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Consumers' intention to use delivery robots in Iran: An integration of NAM, DOI, and TAM

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ABSTRACT

This study seeks to identify factors influencing the adoption of sidewalk autonomous delivery robots (SADRs) as a green delivery method by shoppers. Accordingly, this study proposes a comprehensive model based on a combination of the norm activation model (NAM), diffusion of innovation (DOI) theory, and technology acceptance model (TAM). The data were collected from 463 Iranian buyers through an online questionnaire. The partial least square (PLS) results revealed that relative advantage, compatibility, and observability positively affected the attitude toward using delivery robots, while complexity negatively impacted this attitude. The observations indicated that problem awareness, ascribed responsibility, and environmental concern positively influenced personal norm. Finally, it was found that personal norm and attitudes toward using delivery robots positively affected the intention to use them. The results of the present work not only provide theoretical contributions to the literature but also can be practically helpful to policymakers.

1. Introduction

The last-mile delivery, known as the last step of delivering goods, includes a series of essential activities and procedures for transporting goods from the last point of transit to the ultimate destination (Yuen et al., 2018). Given the remarkable growth of online shopping over recent years, last-mile delivery has received considerable attention from traffic planners and experts. In Iran, the total amount of online shopping has increased by over 100 % from March 2019 to March 2020, reaching 2961 thousand billion Rials (Saeed, 2020). This considerable growth has increased the number of vehicles for last-mile delivery (such as cars, motorcycles, and vans that mostly run on gas in Iran) and the number of trips, leading to intensified traffic congestion, time waste, noise pollution, high energy consumption, and CO_2 emissions (Liu et al., 2019). Given the adverse effects of these problems on the life quality, the economy of society, and traffic safety, the traditional last-mile delivery methods cannot satisfy the requirements of a sustainable and effective transportation system. Therefore, a percentage of these methods should be replaced with new ideas and technologies (Kapser & Abdelrahman, 2020).

Sidewalk autonomous delivery robots (SADRs) are among the new technologies for last-mile delivery that can considerably mitigate the problems of traditional methods. Delivery robots are small robots that deliver light-weight cargo (typically up to 10 kg) to buyers through sidewalks. A van transfers several delivery robots to delivery-demanding areas. Then, the robots leave the van and transport the goods to their exact destinations (Jennings & Figliozzi, 2019, Boysen et al., 2018). They can deliver goods to buyers within a radius of six kilometers at a maximum speed of 16 km/h. These robots are equipped with radars, navigators, different cameras, and sensors, allowing them to detect barriers and reduce potential risks. Moreover, the applications specific to delivery robots inform buyers of the real-time position of the robots and their directions. Using these applications, buyers get informed of the arrival time of robots, and with the allocated passwords, they can open the robots' doors and receive the goods (Hoffmann & Prause, 2018).

These electric and self-driving robots have many advantages over traditional last-mile delivery methods. Given that they use electricity, CO_2 emissions are much lower than traditional methods. Delivery robots do not have any direct CO_2 emissions. Since they move along sidewalks, they do not increase the traffic flow. Moreover, the costs estimated for them are almost 15 times lower than traditional methods. The use of delivery robots makes last-mile delivery smart and improves its efficiency. For instance, goods can be delivered to buyers within 15- to 30-minute periods in some directions. They can also be used during non-working hours, 24 h a day, and 7 days a week (Hoffmann & Prause, 2018, Lee et al., 2016, Kunze, 2016). Previous studies indicate that

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delivery robots have the required potential to reduce the time and costs of last-mile delivery in comparison with traditional methods (Jennings & Figliozzi, 2019). Furthermore, they significantly reduce energy consumption and CO_2 emissions (Figliozzi & Jennings, 2020). Research indicates that depending on the number of customers served, delivery robots emit only 1.4 % to 3.1 % of the CO_2 produced by traditional methods (like vans) (Figliozzi, 2020). Thus, compared to traditional methods, delivery robots are more compatible with the environment and are considered a green method of last-mile delivery (Kunze, 2016). With respect to the mentioned features, this system offers a high potential for causing an evolution in the last-mile delivery of goods and eliminating the problems with traditional methods (Joerss et al., 2016). Road autonomous delivery robots (RADRs) are another kind of these robots with larger dimensions that move through streets. Although they can transport more and heavier goods, they move through the traffic flow (Figliozzi & Jennings, 2020).

In the near future, the competition between delivery robots and other new last-mile delivery technologies, such as delivery drones, will be intense. Although delivery drones can deliver goods to destinations faster, the risks of sending goods with them may be more compared to land robots. For instance, their breakdown, fall, and damage to humans or objects, collision with barriers, getting hacked and misused, privacy violation of individuals, and instability in different climatic conditions are among the concerns and risks existing in the transportation of goods via drones (Yoo et al., 2018). However, there are no such concerns over delivery robots. Although it has been proposed for a while, the idea of delivery robots is still in its infancy in many countries (Lee et al., 2016). In some developed countries, delivery robots are employed in pilot projects and small, unpopulated areas. Iran has not yet effectively adopted the idea of this technology. However, a review of buyers' views on delivery robots can significantly contribute to the development of this system in Iran.

Most cities in Iran consistently suffer from the problems mentioned due to the traditional last-mile delivery methods and face environmental consequences. Thus, a feasibility study of developing new delivery ideas, such as delivery robots, can significantly help policymakers. However, before investigating such ideas, the views and behavior of shoppers toward them should be identified. The studies on the acceptance of delivery robots (the intention of shoppers to use this system) are highly limited (Kapser & Abdelrahman, 2020). Besides, these studies do not investigate the environmental-friendly behavior of shoppers. Hence, unlike previous studies, the present paper has sought to assess the factors influencing the attitude and intention of individuals to use delivery robots and predict their environmental-friendly behavioral intentions. This study has combined the norm activation model (NAM), the diffusion of innovation (DOI), and the technology acceptance model (TAM) for the first time to fill the research gap. The combination of these theories (with discrete but supplementary variables) contributes to developing a comprehensive model for predicting the environmental-friendly behavior of shoppers toward using delivery robots. Accordingly, the research questions were as follows: Which factors can affect the attitude and intention of Iranian consumers to use delivery robots? To what extent can they be influential? How are the environmental-friendly behavior and attitude of consumers toward using delivery robots? The remainder of the study is organized as follows: Section 2 reviews the delivery robot literature. Section 3 proposes several hypotheses and a research model. Section 4 describes the methodology and data collection. Section 5 provides the results. Finally, Section 6 discusses the results and conclusions.

2. Literature review

2.1. Previous studies in last-mile delivery

Multiple studies and reports introducing the delivery robots, their advantages and disadvantages, routing, and level of contamination, have been published (Lee et al., 2016, Figliozzi & Jennings, 2020, Hoffmann & Prause, 2018, Simoni et al., 2020, Chen et al., 2021). For example, Boysen et al. (2018) proposed an effective solution to solve the scheduling problem for launching robots from the van. In some scenarios, Jennings & Figliozzi (2019) found that delivery robots can reduce the last-mile delivery time and cost compared to traditional methods. Also, Figliozzi (2020) calculated the reduction in CO_2 emissions and energy consumption of delivery robots. However, such studies have not addressed the acceptance of delivery robots and the factors affecting them.

Several studies evaluated shoppers' views on using new delivery ideas other than delivery robots (Yoo et al., 2018, Wang et al., 2018, Hwang et al., 2020b, Chen et al., 2020, Wang et al., 2019, Hwang et al., 2019). Table 1 provides a summary of these studies, along with their theories, methodology, and results. A review of previous studies indicates that researchers more often elaborated the adoption of other new delivery ideas than delivery robots as robot delivery has rarely been studied. Kapser and Abdelrahman (2020) investigated the factors affecting the consumers' intention to use delivery robots in Germany. This research is among the first studies conducted in this field. Drawing on the UTAUT2 and structural equation modeling (SEM), they found that performance expectancy, social influence, facilitating conditions, and hedonic motivation positively affected the intention to use delivery robots, while price sensitivity and perceived risk negatively impacted it. In another study, Kapser et al. (2021) developed the UTAUT2 model to assess the effect of gender, as a moderator variable, on the relationships between the main variables. They added two variables, i.e., innovativeness and trust in technology, to the model and showed that all variables, including performance expectancy, social influence, hedonic motivation, innovativeness, price sensitivity, perceived risk, and trust in technology, affected the intention of people to use delivery robots. Also, Pani et al. (2020) employed latent class analysis (LCA) and divided shoppers into six groups in Portland, USA. They examined factors influencing willingness to pay for all six groups during the COVID-19 pandemic. Edrisi and Ganjipour (2022) explored the factors affecting the intention and attitude toward delivery robots in Iran. They employed partial least squares (PLS-SEM) for modeling. The results revealed that optimism and environmental concern had positive and performance risk, delivery risk, and the need for human interaction had a negative impact on users' attitudes toward delivery robots. In addition, optimism, innovativeness, and attitude had a positive effect on intention. Yuen et al. (2022) applied the technology acceptance model (TAM) and theory of planned behavior (TPB) to investigate the consumers' intention to use delivery robots. They found that perceived ease of use, attitude, perceived usefulness, perceived severity, perceived susceptibility, perceived behavioral control and subjective norm impacted the intention of consumers to use these robots.

