Acceptance of Autonomous Delivery Vehicles for Last-Mile Delivery in Germany – Extending UTAUT2 with Risk Perceptions

Abstract

The inevitable need to develop new delivery practices in last-mile logistics arises from the enormously growing business to consumer (B2C) e-commerce and the associated challenges for logistics service providers. Autonomous delivery vehicles (ADVs) are believed to have the potential to revolutionise last-mile delivery in a way that is more sustainable and customer focused. However, if not widely accepted, the introduction of ADVs as a delivery option can be a substantial waste of resources. At present, the research on consumers' receptivity of innovations in last-mile delivery, such as ADVs, is limited. This study is the first that investigates the users' acceptance of ADVs in Germany by utilising an extended Unified Theory of Acceptance and Use of Technology (UTAUT2) and adapted it to the context of ADVs in last-mile delivery. Quantitative data was collected through an online survey approach (n=501) and structural equation modelling was undertaken. The results indicate that price sensitivity is the strongest predictor of behavioural intention (i.e., user acceptance), followed by performance expectancy, hedonic motivation, perceived risk, social influence and facilitating conditions, whereas no effect could be found for effort expectancy. These findings have important theoretical and practical contributions in the areas of technology acceptance and last-mile delivery.

Keywords: user acceptance, home delivery, last-mile transportation, UTAUT2, perceived risk, Germany

Declarations of interest: none.

1. Introduction

Lately, last-mile delivery has received a great deal of attention mainly due to the enormously growing e-commerce (Wang *et al.*, 2016; Liu *et al.*, 2019a; BIEK, 2017, 2018, 2019). In the case of Germany, the overall e-commerce turnover more than tripled from 2009 to 2018, which has especially been driven by the business to consumer (B2C) segment (BIEK, 2017, 2018, 2019; Handelsverband Deutschland, 2019). According to the Handelsverband Deutschland (2019) the German B2C e-commerce turnover has accounted for 53.3 billion euros (including tangible and digital products) in 2018, which was an increase of 9.1 percent compared to the year 2017. Furthermore, the German e-commerce has still not matured and a further major rise is predicted for the years to come (Handelsverband Deutschland, 2019). Following this trend, the increasing monetary value of e-commerce also leads to a simultaneous increase of parcels shipped (BIEK, 2017). In 2018, 1.75 billion shipments were delivered to private homes (i.e., B2C shipments) in Germany. For the year 2019 1.84 billion shipments are forecasted, which will be an increase of 90 million shipments compared to the year 2018 (BIEK, 2019).

Despite the higher convenience for the recipient and the positive effects for logistics service providers through increasing business opportunities, home delivery imposes a variety of social costs due to the increased number of delivery vehicles (e.g., vans and trucks) in residential areas. This includes, but is not limited to, road congestion effects and increasing noise as well as CO_2 emissions (Liu *et al.*, 2019a; Weltevreden, 2008). Since these negative externalities have not only major impact on the life quality and the economic competitiveness of urban areas but also on the overall traffic safety (Savelsbergh and van Woensel, 2016), governments react with traffic restrictions (e.g., road closures for diesel vehicles in Hamburg) (SHZ, 2018). In addition to governmental restrictions, logisticians are also presented with higher customer demands, nowadays. For instance, more environmentally-friendly delivery options, higher flexibility and faster deliveries (Deutsche Post AG, 2012).

Considering these trends from a logistics service provider perspective, it has been argued that current transportation practices (i.e., van delivery) do not seem suitable to cope with this fast changing environment efficiently (Joerss *et al.*, 2016; Marsden *et al.*, 2018; Florio *et al.*, 2018). Thus, the necessity of adjusting last-mile transportation practices arises. Meeting the need for change, especially autonomous delivery vehicles (ADVs), which are defined as electric and self-driving ground vehicles driving on sidewalks and streets, are believed to have the potential to revolutionize the market of last-mile delivery and as such makes it a more sustainable, efficient and customer focused transportation alternative (Joerss *et al.*, 2016; Marsden *et al.*, 2018).

Despite the potential for ADVs in last-mile delivery, logistics service providers need to introduce ADVs in a way that is generally accepted by the public. In fact, if not widely accepted by the public, the development and introduction of ADVs can be a substantial waste of resources for logistics service providers and vehicle developers alike. Therefore, it is necessary to evaluate user acceptance early in the development process (Davis *et al.*, 1989). To date, however, ADVs are still in its developing stage and the investigation of its underlying acceptance has received insufficient attention (e.g., Marsden *et al.*, 2018; Joerss *et al.*, 2016; Prümm *et al.*, 2017). Moreover, the studies available are rather descriptive and little emphasis is placed on the behavioural components involved. In other words, the psychological determinants of ADVs remain to be explored. Since last-mile delivery is a consumer-oriented service, which involves a strong behavioural component (Collins, 2015), it is imperative to identify the factors that determine the acceptance of ADVs as a delivery alternative to be able to design, develop and promote ADVs as an accepted alternative to its conventional delivery option (i.e., van delivery), which is the aim of this paper.

The paper proceeds as follows: First, the theoretical background of this research is presented. This includes previous research on the acceptance of AVs, ADVs, as well as the research gap that will be filled by this study. Next, the theoretical foundation of the research model is presented. Furthermore, the conceptual research model as well as the hypotheses development is outlined in detail. This section is followed by the research methodology applied as well as the data analysis, including the descriptive analysis and the structural equation modelling analysis (i.e., measurement model and structural model analysis). Then the research findings will be discussed mainly in regard to the AVs acceptance literature. Moreover, this section covers the theoretical and practical contributions, the research limitations as well as the suggestions for further research, followed by the final conclusions.

2. Literature Review

2.1. Previous Studies on the Acceptance of Autonomous Vehicles and Research Gap

Autonomous vehicles (e.g., autonomous cars and shuttles) are one of the most disruptive technologies in the transportation sector. In this regard, a large number of public opinion surveys were conducted over the previous years (Payre *et al.*, 2014; Howard and Dai, 2014; Rödel *et al.*, 2014; Schoettle and Sivak, 2014a, 2014b; Kyriakidis *et al.*, 2015; Bansal and Kockelman, 2016; Bansal *et al.*, 2016; Gkartzonikas and Gkritza, 2019). However, these studies are rather descriptive and do not follow any theoretical model to explain user acceptance of autonomous vehicles (AVs) (Zmud *et al.*, 2016b; Zmud and Sener, 2017). Therefore, the knowledge of users' intention to actually use AVs is still very limited (Panagiotopoulos and Dimitrakopoulos, 2018; Nordhoff *et al.*, 2016). For instance, Madigan *et al.* (2016) and Madigan *et al.* (2017) investigated the intention of automated shuttles by utilising the Unified Theory of Acceptance and Use of Technology (UTAUT), Choi and Ji (2015) investigated the importance of trust in AVs by utilising the Technology Acceptance Model (TAM), and Rahman *et al.* (2017) assessed the utility of TAM, Theory of Planned Behaviour (TPB), and UTAUT for advanced driver assistance systems. However, all of the aforementioned studies considered only vehicles that were explicitly developed to carry people from one location to another (e.g., cars or shuttles). Therefore, the focus of acceptance investigations is mostly from a passenger perspective. To date, there is limited research on the psychological factors that determine public acceptance of AVs from an outside vehicle perspective (Hulse *et al.*, 2018) and in particular for AVs that were designed to carry goods only (i.e., designed for logistical purposes). This study differentiates itself from the existing studies on user acceptance of AVs in a way that it looks explicitly into the acceptance determinants from the recipient and as such from an outside perspective in the particular context of last-mile delivery. In other words, the user acceptance of autonomous delivery vehicles (ADVs) is investigated.

