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What are the factors affecting the adoption and use of electric scooter sharing systems from the end user's perspective?

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ABSTRACT

Since their introduction in 2017, Electric Scooter Sharing systems (ESSs) are shown to provide numerous benefits for both individuals and society, including convenient green mobility particularly over short to medium distances, increased access to other modes of transportation, and lower cost of travel. Nevertheless, several barriers still hinder the widespread acceptance of ESSs which can be categorized according to their level of impact as macro (infrastructure), meso (community), and micro (individual/perceptions). The acceptance of ESSs as a critical factor at an individual level seems to be the first obstacle to their widespread use. Previous studies have proposed strategies to encourage the use of ESSs, but little information is available concerning how end-users perceive this innovative technology. In this regard, a comprehensive conceptual framework is developed based on the extended Technology Acceptance Model (TAM) that incorporates system characteristics, social influence, and individual acceptance of the ESSs to assess individuals' intentions. The Partial Least Squares Structural Equation Model framework is used to analyze the conceptual model and 22 hypotheses. An online survey with 560 participants is used. The findings indicate that perceived usefulness, trust, and subjective norms are the most important factors determining the willingness to use ESSs. According to our analysis, the conceptual model provides an effective theoretical framework for identifying factors influencing individuals' acceptance of ESSs, enabling the identification of appropriate policies to improve ESSs operations. Accordingly, ESSs integration into a comprehensive and user-friendly platform, accessibility planning, favorable depiction of ESSs and their advantages in media advertisements, and publicity campaigns to promote e-scooters as a sustainable mode of transportation are the most important policies to attract attention to e-scooters.

1. Introduction

The availability of advanced technologies among individuals over the past few years, such as smart mobile phones and GPS tracking devices has resulted in the rapid evolution of shared modes of transportation (Wang et al., 2010). Shared micro-mobility modes such as electric scooters and bikes are generally considered effective and fast for short to medium-distance travel and as a result, they have gained increasing attention globally (McKenzie, 2019). According to a survey conducted in the United States in 2018, bike-sharing systems (pedals and e-bikes) were used for 38 million trips, dockless e-bikes for 8.5 million trips, and scooters for 37 million trips. In 2019 the numbers for scooter trips grew to 86 million trips (NACTO, 2019). In other words, following the introduction of e-scooter sharing systems in 2017, this mode of transportation has witnessed a dramatic increase in ridership.

Electric Scooter Sharing systems (ESSs) are popular for a variety of reasons. They are viewed as potential solutions to many transportation-induced environmental issues, including noise and air pollution (Gössling, 2020; Markvica et al., 2020; Nishad et al., 2020; Sariişik and Ercoskun, 2021). Moreover, they offer numerous advantages, including effortless use, ease of access, and cost-effectiveness (Rejali et al., 2021), less demanding requirements for parking and movement space similar to shared bikes (James et al., 2019; Schellong et al., 2019), and capacity to improve access to transit stations and parking lots (Hosseinzadeh et al., 2021b).

The choice of the mode of transportation is a complex process (Ma et al., 2022) with three distinct levels of influence including the individual/intrapersonal level (micro), the community/cultural level

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(meso), and the physical environment level (macro) (Mattioli et al., 2016; Sulikova and Brand, 2021). Consequently, a drawback at each one of these levels can serve as a barrier to adopting a particular mode of transportation. For instance, the safety concerns of users (Yang et al., 2020; Ma et al., 2021) and heedless interactions of e-scooters with other vehicles and pedestrians (James et al., 2019) that originate from weak micro-mobility infrastructure in cities are examples of the macro level barriers that hamper the deployment of ESSs. Nevertheless, like any other nascent technology, individual and intrapersonal factors such as attitude, perceived usefulness, and intentions are likely to pose a more significant barrier to the widespread adoption of ESSs (Shariff et al., 2017; Xu et al., 2018).

An essential part of making a new mode a successful component of the transportation system is its acceptance by the users (Eccarius and Lu, 2018; Nastjuk et al., 2020). Previous research on determinant factors of e-scooter acceptance and usage intentions has provided some key insights for accelerating the diffusion of ESSs and has also highlighted areas for further exploration (Rejali et al., 2021; Javadinasr et al., 2022). Besides, little is known about the perception of these innovative technologies among developing country users (Rejali et al., 2021). To understand the factors that contribute to the acceptance of ESSs from a user-centric perspective, we opt for a comprehensive framework to explore the acceptance of ESSs in a developing country context where the system has not yet been fully introduced.

As an integrated model, Technology Acceptance Model 3 (TAM3) provides an in-depth and detailed understanding of the determinants of individual-level adoption and usage (Venkatesh and Bala, 2008). It provides a framework through which, individual, social, and system characteristics related to user acceptance, can be considered (Nastjuk et al., 2020). This comprehensive approach allows for answering the main questions of this research: (1) What factors affect the willingness to use e-scooter in terms of system specifications? (2) How does the heterogeneity among individuals manifest itself? (3) Which parameters have the most significant impact within the general framework?

This paper contributes to the literature by investigating the factors that have not been considered in prior studies on e-scooter sharing systems and by analyzing them from the point of view of the end user according to different causal routes within a single model. In view of the lack of similar research, the theoretical contribution of this study consists of applying its framework model to the context of e-scooters, and its practical implications contribute to providing a detailed understanding of the factors influencing individuals' intention to use ESSs, which in turn, helps to devise efficient policies to increase ESSs success in the context of urban mobility.

The remainder of this paper is structured in the following manner. In Section 2, the literature related to the acceptance of ESSs is discussed. Section 3 presents a modeling framework and evaluates relevant theories for the acceptance of ESSs from the point of view of the end user. Section 4 describes the sample characteristics and the questionnaire used in the study. The outcomes of the data analyses and the related results from the model are presented in Section 5. Lastly, Section 6 summarizes the most important findings, implications, and limitations of the study.

2. Literature review

Few studies had predicted the acceptance of the e-scooter as a mode of transportation before its introduction in 2017 (Caspi et al., 2020; Hosseinzadeh et al., 2021a; Kazemzadeh and Sprei, 2022). However, since the introduction of ESSs on American streets for the first time in 2017, as well as in a number of other cities around the world (Rix et al., 2021), many studies have examined the various aspects of this new mode of transportation such as its effect on active mobility behavior, existing modes that it mostly substitutes, its acceptance among users, as well as its distinctive aspects in comparison to other micro-mobility modes. For example, Smith and Schwieterman (2018) suggest that electric scooters are excellent alternatives to private automobiles for short trips of 0.5–2 miles of distance. Similarly, Portland's pilot project findings indicate that 34% of Portlanders would have chosen motorized transportation in the absence of e-scooters (Portland Bureau of Transportation, 2018). Almost all of the mentioned studies conclude that e-scooters provide a sustainable mode of transportation and highlight their advantages. Nonetheless, e-scooter systems seem not to have been widely adopted by the public yet, suggesting that further research is required to understand the appropriate interventions that can improve their adoption in urban settings.

A significant dissimilarity among different micro-mobility modes has been pointed out in the literature, indicating that findings relevant to one mode cannot be applied to another. In this regard, some studies have examined the differences between ESSs and other micro-mobility forms such as bike-sharing (McKenzie, 2019; Bieliński and Ważna, 2020; Almannaa et al., 2021; Yang et al., 2021). For instance, McKenzie (2019) concludes that bike-sharing is mainly used for commuting to work while e-scooters are not widely used for this purpose. According to Lazarus et al. (2020), one significant difference between e-scooters and other shared services is that the former is more likely to be used for traveling to low-density places. Furthermore, Younes et al. (2020), in their comparative analysis of e-scooters and shared docked bikes, point out that the weather has a lesser impact on shared scooter users compared to users of station-based bike-sharing services. These examples emphasize the need for dedicated research on e-scooters. Compared to the extensive research on the psychological factors influencing the use of bike-sharing (Ma et al., 2018; Cheng et al., 2019a; Xin et al., 2019; Si et al., 2020; Kim et al., 2021), few studies have examined the impact of psychological factors on the intention to use ESSs.