A review of the limited studies mentioned reveals that researchers have applied a particular theory, such as UTAUT2. Meanwhile, the present study seeks to evaluate more effective factors by combining three theories. Furthermore, none of the mentioned studies have investigated the environmental-friendly behavior of shoppers in their research. Overall, there is a significant research gap in this context. The present study attempts to contribute to the research literature by evaluating shoppers' environmental and technology-oriented views. Therefore, a comprehensive model based on a combination of NAM, DOI, and TAM could help fill the gap. Moreover, the important factors like the consumers' attitudes toward delivery robots and concerns over environmental damages (caused by traditional methods of last-mile delivery) have been neither assessed. However, the current study has sought to cover these variables, as well. These make the present study distinct from earlier works.

2.2. Merging NAM, DOI, and TAM

As mentioned, compared to traditional last-mile delivery methods,

Table 1
A summary of relevant studies in last-mile delivery.

Authors (Year)	Title	Theories/ Variables	Statistical Method (Sample Size)	Main Findings
Chen et al. (2018)	Consumer's intention to use self-service parcel delivery service in online retailing: an empirical study	LC,OP,IN NHI,PTP	SEM, PLS (N = 281)	• Positive effect of LC, OP, IN and NHI on intention
Yoo et al. (2018)	Drone delivery: Factors affecting the public's attitude and intention to adopt	DOI + PR,IN, EC	Hierarchical Regression (N = 296)	• RA,CO, IN and PR affect drone delivery adoption
Wang et al. (2018)	An innovation diffusion perspective of e-consumers' initial adoption of self-collection service via Automated Parcel Station	DOI	SEM, AMOS (N = 170)	• Positive effect of RA and AT on intention • Significant effect of CO, TR and CL on AT
Hwang et al. (2019)	Perceived innovativeness of drone food delivery services and its impacts on attitude and behavioral intentions: The moderating role of gender and age	IN, AT	SEM (N = 324)	• Positive effect of IN on attitude • Positive effect of AT on intention • Moderating role of age and gender
Aydin (2019)	Public acceptance of drones: Knowledge, attitudes, and practice	KAP	Qualitative Risk Analysis, Minitab (N = 153)	• The public acceptance of drones for different applications • Relatively slight concern about the probable risks of using drones
Yuen et al. (2019)	The determinants of customers' intention to use smart lockers for last-mile deliveries	RM, PV and TC	SEM, AMOS (N = 230)	• PV and TC fully mediate the effects of CN, PS and RE on intention
Hwang et al. (2020a)	Understanding the Eco-Friendly Role of Drone Food Delivery Services: Deepening the Theory of Planned Behavior	TPB	SEM (N = 406)	• Positive effect of AT, SN and PBC on intention • Moderating role of AC
Hwang et al. (2020b)	Investigating consumer innovativeness in the context of drone food delivery services: Its impact on attitude and behavioral intentions	CI	SEM (N = 321)	• Positive effect of NS, QE, HE and SD on attitude • Positive effect of AT on intention
Chen et al. (2020)	The role of consumer participation readiness in automated parcel station usage intentions	CPR + TA,SC	SEM, AMOS (N = 407)	• TA and SC fully mediate the effects of CPR on intention
Kapser and Abdelrahman (2020)	Acceptance of autonomous delivery vehicles for last-mile delivery in Germany – Extending UTAUT2 with risk perceptions	UTAUT2 + PR	SEM, AMOS (N = 501)	• Positive effect of PE, SI, FC and HM on intention • Negative effect of PR on intention
Kim and Hwang (2020)	Merging the norm activation model and the theory of planned behavior in the context of drone food delivery services: Does the level of product knowledge really matter?	NAM, TPB	SEM, AMOS (N = 401)	• Positive effect of PN, AT, SN and PBC on intention • Moderating role of Product Knowledge
Zhou et al. (2020)	Understanding consumers' behavior to adopt self-service parcel services for last-mile delivery	UTAUT	SEM, AMOS (N = 525)	• Positive effect of PE, EE, SI and FC on intention • Negative effect of PR on intention
Yaprak et al. (2021)	Is the Covid-19 pandemic strong enough to change the online order delivery methods? Changes in the relationship between attitude and behavior towards order delivery by drone	DOI, TAM, PMT	SEM, AMOS (N = 400)	• Significant effect of RA and PR on AT • Positive effect of AT on intention
Tsai and Tiwasing (2021)	Customers' intention to adopt smart lockers in last-mile delivery service: A multi-theory perspective	RM, DOI, TPB	SEM (N = 302)	• Significant effect of RA, CO, CL, RE, CN, PS, PBC and AT on consumers' intention
Kapser et al. (2021)	Autonomous delivery vehicles to fight the spread of Covid-19 – How do men and women differ in their acceptance?	Extended UTAUT2	SEM (N = 501)	• Significant effect of IN, PE, HM, SI and PR on behavioral intention • Significant effect of some constructs only for women

Note: SEM = Structural Equation Modeling; DOI = Diffusion of Innovation; TPB = Theory of Planned Behavior; CPR = Consumer Participation Readiness; UTAUT = Unified Theory of Acceptance and Use of Technology; TAM = Technology Acceptance Model; PMT = Protection Motivation Tehory; RM = Resource Matching; PV = Perceived Value; TC = Transaction Cost; CI = Consumer Innovativeness; KAP = Knowledge, Attitude, and Practice; NAM = Norm Activation Model; RA = Relative Advantage; AT = Attitude; CO = Compatibility; CL = Complexity; TR = Trialability; TA = Technology Anxiety; SC = Service Convenience; LC = Location Convenience; OP = Optimism; IN = Innovativeness; NHI = Need for Human Interaction; PTP = Perceived Time Pressure; CN = Convenience; PS = Privacy Security; RE = Reliability; PE = Performance Expectancy; EE = Effort Expectancy; SI = Social Influence; FC = Facilitating Conditions; PR = Perceived Risk; EC = Environmental Concern; NS = Novelty Seeking; QE = Quality Experience; HE = Hedonic Experience; SD = Social Distinctiveness; AC = Awareness of Consequence; SN = Subjective Norm; PBC = Perceived Behavior Control; PN = Personal Norm.

delivery robots are more compatible with the environment (Figliozzi, 2020, Jennings & Figliozzi, 2019). Thus, predicting the environmental-friendly behavior of users and understanding that to what extent they are ready to help the environment by using less traditional methods can be crucial and valuable. This issue has also been investigated in related studies (Kim & Hwang, 2020). NAM (Schwartz, 1977) is a popular model employed to predict the environmental-friendly behavior of individuals (De Groot & Steg, 2009). It has three main variables, including personal norm (PN), problem awareness (PA), and ascribed responsibility (AR). Several studies consider NAM a moderator model, while others describe it as a mediator model (Schultz & Zelezny, 1998, Steg et al., 2005). In the moderator model of the NAM, personal norm directly influences the intention, while problem awareness and ascribed responsibility moderate this relationship. In the mediator model of the NAM, on the other hand, two scenarios are suggested: (1) problem awareness and ascribed responsibility impact the intention through personal norm, and (2) problem awareness influences ascribed responsibility, ascribed responsibility affects personal norm, and personal norm impacts the intention (Zhang et al., 2018). However, a comparison of the moderator and mediator models of the NAM suggests that the mediator model is more effective (De Groot & Steg, 2009). The NAM model has been used in the present study, since delivery robots are more compatible with the environment than traditional methods, and the present study aims to investigate the environmental-friendly behavior of consumers. A combination of the two scenarios in the mediator model (i.e., considering the direct impact of problem awareness on ascribed responsibility in scenario 1) can contribute to a deeper insight into the environmental behavior of shoppers (Zhang et al., 2018). Thus, this combination was employed in the present work.

The DOI theory (Rogers, 1995) is among the most used models in

social sciences. It describes factors affecting the adoption of new technology or idea by individuals. The DOI theory introduces five influential factors: relative advantage, compatibility, complexity, observability, and trialability (Rogers, 1995). This theory was employed in the present study since it predicts an innovation's diffusion and delivery robots can be considered innovative technology in last-mile delivery. However, trialability has not been employed here. The shoppers' views on this variable can assist policymakers and accelerate the adoption of delivery robots (Yuen et al., 2020b). However, since there are no suitable settings for the trial of delivery robots and they are unknown in Iran, trialability was excluded from the proposed model.

TAM (Davis, 1989) is the most popular and most used model for predicting the adoption and intention to use technology. It involves two key variables: perceived usefulness and perceived ease of use, which influence the intention to use technology through the attitude toward it (Vijayasarathy, 2004). Concerning delivery robots, perceived usefulness is the degree to which the users believe the system has higher performance than traditional methods. Also, ease of use refers to the degree to which the users believe delivery robots to be easily used (Davis, 1989). Perceived usefulness and perceived ease of use in the TAM are very similar to relative advantage and complexity in the DOI theory (Wu & Wang, 2005, Moore & Benbasat, 1991). Accordingly, in the present study, perceived usefulness and perceived ease of use have been replaced with relative advantage and complexity. Table 2 summarizes the similar and unused variables.