Reviewing the literature in this specific research field showed that an insufficient number of studies exist that focus explicitly on the acceptance of ADVs in the context of last-mile delivery (Rohleder, 2016; Eurobarometer, 2017; Joerss *et al.*, 2016; Prümm *et al.*, 2017; Braun and Buckstegen, 2017). Moreover, these studies are rather descriptive in nature and little emphasis is placed on the behavioural components of users' intention decision towards ADVs. Additionally, the attempt to explore the theoretical relationships between the various variables is missing in these studies. Marsden *et al.* (2018) were the first, to the best of our knowledge, that investigated user acceptance of ADVs in more detail. In their quantitative study in 2017 they found, for instance, that ADVs are considered ‘environmentally-friendly’ and ‘innovative’, whereas on the negative side ADVs are considered to be ‘uncanny’, ‘dangerous’ or ‘not trustworthy’. Like the other descriptive studies, they also ignored the use of a theoretical model to investigate users’ acceptance. This knowledge gap will be filled within this study. To the best of our knowledge, this study is the first that investigates the behavioural components of users’ intentions (i.e., user acceptance) in the context of ADVs in last-mile delivery.

2.2. Foundation of the Theoretically Proposed Research Model

The extended Unified Theory of Acceptance and Use of Technology (UTAUT2) will be utilised and further adapted to the context of ADVs, which was explicitly developed to investigate consumer acceptance of technology (Venkatesh *et al.*, 2012). Venkatesh *et al.* (2003) attempt was to overcome the criticisms of previously used technology acceptance models (e.g., technology acceptance model (TAM)) that were stated having a deterministic approach without considering individual characteristics (Agarwal and Prasad, 1998). UTAUT2 is not only a synthesis of eight regularly used theories in technology acceptance research, e.g., theory of reasoned action (TRA) and TAM, but also includes three variables explicitly proposed to be important in the consumer context (i.e., habit, hedonic motivation, and price value). Therefore, it was considered theoretically and practically useful to utilise UTAUT2 as the theoretical basis in this research. However, to fit the model to the context of ADVs some modifications were necessary, which will be presented in the following.

First, behavioural intention is proposed to be the main dependent construct and as such is representing user acceptance in this study. Excluding use behaviour is based on theoretical and practical reasons. From a theoretical point of view, it has been found in various studies that behavioural intention is the key predictor of use behaviour and therefore totally mediates the effect of other constructs on behaviour (Ajzen and Fishbein, 1980; Taylor and Todd, 1995; Ajzen, 1991; Venkatesh and Davis, 2000; Pavlou, 2003; Neufeld *et al.*, 2007; Alalwan *et al.*, 2018). From a practical perspective, it was not possible to investigate use behaviour at this stage of technology introduction, since ADVs are not yet available as a delivery option. This is also the reason for several other studies that dismissed the use behaviour construct in their studies (Tamilmani *et al.*, 2018a; Tamilmani *et al.*, 2018b).

Second, habit was also excluded from the model, although it has been proven in prior studies to be significant (Venkatesh *et al.*, 2012). However, as mentioned before, ADVs are not regularly available in Germany and, therefore, consumers could not develop any habitual behaviour towards this technology. Thus, it was not possible to investigate habit in a reasonable way in this study.

Third, price value, which was explicitly included within the consumer context by Venkatesh *et al.* (2012), was modified to price sensitivity. For investigating price value consumers need to be aware of the price as well as the technology and its benefits beforehand. Again, it was not possible to investigate this construct at this stage of technology introduction. However, price is still considered important in the highly competitive market of last-mile delivery. In comparison to price value, price sensitivity is more related to consumers’ willingness to pay for a specific product or service (Tsai and LaRose, 2015). Thus, this construct can already be investigated before the broad market introduction of ADV services.

Finally, previous research suggests that the technology acceptance is determined by people’s perception of risk (Zhu and Xie, 2015). Specifically, Marsden *et al.* (2018) and Braun and

Buckstegen (2017) found in their studies that ADVs are believed to be a risky delivery alternative. Indeed, ADVs bear potential risks such as safety risk whilst driving autonomously on the public road networks or performance risk whilst dropping of parcels (e.g., risk of malfunctioning of the technology). Following the research stream of AVs acceptance, perceived risk has been investigated in various studies (Liu *et al.*, 2019b; Liu *et al.*, 2019c; Liu *et al.*, 2019d; Liu *et al.*, 2019e; Choi and Ji, 2015; Ward *et al.*, 2017; Gkartzonikas and Gkritza, 2019). Hence, perceived risk was included as an additional construct in this study.

3. Conceptual Research Model and Hypotheses Development

As outlined before, the UTAUT2 will be utilised as a foundation to investigate user acceptance of ADVs in last-mile delivery. However, to examine the specific case of ADVs acceptance the model needed to be modified and extended. The proposed 'Autonomous Delivery Vehicle Acceptance Model (ADV-AM)' is presented in Figure 1. In the following, the constructs of the proposed research model and the developed hypotheses will be presented.

