \{x_1, x_2, \ldots, x_n\}$ as an object set with $U = \{g_1, g_2, \ldots, g_m\}$ as a goal set..

The *m* values of goals for each object can be represented in the form $M_{gi}^{1}, M_{gi}^{2}, \dots, M_{gi}^{m}$ where $i = 1,2,\dots,n$. All $M_{gi}^{j}, (j = 1,2,\dots,m)$ values are TFNs.

Chang's extent analysis (Chang 1996) consist of the following steps:

Step 1: Calculate the degree of possibility S_2 and S_1:

$$S_i = \sum_{j=1}^{m} M_{gi}^{j} \otimes \left(\sum_{i=1}^{n} \sum_{j=1}^{m} M_{gi}^{j}\right)^{-1} \tag{24}$$

where $\sum_{j=1}^{m} M_{gi}^{j} = \left(\sum_{j=1}^{m} l_j, \sum_{j=1}^{m} m_j, \sum_{j=1}^{m} u_j\right)$ and

$\left(\sum_{i=1}^{n} \sum_{j=1}^{m} M_{gi}^{j}\right)^{-1} = \left(\frac{1}{\sum_{i=1}^{n} \sum_{j=1}^{m} u_i}, \frac{1}{\sum_{i=1}^{n} \sum_{j=1}^{m} m_i}, \frac{1}{\sum_{i=1}^{n} \sum_{j=1}^{m} l_i}\right)$.

Step 2: Calculate the degree of possibility of S_2 and S_1 after computing S_2 and S_1 in step 1.

$$V(S_2 \geq S_1) = sup_{y \geq x}[min(\mu_{S_2}(y), \mu_{S_1}(x)] \tag{25}$$

Eq. (25) can also be represented by Eqs. (26) and (27).

$$V(S_2 \geq S_1) = highest(S_1 \cap S_2) = \mu_{S_2}(d) \tag{26}$$

$$\mu_{S_2}(d) = \begin{cases} 1 & if\ m_2 \geq m_1 \\ 0 & if l_1 \geq u_2 \\ \frac{l_1 - u_2}{(m_2 - u_2) - (m_1 - l_1)} & otherwise \end{cases} \tag{27}$$

where *d* is the crossover point's abscissa for S_2 and S_1.

Step 3: Calculate the degree of possibility for a convex fuzzy number to be greater than *k* convex fuzzy numbers S_i(Eq. 28).

$$V(S \geq S_1, S_2, \dots, S_k) = min\, V\,(S \geq S_i), i = 1,2,\dots,k \tag{28}$$

Step 4: Compute the weight vector for each comparison matrix as the following:

$$W'_k = (d(p_1^k), d(p_2^k), \ldots, d(p_n^k))^T \tag{29}$$

Let $d(p_i^k) = min\, V(S_i^k \geq S_j^k)$ for $k = 1,2,..,n\,; k \neq i$, where p_i^k is the ith element of the kth level, $j = 1,2,..,n, j \neq i$. The normalized weight vector is

$$W_k = \left(w(p_1^k), w(p_2^k), \ldots, w(p_n^k)\right)^T \tag{30}$$

5.3.6 The weights of criteria and alternatives

The final weights of the public transit mode alternatives are the product of each public transit mode alternative's weight and those of the quality attributes. Based on the calculated results, the alternatives with higher weights rank higher in importance of ability to achieve the objective.

6. Results

6.4 ***Fuzzy Delphi method***

Initially, the quality attributes are travel cost, reliability, frequency, accessibility, safety, station comfort, welcoming, ticketing, Information provision, comfort, GHG emissions, and responsiveness. Table 6 summarizes the crisp numbers that represent the aggregate opinions from the experts, after defuzzification and screening.

Table 6 First round aggregate opinion ranking of quality attributes.

	Criteria	Defuzzified Numbers of aggregated Fuzzy scales
1	Accessibility	0.59
2	Comfort	0.58
3	Frequency	0.67
4	GHG emissions	0.47
5	Information provision	0.65
6	Reliability	0.70
7	Responsiveness	0.42
8	Safety	0.77
9	Station comfort	0.44
10	Ticketing	0.34
11	Travel cost	0.68
12	Welcoming	0.43

In the next step, the authors provided each expert with a questionnaire that contained the average of opinions on quality attributes in the previous step and their average in that step. The experts then refined their opinions and preferences, which became more consistent with the average of opinions. Table 7 summarizes the aggregate results from the next step.