Since the DOI and TAM have similar variables, they can be supplementary for each other (Yoo et al., 2018). These theories propose that the intention of individuals to use technology (herein, delivery robots) is determined based on the difficulty level of using or understanding them (Davis, 1989, Rogers, 1995). Hence, the two theories can be combined to investigate the acceptance of delivery robots (Di Pietro et al., 2015). Combining the two theories can offer a much stronger model than using any of them alone (Wu & Wang, 2005, Chen et al., 2002). As with many other studies, the present study applied the DOI theory to TAM in order to evaluate the effects of relative advantage and complexity on the intention to use delivery robots through the attitude toward delivery robots (Vijayasarathy, 2004, Yoo et al., 2018, Wang et al., 2018, Di Pietro et al., 2015). Furthermore, combining the NAM with the two theories can improve the explanatory power of the proposed model (Kim & Hwang, 2020, Rezaei et al., 2019, Asadi et al., 2021). Many studies in different fields have successfully integrated the NAM with other theories (Rezaei et al., 2019, Simsekoglu & Klöckner, 2019, Liu et al., 2017). Moreover, combining the three theories, the present study has investigated the effect of different factors on the acceptance of delivery robots and analyzed the environmental-friendly behavior of users. Fig. 1 depicts the proposed model. The next section describes the variables of the incorporated theories.

3. Hypotheses and proposed model

3.1. Problem awareness

Problem awareness refers to the degree to which an individual is aware of the negative environmental impacts of traditional delivery methods (i.e., vehicles) (De Groot & Steg, 2009). Those aware of the environmental damages of traditional delivery methods feel responsible for preventing such consequences (Schwartz, 1977). Problem awareness is the beginning of responsible behavior toward the environment (e.g., using environmental-friendly methods such as delivery robots) (Kim & Hwang, 2020, Hwang et al., 2020a). Various studies have also evaluated the effect of problem awareness on ascribed responsibility (Mehdizadeh et al., 2019a, Huang et al., 2020, Mehdizadeh et al., 2019b, Zhang et al., 2020, Nordfjærn & Rundmo, 2019), as well as personal norm (He & Zhan, 2018, Asadi et al., 2021, Nordlund et al., 2018, Lee et al., 2020, Bobeth & Kastner, 2020, Simsekoglu & Klöckner, 2019). For instance, Asadi et al. (2021) showed that problem awareness affected ascribed responsibility and personal norm positively and significantly. Hence, the consumers' awareness of the adverse consequences of last-mile delivery using traditional methods can positively affect the ascribed responsibility. This awareness also results in a moral commitment to the acceptance of delivery robots. This study combines the two scenarios in the mediator NAM and proposes that:

Hypothesis 1. *Problem awareness has a positive effect on ascribed responsibility*.

Hypothesis 2. *Problem awareness has a positive effect on personal norm*.

3.2. Ascribed responsibility

Ascribed responsibility refers to feeling responsible for environmental pollution arising from traditional delivery methods (De Groot & Steg, 2009). A feeling of responsibility toward environmental damages induced by traditional delivery methods creates moral commitment. Thus, individuals begin to cease previous behavior and attempt to protect the environment. As a result, such commitment encourages environmental-friendly methods such as delivery robots. The effect of ascribed responsibility on personal norm has been assessed in many studies (Kim & Hwang, 2020, He & Zhan, 2018, Huang et al., 2020, Simsekoglu & Klöckner, 2019, Bobeth & Kastner, 2020, Lee et al., 2020). For example, Kim & Hwang (2020) found that the ascribed responsibility was effective in accepting delivery drones. In other words, the effect of ascribed responsibility on personal norm was reported to be significant and positive. Therefore, it is proposed that:

Hypothesis 3. *Ascribed responsibility has a positive effect on personal norm*.

3.3. Environmental concern

Environmental concern is a responsible attitude toward the environment that can encourage using delivery robots as a green delivery service rather than traditional delivery methods (Bamberg, 2003). Feeling concerned about the environment is expected to facilitate the adoption of environmental-friendly methods such as delivery robots. Several studies investigated the impacts of environmental concern on the adoption of new technologies, such as drone delivery, electric vehicles, and autonomous vehicles (Yoo et al., 2018, Wang et al., 2016a, Alzahrani et al., 2019, Wu et al., 2019, Hwang & Kim, 2019). For example, Wu et al. (2019) concluded that environmental concern led to the consumers' intention to use autonomous electric vehicles. Thus, it is proposed that:

Hypothesis 4. *Environmental concern has a positive effect on personal norm*.

3.4. Personal norm

Personal norm is a kind of moral commitment that induces environmental-friendly behavior (Biel & Thøgersen, 2007). The activation of personal norm provokes moral values and commitment in individuals and encourages environmental-friendly behavior (Schwartz, 1977). Feeling responsible for the adverse outcomes of traditional

Table 2
The similar and unused variables in the proposed model.

	TAM	DOI	Similar Studies
Similar Variables	Perceived Usefulness Perceived Ease of Use	Relative Advantage Complexity	Wang et al. (2018), Yoo et al. (2018), Vijayasarathy (2004), Di Pietro et al. (2015)
Unused Variables	–	Trialability	Yoo et al. (2018), Min et al. (2019), Tsai and Tiwasing (2021), Yaprak et al. (2021)

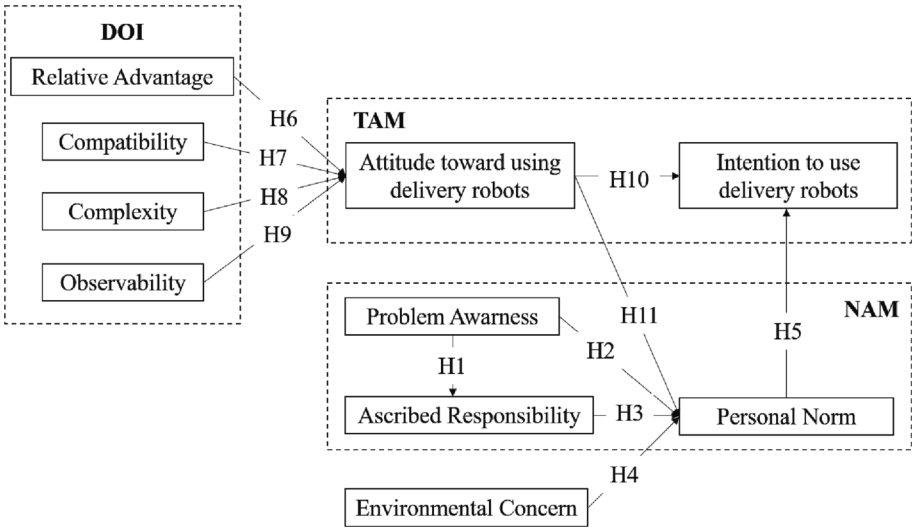

Fig. 1. Combination of NAM, DOI, and TAM for the adoption of delivery robots.

delivery methods induces a moral commitment to replace traditional methods with delivery robots to reduce environmental damage. The effect of personal norm on intention has been investigated in various studies (those with and without NAMs) (Wang et al., 2016a, Kim & Hwang, 2020, He & Zhan, 2018, Huang et al., 2020, Asadi et al., 2021, Bobeth & Kastner, 2020, Lee et al., 2020). Hence, it is proposed that:

Hypothesis 5. *Personal norm has a positive effect on the intention to use delivery robots.*

3.5. Relative advantage

Considering delivery robots to be advantageous in terms of, for example, environmental protection, prices, and transparency over traditional delivery methods provoke higher intention to use such robots. Relative advantage refers to the understanding of to what extent delivery robots outperform traditional delivery methods (Kapser & Abdelrahman, 2020, Kapser et al., 2021). As mentioned, relative advantage resembles perceived usefulness in TAM. Thus, its effects on the attitude toward using delivery robots can be evaluated. Concerning different studies, relative advantage has been effective in the acceptance of new technologies like delivery drones, automated parcel stations, and autonomous vehicles (Wang et al. 2018, Yuen et al., 2018, Tsai & Tiwasing, 2021, Yaprak et al., 2021, Lee et al., 2019). As a result, it is proposed that:

Hypothesis 6. *Relative advantage has a positive effect on the attitude toward using delivery robots.*

3.6. Compatibility

Delivery robots that are compatible with the requirements, favorites, lifestyles, and priorities of online shoppers would be more easily adopted. In other words, compatibility represents to what extent the functionality of a delivery robot is in line with the lifestyles of shoppers (Yuen et al., 2020b). For example, those who attach importance to the environment and have an environmental-friendly lifestyle will likely adopt delivery robots more easily. The effects of compatibility on attitudes toward various aspects were investigated (Vijayasarathy, 2004, Yoo et al., 2018, Wang et al. 2018, Tsai & Tiwasing, 2021, Yaprak et al., 2021). Therefore, it is proposed that:

Hypothesis 7. *Compatibility has a positive effect on the attitude toward using delivery robots.*

3.7. Complexity

Those describing interaction with delivery robots and using a specific application as a complex and difficult process would have a lower intention to use delivery robots (Kapser & Abdelrahman, 2020, Kapser et al., 2021). Complexity represents to what extent delivery robots are viewed to be difficult to learn and use by shoppers (Ajzen, 1991). As mentioned, Complexity in the DOI theory resembles ease of use in TAM in the opposite direction. Thus, the effects of complexity on the attitude toward using delivery robots can be explored. Complexity has been proposed as an effective variable in the research models of many studies (Wang et al. 2018, Yuen et al., 2018, Yoo et al., 2018, Yuen et al., 2020b, Tsai & Tiwasing, 2021). As a result, it is proposed that:

Hypothesis 8. *Complexity has a negative effect on the attitude toward using delivery robots.*