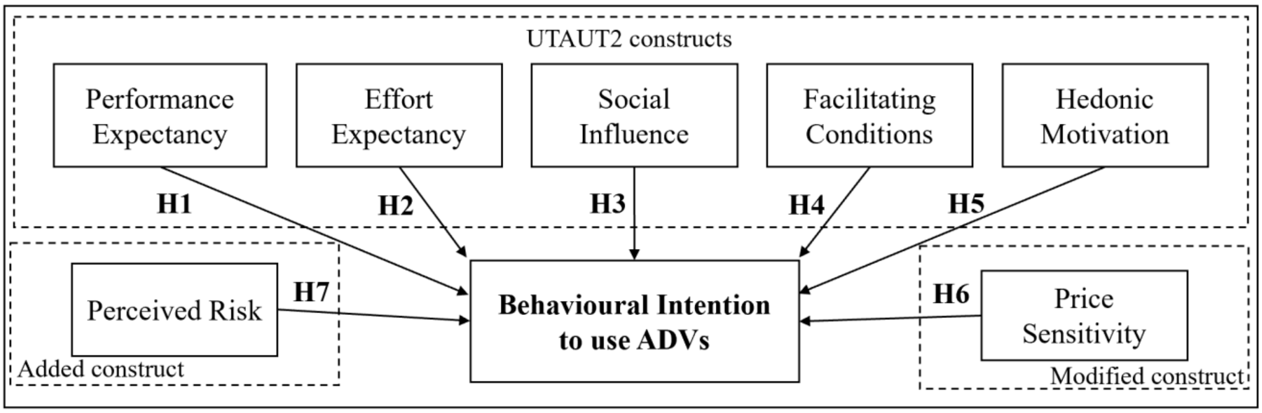

Figure 1: Proposed ADVs Acceptance Model

3.1 UTAUT2 Constructs

Performance expectancy is defined as the degree to which using ADVs as a delivery option will provide benefits to consumers. It has been stated to be one of the major constructs for predicting behavioural intention in various studies. This holds also true for the context of AVs acceptance, where it has been found to be a strong predictor of user acceptance (Madigan *et al.*, 2017; Madigan *et al.*, 2016; Rahman *et al.*, 2017; Kervick *et al.*, 2015; Adell, 2010; Zmud *et al.*, 2016a; Angelis *et al.*, 2017; Moták *et al.*, 2017; Xu *et al.*, 2018; Rahman *et al.*, 2018; Choi and Ji, 2015; Lee *et al.*, 2019). The use of ADVs as a delivery option is believed to be more consumer orientated and therefore more useful over its traditional alternative (i.e., van delivery) (Marsden *et al.*, 2018). This is the case, since the delivery with ADVs will be more flexible, more convenient and highly transparent for the recipient, which has been proven to be highly important in last-mile delivery (Deutsche Post AG, 2012). Therefore, the following hypothesis is proposed:

H1: Performance expectancy positively influences behavioural intention to use ADVs.

Effort expectancy is defined as “the degree of ease associated with consumers’ use of technology” (Venkatesh et al., 2012, p. 159). Effort expectancy (i.e., ease of use) has also been proven influential in various AVs acceptance studies (Choi and Ji, 2015; Madigan *et al.*, 2016; Zmud *et al.*, 2016a; Rahman *et al.*, 2017; Leicht *et al.*, 2018; Panagiotopoulos and Dimitrakopoulos, 2018; Buckley *et al.*, 2018; Xu *et al.*, 2018). In the context of ADVs it is believed that complexity arises when the recipients interact with the vehicles via the mobile app. This is the case because the recipient does not only need to order the vehicle to the right place at the right time, but also must he/she connect his/her smartphone for authorization to the vehicle. While some consumers may perceive the extra effort as only marginal, others may feel it burdensome and thus form unfavourable intentions towards using ADVs as a delivery option. Therefore, the following hypothesis is proposed:

H2: Effort expectancy positively influences behavioural intention to use ADVs.

Social influence is defined as “the extent to which consumers perceive that important others (e.g., family and friends) believe they should use a particular technology” (Venkatesh et al., 2012, p. 159). Social influence has been proven to be a remarkable predictor in several AVs acceptance studies (Adell, 2010; Kervick *et al.*, 2015; Madigan *et al.*, 2016; Madigan *et al.*, 2017; Zmud *et al.*, 2016a; Rahman *et al.*, 2017; Leicht *et al.*, 2018; Panagiotopoulos and Dimitrakopoulos, 2018; Buckley *et al.*, 2018). Like in other contexts where new technologies have been introduced, it seems likely that consumers will be influenced by their peers in the context of ADVs. Thus, the underlying assumption is that users will consult with their social network before using ADVs. Therefore, the following hypothesis is proposed:

H3: Social influence positively influences behavioural intention to use ADVs.

Facilitating condition is defined as “consumers’ perceptions of the resources and support available to perform a behavior” (Venkatesh et al., 2012, p. 159). Facilitating condition has been found to be significant in various AVs acceptance studies (Madigan *et al.*, 2017; Moták *et al.*, 2017; Choi and Ji, 2015; Buckley *et al.*, 2018; Chen and Yan, 2018). For the context of ADVs it is believed that users have different levels of access to information and resources that facilitate their use of ADVs (e.g., personal knowledge, help-hotlines, the internet, peers, etc.). In general, consumers with a lower level of facilitating conditions will have lower intentions to use ADVs. Following the above arguments, the following hypothesis is proposed:

H4: Facilitating conditions positively influence behavioural intention to use ADVs.

Hedonic motivation is defined as “the fun or pleasure derived from using a technology” (Venkatesh et al., 2012, p. 161). Although hedonic motivation has only been studied minorly in the UTAUT2 context; the construct has been found influential in the AVs acceptance context (Madigan *et al.*, 2017). In the underlying context, it is believed that the fun or pleasure derived from using ADVs plays a major role in forming user acceptance. This is because people who believe that ADVs and the interaction with it is enjoyable are more open-minded towards those delivery systems. Therefore, the following hypothesis is proposed:

H5: Hedonic motivation positively influences behavioural intention to use ADVs.

3.2 Added and Modified Constructs in the Context of ADVs

As outlined before, in this study modified or additional constructs are proposed for the specific context of ADVs acceptance. One of which is price sensitivity. In a broader technology acceptance context it is defined as "the way in which buyers react to prices and to price changes" (Goldsmith et al., 2005, p. 501). Although price sensitivity has been investigated and proven influential in previous acceptance studies (Goldsmith et al., 2005; Goldsmith and Newell, 1997), it is one of the areas less researched, especially in the field of technology acceptance and adoption (Tsai and LaRose, 2015; Natarajan et al., 2017; Goldsmith and Newell, 1997). In the context of UTAUT2 it has not been studied before. Even though ADVs as a delivery concept are very likely to decrease the cost (Joerss *et al.*, 2016), it is not clear whether these costs will also lead to a decrease of actual delivery costs for the final customer. Since the ADVs include additional advantages for the user (e.g., higher flexibility), it could also be the case that logistics service providers introduce this kind of delivery as a premium service by which it would include extra costs. Therefore, the following hypothesis is proposed:

H6: Price sensitivity negatively influences behavioural intention to use ADVs.

In the context of ADVs, perceived risk can be defined as overall "potential for loss in the pursuit of a desired outcome" of using ADVs as a delivery option (Featherman and Pavlou, 2003, p. 454). Despite the fact that many new technological services are considered inherently risky (Slade *et al.*, 2015), perceived risk has been overlooked by previous technology acceptance models (Koenig-Lewis *et al.*, 2015). However, according to Cowart *et al.* (2008) studying detractors, like perceived risk, is important since consumers tend to consider not only the incentives but also the threats in their adoption decision. Following this argument, several AVs acceptance studies have investigated the effect of risk perceptions on the acceptance and adoption of AVs (Liu *et al.*, 2019e; Liu *et al.*, 2019d; Liu *et al.*, 2019c; Liu *et al.*, 2019b; Choi and Ji, 2015; Ward *et al.*, 2017; Kervick *et al.*, 2015; Chen and Yan, 2018; Lee *et al.*, 2019). Given the infancy of ADVs and its characteristics it is indicated that there may exist potential risk sources, such as poor technology interaction (e.g., the locker cannot be opened) or the danger of potential accidents on public roads. Furthermore, the higher complexity of ADV services compared to the conventional delivery options might increase the perception of risk in the technology. Thus, it is likely that the adoption of ADVs will be negatively influenced by perceptions of risk. Therefore, the following hypothesis is proposed:

H7: Perceived risk negatively influences behavioural intention to use ADVs.