Table 7 Second round aggregate opinion ranking of mode choice criteria.

	Criteria	Defuzzified numbers of aggregated fuzzy scales	The difference between the averages of opinions in the first and second survey rounds
1	Accessibility	0.70	0.11
2	Comfort	0.68	0.10
3	Frequency	0.70	0.03
4	GHG emissions	0.57	0.10
5	Information provision	0.70	0.05
6	Reliability	0.70	0.00
7	Responsiveness	0.53	0.11
8	Safety	0.78	0.01
9	Station comfort	0.49	0.05
10	Ticketing	0.35	0.01
11	Travel cost	0.70	0.02
12	Welcoming	0.35	0.08

The results indicate that quality attributes involving travel cost, safety, frequency, reliability, and information provision are considered final when they converge by having a difference in their averages of less than 0.1 in two consecutive rounds, and where their average importance is greater than 0.7. Other quality attributes (station comfort, welcoming, and ticketing) failed to reach the accepted level after converging. From the first and second round of surveys for accessibility, responsiveness, comfort, and GHG emissions, there was no consensus on alternatives with differences of less than 0.1 between opinion averages. In the third round of the survey, the remaining quality attributes with no consensus were reassessed by the experts. Table 8 indicates the results from the third round of the survey.

Table 8 Third round aggregate opinion ranking of mode choice criteria.

	Criteria	Defuzzified numbers of aggregated fuzzy scales	The difference between the averages of opinions in the second and third survey rounds
1	Accessibility	0.70	0.00
2	Comfort	0.70	0.02
3	GHG emissions	0.66	0.09
4	Responsiveness	0.45	0.08

These results show that there is consensus on the surveyed criteria such that accessibility and comfort meet the level of acceptance to become other final set of criteria, while responsiveness and GHG emissions fell below the threshold for inclusion. As a result, the experts collectively ranked accessibility, comfort, frequency, information provision, reliability, safety, and travel cost as the most important quality attributes in the selection of public transit mode alternatives. Overall, these findings are not surprising because they are consistent with the commonly used quality attributes, and also with the findings of Nassereddine and Eskandari (2017). However, given the goal of reducing congestion, hence emissions, by moving riders towards more high-efficiency modes of transport spotlights the omission of GHG emissions as unanticipated. Also, Aydin et al. (2015) used station comfort, ticketing, and welcoming as some of the important criteria in assessing the quality of public transit services, but the process in this study eliminated those factors. These differences in results indicate that the preferences of quality factors and their ranking can vary in different regional contexts, and at different time periods due to the evolution of transportation services and the relative influence of new modes such as ride-hailing.

6.2 ***Fuzzy analytic hierarchy process***

The FAHP method uses the hierarchical structure shown in Fig 2. The FDM produced the quality attributes of the middle layer. The authors' knowledge of shared mobility services available in the city of Tehran informed the public transit mode alternatives shown. First, eqs (10), (11), and (12) accumulated and averaged the results extracted from the questionnaires containing pairwise comparisons (Tables 9 and 10). The first part of the table contains the pairwise comparison matrices of relative rankings among all combinations of quality attributes, with respect to the main objective. The remainder of the table contains the pairwise comparisons between public transit mode alternatives, with respect to each of the quality attributes. Given that the dimensions of the pairwise comparison matrices are seven when comparing the importance of attributes and five when comparing the public transit modes, the values for RI^m and RI^g from Table 5 for each of the corresponding dimensions of the matrices are 1.2874 and 0.4090, and 1.0720 and 0.3597, respectively. The CRs with values less than 0.1 in the comparison matrixes indicates that the level of consistency of the pairwise comparisons are acceptable.

The value of the fuzzy synthetic extent is calculated using Eq. (24), followed by calculating the degree of possibility for $S_i \geq S_j$ using Eq. (27). Eq. (28) then determines the degree of possibility for a fuzzy number so that it is greater than k fuzzy numbers. Subsequently, normalizing the values from the previous step produces the final weigh for each of the quality attributes and public transit mode alternatives. Table 11 and 12 summarize the results.

Table 9 Fuzzy pairwise comparison matrices corresponding to the service quality attributes.