3.8. Observability

Observable outcomes of using delivery robots and their functions can lead to the easier adoption of such robots as a replacement for traditional delivery methods. Observability indicates to what extent the benefits, utilization process, and outcomes are observable (Wang et al., 2018). Interaction with delivery robots, the delivery process, and associated outcomes can be easily seen on the internet and social media, further familiarizing users with delivery robots and using them. Also, such content can be shared among users to help more rapidly expand delivery robots. The effect of observability on the acceptance of new technologies has been investigated in different studies (Wang et al. 2018, Yuen et al., 2018, Yuen et al., 2020a, Wang et al., 2020, Yuen et al., 2020b). Hence, it has been proposed that:

Hypothesis 9. *Observability has a positive effect on the attitude toward using delivery robots.*

3.9. Attitude toward using delivery robots

Whether online shoppers view delivery robots to be desirable or undesirable represents their attitude toward using such robots. TAM suggests that the attitude toward using a new technology directly affects their intention to use it (Ajzen, 1991, Lee, 2009). The effect of attitude on intention is among the important relationships assessed in numerous studies (Wang et al., 2019, Hwang et al., 2019, Hwang et al., 2020b, Wang et al. 2018, Chen & Yan, 2019, Tsai & Tiwasing, 2021, Yaprak et al., 2021). A more positive attitude toward delivery robots stands for a

higher intention to use them. Furthermore, several studies examined the effects of attitude on personal norm (Han et al., 2020). A more positive attitude toward using delivery robots is expected to provoke higher commitment to using delivery robots rather than traditional delivery methods for environmental protection purposes. Therefore, it is proposed that:

Hypothesis 10. *Attitude toward using delivery robots positively affects the intention to use delivery robots*.

Hypothesis 11. *Attitude has a positive effect on personal norm.*

4. Methodology

4.1. Questionnaire development

The statistical population consisted of Iranians with experience in online shopping. This study developed a questionnaire in three sections: The first section introduced delivery robots and provided a brief description of their advantages, functions, and delivery processes. Since the respondents might be unaware of delivery robots, several pictures and a 1:30 video file were embedded into the first part of the questionnaire to provide information on delivery robots. The second and main section of the questionnaire included items for the latent constructs at the seven-point Likert scale, where "1″ represented "completely disagree," while "7" meant "completely agree" (Likert, 1932). Table 3 shows the items along with their references, means, and standard deviations. For the attitude and intention, the seven-point semantic differential scale was employed, where "1" and "7" represented negative and positive for attitude, while "1" and "7" indicated "it is impossible that I use it" and "it is possible that I use it." The third part collected socio-demographic data (e.g., age, gender, income, and education).

To distribute the questionnaires among Iranian online shoppers, the items of the second part were translated from English into Persian and then back-translated into English to ensure translation accuracy (Brislin, 1970). Three experts were invited to minimize ambiguity and complexity from the translated items. Once minor modifications were applied, two pre-test stages were performed. In the first pre-test stage, eight relevant experts, including a professor, three Ph.D. students, and four master's students, were invited to respond to the questionnaire. Feedback suggested the multiplicity of the items and pictures and the ambiguity of the questions. The questionnaire was revised accordingly. In the second pre-test stage, forty-two students in the Faculty of Civil Engineering at K.N. Toosi University of Technology, Tehran, Iran, were invited to participate. As no important feedback was obtained, no further modification was applied.

4.2. Data collection procedures

The finalized questionnaire was implemented on the Google Forms platform to be distributed. It was distributed online for four months, from January to April 2020, on social media (i.e., Twitter, Instagram, and Facebook), online messengers (i.e., Telegram and WhatsApp), and email platforms. An average time of 13 min was required to respond to the questionnaire. The respondents who responded to all the items were included in a lottery for five gift cards worth 500,000 IRR each.

To ensure data quality, measures were implemented in the questionnaires. At the beginning of the second part of the questionnaire, the respondents were asked whether they had experienced online shopping. Those who had not experienced online shopping were excluded from the analysis. For complexity, a reverse-scaled item was incorporated (i.e., "it is very easy to use delivery robots"). The data associated with those respondents who assigned the same very high score (or very low score) to this item and CL1 were considered invalid data. Also, the second part included irrelevant questions with evident responses to ensure their focus on the questionnaire. Those who selected the wrong responses were excluded from the modeling process. After exclusions, a total of 463 (out of 529) samples were found to be valid (a valid response rate of 87.5 %). The minimum sample size for this study was calculated using the G*Power software (Faul et al., 2009). Based on the settings suggested by Vidaver-Cohen (1998) ($f^2 = 0.15$, $\alpha = 0.05$, $1\text{-}\beta = 0.8$), the minimum sample size was found to be 114. Thus, the number of data collected in this study ($N = 463$) is sufficient for modeling. Table 4 reports the socio-demographic characteristics of the respondents. The present study performed the non-response bias test according to Armstrong and Overton (1977). The data of the initial and last respondents were compared for all the constructs. The comparison results indicated no significant difference between the respondents. Thus, the absence of non-response bias was ensured. In addition, the study questionnaire, provided in Appendix B, has several characteristics: 1) It was distributed online, and there was no interviewer throughout the procedure to avoid the potential impacts on responses. 2) The survey was anonymous and confidential. 3) The respondents were explained that no correct or incorrect answers existed. 4) The questionnaire consisted of neutralized and concise questions. Regarding these points, the social desirability bias was expected to be at a minimum (Larson, 2019, Esfandiar et al., 2020).

5. Results

To analyze the relationships between the variables existing in the suggested model, the Structural Equation Modeling (SEM) was applied in the present study. This model enjoys a measurement model and a structural model. The measurement model assesses the relationships between the latent and observed variables, while the structural model evaluates the relationships of the latent variables with each other. Several dependent (endogenous) variables can be used through this model, and the relationships between them can be investigated. The model also considers the measurement errors for observed variables (Hair et al., 2010). The SEM has two different methods: the covariance-based approach and the variance-based approach. The present work employed the partial least square structural equation modeling (PLS-SEM) method (Chin, 1998). This method is a variance-based structural equation modeling approach. The proposed model consisted of ten latent variables, thirty-five observed variables, and eleven hypotheses. Due to the proposed model's complex structure and the few studies on adopting delivery robots, the PLS-SEM method best suits the present work (Hair et al., 2011, Hair et al., 2012). Another reason for the use of PLS-SEM in the present study is the small number of samples. The measurement model was evaluated in the first step, and the structural model was assessed in the second step of the two-step approach proposed in Anderson and Gerbing (1988) using SmartPLS V.3.2.8 (Ringle et al., 2015). The measurement and structural models are described below:

5.1. Measurement model

A measurement model relates latent variables to the corresponding observed variables (Hair et al., 2010). Table 5 provides the measurement model results. As can be seen in Table 5, the factor loadings were significantly>0.7 ($p < 0.001$) (Fornell & Larcker, 1981). Cronbach's alpha was obtained to be>0.7 for all the latent variables (Nunnally & Bernstein, 1994). Also, the average variance extracted (AVE) was found to be>0.5 (Kline, 2015). A minimum composite reliability of 0.7 (Chin, 1998) and minimum rho_A of 0.7 (Dijkstra & Henseler, 2015) were met. Therefore, convergent validity was verified. To verify discriminant validity, the AVE square roots of each latent variable are required to be larger than its correlation with the other latent variables (Fornell & Larcker, 1981). According to Table 6, the AVE square roots (i.e., entries along the main diagonal) are larger than the correlation values (i.e., entries below the main diagonal). Furthermore, the Heterotrait-Monotrait (HTMT) ratio (values above the main diagonal) is below 0.9

Table 3
Measurement items with sources, mean scores, and standard deviations.