Various modeling frameworks have been employed for the study of psychological factors on intention. In the Theory of Planned Behavior (TPB) introduced by Ajzen (1991), consumer behavior is characterized by three core factors: perceived behavioral control, subjective norm, and attitude. In this regard, Eccarius and Lu (2020) integrate the TPB model with other constructs including compatibility, environmental values, and awareness/knowledge to examine the behavioral intentions toward using ESSs among 471 Taiwanese university students. They find that awareness/knowledge and environmental values indirectly influence the intention to use ESSs.

The Technology Acceptance Model (TAM) explains the acceptance of innovative tools by applying the two major factors of "perceived usefulness" and "perceived ease of use" (Davis 1989). Using TAM, Ratan et al. (2021) examine the influence of perceived ease of use of mobile apps on other factors for e-scooter adoption based on a survey dataset including 398 records. They find that the perceived ease of use of mobile apps influences both intentions to use and the perceived usefulness of e-scooters. In another study, Rejali et al. (2021) use a combination of TAM and TPB to identify factors that dominate the intention to use ESSs. According to their results, besides factors relevant to TAM and TPB, hedonic motivation and environmental awareness can also positively influence the intention to use ESSs both directly and indirectly. These findings are in agreement with Kopplin et al. (2021), who use an adapted Unified Theory of Acceptance and Use of Technology (UTAUT2) model to examine the relationship between intention to use ESSs and similar psychological factors. Javadinasr et al. (2022) also use an extended TAM to analyze data from an online survey conducted with 2126 shared e-scooter users in Chicago. They conclude that continued use of shared e-scooters is largely determined by perceived usefulness, followed by perceived reliability. In addition, they find out that social influence and perceived ease of use are other factors that contribute to the decision to use an e-scooter.

Despite the vast body of research on the contribution of psychological factors to the intention to use ESSs employing various modeling frameworks such as UTAUT, TAM, TPB, or their extended forms, one can still identify gaps that need addressing: (i) Previous research has for the most part focused on individual factors like environmental concerns that affect the intention to use an e-scooter (Rejali et al., 2021; Javadinasr et al., 2022), but the role of other factors such as privacy concerns, trust, and personal innovativeness has not been explored; (ii) Previous studies have demonstrated the importance of system characteristics such as perceived enjoyment and compatibility (Eccarius and Lu 2020; Rejali et al., 2021; Javadinasr et al., 2022), while other factors such as relative advantage and price evaluation have not been investigated; (iii) a comprehensive framework for considering both system characteristics and individual factors is lacking.

The purpose of this study is to analyze within a single comprehensive framework the contribution of system characteristics, social influence, and individual factors simultaneously for explaining the intention to use ESSs. As an integrated model, TAM3 provides an in-depth and detailed understanding of the determinants of individual-level adoption and usage. The model contains almost all of the main factors of both the TAM and TPB. The key strength of TAM3 is its comprehensive nature and the potential for actionable guidance that it offers (Venkatesh and Bala, 2008). It provides a framework through which, system, social, and individual characteristics can be considered (Venkatesh and Bala, 2008; Nastjuk et al., 2020) within a single framework, a capacity that is missing in other frameworks including TAM, TPB, and UTAUT. Following is a review of the research hypotheses and conceptual framework used in this study.

3. Model structure and hypotheses

In this study, we use the extended version of TAM called TAM3 (Venkatesh and Bala, 2008) to recognize the factors associated with the intention to use e-scooters. Compared to the basic TAM, the extended version includes additional factors such as system characteristics, social influence, and individual characteristics. A review of the literature allows us to identify e-scooter acceptance factors that have been left mostly unexplored. The logic for selecting each factor is described in the following subsections.

Fig. 1 shows the hypotheses and factors for the conceptual model. The model is composed of four parts. The TAM model enriched with attitude constitutes the foundation and major component of the model. It is highlighted in green. Further, three components including Social Influence (red), System Characteristics (blue), and Individual Differences (purple) are added which can be considered effective measurements of ESSs intention to use.

Descriptions of the backgrounds and rationales for each of the factors included in the model and the hypotheses are provided in the following.

3.1. Technology acceptance model

The technology acceptance model or TAM for short refers to the theory developed for recognizing the customer's acceptance of a technology based on three fundamental latent factors which include perceived usefulness, perceived ease of use, and behavioral intention (BI) (Davis, 1989; Davis et al., 1989; Venkatesh, 2000; Venkatesh and Bala, 2008). The attitude was added to the model to determine the intention to use ESSs, in a manner similar to the Theory of Reasoned Action (Ajzen and Fishbein, 1980) and the Theory of Planned Behavior (Ajzen, 1991). These relationships have been used in the literature to investigate the intention to use scooters (Rejali et al., 2021) and other transportation modes (Zhang et al., 2019). Accordingly, we propose the following hypotheses:

H1. Attitude toward e-scooters positively affects the intention to use them.

H2. Perceived usefulness positively affects the intention to use e-scooters.

H3. Perceived usefulness positively affects the attitude toward e-scooters.

H4. Perceived ease of use positively affects the attitude toward e-scooters.

H5. Perceived ease of use positively affects the perceived usefulness of e-scooters.

3.2. Social influence

Subjective norm: It is common for technology users to be influenced by others, including their families, friends, teachers, and the media (Ma et al., 2018). To account for such effects, subjective norm (SN) is usually defined as the perceived amount of social pressure on an individual's opinions, beliefs, and behaviors affecting their acceptance of a technology (Davis, 1989; Ajzen, 1991; Venkatesh, 2000; Venkatesh and Bala, 2008; Karami et al., 2022). For instance, Venkatesh and Bala (2008) found that SN has a positive impact on perceived usefulness and intention, simultaneously. In the context of micro-mobility, Eccarius and Lu (2020) and Rejali et al. (2021) found that SN has a positive impact on behavioral intention to use shared e-scooters. Furthermore, several empirical studies have highlighted the influence of subjective norm on the perceived usefulness of e-scooters (Rejali et al., 2021; Javadinasr et al., 2022). Therefore, we propose the following hypotheses:

H6. Subjective norm positively affects the perceived usefulness of e-scooters.

H7. Subjective norm positively affects the intention to use e-scooters.

3.3. Individual differences

Ecological awareness: The perception of environmental concerns is an important factor in accepting innovation (Wu et al., 2019; Nastjuk

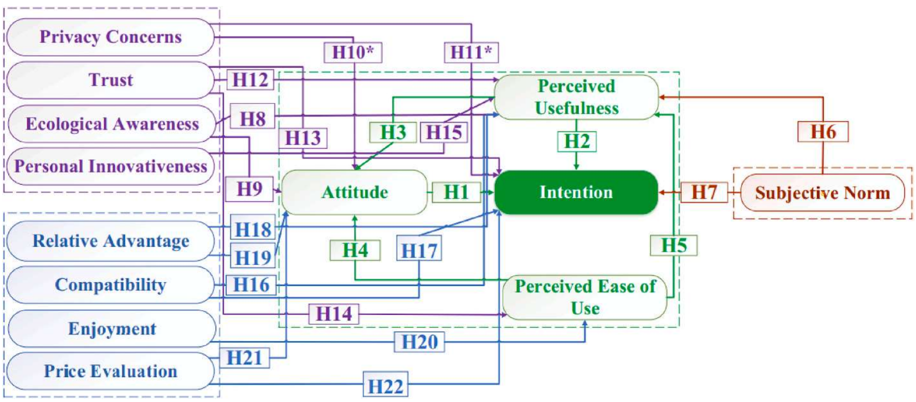

Fig. 1. The proposed model to assess intention to use e-scooter (Note: * indicates factors with negative influence).

et al., 2020). For instance, Wu et al. (2019) point out that ecological awareness by end-users has implications not only for their behavioral intention but also for their insight into green perceived usefulness. Considering the typically short battery life of e-scooters, some advocates of sustainable and livable cities have questioned whether they are environmentally friendly (Hollingsworth et al., 2019). However, we find it more prudent to side with the body of research that advocates electric two-wheelers as greener modes of transport compared to cars and motorcycles powered by fossil fuels (Eccarius and Lu, 2020; Kopplin et al., 2021; Rejali et al., 2021). In this sense, Guerra (2019) suggests that consumers' attitudes toward environmental concerns influence the acceptance of electric two-wheelers. In this regard, we postulate the following hypotheses:

H8. Ecological awareness positively affects the perceived usefulness of e-scooters.