4. Methodology

4.1. Questionnaire

In common with existing quantitative technology acceptance research, a survey methodology was employed by using validated scales. The operationalisation and references of the items are presented in

Table 1. The final questionnaire consists of four parts to be completed. The first part of the questionnaire was the cover letter. The second part of the questionnaire included the demographic characteristics (e.g., age, gender, monthly household net-income, employment status). The third part of the questionnaire was an information sheet, which was designed to give the respondents some

basic information on ADVs (e.g., advantages, size of the vehicles, etc.). The fourth part of the questionnaire contained the questions on the participants familiarity of ADVs as well as on the measurement items, which had been validated in previous technology acceptance studies and are consistent with the definitions used in this study. Items were measured with a seven-point Likert scale ranging from 1 = 'strongly disagree' to 7 = 'strongly agree'. The survey questions (English version) including the information sheet is provided in Appendix "A".

Table 1: Constructs, their items, and sources

Construct	Items	Source adapted
Performance Expectancy (PE)	PE1: I would find autonomous delivery vehicles useful in my daily life. PE2: Using autonomous delivery vehicles would help me accomplish things more quickly. PE3: Using autonomous delivery vehicles would increase my productivity. PE4: Using autonomous delivery vehicles would increase my flexibility in my daily life.	(Venkatesh *et al.*, 2012)
Effort Expectancy (EE)	EE1: Learning how to use autonomous delivery vehicles would be easy for me. EE2: My interaction with the autonomous delivery vehicle via the mobile app would be clear and understandable. EE3: I would find autonomous delivery vehicles easy to use. EE4: It would be easy for me to become skilful at using autonomous delivery vehicles.	(Venkatesh *et al.*, 2012)
Social Influence (SI)	SI1: People who are important to me would think that I should use autonomous delivery vehicles. SI2: People who influence my behaviour would think that I should use autonomous delivery vehicles. SI3: People whose opinion I value would prefer that I use autonomous delivery vehicles.	(Venkatesh *et al.*, 2012)
Facilitating Conditions (FC)	FC1: I have the resources necessary to use autonomous delivery vehicles (i.e., mobile device). FC2: I have the knowledge necessary to use autonomous delivery vehicles. FC3: Autonomous delivery vehicles are compatible with other technologies I use (e.g., smartphone). FC4: I can get help from others when I have difficulties using autonomous delivery vehicles.	(Venkatesh *et al.*, 2012)
Hedonic Motivation (HM)	HM1: Using autonomous delivery vehicles would be fun. HM2: Using autonomous delivery vehicles would be enjoyable. HM3: Using autonomous delivery vehicles would be very entertaining.	(Venkatesh *et al.*, 2012)
Price Sensitivity (PS)	PS1: I would not mind paying more to try out autonomous delivery vehicles as a delivery option *(reverse).* PS2: I would not mind spending a lot of money for getting my orders delivered by autonomous delivery vehicles *(reverse).* PS3: I would be less willing to pay for autonomous delivery vehicles as a delivery option if I thought it to be high in price. PS4: If I knew that autonomous delivery vehicles as a delivery option were likely to be more expensive than conventional delivery options, that would not matter to me *(reverse).* PS5: A really great delivery option would be worth paying a lot of money for.	(Goldsmith *et al.*, 2005)
Perceived Risk (PR)	PR_O1: Overall, using autonomous delivery vehicles as a delivery option would be risky. PR_O2: Overall, autonomous delivery vehicles as a delivery option would be dangerous to use. PR_O3: Using autonomous delivery vehicles as a delivery option would expose me to an overall risk.	(Featherman and Pavlou, 2003)
Behavioural Intention (BI)	BI1: I intend to use autonomous delivery vehicles as a delivery option in the future. BI2: I would always try to use autonomous delivery vehicles as a delivery option in my daily life when available in the future. BI3: I plan to use autonomous delivery vehicles frequently when available in the future.	(Venkatesh *et al.*, 2012)

A pre-test of the survey instrument was conducted with eight participants (i.e., academics and non-academics), which are fluent in English to rectify any problems prior to data collection. The participants recommended some minor changes of the wording of the questionnaire items to increase the simplicity. Additionally, it was recommended to include more information on ADVs into the information sheet to get a better understanding of this delivery system. Considering this feedback, some changes were made to the wording of the items as well as the information sheet provided. Next, the questionnaire was translated by two independent translators using the backwards translation technique (Brislin, 1970). After the translation process was completed, the researcher compared both English versions (original and backtranslation) of the questionnaire and checked it for any discrepancies, mistranslations, or problems in meaning. Since some minor translation discrepancies occurred in the back-translated English version, the researcher discussed those with both translators, which led to a minor refinement of the German questionnaire version. As with the English version of the questionnaire, the German version was pre-tested with nine participants (i.e., academics and non-academics) and the feedback, again, led to few changes in the wording of some questions to decrease the complexity. As a final step, the online version of the final German questionnaire was created on the Qualtrics platform.

4.2. Participants and Procedures

Since this study aims to be approximately representative of the German population, quota sampling was applied based on three quotas (i.e., age, gender, and monthly net-household income). These were developed based on the census data of the Statistical Bureau of Germany (Destatis, 2017b) as well as the European Union (Eurostat, 2017) and are provided in Table 2.

Table 2: Quotas

Criteria	Characteristics	Percentage
Gender	Male	49
	Female	51
Age	18-24 years	9
	25-34 years	15
	35-49 years	24
	50-64 years	27
	65 + years	25
Monthly Household Net Income	< 900 €	9
	900 – below 1,300 €	12
	1,300 – below 1,500 €	7
	1,500 – below 2,000 €	16
	2,000 – below 2,600 €	15
	2,600 – below 3,200 €	11
	3,200 – below 4,500 €	16
	4,500 – below 6,000 €	8
	> 6,000 €	6

Due to the necessity for statistical analysis (structural equation modelling), the sample size was set to be at least 500. Based on this number the quotas were calculated appropriately. To be able to collect the highest quality of data the sampling and data collection of the research was conducted in cooperation with Qualtrics. Respondents were randomly selected by Qualtrics panel partners from the German panel base. German panel members (i.e., 18 years and above) were invited via email to participate in this study. Qualtrics stopped collecting data for the quotas when they were appropriately filled. Only complete datasets were saved, whereas incomplete datasets were automatically discarded by the system. The data collection took place in December 2018 and January 2019.