Measurement items	Mean	S.D.
Relative Advantage (RA); Source: (Moore and Benbasat, 1991, Meuter et al., 2005)		
RA1: I feel using delivery robots would enable me to receive my parcel more quickly compared to home delivery (motorcycle or car).	5.547	1.137
RA2: I feel using delivery robots improves the parcel delivery process.	5.017	1.589
RA3: I feel using delivery robots would be advantageous compared to home delivery (motorcycle or car).	5.146	1.443
RA4: I feel using delivery robots is the best way to receive my parcels.	5.408	1.343
Compatibility (CA); Source: (Moore and Benbasat, 1991, Meuter et al., 2005)		
CA1: I feel using delivery robots would be compatible with my lifestyle.	5.174	1.559
CA2: I feel using delivery robots fits well with the way I like to receive parcels.	5.436	1.360
CA3: I feel using delivery robots would be compatible with my needs.	5.265	1.359
CA4: I feel using delivery robots would be compatible with my current situation.	4.923	1.551
Complexity (CL); Source: (Moore and Benbasat, 1991, Meuter et al., 2005)		
CL1: I feel delivery robots are difficult to use.	2.829	1.591
CL2: I feel delivery robots are frustrating to use.	2.237	1.280
CL3: I feel delivery robots are cumbersome to use.	2.679	1.510
CL4: I feel delivery robots require a lot of effort to use.	3.139	1.831
Observability (OB); Source: (Moore and Benbasat, 1991, Meuter et al., 2005)		
OB1: I feel I can learn how to use delivery robots.	6.415	0.707
OB2: I feel I can explain to others how to use delivery robots.	6.160	0.877
OB3: I would have no difficulty explaining why using delivery robots is or is not beneficial.	5.718	1.250
OB4: The process of using delivery robots is apparent to me.	5.878	1.161
Environmental Concern (EC); Source: (Wang et al., 2016)		
EC1: I think environmental problems are becoming more and more serious in recent years.	6.540	0.921
EC2: I think human beings should live in harmony with nature in order to achieve sustainable development.	6.568	0.766
EC3: I think we are not doing enough to save scarce natural resource from being used up.	6.282	1.056
EC4: I think individuals have the responsibility to protect the environment.	6.655	0.744
Problem Awareness (PA); Source: (Kim and Hwang, 2020)		
PA1: Current delivery methods (e.g., motorcycle or car) can cause air pollution.	6.045	1.026
PA2: Current delivery methods (e.g., motorcycle or car) can potentially have a negative impact on global warming.	5.920	1.251
PA3: Current delivery methods (e.g., motorcycle or car) can lead environmental pollution.	6.070	1.054
Ascribed Responsibility (AR); Source: (Kim and Hwang, 2020)		
AR1: I believe that consumers are partly responsible for environmental problems potentially caused by current delivery methods (e.g., motorcycle or car).	3.672	1.774
AR2: I feel that consumers are jointly responsible for the environmental deterioration potentially caused by current delivery methods (e.g., motorcycle or car).	3.397	1.738
AR3: I believe that every consumer is partly responsible for the environmental problems caused by current delivery methods (e.g., motorcycle or car).	3.443	1.712
Personal Norm (PN); Source: (Kim and Hwang, 2020)		
PN1: I feel an obligation to choose an environmentally friendly way, such as delivery robots when ordering products online.	5.418	1.279
PN2: Regardless of what other people do, because of my own values/principles I feel that I should behave in an environmentally friendly way when ordering products online.	5.704	1.183
PN3: I feel it is important that consumers behave in a sustainable way when ordering products online.	5.784	1.167
Attitude toward using delivery robots (AT); Source: (Collier et al., 2014)		
AT1: Semantic differential - Negative/Positive	5.561	1.083
AT2: Semantic differential - Unpleasant/Pleasant	5.599	1.118
AT3: Semantic differential - Unfavorable/Favorable	5.418	1.180
Intention to use delivery robots (IN); Source: (Collier et al., 2014)		
IN1: Semantic differential - Impossible/Possible	6.024	1.191
IN2: Semantic differential - Not probable/Very probable	5.864	1.252
IN3: Semantic differential - Very unlikely/Very likely	5.655	1.264

(Henseler et al., 2015). Thus, discriminant validity was verified for this study. The cross-loadings are provided in Appendix A.

According to Podsakoff et al. (2003), the present study employed Harman's single factor to detect the common method bias (CMB). The results indicated that the single factor accounted for 30.58 % of the variance. This value should be smaller than 50 % (Harman, 1976). In addition, the marker variable approach was used to check the CMB. No significant differences were found between the original and CMB-adjusted correlations for all constructs (Lindell & Whitney, 2001). Therefore, the absence of CMB was ensured. Also, this study calculated the variance inflation factor (VIF) to find the degree of collinearity. The results showed that VIF was in the range of 1.000–2.219, below the maximum proposed value of 3.3 (Kock, 2015). Thus, the absence of multicollinearity was ensured.

5.2. Structural model

A structural model relates latent variables to each other (Hair et al., 2010). This study employed the bootstrapping technique with 5,000 subsamples for modeling. Table 7 provides the structural model results.

Table 4
Descriptive statistics of the sample.

	Frequency	Percentage
Gender		
Male	252	54.4
Female	211	45.6
Age (years old)		
<19	39	8.4
20–29	169	36.5
30–39	145	31.3
40–49	61	13.2
>50	49	10.6
Household Income (10^7 Rials (IRR)/month)		
<2	81	17.5
2–3.99	154	33.3
4–5.99	101	21.8
6–8	50	10.8
>8	77	16.6
Education		
High school or below	59	12.7
Diploma	94	20.3
Associate degree/Some College	31	6.7
Bachelor degree	143	30.9
Master degree	116	25.1
Ph.D./Doctoral or higher	20	4.3
Delivery Robot Familiarity (through the Internet or media)		
Familiar	216	46.7
Unfamiliar	247	53.3

Table 5
Reliability indices for the measurement model.

Construct	Item	Factor Loading	α	rho_A	CR	AVE
AR	AR1	0.923***	0.927	0.930	0.954	0.873
	AR2	0.956***				
	AR3	0.923***				
PA	PA1	0.926***	0.899	0.916	0.937	0.831
	PA2	0.865***				
	PA3	0.942***				
PN	PN1	0.920***	0.922	0.923	0.950	0.865
	PN2	0.947***				
	PN3	0.922***				
EC	EC1	0.822***	0.824	0.846	0.883	0.654
	EC2	0.880***				
	EC3	0.708***				
	EC4	0.815***				
RA	RA1	0.822***	0.862	0.867	0.907	0.709
	RA2	0.758***				
	RA3	0.888***				
	RA4	0.894***				
CA	CA1	0.842***	0.880	0.889	0.917	0.736
	CA2	0.859***				
	CA3	0.901***				
	CA4	0.827***				
CL	CL1	0.775***	0.825	0.835	0.883	0.654
	CL2	0.849***				
	CL3	0.834***				
	CL4	0.776***				
OB	OB1	0.744***	0.810	0.814	0.876	0.640
	OB2	0.876***				
	OB3	0.780***				
	OB4	0.793***				
AT	AT1	0.916***	0.900	0.901	0.937	0.833
	AT2	0.920***				
	AT3	0.903***				
IN	IN1	0.943***	0.951	0.953	0.968	0.911
	IN2	0.969***				
	IN3	0.952***				

α: Cronbach's Alpha, CR: Composite Reliability, AVE: Average Variance Extracted.
*** $P < 0.001$.

As shown in Table 7, the t-value was>1.96 for all the relationships between the latent variables ($p < 0.05$). Thus, all eleven proposed hypotheses were supported. Moreover, Table 8 indicates the results obtained from the indirect effect of variables on the individuals' intention to use delivery robots. As is evident, all indirect effects have acceptable significance and are of the partial type. In other words, attitude is a partial mediator between the variables of the DOI theory and intention. The personal norm is also a partial mediator between the variables of the NAM and intention.

In the aspect of technology-oriented views of shoppers, relative advantage, compatibility, and observability had positive effects, while complexity had negative impacts on the attitude toward using delivery robots. The relative advantage was found to have the strongest effect on attitude. In the aspect of environmental views of shoppers, problem awareness, ascribed responsibility, and environmental concern were found to have positive effects on personal norm. Environmental concern has the largest effect on personal norm. Furthermore, problem awareness is positively related to ascribed responsibility. Finally, the attitude toward using delivery robots was expectedly found to positively influence personal norm, and the intention to use delivery robots was observed to be positively influenced by the attitude and personal norm.

In this study, gender (male = 1, female = 0), age (<19 = 1, 20–29 = 2, 30–39 = 3, 40–49 = 4, and > 50 = 5), education (high school or below = 1, diploma = 2, associate degree = 3, bachelor degree = 4, master degree = 5, and Ph.D. or higher = 6), monthly household income (<2 million Tomans = 1, 2–3.99 = 2, 4–5.99 = 3, 6–8 = 4, and > 8 = 5), and delivery robot familiarity (familiar = 1, unfamiliar = 0) were controlled against intention. Table 9 provides the results of the control variables. As can be seen, the effect of monthly household income and delivery robot familiarity have been reported as positive and significant. Although the effect of these variables was significant, none of them made significant changes in the relationships between variables. In general, introducing the control variables in the structural model resulted in no significant change in path coefficients and p-values. This indicates the robustness of the research model (Kapser & Abdelrahman, 2020). Table 10 reports the R^2 and Q^2 values for the endogenous variables. The R^2 values of 0.67, 0.33, and 0.19 are described as substantial, moderate, and weak, whereas a Q^2 value above 0.35 represents high predictive relevance of a model (Chin, 1998, Hair et al., 2012). According to Table 10, the model was concluded to have satisfactory predictive power. Moreover, according to Hult et al. (2018), the Gaussian copula approach (Park & Gupta, 2012) was applied to evaluate the potential endogeneity. At first, the Kolmogorov-Smirnov test revealed that none of the variables with potential endogeneity was normally distributed. Hence, the Gaussian copula approach was applied using the R software. The outcomes showed that none of the Gaussian copulas (such as PA, AR, and EC) had acceptable significance (P-value > 0.05). Hence, there was no concern over endogeneity in the present study, indicating the robustness of the proposed structural model (Hult et al., 2018, Sarstedt et al., 2020).

6. Discussion and conclusion

6.1. Relationships between the latent variables

Based on the results obtained from the structural model and the related studies, this section discusses the whole research hypotheses. Like the related studies, in the NAM, problem awareness had a significant positive effect on ascribed responsibility (H1) (Mehdizadeh et al., 2019a, Huang et al., 2020, Asadi et al., 2021, Mehdizadeh et al., 2019b, Zhang et al., 2020, Nordfjærn & Rundmo, 2019) and personal norm (H2) (He & Zhan, 2018, Huang et al., 2020, Simsekoglu & Klöckner, 2019, Lee et al., 2020, Liu et al., 2017, Nordlund et al., 2018, Bobeth & Kastner, 2020). Also, ascribed responsibility positively influenced personal norm (H3). This finding is consistent with many previous works (Huang et al., 2020, He & Zhan, 2018, Kim & Hwang, 2020, Bobeth & Kastner, 2020, Lee et al., 2020). Those who gradually understand the environmental damages of traditional delivery methods (i.e., vehicles)

Table 6
AVE, correlations, and Heterotrait-Monotrait (HTMT) ratio.