Fuzzy Pairwise Comparison Matrix for the Quality Attributes with Respect to the Main Objective							
$\lambda^m = 7.25$, $\lambda^g = 7.23$, $CR^m = 0.03$, $CR^g = 0.09$							
	Reliability	Travel cost	Safety	Frequency	Accessibility	Comfort	Info. Prov.
Reliability	(1.00,1.00,1.00)	(1.10,1.59,2.10)	(0.64,0.85,1.13)	(0.81,1.12,1.49)	(1.17,1.70,2.26)	(1.06,1.06,2.16)	(1.11,1.62,2.13)
Travel cost	(0.48,0.63,0.91)	(1.00,1.00,1.00)	(0.45,0.61,0.87)	(0.82,1.10,1.42)	(1.00,1.18,1.38)	(0.65,0.90,1.27)	(0.72,0.98,1.32)
Safety	(0.89,1.18,1.57)	(1.15,1.65,2.24)	(1.00,1.00,1.00)	(0.83,1.19,1.58)	(0.85,1.17,1.54)	(1.53,2.33,3.17)	(1.71,2.56,3.40)
Frequency	(0.67,0.89,1.23)	(0.70,0.91,1.21)	(0.63,0.84,1.20)	(1.00,1.00,1.00)	(1.00,1.42,1.90)	(0.96,1.31,1.71)	(0.77,1.04,1.38)
Accessibility	(0.44,0.59,0.86)	(0.73,0.85,1.00)	(0.65,0.86,1.18)	(0.53,0.70,1.00)	(1.00,1.00,1.00)	(0.67,0.82,1.07)	(1.03,1.40,1.81)
Comfort	(0.46,0.62,0.95)	(0.79,1.11,1.55)	(0.53,0.70,1.00)	(0.59,0.76,1.04)	(0.93,1.22,1.50)	(1.00,1.00,1.00)	(0.71,0.95,1.27)
Info. Prov.	(0.47,0.62,0.90)	(0.76,1.02,1.38)	(0.59,0.76,1.04)	(0.72,0.96,1.31)	(0.55,0.71,0.97)	(0.71,0.95,1.27)	(1.00,1.00,1.00)

Table 10A Fuzzy pairwise comparison matrices corresponding to the public transit modes.

Fuzzy Pairwise Comparison Matrix for the Alternatives with Respect to Reliability					
$\lambda^m = 5.04$, $\lambda^g = 5.03$, $CR^m = 0.01$, $CR^g = 0.02$					
	subway	Car-hailing	Van and taxi	Bus	BRT
Subway	(1.00,1.00,1.00)	(0.88,1.12,1.39)	(1.31,1.93,2.55)	(1.47,2.27,2.99)	(0.80,1.09,1.47)
Car-hailing	(0.72,0.89,1.14)	(1.00,1.00,1.00)	(1.15,1.64,2.15)	(1.53,2.49,3.39)	(0.59,0.82,1.18)
Van and taxi	(0.39,0.52,0.76)	(0.47,0.61,0.87)	(1.00,1.00,1.00)	(1.06,1.46,1.83)	(0.32,0.44,0.70)
Bus	(0.33,0.44,0.68)	(0.30,0.40,0.65)	(0.55,0.68,0.94)	(1.00,1.00,1.00)	(0.50,0.62,0.83)
BRT	(0.68,0.91,1.24)	(0.85,1.22,1.69)	(1.42,2.27,3.15)	(1.21,1.62,1.98)	(1.00,1.00,1.00)
Fuzzy Pairwise Comparison Matrix for the Alternatives with Respect to Travel Cost					
$\lambda^m = 5.03$, $\lambda^g = 5.02$, $CR^m = 0.01$, $CR^g = 0.02$					
	subway	Car-hailing	Van and taxi	Bus	BRT
Subway	(1.00,1.00,1.00)	(2.02,3.14,4.20)	(1.59,2.47,3.30)	(0.91, 1.09,1.29)	(0.90,1.08,1.27)
Car-hailing	(0.24,0.32,0.50)	(1.00,1.00,1.00)	(0.64,0.83,1.13)	(0.33,0.44,0.68)	(0.30,0.42,0.68)

Table 10B Fuzzy pairwise comparison matrices corresponding to the public transit modes.