4.3. Data Analysis

Structural equation modelling (SEM), which combines multiple regression with factor analysis, was used to analyse the data. The reason for this was that SEM allows simultaneous analysis of all relationships as well as allows observed and unobserved variables to be analysed at the same time (Hair *et al.*, 2014). Furthermore, SEM takes into consideration measurement errors of the observed variables (Hair *et al.*, 2014). The two step approach recommended by Anderson and Gerbing (1988) was utilised. As such, confirmatory factor analysis was conducted, which was then followed by the structural analysis of the relationships (i.e., path analysis). AMOS version 25 (Maximum Likelihood Estimations) were used as a software package for data analysis.

5. Results

5.1. Descriptive Results

In total, 501 complete datasets were saved and used for data analysis (conversion rate 47%[1]). The quotas were all appropriately filled. There were only slight differences in the age section (35-49 years -1%; 50-64 years +0.5%; 65+ years +0.5%) in comparison to the quotas set. Since they are rather small (≤ 1%), they are acceptable. Overall, the gathered data is comparable on a relative basis to the census of Germany in terms of gender, age, and monthly household net-income and, therefore, considered partially representative for the German population (see Table 3).

Table 3: Demographic Characteristics and Familiarity with ADVs

Variable	Category	Frequency (n=501)	Percentage
Gender	Male	247	49
	Female	254	51
Age	18-24 years	44	9
	25-34 years	76	15
	35-49 years	115	23
	50-64 years	138	27.5
	65 + years	128	25.5
Monthly Household Net Income	< 900 €	46	9
	900 € - below 1,300 €	60	12
	1,300 € - below 1,500 €	35	7
	1,500 € - below 2,000 €	78	16
	2,000 € - below 2,600 €	74	15
	2,600 € - below 3,200 €	57	11
	3,200 € - below 4,500 €	82	16
	4,500 € - below 6,000 €	39	8
	6,000 € and above	30	6
Education	Secondary School Certificate or below	224	45
	High school degree	109	22
	University diploma	46	9
	Bachelor's degree	50	10
	Master's degree	48	10
	Doctorate	5	1
	No degree	4	1
	other	15	3
Employment status	Full-time employment	192	38
	Part-time employment	60	12
	Seeking work	28	6
	Retired	163	33
	Pupil	5	1
	Student	29	6
	Unable to work	24	5
Heard about ADVs (‚familiarity')	Yes	245	49
	No	252	51

Almost half of the participants stated that their highest degree was a Secondary School Certificate (45 percent), whereas higher education levels were rather low (e.g., bachelor's and master's degree together only 20 percent). Considering the actual numbers of the Statistical Bureau of Germany, 53 percent of the German population has a secondary school certificate or below, whereas only 18 percent have university education. Therefore, this sample includes a slight amount of higher educated people compared to the German population (Destatis, 2017a). Furthermore, the data shows a good mixture of participants' employment status. 50 percent of the participants are working either full-time or part-time and 33 percent are retirees, which is not surprising, since more than one-fourth of the participants are above the age of 65 years. Moreover, seven percent of respondents stated to be students. Compared to the number of the German Bureau of Statistics 2.9 million students are

[1] Conversion rate = how many people completed the survey vs. how many people accessed it.

enrolled at German universities, which represents 3.5 percent of the German population (Destatis, 2019). In this study double as much students took part; thus, students are overrepresented. Interestingly, 49 percent (i.e., 245 participants) have already heard about ADVs as a delivery option, whereas for 51 percent this type of delivery was completely new.

5.2. Measurement Model Assessment

There is no single index that can be used to distinguish good models from poor ones (Hair *et al.*, 2014). Accordingly, it is recommended to use multiple fit-indices, which can support determining acceptable model fit (Hair *et al.*, 2014; Byrne, 2016). It is suggest complementing the Chi-square and the associated degrees of freedom with at least one absolute fit index as well as one incremental fit index (Hair *et al.*, 2014). Therefore, the model fit was assessed in terms of four measures commonly used: CMIN/DF (normed chi-square; $1.0 < \chi^2/df < 3.0$), comparative fit index (CFI; ≥ 0.95), Tucker-Lewis index (TLI; ≥ 0.95), and the Root Mean Square Error of Approximation (RMSEA; ≤ 0.07) (Hair *et al.*, 2014; Byrne, 2016; Hu and Bentler, 1999). Additionally, through the analysis of the standardised regression weights (i.e., beta-coefficients; threshold > 0.60), the standardised residual covariances (range |2,58|), and the modification indices (high standardised regression weights) it was decided to remove PS3 and PS1, which significantly improved the model fit indices to a good model fit. The results can be found in Table 4.

Table 4: Measurement Model Assessment

Indices	χ^2	df	CMIN/DF	RMSEA	TLI	CFI
Standards	-	-	Between 1 and 3	≤ 0.07	≥ 0.95	≥ 0.95
Results	790.152	296	2.669	0.058	0.963	0.969

In addition to the model fit, the measurement model was assessed in terms of convergent validity, discriminant validity as well as internal consistency (see Table 5). In this study we test the items using analysis of cross-loading, discriminant validity and reliability. The items that were refined (Table 5 and Appendix "B") were tested with the aim to obtain the factor analysis that had convergent validity, which was highly standardised.

Table 5: Results of factor loadings, construct reliability, AVE, item means, and standard deviation

Construct	Item	Factor loading	CR	AVE	Mean	SD
Performance Expectancy	PE1	0.868	0.941	0.801	4.66	1.78
	PE2	0.940			4.47	1.83
	PE3	0.885			4.05	1.91
	PE4	0.884			4.48	1.87
Effort Expectancy	EE1	0.888	0.950	0.825	5.16	1.55
	EE2	0.899			5.03	1.57
	EE3	0.919			4.92	1.60
	EE4	0.926			4.94	1.60
Social Influence	SI1	0.933	0.965	0.903	4.03	1.75
	SI2	0.965			3.98	1.76
	SI3	0.952			3.88	1.72
Facilitating Conditions	FC1	0.849	0.897	0.685	5.11	2.04
	FC2	0.807			4.77	1.82
	FC3	0.909			5.10	1.80
	FC4	0.736			4.80	1.67
Hedonic Motivation	HM1	0.943	0.964	0.900	4.67	1.83
	HM2	0.972			4.54	1.81
	HM3	0.931			4.50	1.81
Price Sensitivity	PS1	0.878	0.914	0.727	5.58	1.73
	PS2	0.832			5.25	1.74
	PS3	0.882			5.29	1.79
Perceived Risk	PR1	0.939	0.934	0.825	4.37	1.56
	PR2	0.956			4.26	1.61
	PR3	0.826			4.03	1.63
Behavioural Intention	BI1	0.929	0.966	0.905	3.83	1.81
	BI2	0.956			3.86	1.78
	BI3	0.968			3.94	1.77

Note: CR = composite reliability; AVE = average variance extracted; SD = standard deviation.