	AR	AT	CA	CL	EC	IN	OB	PA	PN	RA
AR	**0.934**	0.129	0.194	0.082	0.141	0.061	0.081	0.288	0.365	0.279
AT	0.117	**0.913**	0.684	0.451	0.257	0.761	0.425	0.336	0.524	0.758
CA	0.175	0.614	**0.858**	0.422	0.187	0.629	0.416	0.370	0.510	0.821
CL	0.056	−0.395	−0.367	**0.809**	0.185	0.442	0.574	0.147	0.202	0.360
EC	0.127	0.223	0.161	−0.146	**0.809**	0.212	0.319	0.612	0.538	0.265
IN	0.058	0.705	0.578	−0.401	0.185	**0.954**	0.462	0.220	0.441	0.608
OB	−0.010	0.363	0.354	−0.472	0.256	0.405	**0.800**	0.157	0.281	0.329
PA	0.265	0.305	0.334	−0.133	0.536	0.207	0.136	**0.912**	0.578	0.425
PN	0.339	0.479	0.464	−0.184	0.477	0.416	0.243	0.533	**0.930**	0.559
RA	0.247	0.669	0.718	−0.313	0.226	0.555	0.278	0.379	0.500	**0.842**

Table 7
Structural Model Results.

Hypothesis	Path	Path Coefficient	STD	T-Statistics	P-Values	Results
H1	PA -> AR	0.268	0.056	4.730	0.000	Supported
H2	PA -> PN	0.251	0.079	3.159	0.002	Supported
H3	AR -> PN	0.201	0.048	4.284	0.000	Supported
H4	EC -> PN	0.256	0.089	2.738	0.006	Supported
H5	PN -> IN	0.101	0.049	2.067	0.039	Supported
H6	RA -> AT	0.453	0.064	7.062	0.000	Supported
H7	CA -> AT	0.204	0.065	3.199	0.001	Supported
H8	CL -> AT	−0.131	0.049	2.615	0.009	Supported
H9	OB -> AT	0.106	0.051	2.051	0.041	Supported
*H*10	AT -> IN	0.659	0.053	12.416	0.000	Supported
*H*11	AT -> PN	0.320	0.051	6.344	0.000	Supported

Table 8
Results of mediation effect analysis.

Mediation Effects	β	Standard Deviation
RA -> ATT -> INT	0.296**	0.049
CA -> ATT -> INT	0.134**	0.046
CL -> ATT -> INT	−0.084**	0.034
OBS -> ATT -> INT	0.071**	0.035
PA -> PN -> INT	0.026**	0.017
AR -> PN -> INT	0.020**	0.011
EC -> PN -> INT	0.025*	0.015
ATT -> PN -> INT	0.032**	0.018
PA -> AR -> PN	0.054**	0.019

* $P < 0.1$.
** $P < 0.05$.

begin to exert environmental-friendly behavior. Once a sense of responsibility appears, they seek to replace traditional delivery methods with environmental-friendly delivery methods (e.g., delivery robots). Environmental concern was found to affect personal norm (H4) positively. Those concerned about the negative environmental impacts of traditional delivery methods become more committed to environmental-friendly behavior. Thus, they prefer to employ green services such as delivery robots instead of traditional delivery methods. Unlike the results found in Yoo et al. (2018) about delivery drones, this result agrees with many related studies (Wang et al., 2016a, Alzahrani et al., 2019, Wu et al., 2019, Hwang & Kim, 2019, Mathew et al., 2021).

According to the mentioned cases, it is concluded that the use of green and environmentally friendly methods in last-mile delivery (instead of traditional methods that are generally contrary to the preservation of the environment) is accepted by users. The spread of environmental pollution has affected their attitude and sense of responsibility towards the environment. Therefore, users consider themselves responsible for the environment and try to protect it. In this regard, according to its characteristics (compatibility with the environment, reduction of pollution and energy consumption), the delivery robot can influence the choice of users to use green methods and play an important role in preserving the environment.

In the DOI theory, the relative advantage strongly affected the attitude toward using delivery robots (H6). The advantages and superb characteristics of delivery robots distinguish them from traditional delivery methods and strongly influence shoppers. An understanding of the benefits of delivery robots would improve the attitude toward using such robots. Therefore, this finding can be interesting to policymakers in this context. Many previous studies reported the same result (Wang et al., 2018, Yuen et al., 2018, Yaprak et al., 2021, Tsai & Tiwasing, 2021). Compatibility had a significant positive effect on attitude (H7), like what was reported in the related studies (Wang et al., 2018, Yuen et al., 2018, Tsai & Tiwasing, 2021). Higher compatibility of the characteristics and functions of delivery robots with the lifestyles, requirements, and priorities of shoppers would result in a better attitude toward delivery robots. Complexity is the only construct to have a negative, significant impact on the attitude toward using delivery robots (H8). Those who view delivery robots to be complex and confusing to use (including interacting with the robot and handling the application) would not have a positive attitude toward using such robots. Unlike Yuen et al. (2018), in which complexity was not found an effective variable, this finding was in accordance with the results obtained from other similar studies (Yoo et al., 2018, Wang et al., 2018, Tsai & Tiwasing, 2021). Concerning H9, observability was found to have a positive effect on the attitude toward using delivery robots. Higher familiarity with delivery robots through the internet and media helps more easily learn to use such robots. In other words, robot delivery would be more straightforward to such individuals. This could exhibit a better vision of this method to shoppers and provoke a positive attitude. Unlike Yuen et al. (2018) and Wang et al. (2018), in which observability was not known as an effective variable, the result of the present research is close to those of related studies (Yuen et al., 2020a, Wang et al., 2020, Yuen et al., 2020b).

The attitude toward using delivery robots was found to have a positive and significant effect on the intention to use delivery robots (*H*10), as expected in previous research (Hwang et al., 2019, Chen & Yan, 2019, Hwang et al., 2020b, Yaprak et al., 2021, Tsai & Tiwasing, 2021). A more positive attitude toward delivery robots leads to a stronger intention to use such robots instead of traditional methods. Furthermore, the attitude toward delivery robots was concluded to positively influence personal norm (*H*11) (Han et al., 2020). Those with a positive attitude toward delivery robots are more committed to replacing traditional delivery methods with green services such as delivery robots to protect the environment. Finally, personal norm was observed to positively and significantly affect the intention to use delivery robots (H5). Those who are morally committed to environmental-friendly behavior feel an obligation to less often employ traditional delivery methods.

Table 9
Results of Control Variables.

Path	Path Coefficient	STD	T-Statistics	P-Values	Results
Gender -> IN	0.006	0.044	0.132	0.895	Not significant
Age -> IN	−0.025	0.041	0.589	0.556	Not significant
Education -> IN	−0.061	0.038	1.615	0.107	Not significant
Income -> IN	0.133	0.044	3.071	0.002	Significant
Delivery Robot Familiarity -> IN	0.134	0.040	3.343	0.001	Significant

Table 10
R^2 and Q^2 for Endogenous Constructs.

Endogenous Construct	R^2	Adjusted R^2	Q^2
AR	0.070	0.067	0.056
AT	0.517	0.510	0.408
IN	0.505	0.502	0.434
PN	0.474	0.467	0.383

Thus, they would have a stronger tendency to use delivery robots rather than traditional delivery methods since they realize that traditional methods are very environmentally destructive. This finding is consistent with different studies (Kim & Hwang, 2020, Huang et al., 2020, Mehdizadeh et al., 2019a, Asadi et al., 2021, Bobeth & Kastner, 2020). Moreover, like previous studies (Kapser & Abdelrahman, 2020, Yoo et al., 2018), age, gender, and education level, as control variables, did not affect the intention of individuals to use delivery robots. However, the monthly income of the household and delivery robot familiarity impacted users' intention positively and significantly. Unlike the present study, in Kapser & Abdelrahman (2020), the effect of income was reported as insignificant, and the delivery robot familiarity had a significant negative effect.

It should be noted that, in addition to the variables mentioned in this research, there are other key characteristics in the field of acceptance of a delivery robot that influence the use of this system in reality. For example, characteristics such as the price of the sending goods by a delivery robot, time of delivery of goods, reliability and availability can affect the attitudinal factors and are important to choose this method as an alternative to traditional delivery methods, both for users and for policymakers. As at the end of mentioned in this paper, future studies may explore these characteristics and include them in the model along with the variables in this study to obtain more complete results.