H9. Ecological awareness positively affects the attitude toward e-scooters.

Privacy concerns: Privacy concerns associated with such social network and e-commerce services as e-scooters and other sharing services affect consumers' decision-making behavior because consumers are usually required to disclose their personal information (Lim, 2003; Min and Kim, 2015; Kim et al., 2020). In the theory of consumers' perceived risk, it is postulated that consumers perceive risk in their purchases because they face uncertainty and the possibility of unwanted outcome (Dowling and Staelin, 1994). Several studies have corroborated the ramifications of privacy concerns in dramatically attenuating the intention/attitude to use (Kim et al., 2008, 2020; Nasri and Charfeddine, 2012; Min and Kim, 2015; Cheng et al., 2019b). The following hypotheses are proposed accordingly:

H10. Privacy concerns negatively affect the attitude toward e-scooters.

H11. Privacy concerns negatively affect the intention to use e-scooters.

Trust: Trust refers to the most relevant psychological state which is derived from the willingness to accept vulnerability (Rousseau et al., 1998), and is a key factor contributing to the adoption and use of a technology (Hengstler et al., 2016; Xu et al., 2018). Zhang et al. (2020) find that BI is directly and proportionally affected by the expressed degree of trust. In addition, Xu et al. (2021) recognize that trust not only has a direct and strong correlation with behavioral intention, but it also has a significantly positive relationship with both perceived usefulness and perceived ease of use. To the best of authors' knowledge trust has not been considered in the literature related to ESSs. Accordingly, we postulate the following hypotheses:

H12. Trust positively affects the perceived usefulness of e-scooters.

H13. Trust positively affects the intention to use e-scooters.

H14. Trust positively affects the perceived ease of use of e-scooters.

Personal innovativeness: Personal innovativeness refers to the intention of people to try out ESSs. Therefore, it is plausible to be considered an important factor contributing to people's intention to use ESSs (Midgley and Dowling, 1993). Findings from similar studies confirm the positive effect of personal innovativeness on the perceived usefulness (Lin et al., 2007; Kuo and Yen, 2009). However, to the best of authors' knowledge personal innovativeness has not been considered in the literature related to ESSs. Hence, the following hypothesis is formulated:

H15. The greater the individual's innovativeness in relation to e-scooters, the greater the perceived usefulness.

3.4. System characteristics

Compatibility: In addition to the factors discussed in the previous section, Tornatzky and Klein (1982) propose that people's level of compatibility can affect their use of innovations. This hypothesis is also supported by Nastjuk et al. (2020) who conclude that compatibility is positively associated with both attitude and perceived usefulness. Eccarius and Lu (2020) study the use of e-scooters sharing system among Taiwanese students and conclude that perceived compatibility has a positive effect on usage intention and attitude. Such a positive relation between perceived usefulness, behavioral intention, attitude, and compatibility is supported by other studies within other research contexts (Wu and Wang, 2005; Karahanna et al., 2006). Based on these studies, the following hypotheses are proposed:

H16. Compatibility positively affects the perceived usefulness of e-scooters.

H17. Compatibility positively affects the intention to use e-scooters.

Relative advantage: Relative advantage is another factor that can be considered in the decision-making process toward accepting a technology. Kulviwat et al. (2007) state that people become more positive about an innovation as it becomes perceived as more useful than its precursor. In a thorough investigation, Lee et al. (2019) unfold a positive correlation between relative advantage on one hand and behavioral intentions to use and perceived usefulness on the other hand. Similar results can be found in previous studies (Shih, 2007; Wu et al., 2010; Lee et al., 2019). However, to the best of authors' knowledge relative advantage has not been considered in the literature related to ESSs. Our hypotheses are therefore formulated as follows:

H18. Relative advantage positively affects the perceived usefulness of e-scooters.

H19. Relative advantage positively affects attitude toward e-scooters.

Perceived enjoyment: The influence of perceived enjoyment on individuals' decision-making has been widely tested in previous studies. Kopplin et al. (2021) demonstrate that perceived enjoyment affects the intention to use. Javadinasr et al. (2022) show the presence of a beneficial effect of perceived enjoyment on perceived ease of use, which is consistent with former studies (Venkatesh, 2000; Sun and Zhang, 2006; Nastjuk et al., 2020). Accordingly, the following hypothesis is formulated:

H20. Perceived enjoyment positively affects the perceived ease of use of e-scooters.

Price evaluation: Price value is "consumers' cognitive tradeoff between the perceived benefits of the applications and the monetary cost for using them" (Venkatesh et al., 2012), which may also have a sizeable impact on technology purchasers. Regarding this, in order for a future technology to succeed, Bansal et al. (2016) demonstrate that it is required to either lower the costs which also involves improving the price/performance ratio or enhance consumers' willingness to pay. Nastjuk et al. (2020) show that price evaluation has a positive influence on the intention to use a new product. Accordingly, the relevant hypotheses are stated as follows:

H21. Price evaluation positively affects attitude toward e-scooters.

H22. Price evaluation positively affects the intention to use e-scooters.

4. Method

Once the conceptual model structure is laid out a comprehensive survey is designed that incorporates the standard relevant items. Residents of Tehran were targeted for the survey. A Partial Least Squares Structural Equation Model (PLS-SEM) framework is employed for the analysis of the collected data using the SmartPLS software (Ringle et al., 2022). After validating the measurement model, we proceed to evaluate the structural equation model, in which the hypotheses of the research are tested. A detailed description of the mentioned steps is presented in the following sections.

4.1. Data

An online survey was conducted through social network apps among the citizens of Tehran, the capital city of Iran, during March and April 2022. In total 699 respondents participated in the survey. According to the purpose of the study, two criteria were imposed for the participants: to be a resident of Tehran and to have the ability (e.g., age) to ride an e-scooter for short-distance trips. Telegram is one of the most popular social networks in Iran and people use different capabilities of this platform, such as channels and groups, to communicate with each other, and receive news and entertainment. Administrators of these channels and groups accept to place questionnaires and advertisements in exchange for a monetary fee. In this study, the questionnaire was distributed using this instrument. Furthermore, three lotteries with the possibility of winning 45 USD were considered as an incentive for a response.

A total of 560 valid records were considered for further analysis after refining the data. The average completion time was about 7 min with a standard deviation of 3 min, which indicates that the participants filled out the questionnaire carefully. The sample consists of 41% male and 59% female. Age ranged from 14 to 56 years, with an average of 22.85 (median = 21) and a standard deviation of 6.29 years. As for educational status, 47% of the respondents held a high school or apprenticeship diploma, 36% held a bachelor's degree, and the remainder (17%) held a master's degree or higher. An overrepresentation of young people and people with higher education stems possibly from the online nature of the survey and can be seen among other online surveys as well (Al Haddad et al., 2020).