Van and taxi	(0.78,0.92,1.10)	(1.47,2.28,3.06)	(1.00,1.00,1.00)	(1.48,2.38,3.22)	(0.40,0.53,0.82)
Bus	(0.78,0.92,1.10)	(1.47,2.28,3.06)	(1.48,2.38,3.22)	(1.00,1.00,1.00)	(0.60,0.74,0.95)
BRT	(0.79,0.93,1.11)	(1.47,2.40,3.29)	(1.22,1.88,2.47)	(1.05,1.36,1.66)	(1.00,1.00,1.00)
Fuzzy Pairwise Comparison Matrix for the Alternatives with Respect to Safety					
$\lambda^m = 5.02, \lambda^g = 5.02, CR^m = 0.01, CR^g = 0.00$					
	subway	Car-hailing	Van and taxi	Bus	BRT
Subway	(1.00,1.00,1.00)	(1.08,1.65,2.20)	(1.16,1.68,2.17)	(1.02,1.28,1.51)	(0.93,1.22,1.56)
Car-hailing	(0.46,0.61,0.93)	(1.00,1.00,1.00)	(0.94,1.09,1.25)	(0.44,0.58,0.81)	(0.49,0.64,0.92)
Van and taxi	(0.46,0.60,0.86)	(0.80,0.91,1.06)	(1.00,1.00,1.00)	(0.54,0.68,0.92)	(0.44,0.59,0.84)
Bus	(0.66,0.78,0.98)	(1.24,1.74,2.28)	(1.08,1.46,1.85)	(1.00,1.00,1.00)	(0.62,0.76,0.98)
BRT	(1.09,0.82,1.08)	(1.09,1.56,2.05)	(1.20,1.70,2.29)	(1.02,1.32,1.62)	(1.00,1.00,1.00)
Fuzzy Pairwise Comparison Matrix for the Alternatives with Respect to Frequency					
$\lambda^m = 5.04, \lambda^g = 5.04, CR^m = 0.01, CR^g = 0.03$					
	subway	Car-hailing	Van and taxi	Bus	BRT
Subway	(1.00,1.00,1.00)	(0.41,0.52,0.74)	(0.43,0.59,0.92)	(1.39,2.06,2.63)	(0.92,1.12,1.32)
Car-hailing	(1.35,1.93,2.46)	(1.00,1.00,1.00)	(1.04,1.47,1.93)	(1.54,2.48,3.38)	(1.35,1.97,2.51)
Van and taxi	(1.09,1.69,2.30)	(0.52,0.68,0.96)	(1.00,1.00,1.00)	(1.20,1.84,2.38)	(0.99,1.31,1.68)
Bus	(0.38,0.49,0.72)	(0.30,0.40,0.65)	(0.42,0.54,0.83)	(1.00,1.00,1.00)	(0.37,0.53,0.82)
BRT	(0.76,0.89,1.08)	(0.40,0.51,0.74)	(0.60,0.76,1.01)	(1.23,1.89,2.68)	(1.00,1.00,1.00)
Fuzzy Pairwise Comparison Matrix for the Alternatives with Respect to Accessibility					
$\lambda^m = 5.15, \lambda^g = 5.12, CR^m = 0.04, CR^g = 0.09$					
	Subway	Car-hailing	Van and taxi	Bus	BRT
Subway	(1.00,1.00,1.00)	(0.42,0.59,1.00)	(0.56,0.73,1.05)	(1.05,1.46,1.88)	(0.43,0.60,0.94)
Car-hailing	(1.00,1.69,2.38)	(1.00,1.00,1.00)	(1.09,1.53,2.03)	(1.44,2.01,2.50)	(1.22,2.07,2.85)
Van and taxi	(0.95,1.36,1.80)	(0.49,0.65,0.92)	(1.00,1.00,1.00)	(0.92,1.15,1.37)	(0.99,1.41,1.91)
Bus	(0.53,0.69,0.95)	(0.40,0.50,0.70)	(0.73,0.87,1.08)	(1.00,1.00,1.00)	(1.16,1.76,2.27)
BRT	(1.06,1.65,2.36)	(0.35,0.48,0.82)	(0.44,0.57,0.86)	(0.44,0.57,0.86)	(1.00,1.00,1.00)
Fuzzy Pairwise Comparison Matrix for the Alternatives with Respect to Comfort					
$\lambda^m = 5.02, \lambda^g = 5.02, CR^m = 0.01, CR^g = 0.02$					
	Subway	Car-hailing	Van and taxi	Bus	BRT
Subway	(1.00,1.00,1.00)	(0.41,0.53,0.77)	(0.68,0.90,1.20)	(1.03,1.42,1.83)	(0.81,1.01,1.24)
Car-hailing	(1.29,1.87,2.46)	(1.00,1.00,1.00)	(0.93,1.40,1.88)	(1.66,2.35,2.97)	(1.50,2.21,2.92)
Van and taxi	(0.83,1.11,1.46)	(0.53,0.71,1.07)	(1.00,1.00,1.00)	(1.21,1.66,2.14)	(1.22,1.81,2.40)
Bus	(0.55,0.70,0.97)	(0.34,0.42,0.60)	(0.47,0.60,0.83)	(1.00,1.00,1.00)	(0.94,1.24,1.53)
BRT	(0.81,0.99,1.24)	(0.34,0.45,0.67)	(0.42,0.55,0.82)	(0.65,0.81,1.06)	(1.00,1.00,1.00)
Fuzzy Pairwise Comparison Matrix for the Alternatives with Respect to Information Provision					
$\lambda^m = 5.02, \lambda^g = 5.02, CR^m = 0.02, CR^g = 0.04$					
	Subway	Car-hailing	Van and taxi	Bus	BRT
Subway	(1.00,1.00,1.00)	(0.41,0.52,0.70)	(1.58,2.48,3.42)	(1.56,2.41,3.24)	(0.81,1.16,1.56)
Car-hailing	(1.42,1.92,2.45)	(1.00,1.00,1.00)	(1.67,2.45,3.25)	(1.74,2.70,3.61)	(1.50,2.23,2.95)
Van and taxi	(0.29,0.40,0.63)	(0.31,0.41,0.60)	(1.00,1.00,1.00)	(0.55,0.76,1.17)	(0.39,0.56,0.84)
Bus	(0.31,0.42,0.64)	(0.28,0.37,0.57)	(0.85,1.31,1.83)	(1.00,1.00,1.00)	(0.35,0.46,0.67)
BRT	(0.64,0.86,1.23)	(0.34,0.45,0.67)	(1.18,1.79,2.54)	(1.49,2.18,2.89)	(1.00,1.00,1.00)