The standardised factor loadings were all above the threshold of 0.7 (Hair *et al.*, 2014), ranging from 0.736 – 0.968. Moreover, the average variance extracted (AVE) was also above the required threshold of 0.5 (Fornell and Larcker, 1981), thus demonstrating convergent validity. Since the square roots of the AVE for each construct was greater than the inter-construct correlation (see Table 5), discriminant validity is supported. Finally, the composite reliabilities are all above the recommended treshold of 0.70 (Hair *et al.*, 2014) and therefore support internal consistency (see Table 6).

Table 6: Results of Discriminant Validity of Measures and Correlation Matrix

	PR	**HM**	**PS**	**PE**	**EE**	**SI**	**FC**	**BI**	**Mean**	**SD**
PR	**0.909**								4.22	1.60
HM	-0.427	**0.949**							4.57	1.82
PS	0.246	-0.478	**0.864**						5.37	1.75
PE	-0.423	0.806	-0.450	**0.895**					4.42	1.85
EE	-0.363	0.664	-0.309	0.714	**0.908**				5.01	1.58
SI	-0.363	0.734	-0.526	0.740	0.639	**0.95**			3.96	1.74
FC	-0.346	0.628	-0.274	0.601	0.788	0.624	**0.828**		4.95	1.83
BI	-0.513	0.770	-0.634	0.760	0.601	0.744	0.584	**0.951**	3.90	1.79

Note: SD = standard deviation; PR = perceived risk; HM = hedonic motivation; PS = price sensitivity; PE = performance expectancy; EE = effort expectancy; SI = social influence; FC = facilitating conditions; BI = behavioural intention. The values on the diagonal are the square roots of the AVE; values below the diagonal are the inter-construct correlations ($p < 0.001$).

5.3. Structural Model Assessment

The procedure of the structural model assessment followed the same steps as with the confirmatory factor analysis. As a result, the structural model fit was also good (CMIN/DF: 2.669; CFI: 0.969;

TLI: 0.963; RMSEA: 0.058). The analysis of the paths revealed that eight of the nine structural hypotheses could be supported (see Table 7).

Table 7: Summary of Results of Structural Relationships

Hypothesis	Path	Proposed effect	β	Significance	Result
H1	PE → BI	+	0.231	<0.001	supported
H2	EE → BI	+	-0.048	0.347	rejected
H3	SI → BI	+	0.167	<0.001	supported
H4	FC → BI	+	0.103	<0.05	supported
H5	PS → BI	-	-0.281	<0.001	supported
H6	HM → BI	+	0.220	<0.001	supported
H7	PR → BI	-	-0.173	<0.001	supported

Note: PR = perceived risk; HM = hedonic motivation; PS = price sensitivity; PE = performance expectancy; EE = effort expectancy; SI = social influence; FC = facilitating conditions; BI = behavioural intention.

Significant positive relationships were found between performance expectancy and behavioural intention (confirming H1), social influence and behavioural intention (confirming H3), facilitating conditions and behavioural intention (confirming H4), hedonic motivation and behavioural intention (confirming H5). Significant negative relationships were found between perceived risk and behavioural intention (confirming H7) as well as price sensitivity and behavioural intention (confirming H5). However, no significant effect was found for the relationship between effort expectancy and behavioural intention (rejecting H2).

In a second step, ‘age’, ‘gender’, ‘education’, ‘monthly household net-income’, ‘employment’ and ‘heard about ADVs’ were controlled against behavioural intention in this study. All controls, except for ‘heard about ADVs’ were found insignificant (see Table 8). Even though ‘heard about ADVs’ was found significant, it did not change any of the hypothesised relationships significantly. As a result, including the control variables does not alter any of the significance levels of the path coefficient in the structural model, which shows the robustness of the overall research model. Overall, the six significant relationships on behavioural intention explained 76 percent of the variance on behavioural intention.

Table 8: SEM Analysis Control Variables

Path	β	Significance
Age → BI	-0.003	0.922
Gender → BI	-0.007	0.794
Education → BI	-0.016	0.547
Monthly Household Net-Income → BI	-0.002	0.930
Employment → BI	0.015	0.592
Heard about ADVs → BI	-0.069	0.009 (significant)

Note: BI = behavioural intention

6 Discussion

6.1. User Acceptance

In this study we investigated the user acceptance of ADVs, which are stated to have the potential to revolutionise last-mile delivery in a way that is more efficient, sustainable and customer-focused (Marsden *et al.*, 2018; Joerss *et al.*, 2016). The descriptive analysis revealed that the sample is partially representative for the German population in terms of age, gender, and monthly household net-income. Therefore, it is possible to generalise the findings to a larger population in Germany.

Overall, the respondents of our study seem to hold neutral acceptance towards the use of ADVs as a delivery alternative. Mathematically speaking, the mean scores of behavioural intentions (i.e., user acceptance) to use ADVs were not higher than the scale mid-point 4 (see Table 4). According to Liu *et al.* (2019b) it is quite common for the public to hold a neutral option of emerging technologies, because the public still needs to form an opinion in relation to the technology. This supports the need for investigating the acceptance of ADVs at an early stage, because the findings can still be incorporated into the development and design of such vehicles, which might improve the acceptance during the introduction stage.

6.2. Determinants of ADVs Acceptance

This study has produced two major observations. First, it was able to provide further evidence for some of the UTAUT2 constructs in the context of last-mile delivery and second, price sensitivity is the most important construct in acceptance formation at this point of technology introduction. Since price sensitivity was added to the original UTAUT2 model, this supports the need to tailor acceptance theories to their underlying context. In respect to the relationship strength (beta-coefficient) price sensitivity is followed by performance expectancy, hedonic motivation, perceived risk, social influence and facilitating conditions. In the following the constructs, will be discussed individually in regard to previous AVs acceptance studies.

First, concurrent with previous AVs acceptance studies (Adell, 2010; Kervick *et al.*, 2015; Madigan *et al.*, 2017; Rahman *et al.*, 2017; Xu *et al.*, 2018) the role of performance expectancy (i.e., usefulness) was supported in the context of ADVs acceptance (H1). Therefore, utilitarian benefits are an important aspect when accepting this innovative delivery technology. While in their original study, Venkatesh *et al.* (2003) found performance expectancy to be the most important construct. In this study, however, performance expectancy was only found to be the second strongest predictor after price sensitivity, indicating that the price for the delivery is more important to potential users than the usefulness of the technology itself. In other words, when the price is higher than the current price for home-delivery, Germans will very likely not accept this new kind of delivery.

Second, in accordance to the findings from several AVs acceptance studies (Madigan *et al.*, 2016; Madigan *et al.*, 2017; Panagiotopoulos and Dimitrakopoulos, 2018; Buckley *et al.*, 2018), social influence also plays a significant role in the acceptance formation in the context of ADVs. Indicating that our respondents are likely do depend on their peers' opinion in regard to ADVs. In other words, peer pressure can be taken into consideration for marketing purposes.