6.2. Theoretical and practical contributions

Theoretically, to the best of the authors' knowledge, the present work pioneers the investigation of pro-environmental views among shoppers concerning the adoption of delivery robots. Previous studies prove that delivery robots are environmentally friendly (Figliozzi, 2020, Jennings & Figliozzi, 2019, Figliozzi & Jennings, 2020). Therefore, this delivery method can contribute to environmental protection. Previous studies have ignored the effect of individual environmental concerns and the prediction of individual environmental-friendly behaviors. Unlike studies by Kapser & Abdelrahman (2020), Pani et al. (2020), and Kapser et al. (2021), the present study has investigated the different factors effective in the attitude and intention of individuals to use delivery robots plus the environmental-friendly behavior of users. Thus, the present study's findings can contribute to the literature since they describe the formation of environmental-friendly behavior among shoppers concerning delivery robots. Furthermore, unlike previous studies by Kapser and Abdelrahman (2020) and Kapser et al. (2021), which are mostly based on a single theory, this study has proposed a combined NAM-DOI-TAM model to evaluate the factors influencing the adoption of delivery robots in terms of environmental protection and innovation attributes. Although each of these three theories is along helpful in modeling the adoption of new technologies, their combination can enhance the explanatory power of the proposed model (Rezaei et al., 2019, Kim & Hwang, 2020, Asadi et al., 2021). Adding environmental concern and considering its effect on the personal norm, this study has also extended the NAM. Most studies in related fields, such as delivery drones and electric vehicles (Kim & Hwang, 2020, He & Zhan, 2018, Asadi et al., 2021), have only assessed the effect of problem awareness and ascribed responsibility on personal norm while neglecting the effective role of environmental concern. The results of the present study reveal that environmental concern has a significant positive effect on personal norm. Therefore, it can be seen as an effective variable in the acceptance of delivery robots.

Practically, the results of the present work could be very helpful to policymakers. The results indicated that problem awareness, ascribed responsibility, and environmental concern had significant positive effects on personal norm. This outcome helps policymakers raise the moral obligation of users to the environment. Policymakers should use the maximum capacity required for advertisements, networking, and social media to promote the compatibility of delivery robots with the environment. Such advertisements should describe the energy consumption and air pollution caused by traditional last-mile delivery methods, such as cars, motorcycles, and vans. Accordingly, the users get aware of the negative consequences of these methods on the environment. The advertisements should also mention the percentage of reduction in energy consumption and air pollution in the case of using delivery robots (as a green method for last-mile delivery) and compare it with traditional methods, creating a sense of responsibility and moral commitment to the environment in users (He & Zhan, 2018, Asadi et al., 2021). Therefore, users may conclude that in the case of the promotion of delivery robots, they can also contribute to reducing air pollution and preserving the environment.

Moreover, the companies that tend to use delivery robots for last-mile delivery can inform their customers of the environmental problems caused by traditional methods and suggest a green alternative (delivery robots) through green advertising by sending motivating messages, pop-up messages, info graphs, and figures to them. Such advertising provokes an environmental-friendly attitude among shoppers (Hartmann & Apaolaza-Ibanez, 2010, Muralidharan et al., 2017, Kim & Hwang, 2020, Hwang & Kim, 2019). The advertisements can be accompanied by considering discounts, points, and samples for customers. For example, companies can give points to customers for each time using the "green method = delivery robot" for last-mile delivery. After the points reach a particular value, the customers can receive discounts for their future purchases.

Furthermore, raising public awareness by holding educational classes, advertisement campaigns, sessions, reporting seminars, and webinars in schools, universities, and the workspace for free can be very useful to grow moral commitment in individuals (Wu et al., 2019). When a moral commitment to the environment is made in a user, he/she will be more likely to receive goods through delivery robots instead of traditional methods. Since personal norm has a significant positive effect on intention, the mentioned policies can be useful for the acceptance of delivery robots by customers.

In terms of innovation attributes, the relative advantage had a significant positive effect on attitude. This variable was among the important and effective variables in the acceptance of delivery robots. It is suggested that the characteristics of delivery robots be promoted as these characteristics bring delivery robots to a higher position over traditional delivery methods. In addition to the compatibility of delivery robots with the environment, policymakers can concentrate on fast delivery, flexible time windows, and lower costs of delivery robots in their advertisements. The advantage of delivery robots over traditional delivery can turn shoppers' attitudes toward new and green services. Lowering their costs or offering their customers some discounts or points for using delivery robots, companies can persuade their customers to use this method (Kapser & Abdelrahman, 2020).

In this study, the effect of compatibility on attitude was reported as significant and positive. Thus, policymakers can accordingly invest more in a group of society whose lifestyle is compatible with the delivery robot systems: For instance, those with environmental concerns or who favor new technologies (Yuen et al., 2020b). Companies can also provide the items associated with delivery robots according to the needs and lifestyles of customers. For example, a delivery robot application can be designed in a user-friendly way to be compatible with the priorities and expectations of most users, or the appearance of robots can be designed such that they agree with the values and lifestyle of Iranian society. Accordingly, the users can interact with this system and use delivery robots with a more positive attitude. It is suggested that short surveys are implemented in advertisements to inquire shoppers about their requirements and expectations of delivery robots so that robots with higher compatibility with their lifestyles could be designed.

Complexity was the only variable in the suggested model that had a significant negative effect on attitude. Therefore, policymakers can show users how to work with delivery robots for free by providing a suitable and user-friendly environment so that by testing the robots in this stage, customers become almost familiar with their performance

and learn how to use them. As a result, any ambiguity or complexity is eliminated for the users, and they will have a stronger intention to use delivery robots. The companies are also recommended to design simple customer interaction with applications and, in general, avoid the complication of the interaction between buyers and delivery robots. Hence, receiving goods by users becomes much easier, and they have more positive attitudes toward this method.

Furthermore, it is suggested that a cyber-environment is provided through social media, applications, and websites to further introduce the functioning of delivery robots. In such a case, the utilization process of delivery robots would be clearer to shoppers. However, the possible complexity of utilization would decrease, explicating the performance results and use of delivery robots for those who have not participated in the trials and improving observability. The study results showed that observability significantly and positively affected the users' attitudes toward using delivery robots. Therefore, with such an approach, the users may show more intention to use delivery robots.

6.3. Limitations and future research

The present study had limitations that should be considered for future studies. First, this study collected 463 data. A larger number of data for future studies can better represent the whole population of Iran. Second, despite the fact that online questionnaires and nonprobability sampling are frequently employed, these methods have drawbacks that add to the concerns about possible biases (Wright, 2005). Although the authors had to select these methods due to the Covid-19 pandemic, future studies are recommended to employ random sampling and in-person interviews to collect data for higher accuracy and generalization. Third, the present study has used the cross-sectional method. This method indicates the attitude and behavior of users at a specific point in time. It is suggested to use a longitudinal method in future studies. Forth, delivery robots are still in their infancy in Iran, and shoppers are not perfectly familiar with this delivery method. Nearly 53 % of the respondents were unfamiliar with delivery methods and responded to the items based on the information provided in the questionnaire. Therefore, it is recommended that future studies invite individuals who have used delivery robots (even those with little experience) or attended trials for data collection. Future studies can also evaluate the interaction between humans and delivery robots (e.g., the Need for Human Interaction (NHI) variable). Furthermore, it is strongly recommended for future research to investigate the fundamental attributes of delivery robot (delivery cost, delivery time, availability/accessibility, and reliability) using a stated-preference survey. It is also recommended to add a theory from a marketing view (e.g., consumer behavior) or the important variables, such as expectancy and social influences, to the suggested model. Eventually, future works can extend NAM or integrate it with other important theories (e.g., TPB and UTAUT) to propose models with satisfactory explanatory power.

Declaration of Competing Interest

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

Appendix A. Cross loadings

	AR	AT	CA	CL	EC	IN	OB	PA	PN	RA
AR1	**0.923**	0.102	0.143	0.071	0.130	0.053	0.004	0.283	0.319	0.197
AR2	**0.956**	0.099	0.180	0.023	0.123	0.068	0.004	0.257	0.305	0.233
AR3	**0.923**	0.130	0.170	0.063	0.101	0.042	−0.040	0.198	0.327	0.267
AT1	0.105	**0.916**	0.564	−0.370	0.176	0.669	0.336	0.256	0.421	0.638
AT2	0.106	**0.920**	0.554	−0.361	0.213	0.644	0.355	0.313	0.461	0.602
AT3	0.110	**0.903**	0.564	−0.350	0.224	0.618	0.303	0.267	0.430	0.590
CA1	0.155	0.514	**0.842**	−0.353	0.124	0.510	0.279	0.310	0.424	0.593
CA2	0.144	0.574	**0.859**	−0.265	0.136	0.509	0.337	0.274	0.395	0.638
CA3	0.168	0.565	**0.901**	−0.343	0.170	0.519	0.316	0.313	0.413	0.646
CA4	0.132	0.437	**0.827**	−0.302	0.116	0.437	0.274	0.244	0.354	0.580
CL1	−0.024	−0.336	−0.357	**0.775**	−0.011	−0.321	−0.375	−0.128	−0.201	−0.348
CL2	0.084	−0.366	−0.324	**0.849**	−0.184	−0.418	−0.414	−0.150	−0.184	−0.255
CL3	0.060	−0.295	−0.305	**0.834**	−0.143	−0.304	−0.420	−0.052	−0.097	−0.201
CL4	0.065	−0.262	−0.174	**0.776**	−0.137	−0.225	−0.304	−0.085	−0.092	−0.190
EC1	0.122	0.246	0.173	−0.160	**0.822**	0.178	0.193	0.487	0.381	0.222
EC2	0.108	0.160	0.109	−0.122	**0.880**	0.144	0.212	0.465	0.447	0.153
EC3	0.057	0.119	0.096	−0.089	**0.708**	0.143	0.221	0.314	0.274	0.109
EC4	0.113	0.189	0.142	−0.098	**0.815**	0.137	0.212	0.443	0.412	0.235
IN1	0.036	0.654	0.551	−0.377	0.205	**0.943**	0.383	0.186	0.367	0.511
IN2	0.067	0.663	0.560	−0.401	0.173	**0.969**	0.392	0.207	0.397	0.516
IN3	0.062	0.701	0.545	−0.372	0.153	**0.952**	0.384	0.200	0.424	0.559
OB1	−0.124	0.274	0.253	−0.373	0.250	0.308	**0.744**	0.126	0.180	0.159
OB2	−0.004	0.310	0.292	−0.354	0.210	0.330	**0.876**	0.067	0.186	0.206
OB3	0.050	0.290	0.263	−0.364	0.225	0.324	**0.780**	0.152	0.210	0.273
OB4	0.038	0.287	0.323	−0.422	0.137	0.334	**0.793**	0.094	0.202	0.249
PA1	0.230	0.317	0.352	−0.138	0.523	0.226	0.163	**0.926**	0.526	0.381
PA2	0.230	0.223	0.242	−0.094	0.437	0.130	0.076	**0.865**	0.392	0.283
PA3	0.265	0.285	0.309	−0.127	0.499	0.200	0.124	**0.942**	0.525	0.362
PN1	0.373	0.508	0.516	−0.206	0.404	0.427	0.242	0.505	**0.920**	0.560
PN2	0.276	0.408	0.412	−0.148	0.472	0.370	0.235	0.469	**0.947**	0.437
PN3	0.292	0.414	0.358	−0.155	0.457	0.358	0.199	0.510	**0.922**	0.390
RA1	0.152	0.594	0.585	−0.276	0.148	0.501	0.248	0.277	0.389	**0.822**
RA2	0.172	0.504	0.509	−0.144	0.201	0.356	0.144	0.245	0.364	**0.758**
RA3	0.287	0.556	0.649	−0.327	0.228	0.486	0.240	0.384	0.524	**0.888**
RA4	0.222	0.590	0.666	−0.295	0.189	0.512	0.292	0.364	0.408	**0.894**