Table 11 Fuzzy Synthetic Extent and Degree of Possibility for the Quality Attributes.

Fuzzy Synthetic Extent, Degree of Possibility, Weights for the Quality Attributes with Respect to the Objective												
Alternatives	Fuzzy Synthetic Extent			Degree of Possibility of $S_i \geq S_j$							Degree of Possibility	Normalization
Reliability	0.10	0.18	0.30		1.00	0.76	1.00	1.00	1.00	1.00	0.76	0.203
Travel cost	0.07	0.12	0.20	0.64		0.39	0.86	1.00	1.00	1.00	0.39	0.105
Safety	0.13	0.23	0.40	1.00	1.00		1.00	1.00	1.00	1.00	1.00	0.268
Frequency	0.08	0.14	0.23	0.78	1.00	0.54		1.00	1.00	1.00	0.54	0.144
Accessibility	0.07	0.11	0.18	0.54	0.90	0.30	0.76		0.90	0.96	0.30	0.079
Comfort	0.07	0.12	0.20	0.64	1.00	0.40	0.86	1.00		1.00	0.40	0.107
Info. Prov.	0.07	0.11	0.19	0.59	0.94	0.35	0.81	1.00	0.95		0.35	0.095

Table 12A Fuzzy Synthetic Extent and Degree of Possibility for the Mode Alternatives.

With Respect to Reliability										
Alternatives	Fuzzy Synthetic Extent			Degree of Possibility of $S_i \geq S_j$					Degree of Possibility	Normalization
Subway	0.15	0.26	0.44		1.00	1.00	1.00	1.00	1.00	0.284
Car-hailing	0.14	0.24	0.41	0.93		1.00	1.00	0.98	0.93	0.263
Van & taxi	0.09	0.14	0.24	0.43	0.51		1.00	0.48	0.43	0.122
Bus	0.07	0.11	0.19	0.21	0.29	0.77		0.26	0.21	0.060
BRT	0.14	0.25	0.42	0.95	1.00	1.00	1.00		0.95	0.270
With Respect to Travel Cost										
Alternatives	Fuzzy Synthetic Extent			Degree of Possibility of $S_i \geq S_j$					Degree of Possibility	Normalization
Subway	0.17	0.29	0.49		1.00	1.00	1.00	1.00	1.00	0.340
Car-hailing	0.06	0.10	0.18	0.05		0.85	0.21	0.18	0.05	0.017
Van & taxi	0.08	0.12	0.21	0.19	1.00		0.36	0.32	0.19	0.065
Bus	0.14	0.24	0.41	0.83	1.00	1.00		0.97	0.83	0.284
BRT	0.14	0.25	0.42	0.86	1.00	1.00	1.00		0.86	0.294
With Respect to Travel Safety										
Alternatives	Fuzzy Synthetic Extent			Degree of Possibility of $S_i \geq S_j$					Degree of Possibility	Normalization
Subway	0.16	0.26	0.40		1.00	1.00	1.00	1.00	1.00	0.285
Car-hailing	0.10	0.15	0.23	0.40		1.00	0.57	0.46	0.40	0.115
Van & taxi	0.10	0.14	0.22	0.36	0.96		0.53	0.42	0.36	0.102
Bus	0.14	0.22	0.33	0.81	1.00	1.00		0.88	0.81	0.232
BRT	0.15	0.24	0.38	0.93	1.00	1.00	1.00		0.93	0.266
With Respect to Frequency										
Alternatives	Fuzzy Synthetic Extent			Degree of Possibility of $S_i \geq S_j$					Degree of Possibility	Normalization
Subway	0.113	0.184	0.305		0.52	0.80	1.00	1.00	0.52	0.185
Car-hailing	0.171	0.309	0.520	1.00		1.00	1.00	1.00	1.00	0.356
Van & taxi	0.131	0.227	0.384	1.00	0.72		1.00	1.00	0.72	0.258
Bus	0.067	0.103	0.185	0.47	0.07	0.31		0.51	0.07	0.023
BRT	0.108	0.176	0.301	0.96	0.50	0.77	1.00		0.50	0.177