4.2. Questionnaire

The questionnaire is organized into two sections. The first section inquires about the demographic characteristics of the respondent, such as age, gender, and education level. The second section includes standardized measurement tools of psychological theories. All of these items were scored on a 5-point Likert scale ranging from (1) strongly disagree to (5) strongly agree.

The components of the TAM were measured through a standardized and modified framework, introduced by Venkatesh and Bala (2008) and Ajzen and Fishbein (1980). There are items in this instrument that cover attitudes, perceived usefulness, and perceived ease of use components. This tool contains three items for measuring attitudes, and four items to measure perceived usefulness and perceived ease of use.

Additionally, the four components of individual differences were measured using tools that have been tested in previous studies. To match the components with the research question, these items were modified slightly. Privacy concern was assessed using three items measuring people's worriedness about the collection and use of individual data when using ESSs (Vijayasarathy, 2004; Nasri and Charfeddine, 2012). Items for measuring trust were adopted from (Choi and Ji, 2015, Nees, 2016) and the ecological awareness items were obtained from Roberts (1995). Furthermore, personal innovativeness was measured by a standardized 3-item instrument introduced by Parasuraman (2000).

System characteristics were assessed using four components including relative advantage, compatibility, enjoyment, and price evaluation. Four items associated with the relative advantage component were obtained from Moore and Benbasat (1991). These items measure the level up to which ESSs are perceived as better than currently available mobility options. For the compatibility component, measurement items were adopted from Moore and Benbasat (1991). For the price evaluation component, we utilized the items from Venkatesh et al. (2012) and Nees (2016). Finally, for the enjoyment component, the items were derived from Venkatesh and Bala (2008).

5. Data analysis and results

The data is used to estimate a Partial Least Squares Structural Equation Model (PLS-SEM) using the SmartPLS software, which implements the widely accepted two-step modeling approach. In this approach, measures are evaluated first before testing the structural model, according to the recommended procedures (Hair et al., 2011). The choice of the most appropriate data analysis method involves a number of considerations. Firstly, the research relates to the testing of a theoretical framework which incorporates a complex structural conceptual model encompassing a number of constructs, indicators, and relationships. Moreover, it is intended to explore theoretical extensions of established theories in order to better understand the increasing complexity. In addition, there are concerns regarding the distribution of the collected data. These cases are all consistent with the criteria outlined by Hair et al. (2019) for when Partial Least Squares Structural Equation Model (PLS-SEM) framework should be applied. This section describes the results of the measurement model analysis, followed by an assessment of the structural model.

5.1. Validation of measurements

A measure should be assessed in terms of its content, convergent validity, and discriminant validity (Fornell and Larcker, 1981a; Hair et al., 2011). As the questionnaire items were sourced from the literature, the content is deemed valid. Moreover, since the questionnaire was designed in Persian, to confirm the accuracy of the translation, it was submitted to experts, and the final questionnaire was developed following confirmation. To assess the convergent validity, three parameters were examined: item reliability, average variance extracted (AVE), which must be greater than 0.5, and composite construct reliability (CR), which must be greater than 0.7 (Fornell and Larcker, 1981a; Hair et al., 2011). Table 1 presents the measures of converge validity and reliability, which include mean values of items, factor loadings, t-values, AVE, CR, and Cronbach's alpha. We tested the reliability of individual items using the cross- and factor-loading of items to their related latent constructs. The factor loadings for three items were too low to include them in the constructs. Accordingly, all items had loadings above 0.60 on their respective constructs, which is an acceptable threshold (Bagozzi and Yi, 1988; Chin, 1998). Further, all items loaded strongly on the factor they were associated with rather than any other construct. Besides, the factor loadings on all factors were statistically significant ($p < 0.01$). To conduct a meaningful test of items, for a large enough sample, if the t-value, which is a measure of statistical significance, is within the −2.576 to 2.576 range, its corresponding hypothesis is rejected; otherwise, it is accepted at a 0.01 level of significance. As shown in Table 1 all of the factors satisfy this criterion. In addition, the CR and AVE values for all constructs exceed their respective recommended thresholds. The internal reliability of the questionnaire was measured using Cronbach's alpha. Alpha values of 0.6–0.7 show an acceptable level of reliability, whereas alpha values of 0.8 or higher show excellent reliability (Eisinga et al., 2013). The results are summarized in Table 1. Discriminant validity is examined to determine the distinction between latent constructs. As summarized in Table 2 the square roots of all AVEs exceed the correlation values in corresponding columns and rows, indicating that the discriminant validity criteria have been met (Fornell and Larcker, 1981b). As a whole, the measurement model fits well with the data, and its validity and reliability are considered satisfactory.

5.2. Structural model

Following the measurement analyses which demonstrated the

Table 1
Reliability and validity of the latent constructs.

Constructs	Items	Mean	Factor loadings	t-value	CA	CR	AVE
Attitude	I like the idea of using shared E-scooters.	4.33	0.851	43.93	0.77	0.87	0.68
	I think that using shared E-scooters is a good idea.	4.42	0.837	58.11			
	I think that using shared E-scooters is a wise idea.	4.15	0.788	30.06			
Personal Innovativeness	I would like to try shared E-scooters.	4.65	0.815	31.35	0.81	0.89	0.73
	In general, I will not be hesitant to try out shared E-scooters	4.13	0.836	52.36			
	In general, I would like to experiment with shared e-scooters	4.37	0.908	91.78			
Compatibility	I think using shared E-scooters would be compatible with my mobility behavior.	3.86	0.915	76.51	0.92	0.95	0.86
	I think using shared E-scooters is compatible with all aspects of my mobility behavior.	3.91	0.947	152.47			
	I think using shared E-scooters would fit well into my mobility behavior.	3.90	0.925	92.11			
Enjoyment	Using shared E-scooters is enjoyable.	4.54	0.827	32.39	0.89	0.92	0.75
	I think using shared E-scooters will make me feel good.	4.37	0.870	47.31			
	I think using shared E-scooters is pleasant.	4.37	0.896	68.27			
	Using shared E-scooters is fun.	4.42	0.874	56.37			
Ecological Awareness	The impact of shared E-scooters on the environment would influence my usage decision.	4.48	0.829	38.49	0.90	0.93	0.77
	The degree to which shared E-scooters cause pollution would influence my usage decision.	4.27	0.865	53.57			
	If I understand the impact E-scooters have on the environment, it will influence my usage decision.	4.31	0.898	63.19			
	The extent to which shared E-scooters impact the environment would influence my usage decision.	4.26	0.913	101.58			
Usage Intention	With the expansion of shared E-scooters in the future, I intend to use it for short to medium trips.	4.18	0.827	48.18	0.93	0.94	0.77
	If I have access to a shared E-scooter, I intend to use it for short to medium trips.	4.20	0.862	53.64			
	I will think about using a shared E-scooter for short to medium trips in the future.	4.27	0.855	45.72			
	Assuming I have access to a shared E-scooter, I will use it for short to medium trips.	4.20	0.924	113.58			
	With the availability of a shared E-scooter, I want to use it on short to medium trips.	4.20	0.922	102.08			
Perceived Ease of Use	I expect learning to use shared E-scooter will be easy for me.	4.47	0.758	21.29	0.87	0.91	0.72
	I expect to be a master in using a shared E-scooter very soon.	4.32	0.859	52.78			
	Generally, I expect shared E-scooter will be easy to use.	4.30	0.882	77.89			
	I think I will learn to interact with shared E-scooters very soon.	4.42	0.894	74.08			
Privacy Concerns	I believe that my privacy would be compromised when using shared E-scooters.	2.40	0.908	35.28	0.76	0.84	0.64
	I would be worried about my privacy when using shared E-scooters.	2.95	0.756	15.10			
	I believe that using shared E-scooters would threaten my privacy.	2.77	0.730	11.64			
Price Evaluation	The benefits of shared E-scooters would outweigh their monetary cost.	3.94	0.724	27.95	0.83	0.88	0.66
	Given the benefits of a shared E-scooter, I think it would be reasonable to spend a little more on it.	3.40	0.791	30.60			
	Given the benefits of a shared E-scooter, I think it is worth spending a little more on it.	3.56	0.888	77.04			
	I would be willing to pay more to use a shared E-scooter.	3.38	0.829	42.85			
Perceived Usefulness	Using a shared E-scooter will increase my efficiency on short to medium trips.	4.23	0.789	33.07	0.87	0.91	0.72
	Using a shared E-scooter saves me time on short to medium trips.	4.23	0.816	37.98			
	Using a shared E-scooter makes my travel more convenient on short to medium trips.	4.25	0.897	81.33			
	Changing to use of shared E-scooters is useful for me on short to medium trips.	4.17	0.877	66.18			
Relative Advantage	Using E-scooter is easier than the predominant modes I usually use on short to medium trips.	3.87	0.851	51.76	0.90	0.93	0.77
	E-scooters are more useful than the predominant modes I use on short to medium trips.	3.57	0.904	62.73			
	E-scooters are more comfortable than the predominant modes I use on short to medium trips.	3.70	0.916	87.74			
	E-scooter allows me to improve my travels compared to the predominant modes I use.	3.42	0.830	40.08			
Subjective Norm	I think, if the people who are important to me consider the benefits of shared E-scooters, their opinion is that I would be better off using a shared E-scooter in the future.	4.05	0.931	115.16	0.93	0.96	0.88
	I think, if the people whose opinions are valuable to me consider the benefits of shared E-scooters, their opinion will be that I would be better off using a shared E-scooter in the future.	4.03	0.942	141.14			
	I think, if the people who influence me consider the benefits of shared E-scooters, they will think that I would be better off using a shared E-scooter in the future.	4.04	0.948	168.88			
Trust	Overall, I would trust shared E-scooters.	3.97	0.884	76.10	0.90	0.93	0.72
	I expect shared E-scooters to be reliable.	4.06	0.860	63.77			
	I expect shared E-scooters to be dependable.	3.97	0.897	90.95			
	I believe that using shared E-scooters will be safe.	3.61	0.732	28.89			
	Overall, I would trust shared E-scooters to get me safely to my destination.	3.92	0.866	68.60			