An Item's loadings on its own variable (in bold) are higher than all of its cross-loadings with other variable.

Appendix B. . Questionnaire of the study

Part 1: Information sheet

Dear respondent,

The present questionnaire has been designed to carry out an academic study. This section provides the required information to fill it if you would like. Undoubtedly, your honest and precise answers will considerably help the practical aspects of the project. With regards.

- What is the goal of the questionnaire?

This questionnaire has been designed to evaluate people's attitudes toward using delivery robots (as a method to receive goods purchased online) instead of traditional methods (via car or motorcycle).

- Who are eligible to respond to the questionnaire?

Respected respondents should have experienced online shopping at least once.

- Is it obligatory to fill the questionnaire?

Filling the questionnaire by respected respondents is completely voluntary. They can withdraw from filling the questionnaire at any stage they intend. It is worth noting that the questionnaire is only aimed at an academic study, and no personal information will be asked in it.

- Will my personal information be asked?

Undoubtedly, your identity will remain anonymous in the questionnaire, and no personal information (such as first name, last name, ID number, birth certificate number, phone number, address, or postal code) will be asked. Therefore, the respondents will have no concern in this regard.

- Will the answers remain confidential?

It should be noted that respondents are asked no questions regarding identity in this questionnaire. Hence, the identity of none of the respondents will be determined. Moreover, the questionnaire has only academic objectives, and its data will be kept only by the researcher completely confidential.

- Are the questions of the questionnaire difficult?

It has been sought to design the questionnaire as simple as possible and avoid any complexity or ambiguity.

- Do the questions of the questionnaire have correct or incorrect answers?

No, the questionnaire has no correct or incorrect answers. The answers to the questions are respected regarding the personal attitude of each respondent and can undoubtedly differ from those of other respondents.

- How long does it take to complete the questionnaire?

Between 8 and 13 min.

- Given the points mentioned, are you willing to complete the questionnaire?

Yes ○No○.

A brief introduction of delivery robots.

Delivery robots are a new technology in last-mile delivery. They are electrical, small, and self-driving robots that move through sidewalks. These robots can deliver goods with a maximum weight of 18 kg to buyers within a radius of 6 km with a maximum speed of 16 km/h. They are equipped with different radars, cameras, and ultrasonic sensors to select the shortest route and detect any barrier on their way. Using the related application, a buyer can follow the movement direction of a robot and its real-time location. The door of the delivery robot is mechanically locked in the direction. When the robot reaches the intended location, the application informs the buyer. Then, using the application, the buyer can open the robot's door and receive the goods.

Please watch the video below (with a duration of 1 min and 30 s) to become more familiar with delivery robots.

Part 2: Opinions of the respondents about delivery robots

- Have you ever purchased a good online?

Yes ○No○.

- Have you ever read or heard any content about delivery robots?

Yes ○No○.

- In the case of promotion of delivery robots in the future, express how much you agree/disagree with the following statements according to your personal attitude.

Statements	Strongly Disagree	Disagree	Somewhat Disagree	Neither Agree Nor Disagree	Somewhat Agree	Agree	Strongly Agree
1. I feel using delivery robots would enable me to receive my parcel more quickly compared to home delivery (motorcycle or car).	○	○	○	○	○	○	○
2. I feel using delivery robots would enable me to receive my parcel in a more environmentally friendly way.	○	○	○	○	○	○	○
3. I feel using delivery robots improves the parcel delivery process.	○	○	○	○	○	○	○
4. I feel using delivery robots would be advantageous compared to home delivery (motorcycle or car).	○	○	○	○	○	○	○
5. I feel using delivery robots is the best way to receive my parcels.	○	○	○	○	○	○	○
6. I feel using delivery robots would be compatible with my lifestyle.	○	○	○	○	○	○	○
7. I feel using delivery robots fits well with the way I like to receive parcels.	○	○	○	○	○	○	○
8. I feel using delivery robots would be compatible with my needs.	○	○	○	○	○	○	○
9. I feel using delivery robots would be compatible with my current situation.	○	○	○	○	○	○	○
10. I feel delivery robots are difficult to use.	○	○	○	○	○	○	○
11. I feel delivery robots are frustrating to use.	○	○	○	○	○	○	○
12. I feel delivery robots are cumbersome to use.	○	○	○	○	○	○	○
13. I feel delivery robots require a lot of effort to use.	○	○	○	○	○	○	○
14. I feel delivery robots are easy to use.	○	○	○	○	○	○	○
15. I feel delivery robots are difficult to learn how to use.	○	○	○	○	○	○	○
16. I feel I can learn how to use delivery robots.	○	○	○	○	○	○	○
17. I feel I can explain to others how to use delivery robots.	○	○	○	○	○	○	○
18. I would have no difficulty explaining why using delivery robots is or is not beneficial.	○	○	○	○	○	○	○
19. The process of using delivery robots is apparent to me.	○	○	○	○	○	○	○
20. I think environmental problems are becoming more and more serious in recent years.	○	○	○	○	○	○	○
21. I think human beings should live in harmony with nature in order to achieve sustainable development.	○	○	○	○	○	○	○
22. I think we are not doing enough to save scarce natural resource from being used up.	○	○	○	○	○	○	○
23. I think individuals have the responsibility to protect the environment.	○	○	○	○	○	○	○
24. Current delivery methods (e.g. motorcycle or car) can cause air pollution.	○	○	○	○	○	○	○
25. Current delivery methods (e.g. motorcycle or car) can potentially have a negative impact on global warming.	○	○	○	○	○	○	○
26. Current delivery methods (e.g. motorcycle or car) can lead environmental pollution.	○	○	○	○	○	○	○
27. I believe that consumers are partly responsible for environmental problems potentially caused by current delivery methods (e.g. motorcycle or car).	○	○	○	○	○	○	○
28. I feel that consumers are jointly responsible for the environmental deterioration potentially caused by current delivery methods (e.g. motorcycle or car).	○	○	○	○	○	○	○
29. I believe that every consumer is partly responsible for the environmental problems caused by current delivery methods (e.g. motorcycle or car).	○	○	○	○	○	○	○
30. I feel an obligation to choose an environmentally friendly way, such as delivery robots when ordering products online.	○	○	○	○	○	○	○
31. Regardless of what other people do, because of my own values/ principles I feel that I should behave in an environmentally friendly way when ordering products online.	○	○	○	○	○	○	○
32. I feel it is important that consumers behave in a sustainable way when ordering products online.	○	○	○	○	○	○	○

33. What is your opinion about delivery robots?

	1	2	3	4	5	6	7	
(1) Negative	○	○	○	○	○	○	○	(7) Positive
(1) Unpleasant	○	○	○	○	○	○	○	(7) Pleasant
(1) Unfavorable	○	○	○	○	○	○	○	(7) Favorable

34. In the case of the promotion of delivery robots in the future, what is your decision to use them as a method to receive goods?

	1	2	3	4	5	6	7	
(1) Impossible	○	○	○	○	○	○	○	(7) Possible
(1) Not Probable	○	○	○	○	○	○	○	(7) Very Probable
(1) Very Unlikely	○	○	○	○	○	○	○	(7) Very Likely

Part 3: Respondent's profile

1 Gender:
○Male ○Female

2. Age:

○<19 ○20-29 ○30-39 ○40-49 ○>50

3. Household income (Million Tomans/Month):

○<2 ○2-3.99 ○4-5.99 ○6-8 ○>8

4. Education:

○High school or below ○Diploma ○Associate degree/Some College
○Bachelor degree ○Master degree ○PhD/Doctoral or higher

5. Marital Status:

○Single ○Married ○Divorced
○Living apart from my spouse. ○I have lost my spouse.

- Comment/ suggestion/ criticism about the questionnaire:
  Thank you for your contributions.

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