Table 12B Fuzzy Synthetic Extent and Degree of Possibility for the Mode Alternatives.

With Respect to Accessibility										
Alternatives	Fuzzy Synthetic Extent			Degree of Possibility of $S_i \geq S_j$					Degree of Possibility	Normalization
Subway	0.10	0.16	0.28		0.46	0.79	0.92	0.99	0.46	0.150
Car-hailing	0.16	0.30	0.52	1.00		1.00	1.00	1.00	1.00	0.324
Van & taxi	0.12	0.20	0.34	1.00	0.64		1.00	1.00	0.64	0.208
Bus	0.11	0.18	0.29	1.00	0.50	0.86		1.00	0.50	0.163
BRT	0.09	0.16	0.29	1.00	0.48	0.80	0.93		0.48	0.156
With Respect to Comfort										
Alternatives	Fuzzy Synthetic Extent			Degree of Possibility of $S_i \geq S_j$					Degree of Possibility	Normalization
subway	0.11	0.18	0.28		0.41	0.74	1.00	1.00	0.41	0.164
Car-hailing	0.18	0.32	0.52	1.00		1.00	1.00	1.00	1.00	0.406
Van & taxi	0.14	0.23	0.37	1.00	0.68		1.00	1.00	0.68	0.274
Bus	0.09	0.14	0.23	0.78	0.21	0.52		1.00	0.21	0.084
BRT	0.09	0.14	0.22	0.74	0.18	0.48	0.96		0.18	0.072
With Respect to Information Provision										
Alternatives	Fuzzy Synthetic Extent			Degree of Possibility of $S_i \geq S_j$					Degree of Possibility	Normalization
subway	0.13	0.25	0.44		0.74	1.00	1.00	1.00	0.74	0.301
Car-hailing	0.18	0.33	0.58	1.00		1.00	1.00	1.00	1.00	0.405
Van & taxi	0.06	0.10	0.19	0.28	0.03		0.90	0.42	0.03	0.011
Bus	0.07	0.12	0.21	0.37	0.11	1.00		0.51	0.11	0.044
BRT	0.11	0.20	0.37	0.85	0.59	1.00	1.00		0.59	0.238

Based on the results encapsulated in Table 11, **safety** was identified as the quality attribute with the highest ranking, which agrees with another study conducted by Nassereddine and Eskandari (2017). However, in this study, frequency ranks higher than travel cost, which was the reverse find of Nassereddine and Eskandari (2017). Nevertheless, the difference in normalized scores was relatively small. In both of the studies, accessibility is ranked lowest in importance, likely because Tehran's residents adapt well to using public transit services, even with low accessibility.

In Table 12, regarding **reliability**, subway and BRT rank the highest. This is anticipated because their dedicated right-of-way increases the travel-time and waiting-time reliabilities. Although car-hailing services aim to provide passengers with the most reliable services, crashes or other incidents during a journey can change the expected travel time. Taxi and buses are ranked lowest in reliability, likely because of chronically heavy traffic congestion in Tehran.

Comparing of **travel cost** reveals that subway is the most cost-effective mode while car-hailing is the most expensive. In a similar study conducted by Nassereddine and Eskandari (2017), subway was the most cost-effective. The order ranking is similar to the results of Nassereddine and Eskandari (2017) when comparing safety. However, this study found that car-hailing is considered safer than taxis or vans, likely based on the privacy of a ride. Subway seems to be considered safest.