Note: CA is Cronbach's Alpha.

Table 2
Correlation matrix and discriminant validity.

	Construct	1	2	3	4	5	6	7	8	9	10	11	12	13
1	Attitude	**0.83**												
2	Personal Innovativeness	0.72	**0.85**											
3	Compatibility	0.54	0.52	**0.93**										
4	Perceived Enjoyment	0.77	0.81	0.54	**0.87**									
5	Ecological Awareness	0.58	0.57	0.44	0.60	**0.88**								
6	Usage Intention	0.69	0.78	0.59	0.76	0.56	**0.88**							
7	Perceived Ease of Use	0.62	0.69	0.43	0.70	0.43	0.64	**0.85**						
8	Privacy Concerns	−0.26	−0.25	−0.19	−0.27	−0.08	−0.31	−0.27	**0.80**					
9	Price Evaluation	0.53	0.49	0.48	0.50	0.48	0.51	0.43	−0.11	**0.81**				
10	Perceived Usefulness	0.69	0.74	0.63	0.71	0.55	0.85	0.63	−0.28	0.52	**0.85**			
11	Relative Advantage	0.23	0.26	0.30	0.25	0.26	0.27	0.22	−0.02	0.22	0.29	**0.88**		
12	Subjective Norm	0.65	0.66	0.60	0.67	0.59	0.69	0.53	−0.21	0.56	0.69	0.25	**0.94**	
13	Trust	0.72	0.69	0.62	0.70	0.54	0.73	0.67	−0.35	0.59	0.75	0.29	0.69	**0.85**

Note: Bold numbers on the diagonal are square roots of AVEs.

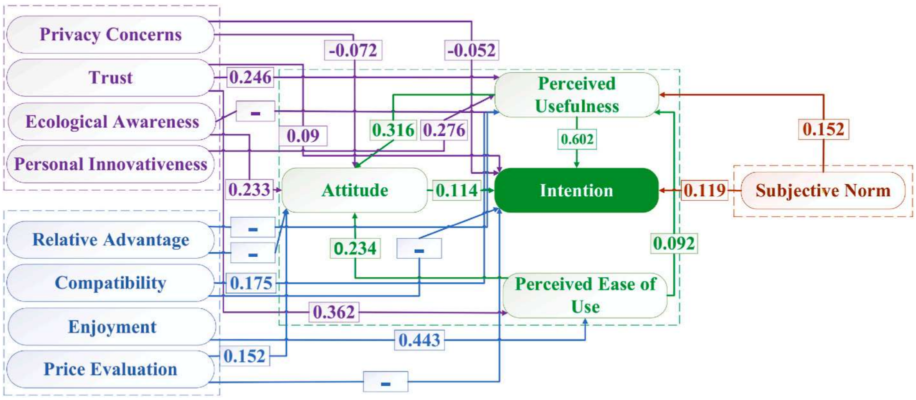

Fig. 2. Estimated model (Note: All values are statistically significant at least at 0.05 level).

Table 3
Structural equation model statistics.

Hypothesis and Number		Path coefficient			Total effect		
		β	P-Value	Conclusion	β	P-Value	Conclusion
Attitude→ Usage Intention	H1	0.114	0.001	Accepted	0.114	0.001	Accepted
Perceived Usefulness→ Usage Intention	H2	0.602	0.000	Accepted	0.638	0.000	Accepted
Perceived Usefulness →Attitude	H3	0.316	0.000	Accepted	0.316	0.000	Accepted
Perceived Ease of Use→Attitude	H4	0.234	0.000	Accepted	0.263	0.000	Accepted
Perceived Ease of Use → Perceived Usefulness	H5	0.092	0.013	Accepted	0.092	0.013	Accepted
Subjective Norm → Perceived Usefulness	H6	0.152	0.000	Accepted	0.152	0.000	Accepted
Subjective Norm → Usage Intention	H7	0.119	0.001	Accepted	0.216	0.000	Accepted
Ecological Awareness→ Perceived Usefulness	H8	0.052	0.150	Rejected	0.052	0.150	Rejected
Ecological Awareness→Attitude	H9	0.233	0.000	Accepted	0.249	0.000	Accepted
Privacy Concerns→Attitude	H10	−0.072	0.010	Accepted	−0.072	0.010	Accepted
Privacy Concerns→ Usage Intention	H11	−0.052	0.014	Accepted	−0.060	0.004	Accepted
Trust→ Perceived Usefulness	H12	0.246	0.000	Accepted	0.279	0.000	Accepted
Trust → Usage Intention	H13	0.090	0.041	Accepted	0.278	0.000	Accepted
Trust → Perceived Ease of Use	H14	0.362	0.000	Accepted	0.362	0.000	Accepted
Personal Innovativeness→ Perceived Usefulness	H15	0.276	0.000	Accepted	0.276	0.000	Accepted
Compatibility→ Perceived Usefulness	H16	0.175	0.000	Accepted	0.175	0.000	Accepted
Compatibility→ Usage Intention	H17	0.014	0.644	Rejected	0.126	0.001	Accepted
Relative Advantage→ Perceived Usefulness	H18	0.024	0.347	Rejected	0.024	0.347	Rejected
Relative Advantage →Attitude	H19	−0.006	0.839	Rejected	0.002	0.948	Rejected
Enjoyment → Perceived Ease of Use	H20	0.443	0.000	Accepted	0.443	0.000	Accepted
Price Evaluation→Attitude	H21	0.152	0.000	Accepted	0.152	0.000	Accepted
Price Evaluation→Intention	H22	−0.003	0.908	Rejected	0.014	0.617	Rejected
Personal Innovativeness→ Usage Intention	–	–	–	–	0.176	0.000	Accepted
Perceived Ease of Use→ Usage Intention	–	–	–	–	0.086	0.001	Accepted
Ecological Awareness→ Usage Intention	–	–	–	–	0.059	0.018	Accepted
Enjoyment→ Usage Intention	–	–	–	–	0.038	0.003	Accepted
Relative Advantage→ Usage Intention	–	–	–	–	0.015	0.368	Rejected