Third, the positive effect of facilitating conditions in the context of AVs found by Madigan *et al.* (2017), Choi and Ji (2015) and Buckley *et al.* (2018) holds also true for the context of ADVs in last-mile delivery. Thus, providing evidence that external resources like peer support plays an important aspect in user acceptance of ADVs.

Fourth, in line with the findings from Madigan *et al.* (2017) and Moták *et al.* (2017), who found that hedonic motivation (e.g., enjoyment) plays a significant role in determining behavioural intention in the context of AVs, within this study this effect has also been observed for the context of ADVs in last-mile delivery. Therefore, the fun and entertainment derived from using ADVs seems important to determine user acceptance.

Fifth, despite the fact that risk perceptions have been proposed to be important in the context of AVs (Liu *et al.*, 2019b; Liu *et al.*, 2019c; Liu *et al.*, 2019e; Choi and Ji, 2015; Kervick *et al.*, 2015), the empirical findings are rather mixed. For instance, Choi and Ji (2015) found an insignificant effect of perceived risk on behavioural intention and argue that this might be due to the high effect of trust in AVs, which reduces the environmental uncertainty and related risks. Liu *et al.* (2019b) found an insignificant effect of perceived risk on behavioural intention for highly automated vehicles, whereas for fully automated vehicles this effect was significant. Therefore, they argue that perceived risk cannot be seen as a steady predictor of AVs acceptance (Liu *et al.*, 2019b). However, in our study perceived risk has been proven as an important determinant of users' acceptance of ADVs. Indicating, the higher the risk perception by potential users' the lower the acceptance of ADVs.

Sixth, alongside all the positive findings in this study it was proposed that effort expectancy positively influence behavioural intention to use ADVs. However, no significant effect could be established in this study, which is in line with various other AVs acceptance studies (Kervick *et al.*, 2015; Madigan *et al.*, 2017; Angelis *et al.*, 2017; Rahman *et al.*, 2018). It was argued that the delivery process changes completely compared to the conventional delivery process, since the recipient has to take greater tasks to get their parcel delivered (e.g., connecting their smartphone to the vehicle via Bluetooth) and, therefore, increases the complexity for the recipient. However, the use of a smartphone and mobile apps seems to be ubiquitously for many purposes for most people nowadays and many people consider themselves as experienced when it comes to smartphone technology (Koenig-Lewis *et al.*, 2015). Since the use of ADVs is to a large extent operated via a mobile app, and people are experienced with mobile apps it might, therefore, be not that surprising and providing a reasonable argument that the effect of effort expectancy is insignificant in this study. However, it needs to be considered that ADVs are not regularly available in Germany yet. Therefore, participants of this study imagined the use of ADVs, including the imagination of the complexity of the mobile app. Thus, the effect might change after people had their first experience with ADVs (Xu *et al.*, 2018).

6.3. Theoretical and Practical Contributions

This study is an important effort towards a deeper understanding of the factors that affect user acceptance of ADVs for last-mile delivery in Germany. Therefore, this study enriches not only the academic literature in the fields of technology acceptance and logistics innovations but also provides guidance for logistics service providers on how to promote and market ADVs in a successful manner.

From a theoretical point of view, this is the first study that investigates user acceptance of ADVs in last-mile delivery by utilising a technology acceptance model. In doing so, UTAUT2 was applied to a new technological context (i.e., ADVs) as well as to the logistical context of last-mile transportation. Second, even though UTAUT2 was argued to be one of the most comprehensive research models in the field of technology acceptance, within this research it was necessary to adapt the model to the specific context of ADVs by incorporating perceived risk as well as modifying price value to price sensitivity. Finally, even though UTAUT2 was developed to investigate the acceptance of consumer technologies (e.g., mobile internet), no study could be identified that utilised UTAUT2 in the cultural context of Germany. Thus, some of the constructs investigated have also proven its applicability for the German consumer context with focus on last-mile delivery services.

From a practical point of view, this research has also several contributions. First, price sensitivity was identified as the most important construct in user acceptance of ADVs at this point of technology introduction (i.e., before the actual market introduction). Therefore, the pricing of this delivery system should be considered carefully. To attract as many potential users as possible, it is recommendable that the price should be lower than for conventional home-delivery. Second, this study found that utilitarian benefits (i.e., performance expectancy) of ADVs are also very important to potential users. Hence, developers, designers, and marketers should focus the development and the marketing communication activities of ADVs on the usefulness of this last-mile delivery option (e.g., higher flexibility, higher convenience, etc.) compared to conventional delivery options. Third, perceived risk was found to determine ADVs acceptance to a large extent. Therefore, marketers should take this into consideration when promoting ADVs. Specifically, ADVs should be promoted as a safe last-mile delivery alternative. Finally, social influence and hedonic motivation also contribute a reasonable amount of strength to the acceptance of ADVs. Therefore, marketers might use the influence of social pressure to their advantage when promoting ADVs during the market introduction stage. Moreover, developers should focus on the hedonic factors for the improvement of the prototype and include aspects or features of the technology that are actually enjoyable and entertaining.

6.4. Limitations and Future Work

This study is not without limitations. First, within this study, 51 percent of the participants stated that they have 'never heard about ADVs' as a delivery option after they read the information sheet. Although this is not surprising since ADVs are not regularly available as a delivery option in Germany, it needs to be considered that participants responded on the base of the information provided in the information sheet as well as their imagination of ADVs. Future research should explicitly focus on participants that are more familiar with this kind of delivery (e.g., participants who took part in the trials). As such, future research could not only compare the behavioural intentions of non-users and users to identify the differences but could also investigate the relationship between behavioural intention and use behaviour, which was not possible at this stage of research. Second, within this study non-probability quota sampling was applied to represent the German population in regard to age, gender, and monthly household net-income and an online survey approach was chosen. However, it needs to be considered by choosing this sampling and data collection technique that the findings are not totally representative of the German population as some bias might exist (e.g., self-selection bias). Therefore, the findings need to be interpreted with care. As a consequence, future research might apply probability sampling and by that collect a totally representative sample. Finally, this study conducted a cross-sectional approach; however, since consumer behaviour is difficult to capture as well as changing continuously, future research should take a longitudinal approach. This would enable to investigate the change of importance in the constructs and might even reveal the importance of effort expectancy, which was insignificant in this study.

7. Conclusions

This research provided a comprehensive view of user acceptance of ADVs for last-mile delivery in Germany. As such, it adds valuable findings to the literature of ADVs in last-mile delivery as well as to technology acceptance research in a modern consumer context through the creation of a context-specific research model that identifies the constructs that affect potential users' acceptance of ADVs in Germany. This study tested seven direct factors of behavioural intention, whereas only six could be statistically proven (i.e., price sensitivity, performance expectancy, facilitating conditions, social influence, hedonic motivation, and perceived risk). Overall, the findings of our study offer valuable insights for theorists and practitioners alike to increase user acceptance of ADVs in the last-mile delivery context and implement this innovative technology in the near future successfully.