With respect to **frequency** car-haling ranks highest frequency while bus ranked lowest. Van and Taxis are ranked as the second mode with high frequency of service, likely because they are easily reachable at their stations or through hailing. The results from Nassereddine and Eskandari (2017) also shows the same results, but they did not include car-hailing among the available modes.

Car-hailing ranked highest in **accessibility** whereas BRT and subway ranked lowest. A likely explanation is that in Tehran, BRT and subway stations are usually further from passengers' residencies as compared to the other modes.

With respect to **comfort**, car-hailing ranked highest rank, followed by taxis. This is likely because of their more personalized usage and privacy as compared with other modes. Subway, bus, and BRT ranked the lowest, likely because passengers often experience crowding, poor weak weather conditions, and noise. Buses ranked higher in comfort than BRT, likely because buses are less crowded.

Information provision is one of the important factors that differentiate car-hailing services from the other modes in Tehran in that users are aware about all the process of their journey by using real-time data transmitted to their smartphones.

Subway and BRT ranked below car-hailing, likely because they provide passengers with enough information about the route, stations, maps, and other information.

Table 13 Final evaluation of public transit mode alternatives.

Transit Mode Alternatives	Final weight	Priority
Subway	0.254	1
Ride-hailing services	0.245	2
Van and taxi	0.143	4
Bus	0.134	5
BRT	0.225	3

Finally, after combining the results from ranking the quality attributes across all modes with the results from the paired comparisons, the method produced a ranking of the importance of the available alternatives (Table 13). The final weights resulted from multiplying the normalized weights of the transit mode alternatives with respect to each quality attribute with the normalized weights of the quality attributes.

The results indicate that the subway is the most effective mode alternative in its ability to achieve the desired quality attributes and attracting more users to public transit services. Conversely, the method identified ride hailing as the most critical mode alternative when the quality attributes of high frequency, better information provision, more comfort, and greater accessibility dominate.

This result shows that the experts consider subway to be the mode that is the most effective in attracting new users into the system. The method did not rank buses as highly as the other modes. In their study, Nassereddine and Eskandari, (2017) also found that subway and buses ranked highest and lowest, respectively, in the service quality provided. However, there were important differences. That study did not consider ride-hailing services, and used different weightings based on different definitions of the quality attributes. In contrast, this study considered additional attributes, including information provision, comfort, and reliability.

7. Conclusion

Big and crowded cities like Tehran has always been dealing with the problem of traffic congestion due to increasing travel demand and heavy use of personal cars. Using a public transit system can be helpful in attracting private care users. However, service quality is a concern for users who would consider shifting into public transit services. Hence, public transit service providers need to improve the quality of their services by first identifying the most important quality attributes that affect travel choice and second, mapping those attributes to public transit modes. The hybrid approach proposed in this study will help policymakers to evaluate the quality of public transit services and balance their funding proportionately to improve quality of the services that would achieve their objectives.

The main contribution of this study is an application of the combined techniques of Fuzzy Delphi Method and the Fuzzy Analytic Hierarchy Process to identify and rank the importance of quality attributes in public transit mode choice, and to rank the effectiveness of each available public transit mode in attracting more users. The method handles imprecise or subjective data and can be replicated for different cities.

As a case study, the authors applied the integrated model to the city of Tehran, Iran and found the order of quality attribute importance ranking to be safety, reliability, frequency, comfort, travel cost, information provision, and accessibility. This result implies that transportation officials should consider allocating more resources towards improving the safety of reliability of public transit services in Tehran.

The ranking of effectiveness in ability to achieve the identified quality attributes was subway, ride hailing, bus rapid transit, bus public transit, vans, and taxis. It is likely that ride-hailing services rank second because they currently provide shorter waiting-times and greater accessibility than taxis or vans. An important implication is that spurring a shift away from private car usage will require a significant improvement in travel time and waiting time for public transit. Investments to improve connectivity with subways and buses could include collaborations with ride-hailing services to enhance accessibility and reduce cost while reducing travel time and waiting time. Adding more buses and using dedicated lanes and transit signal priority to reduce their travel time could spur the needed improvements. Transit providers can use the method to determine the effectiveness of each of the transit modes and the quality service factors that affect shifts from private to public transit. The results will inform agencies about modes that need improvement based on a quality attribute. One limitation of this study is the number of experts who participated. However, the integrated method can serve as a framework to extend the analysis as more experts become available.