acceptability and reliability of the constructs, we proceed to the evaluation of the structural paths. The structural paths of the model were evaluated using bootstrapping with 5000 bootstrapping samples (Hair et al., 2011). The outcomes of the structural model analysis are shown in Fig. 2. Moreover, Table 3 summarizes the hypothesis test results.

As presented in Table 3, the factors contributing to perceived usefulness are personal innovativeness ($\beta = 0.276$, $p < 0.05$), trust ($\beta = 0.246$, $p < 0.05$), compatibility ($\beta = 0.175$, $p < 0.05$), subjective norm ($\beta = 0.152$, $p < 0.05$), and perceived ease of use ($\beta = 0.092$, $p < 0.05$) in decreasing order of importance. Based on the mentioned values, hypotheses 15, 12, 16, 6, and 5 are accepted. Hypotheses 8 and 18 which assumed ecological awareness and relative advantage were influential factors affecting perceived usefulness do not hold true. Furthermore, both enjoyment ($\beta = 0.443$, $p < 0.05$) and trust ($\beta = 0.362$, $p < 0.05$) significantly affect perceived ease of use. These results support hypotheses 14 and 20. Additionally, five effective factors affect attitude: perceived usefulness ($\beta = 0.316$, $p < 0.05$), perceived ease of use ($\beta = 0.234$, $p < 0.05$), price evaluation ($\beta = 0.152$, $p < 0.05$), privacy concerns ($\beta = -0.072$, $p < 0.05$) and ecological awareness ($\beta = 0.233$, $p < 0.05$), which support hypotheses 3, 4, 21, 10, and 9. However, hypothesis number 19, which assumed a significant relationship between relative advantage and attitude, is rejected.

As regards the ultimate goal of this research, the impact assessment of different factors toward usage intention is the top priority. Accordingly, as can be seen from Table 3, the significant direct relationship between perceived usefulness ($\beta = 0.602$, $p < 0.05$), subjective norm ($\beta = 0.119$, $p < 0.05$), attitude ($\beta = 0.114$, $p < 0.05$), trust ($\beta = 0.09$, $p < 0.05$), and privacy concerns ($\beta = -0.052$, $p < 0.05$) with usage intention are supported, which represents hypothesis 2, 7, 1, 13, and 11. Yet, the direct effect of compatibility was rejected. This construct, however, had a significant indirect effect on Usage Intention, resulting in a significant total effect. Specifically, compatibility ($\beta = 0.126$, $p < 0.05$) has significant indirect effects on usage intention. The only factor in the list of hypotheses that does not directly impact usage intention is price evaluation, which means that hypothesis number 22 is not supported.

According to the conceptual model of the research, five factors were not directly associated with usage intention. Among these factors, personal innovativeness ($\beta = 0.176$, $p < 0.05$), perceived ease of use ($\beta = 0.086$, $p < 0.05$), ecological awareness ($\beta = 0.059$, $p < 0.05$), and perceived enjoyment ($\beta = 0.038$, $p < 0.05$) have a significant indirect effect on usage intention. Out of all the factors defined in this research, only relative advantage and price evaluation are not significantly related to usage intention. Furthermore, according to the R square values of the endogenous variables, the conceptual model accounts for 59.7%, 55.2%, 69.6%, and 76.2% of the variance of the attitude perceived ease of use, perceived usefulness, and usage intention, respectively.

6. Discussion and conclusion

6.1. Theoretical implications

As shown in Table 3, the Hypothesis Tests column contains the standard estimation results and the significance of the direct effect of constructs on hypotheses testing. Table 3 also includes a total effect column that provides the sum of the direct and indirect effects of all relationships presented in the first column and other latent variables that do not directly relate to usage intention. The p-values of all total effects are also reported to judge the significance of the relationship. Indirect effects occur when a variable affects another variable through the mediation of a third variable. This means that the relationship between the two variables is influenced by the mediator (Carrión et al., 2017). In this way, the indirect effect can be used to better understand the relationship between the two latent variables. Therefore, evaluating both the indirect and direct effects simultaneously is a more effective approach to prioritizing the most relevant elements of a Scooter's use intention.

In accordance with the existing literature, the component of *perceived usefulness*, from TAM, was found to have a positive relationship with the behavioral intention to use an e-scooter, confirming the expectations expressed in H2 (Panagiotopoulos and Dimitrakopoulos, 2018; Cheng et al., 2019a; Kopplin et al., 2021; Ratan et al., 2021; Rejali et al., 2021; Javadinasr et al., 2022). In addition to its direct effect, attitude mediates the effect of perceived usefulness on usage intention. Therefore, how people perceive the usefulness of e-scooters to fulfill their mobility requirements is of the utmost importance when deciding whether or not to purchase them. In determining the perceived usefulness of micro-mobility, and in particular e-scooters, some effective positive concepts include accessibility, avoiding traffic, and saving time and money.

A positive relationship was also found between *trust,* from individual differences part of TAM3, and the behavioral intention to use an e-scooter, confirming H13's expectations. Both its direct and indirect effects are significant. The findings indicate that perceived usefulness, attitude, and perceived ease of use mediate the effect of trust on usage intention, with the result being a significant total effect. Based on this result, transparency, the ability to comprehend and predict the functionality of e-scooters, correlates positively with the intention of using e-scooters. In our experience, this construct has never been examined in relation to the intention of using e-scooters. However, it has been examined in other contexts. For instance, numerous studies have confirmed a significant relationship between trust and intention to use autonomous vehicles (Choi and Ji, 2015; Hengstler et al., 2016; Hohenberger et al., 2017; Buckley et al., 2018; Nastjuk et al., 2020).

Further, it was observed that *subjective norm,* the social influence indicator within TAM3, was positively correlated with behavioral intentions to use an e-scooter, which is in agreement with expectations expressed in H7. Both direct and indirect effects are associated with it. Perceived usefulness and attitude, mediate the indirect effect of subjective norms on usage intention. The study by Venkatesh (2000) indicates that third-party opinion is likely to influence inexperienced individuals' acceptance. Thus, the results show that people are positively influenced by the opinions of others when choosing to use an e-scooter as a mode of transportation. It has also been demonstrated in the literature that subjective norms play a critical role in users' intentions in regard to e-scooter use (Eccarius and Lu, 2020; Kopplin et al., 2021).

Based on the results, users' intentions to ride an e-scooter are positively influenced by the *personal innovativeness* construct from individual differences part of TAM3. The conceptual model of this study does not demonstrate a direct relationship between personal innovativeness and usage intention. Perceived usefulness and attitude, however, mediate the effect of personal innovativeness on usage intention and determine its indirect impact. In the field of e-scooter adaptation, previous studies have not examined personal innovativeness as a significant factor for usage intention. However, these results support other studies on other technologies like autonomous cars (Lin et al., 2007; Nastjuk et al., 2020). Individuals who are inclined to test novel technologies like e-scooters and who are motivated by new ideas are more likely to form positive perceptions and view e-scooters positively. Likewise, their resistance to change is usually the lowest (Hurt et al., 1977).