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Appendix "A": Survey Questions

Part 1/3: Respondent's Profile

1. **What is your age?**
   a. 18-24 years
   b. 25-34 years
   c. 35-49 years
   d. 50-64 years
   e. 65 + years

2. **What is your gender?**
   a. Female
   b. Male

3. **What is your nationality?**
   a. German
   b. Other, please specify

4. **What is your monthly household-income (net)?**

This is the sum of all salaries, wages and incomes from people living together in one household.

a. below 900 €
b. 900 € until < 1,300 €
c. 1,300 € until < 1,500 €
d. 1,500 € until < 2,000 €
e. 2,000 € until < 2,600 €
f. 2,600 € until < 3,200 €
g. 3,200 € until < 4,500 €
h. 4,500 € until < 6,000 €
i. 6,000 € and above

5. **What is your highest education?**
   a. Secondary school certificate or below
   b. High school degree
   c. University diploma
   d. Bachelor's degree
   e. Master's degree
   f. Doctorate
   g. No degree
   h. Other, please specify

6. **What is your current employment status?**
   a. full-time employment
   b. part-time employment
   c. seeking work
   d. retired
   e. pupil
   f. student
   g. unable to work

Part 2/3: Information Sheet

Please read the following information carefully!

Autonomous Delivery Vehicles

In this research autonomous delivery vehicles are defined as **self-driving ground vehicles**, which use **electric energy** as a power source. These vehicles drive at a speed of **approximately 5-10 km/h and drive on sidewalks rather than streets**. For safety and security reasons, those vehicles are equipped with various cameras, sensors and satellite navigation system (GPS). Autonomous delivery vehicles look like little robots (picture 1) or like a mobile parcel locker (picture 2) and can **deliver parcels or other goods** like groceries to the doorstep.

To date, autonomous delivery vehicles are in a **testing phase on public roads. In Germany, for instance in Hamburg and Dusseldorf, autonomous delivery vehicles are tested for parcel delivery.** However, they are **not yet regularly available as a delivery option.**

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Source: https://www.thestar.com

Picture 1 Picture 2

Delivery Process: Interaction and Advantages

To use autonomous delivery vehicles, **you need a mobile device (e.g., smartphone or tablet) for running the mobile app**. **Via the mobile app**, the recipient will be requested to **set the date and timeslot** in which he/she wants to receive the ordered goods. For the recipients this makes the delivery process with autonomous delivery vehicles **more flexible and convenient compared to conventional delivery options**. The mobile app is **easy to use** and regarding the severity for instance comparable to conventional apps like the Amazon or eBay app.

Once the autonomous delivery vehicle arrives at the final destination, **the recipient will receive a message through the app to collect the goods**. To **authorize and to open the locker** of the vehicle the **recipient has to connect their mobile device via Bluetooth to the vehicle**. In the case of an unexpected situation (e.g. the locker cannot be opened), the **recipient can directly call for assistance** through the mobile app or the interface of the vehicle.

Part 3/3: Autonomous Delivery Vehicles and User Acceptance

Have you heard about autonomous delivery vehicles before?

a) Yes
b) No

For the following questions please imagine autonomous delivery vehicles will be reality in the near future.

Based on your own opinion and judgement, please state to what extent you agree or disagree with the following:

	Strongly disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly agree
I would find autonomous delivery vehicles useful in my daily life.							
Using autonomous delivery vehicles would help me accomplish things more quickly.							
Using autonomous delivery vehicles would increase my productivity.							
Using autonomous delivery vehicles would increase my flexibility in my daily life.							
Learning how to use autonomous delivery vehicles would be easy for me.							
My interaction with the autonomous delivery vehicle via the mobile app would be clear and understandable.							
I would find autonomous delivery vehicles easy to use.							
It would be easy for me to become skilful at using autonomous delivery vehicles.							
People who are important to me would think that I should use autonomous delivery vehicles.							
People who influence my behaviour would think that I should use autonomous delivery vehicles.							
People whose opinion I value would prefer that I use autonomous delivery vehicles.							
I have the resources necessary to use autonomous delivery vehicles (i.e., mobile device).							
I have the knowledge necessary to use autonomous delivery vehicles.							
Autonomous delivery vehicles are compatible with other technologies I use (e.g., smartphone).							
I can get help from others when I have difficulties using autonomous delivery vehicles.							
Using autonomous delivery vehicles would be fun.							
Using autonomous delivery vehicles would be enjoyable.							
Using autonomous delivery vehicles would be very entertaining.							
I would not mind spending a lot of money for getting my orders delivered by autonomous delivery vehicles.							
If I knew that autonomous delivery vehicles as a delivery option were likely to be more expensive than conventional delivery options, that would not matter to me.							
A really great delivery option would be worth paying a lot of money for.							
Autonomous delivery vehicles might not perform well and create problems during parcel drop off (e.g., locker cannot be opened, failure of Bluetooth connection, etc.).							
Autonomous delivery vehicles might not work properly during parcel drop off.							
The chances that something would be wrong with the performance of autonomous delivery vehicles during parcel drop off would be high.							
Autonomously driving delivery vehicles on public roads would be risky.							

Autonomously driving delivery vehicles on public roads would be dangerous.							
Autonomously driving delivery vehicles would add great uncertainty to public roads.							
Overall, using autonomous delivery vehicles as a delivery option would be risky.							
Overall, autonomous delivery vehicles as a delivery option would be dangerous to use.							
Using autonomous delivery vehicles as a delivery option would expose me to an overall risk.							
I believe that the interaction with autonomous delivery vehicles during parcel drop off would be free of error.							
I believe that I could depend and rely on autonomous delivery vehicles during parcel drop off.							
I believe that autonomous delivery vehicles would perform consistently under a variety of circumstances during parcel drop off.							
I intend to use autonomous delivery vehicles as a delivery option in the future.							
I would always try to use autonomous delivery vehicles as a delivery option in my daily life when available in the future.							
I plan to use autonomous delivery vehicles frequently when available in the future.							

Appendix "B": Factor loading after the testing of items

Item	PE	EE	SI	FC	HM	PS	PR	BI
PE1	0.868							
PE2	0.94							
PE3	0.885							
PE4	0.884							
EE1		0.888						
EE2		0.899						
EE3		0.919						
EE4		0.926						
SI1			0.933					
SI2			0.965					
SI3			0.952					
FC1				0.849				
FC2				0.807				
FC3				0.909				
FC4				0.736				
HM1					0.943			
HM2					0.972			
HM3					0.931			
PS1						0.878		
PS2						0.832		
PS3						0.882		
PR1							0.939	
PR2							0.956	
PR3							0.826	
BI1								0.929
BI2								0.956
BI3								0.968

Author Statement

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Sebastian Kapser: conceptualization, methodology, validation, formal analysis, investigation, writing – original draft, writing – review & editing, visualization

Mahmoud Abdelrahman: methodology, validation, formal analysis, writing – review & editing, visualization