This research demonstrates a method of planning that achieves consensus among experts about strategies that could enhance the attraction to public transit by applying an integrated decision-making model to process opinions. The case study demonstrates that, even with uncertainty, the method provides a general understanding and an overall agreement of the factors and their relative importance in motivating or impeding the use of various public transportation modes. The model and the approach of using experts based on their objective understanding of all the available transportation modes in the city can lead to more informed decision-making in the allocation of resources to improve transportation services. This case study supports the hypothesis that it is worthwhile for big cities to ramp investments that could improve public transit even as ride-hailing services proliferate in big cities.

This model serves as a baseline for future work that will involve another survey to observe any changes in the results as ride-hailing services and new micromobility modes of transportation continue to proliferate. The authors also plan to apply the model to other major cities of the world to compare results and identify trends. The future work will evaluate rider opinions of different public transit modes to evaluate any gaps between the expectation of experts and the perception of the users.

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Declaration of Competing Interest

The authors declare that they have no conflict of interest.

Appendix A

Table A1 shows the quantification for the question "Indicate your level of agreement on inclusion of the public transit service quality attributes with the following statements:"

Table A1 Level of agreement

Intensity of Agreement	Description
1	Extremely disagree
2	Disagree
3	Neutral
4	Agree
5	Extremely agree

Table A2 shows the results from the first round of questionnaire distribution that was intended to find the most effective service quality attributes.

Table A2 Ranking of quality attributes

Service quality attribute	**Level of agreement**				
Accessibility	1	2	3	4	5
Comfort	1	2	3	4	5
Frequency	1	2	3	4	5
GHG emissions	1	2	3	4	5
Info. provision	1	2	3	4	5
Reliability	1	2	3	4	5
Responsiveness	1	2	3	4	5
Safety	1	2	3	4	5
Station comfort	1	2	3	4	5
Ticketing	1	2	3	4	5
Travel cost	1	2	3	4	5
Welcoming	1	2	3	4	5

Table A3 shows the results from the second round of questionnaire distribution that was intended to find the most effective service quality attributes.

Table A3 Ranking of quality attributes

Service quality attribute	**Average of level of agreement form the first round**	**Level of agreement**				
Accessibility		1	2	3	4	5
Comfort		1	2	3	4	5
Frequency		1	2	3	4	5
GHG emissions		1	2	3	4	5
Info. provision		1	2	3	4	5
Reliability		1	2	3	4	5
Responsiveness		1	2	3	4	5
Safety		1	2	3	4	5
Station comfort		1	2	3	4	5
Ticketing		1	2	3	4	5
Travel cost		1	2	3	4	5
Welcoming		1	2	3	4	5

Appendix B

Table B1 quantifies the importance levels.

Table B1 Intensity of importance levels.

Intensity of Importance	Description
1	Equally important
2	Equal to moderately more important
3	Moderately more important
4	Moderately to strongly more important
5	Strongly more important
6	Strongly to very strongly more important
7	Very strongly more important
8	Very strongly and extremely more important
9	Extremely more important

Table B2 shows the results from the pairwise comparison of the relative importance of 7 quality attributes with respect to the main goal.

Table B3 Pairwise comparison of quality attributes.

Service quality attribute	Intensity of Importance																	Service quality attribute
Reliability	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Travel cost
Reliability	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Safety
Reliability	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Frequency
Reliability	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Accessibility
Reliability	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Comfort
Reliability	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Info. provision
Travel cost	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Safety
Travel cost	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Frequency
Travel cost	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Accessibility
Travel cost	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Comfort
Travel cost	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Info. provision
Safety	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Frequency
Safety	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Accessibility
Safety	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Comfort
Safety	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Info. Provision
Frequency	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Accessibility
Frequency	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Comfort
Frequency	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Info. provision
Accessibility	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Comfort
Accessibility	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Info. provision
Comfort	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Info. provision

Table B3 shows the results from the pairwise comparison of the relative importance of 7 quality attributes with respect to each quality attribute.

Table B3 Pairwise comparison of public transit alternatives with respect to quality attributes.

Public transit alternatives	Intensity of importance																	Public transit alternatives
Subway	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Car-hailing
Subway	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Taxi
Subway	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Bus
Subway	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	BRT
Car-hailing	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Taxi
Car-hailing	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Bus
Car-hailing	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	BRT
Taxi	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Bus
Taxi	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	BRT
Bus	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	BRT

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