E-scooter *compatibility*, a component of system characteristics of TAM3, is also positively correlated with usage intentions as expected in H17. Although the direct effect of this construct is insignificant, its indirect effect is significant. According to the results, for e-scooter use, compatibility is a significant determinant of perceived usefulness, attitude and intention. Specifically, perceived usefulness and attitude appear to mediate the effect of compatibility towards usage intention, leading to a significant total effect. This conclusion is consistent with Eccarius and Lu (2020). The feeling of greater compatibility of the use of e-scooters with common travel behavior ultimately results in a reduced sense of change in common behavior, which in turn leads to an increase in acceptance of e-scooters.

Additionally, *attitude* is another construct from all TAMs that correlates positively with willingness to use an e-scooter, confirming H1. Similar to the conclusions of Rejali et al. (2021), as well as Eccarius and Lu (2020), this study acknowledges that attitude is a significant parameter to predict the intention to use an e-scooter. As previously documented, a positive attitude is associated with a greater likelihood of usage intention and, consequently, actual use (Davis, 1989; Ajzen, 1991; Chin et al., 2008). As evidenced by the results of the study, ecological awareness, perceived ease of use, perceived usefulness, and price evaluation are positively correlated with attitudes toward e-scooter usage, while privacy concern is negatively correlated. In line with the findings of previous research (Rejali et al., 2021; Javadinasr et al., 2022) the relationship between attitude, perceived usefulness, and perceived ease of use and the intention to use e-scooters has been supported. In previous studies, there has not been a comprehensive examination of the effects of privacy concerns, ecological awareness, and price evaluation on attitude towards e-scooters. Accordingly, the results of our research suggest that attitudes toward e-scooters are strongly influenced by how useful and easy the device is considered to be.

Next on the list of factors that are positively associated with the intention to use e-scooters is *perceived ease of use*, which is one the main components of TAM. Despite the absence of a direct relationship between perceived ease of use and usage intention in the conceptual model, there is a significant indirect effect between the two. The mediators of this meaningful relationship are perceived usefulness and attitude. Studies in various areas, including bike-sharing services (Shao and Liang, 2019), autonomous vehicles (Dirsehan and Can, 2020), and e-scooters (Kopplin et al., 2021; Ratan et al., 2021; Javadinasr et al., 2022) support this conclusion. The perception of e-scooters as easy, convenient, and involving less mental or physical strength could persuade individuals to consider it a more convenient mode of transportation, ultimately improving their perception of e-scooters. This may also result in an increased use of e-scooters in the future. The eighth position for perceived ease of use is considered to be reasonable, because it is more likely that people who have already adopted a service will not consider the ease of use to be an important parameter. The same idea is also supported by Cheng et al. (2019a) when it comes to bike-sharing.

The only factor that is negatively associated with users' intentions to use e-scooters is *privacy concerns,* from individual differences part of TAM3, proving hypothesis number 11 (H11). The construct has not previously been studied in relation to e-scooters. However, some studies examine the effect of this factor on other types of vehicles, such as autonomous vehicles (Fraedrich and Lenz, 2016; Nastjuk et al., 2020). In particular, it refers to the collection, storage, and analysis of movement data, which are highly concerning to potential users of transportation vehicles, reducing their willingness to use them. The disclosure of vehicle location information is of particular concern to individuals. Concerns revolve primarily around the privacy issues and invasion of personal space that occur as a result of processing personal information. Consequently, the results indicate that privacy concerns negatively affect the intention to use an e-scooter.

Also, one of the factors positively associated with intention to use an e-scooter is *ecological awareness*. It is one of the components of individual differences in TAM3. These findings support the hypothesis that ecological awareness has a positive and significant influence on attitudes and intention to use e-scooters. The findings of this study confirm those of previous studies (Guerra, 2019; Eccarius and Lu, 2020; Kopplin et al., 2021; Rejali et al., 2021).

Finally, *perceived enjoyment* of riding an e-scooter is the least significant factor associated with usage intention. It is one of the representative factors of system characteristics. There is no direct correlation between perceived enjoyment and usage intention in the conceptual model of this study. However, perceived ease of use, perceived usefulness, and attitude mediate the relationship between perceived enjoyment and usage intention. It is an internal motivation that influences the intention to use an e-scooter. As a result, if using e-scooters is perceived as a fun activity, individuals will find the scooter more appealing and user-friendly. These findings are in agreement with previous research (Kopplin et al., 2021; Javadinasr et al., 2022). It was expected, however, that perceived enjoyment would have more influence on the usage intention of the e-scooter. Javadinasr et al. (2022) refer to this concept and suggest further assessments of the perceived enjoyment and usage intention relationship. Surprisingly, our results support their findings. In addition, the results indicate that perceived enjoyment has a positive impact on perceived ease of use of e-scooters. Accordingly, a higher level of perceived enjoyment results in a greater innate eagerness to use an e-scooter, which facilitates greater interaction with it.

6.2. Practical implications

Perceived usefulness of e-scooters is the most critical factor that influences individuals' intentions toward using them. In addition, trust, subjective norm, perceived ease of use (Aman et al., 2021), compatibility, and personal innovativeness are significantly and positively correlated with perceived usefulness. Accordingly, authorities should use the above parameters to identify policy gaps to improve the perceived usefulness of e-scooters among the public. Micro-mobility is mostly useful for trips that fall under the last mile concept and serves as a complementary mode of transportation. As such, policies and plans should be based on micro-mobility's primary function, which is to facilitate short to medium-distance trips. Thus, policies mandating the establishment of micro-mobility parking lots at transportation stations and logistics and economic hubs can facilitate the implementation of e-scooters as complements to multimodal transportation systems. Moreover, it can be used in places and under circumstances where other modes of transportation usually have a lower utility such as Central Business Districts (CBD) (Cao et al., 2021; Javadinasr et al., 2022).

Trust is the second most important factor in shaping and improving the intentions toward using e-scooters, and it is also the most important latent construct in determining perceived usefulness. Hence, authorities should prioritize making policies to build a sense of trust in users, which can be achieved through a variety of ways such as committing to providing a safe and accessible e-scooter system (Aman et al., 2021). Aman et al. (2021) has indicated that increasing scooter ridership may be achieved by emphasizing the safety and app issues that influence the satisfaction of users. User satisfaction and loyalty to services have been shown to be positively correlated (Söderlund, 1998). Safety measures can include durable vehicles and separated routes dedicated for light vehicles. So, the relevant authorities should commit to greater budgetary allocation for implementation of dedicated micro-mobility infrastructure in cities. Moreover, because an e-scooter is not just aimed at recreation, providing sufficient number of e-scooters in all the necessary places can help ensure people rely on e-scooters for their routine or important trips such as commuting. Also, a comprehensive smartphone platform for reserving e-scooters can improve the perception of reliability (Javadinasr et al., 2022). Further, accessibility planning for e-scooters can be accomplished by identifying the temporal and spatial variations of the demand in all TODs (Transit Oriented Districts) of the city, and by integrating shared e-scooter platforms with the MaaS platform.

As the next most important factor influencing the intention to use e-scooters, subjective norms play a significant role. This indicates the effect of a person's social setting on their decision to use e-scooters. The promotion of micro-mobility on popular social media platforms has been suggested to influence consumer behavior (Kumar et al., 2016; Allem and Majmundar, 2019). Furthermore, Klein et al. (2023) demonstrate how messages in apps and sidewalk decals can be used to influence changes in behavior. Therefore, advertising in all possible media channels, such as social media, displays a favorable image of shared e-scooters and provides a viable way to encourage the use of e-scooters. Advertising for e-scooters can highlight their benefits, such as accessibility, sustainability, fun, and other features (Javadinasr et al., 2022). Similarly, it is important to emphasize the cool and fun experience customers can have with e-scooters in the ads in order to appeal to their desire for enjoyment, a critical factor that influences individuals' intention to use e-scooters. For instance, findings of Dormanesh et al. (2020) indicate that the official social media accounts of Bird and Tier Mobility, two popular e-scooter companies in the United States and Europe, do not model and promote safety, which may result in a normalization of unsafe riding behaviors. Hence, it appears that no policies exist for advertisements related to ESSs, resulting in the presentation of the wrong image. Therefore, it would be beneficial to add policies that mandate that e-scooter advertisements show safety while riding. So, to educate the public, public health officials may be able to intervene via social media platforms (Dormanesh et al., 2020). This can contribute to increasing the use of e-scooter systems by a variety of groups of people. Further, a good design of e-scooters may contribute to a positive user experience as well.

Similarly, the latent variable of personal innovativeness appears to have a significant positive effect on the intention to use an e-scooter. By evoking a sense of innovation in people, we might get them to be more inclined to use an e-scooter. Promoting policies such as free trials for first-time users can increase their sense of personal innovation, which will increase their intention to use the service in the future. Compatibility is very important as well. As mentioned previously, a MaaS platform that facilitates the use of an e-scooter and ensures accessibility to vehicles in TODs ensures e-scooter use is compatible with people's transportation needs.

Perceptions of e-scooters among the general public are also affected by their awareness of environmental issues, privacy concerns, and their attitudes. Perceived ease of use, perceived usefulness, and price evaluation are positively correlated with attitude, while privacy concerns negatively correlate with attitude. In order to increase the attitude of individuals toward e-scooter usage and subsequently their intention to use those, policymakers should lower the costs of its usage The price of scooter riding must be low enough to satisfy riders, but high enough for private companies to sustain their business model (Espinoza et al., 2019). There was also a general support for targeted discount pricing schemes, suggesting that they may offer a viable solution to certain equity concerns in the transportation sector (Lo et al., 2020). To overcome cost-efficiency challenges, Shaheen and Cohen (2019) have proposed subsidized or discounted plans for underprivileged individuals. As well as negotiating an equitable (pricing) structure, public-private partnerships can also facilitate the negotiation of options for mileage-based pricing, frequency-based pricing, and need-based pricing. It may also be possible to institute discount programs and transit passes similar to those that are offered for traditional modes of transportation. It is also important for policymakers to emphasize the merits of conserving the environment, such as reducing noise and air pollution, in order to increase the attitude of individuals toward the use of e-scooters. To visualize how e-scooters might make an advantageous integration into a multi-modal urban mobility system, all three sustainability dimensions, environment, social and economic aspects (Nosratzadeh et al., 2022) must be considered (Kjærup et al., 2021).

Furthermore, to address citizens' concerns regarding their privacy and personal information, governments should ensure that service providers are protecting citizens' personal information. Additionally, perceived ease of use is another construct that positively influences users' intentions toward e-scooter systems. Developing a user-friendly and comprehensive application that integrates all companies that provide e-scooter services into one platform can facilitate the use of these vehicles. According to numerous studies, the inability to use the online interface of shared mobility technologies presents a significant obstacle to their usage (Dowling and Kent, 2015; McNeil et al., 2018). Moreover, incorporating the needs of disabled customers can make these vehicles more convenient for use.

6.3. Summary

Adapting new technologies has been a topic of discussion in numerous fields. In order to ensure the deployment of an intended technology, it is critical to identify the factors that will motivate people to use the new system and reduce their resistance to change. Accordingly, this study aims to identify the factors that influence the intention of individuals to use ESSs in Tehran. From a transport policy perspective, where responsibilities include carbon emission reduction, it is important to understand, and potentially influence, how sustainable services like ESSs evolve.

In this study, a conceptual model has been developed based on the extended Technology Acceptance Model (TAM3). Additional factors have been included in this model as new hypotheses to develop the theoretical model and assess the effect of these constructs on individuals' intentions to use e-scooters. The outputs of the analysis confirmed the consistency and explanation of the developed model, demonstrating its reliability. According to the findings, the following eleven constructs significantly influence e-scooter usage intentions: perceived usefulness, trust, subjective norm, personal innovativeness, compatibility, and attitude, perceived ease of use, privacy concerns, ecological awareness, and perceived enjoyment.

These results contribute to the development of practical guidelines for transportation planners, policymakers, and e-scooter operators in order to promote the use of e-scooters in cities. E-scooter integration into a MaaS plan, accessibility planning, correct depiction of ESSs and its advantages in media advertisements, and proper publicity campaigns to promote e-scooters as a sustainable mode of transportation are the most important policies to attract attention to e-scooters. In accordance with the central role of micro-mobility in sustainable development, these policies will foster an increased preference for using e-scooters and help move toward a more sustainable and smarter urban environment.

6.4. Limitations and future research

A contribution is made to the body of knowledge by this study about individual behavior and their intentions to use e-scooter by examining the behavior intentions of individuals. As well as presenting novel insights, several new questions have been raised by this study that deserve further investigation. This suggests that the model should be examined further on a national and international scale in light of the possibility of entirely different results resulting from a larger sample size. Four areas for future research have been identified as a result of limitations in the research focus and study design.

The first limitation relates to the data and the collection methods. A cross-sectional sample of respondents was used in this study, as in previous research on TAM. Due to the small sample size and cross-sectional nature of the study, causality cannot be determined. Future research should therefore consider using a larger sample size to better predict behavioral intentions. Considering the lack of information regarding this topic, tracking the effectiveness of useful policies concluded in this research and the previous ones should be carried out in a live lab with a control group. Additionally, there is an opportunity related to the full spectrum of emotions and their impact on behavior intentions. As opposed to affective processing models, TAMs disregard emotional constructs such as threats, fears, moods, and negative emotions. In order to develop a realistic model of the adoption of e-scooters, it is vital to investigate the full spectrum of emotions that are associated with the adoption decision of e-scooters (Nosratzadeh and Edrisi, 2023).

In addition, the study was confined to only one city, Tehran, which is densely populated and heavily congested (Nosratzadeh and Edrisi, 2023). As such, generalization is difficult. Different cultures and patterns of travel may affect how individuals in other cities choose their mode of transportation. Consequently, the model can be applied to respondents in different geographical locations.

In addition, there is one more opportunity that has been identified in other models for the prediction of technological adoption. It is difficult to evaluate the full potential of a new model without modeling its range of options. In this study, the emphasis is on an extension of the TAM model, however, future studies are expected to compare them with other technology adoption models such as the motivation model, the TCT (Technology Continuance Theory), and the UTAUT (Unified Theory of Acceptance and Use of Technology), or even expanding the previous models with new constructs such as perceived risk and perceived safety. As a result, future research may examine interactions among these models (Dormanesh et al., 2020).

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Authorship contributions

Samadzad: Conception and design of study, Drafting the manuscript, revising the manuscript critically for important intellectual content, Approval of the version of the manuscript to be published, Nosratzadeh: Conception and design of study, Drafting the manuscript, analysis and interpretation of data, Revising the manuscript critically for important intellectual content, Approval of the version of the manuscript to be published, H. Karami: Conception and design of study, Acquisition of data, Analysis and interpretation of data, Drafting the manuscript, Revising the manuscript critically for important intellectual content, Approval of the version of the manuscript to be published, A. Karami: Acquisition of data, Drafting the manuscript, Revising the manuscript critically for important intellectual content, Approval of the version of the manuscript to be published.

Declaration of competing interest

The authors have no conflict of interest to report.

Data availability

Data will be made available on request.

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