

Autonomous delivery vehicles to fight the spread of Covid-19 – How do men and women differ in their acceptance?

Abstract

Covid-19 seriously impacts and endangers lives of millions worldwide. To fight the spread of the virus, governments have taken various restricting measures including stay at home orders. Ultimately, the home delivery volume increased significantly, which still bears the risk of humanhuman infection during the final delivery. From a logisticians perspective, autonomous delivery vehicles (ADV)s, which are a contactless delivery solution, have the potential to radically change the way groceries are delivered to customer homes and help to stop the spread of the virus. However, to date, research on user acceptance of ADVs is rare. This paper theoretically extends the Unified Theory of Acceptance and Use of Technology (UTAUT2) including gender as a moderator. The study is based on quantitative data collected in Germany through an online questionnaire (n=501). Data were analysed using structural equation modelling. The results indicate that trust in technology, price sensitivity, innovativeness, performance expectancy, hedonic motivation, social influence, and perceived risk determine behavioural intention. However, some constructs are only significant for women. The findings of this paper have theoretical, managerial and policy contributions and implications within the areas of last-mile delivery and technology acceptance.

Keywords: Covid-19; acceptance; last-mile; UTAUT2; Germany; moderator analysis; gender

1. Introduction

Pandemics are one of the largest threats to human lives, economies, and society (Kummitha, 2020). Given the current situation of the Covid-19 outbreak, more than 33 million people are infected, and more than one million people already died worldwide (WHO, 2020)¹. Starting in Wuhan (China), the virus quickly transmitted due to the globalised world to almost every country worldwide. Several countries around the world have been heavily impacted by the virus. Around 200,000 to 300,000 new cases are detected each day in more than 200 countries and territories around the world with the US, Brazil, India, and Mexico experiencing the most death cases, followed by the UK, Italy, and France (WHO, 2020).²

To be able to slow the transmission of the virus, governments around the world have reacted with various restricting measures. These include, but are not limited to, closing borders, banding flights and applying quarantine for fourteen days. Moreover, the societal life has been locked down completely in many countries, including Germany, since the mid of March 2020. Despite the fact, that, for instance, most of the restaurants and bars opened again lately, they still have to apply some major restrictions like limited seating areas or apply distancing rules. Moreover, even in public, people need to keep a minimum distance of 1-2 metres to others.

Due to the possible infection risk when leaving the home or the fact that several thousand people are quarantined at home, the demand for home delivery of groceries increased heavily since the end of February 2020. For instance, Picnic, which is an online supermarket, delivering the regions of Ruhr and Rhineland in Germany, has been experiencing an increasing demand more than twice the normal level. The same holds true for the demand of Amazon Fresh or REWE. Moreover, due to the high demand, the orders will not be delivered for one or two weeks (Lebensmittelzeitung, 2020). Despite the fact that home delivery can help to stop the transmission of the virus, there is still a human contact involved when it comes to the final drop off. Fortunately, logisticians have introduced a new way of ‘contactless’ delivery to the last-mile delivery market lately – Autonomous Delivery Vehicles (ADVs).

ADVs are electric and self-driving ground vehicles, which drive on streets or sidewalks with limited speed of 5-10 km/h (Marsden *et al.*, 2018). They are still in the introduction and trial phase, for instance, in Dusseldorf and Hamburg (Germany). Given their transport capacity, they are able to deliver smaller goods like groceries directly to the doorstep. ADVs are able to manage all driving tasks by themselves without human intervention in a mixed traffic environment. For security and safety reasons, they are equipped with various sensors, cameras and GPS tracking. Contrary to the conventional delivery practices, the interaction is based on a human-technology interface (i.e., mobile app). In other words, no human-human interaction is involved during the final drop-off (Marsden *et al.*, 2018). However, it needs to be acknowledged that there is a slight risk that the goods get contaminated during the loading process through smear infections. Following the latest studies in this regard there is no clear evidence of any current cases. As such, the risk of virus infection for recipients is very limited (Bundesinstitut für Risikobewertung, 2020). As a matter of fact, ADVs are believed to be the ideal solution and the current crisis has even served as a catalyst for its further development (SQLI Digital Experience, 2020). However, despite the great potential

¹ Effective September 2020

² Effective September 2020

of ADVs to help stopping the further spread of the virus, consumers need to broadly accept this kind of delivery to make it a success.

Over the last couple of years, ADVs have only been discussed as a conceptual idea. Despite the fact that several researchers have investigated the acceptance of autonomous vehicles (AVs) in general (e.g., autonomous cars and shuttles) (Hohenberger *et al.*, 2016; Panagiotopoulos and Dimitrakopoulos, 2018; Hegner *et al.*, 2019), very little is known about the acceptance of ADVs (Kasper and Abdelrahman, 2020b, 2019, 2020a; Marsden *et al.*, 2018; Pani *et al.*, 2020). To get a more comprehensive overview of the constructs determining user acceptance of ADVs, within this study a modified UTAUT2 model, which has been verified in previous research is adopted and extended with additional important constructs based on a systematic literature review (Kasper and Abdelrahman, 2019, 2020b). Verifying the extended UTAUT2 empirically is the first goal of this paper. Moreover, gender differences have been argued to play an outstanding role in technology acceptance research (Venkatesh *et al.*, 2003; Venkatesh *et al.*, 2012; Ameen *et al.*, 2018). Thus, understanding the differences between women and men of ADVs acceptance is imperative, which is the second goal of this paper.

This paper is structured as follows: First, the background is outlined theoretically by reviewing previous research on user acceptance of AVs, ADVs, and a detail outline of the research gaps that will be covered within this study. Next, the proposed framework and the development of the hypotheses are presented. Following these theoretical sections, the research methodology and the data analysis procedures are presented. Furthermore, the research findings will be discoursed and the theoretical and managerial contributions as well as policy implications, which are followed by the research limitations and the proposal for further research as well as the final conclusions will be outlined.

2. Literature Review

2.1. Autonomous Vehicle Acceptance Research

Autonomous vehicles (AVs) are heavily discussed not only in science but also in the public due to its disruptive force in the transportation sector. Meanwhile, there are several public opinion surveys available that were conducted in various countries (Schoettle and Sivak, 2014a, 2014b; Kyriakidis *et al.*, 2015; Bansal and Kockelman, 2016; Bansal *et al.*, 2016; Gkartzonikas and Gkritza, 2019). Despite the fact all these studies shed great light into the phenomena of user acceptance of AVs, most of them are rather descriptive. Moreover, none of these studies have utilized an existing theoretical model as a foundation to explain users' acceptance of autonomous vehicles (Zmud and Sener, 2017). According to Panagiotopoulos and Dimitrakopoulos (2018) the knowledge on users' behavioural intention to actually use autonomous vehicles is still low. Examples that explicitly used an underlying acceptance theory are, for instance, Madigan *et al.* (2017) who investigated the acceptance of automated shuttles using the UTAUT model, Rahman *et al.* (2017) who assessed the utility of the Technology Acceptance Model, the Theory of Planned Behaviour (TPB), and the UTAUT model for advanced driver assistance systems, Choi and Ji (2015) who studied the importance of trust in autonomous vehicles by applying the TAM, and Hegner *et al.* (2019) who investigated the intention to use autonomous vehicles by also utilizing the TAM.

Interestingly, all the aforementioned studies focused on the transportation of people (e.g., cars, buses, shuttles), neglecting the importance and benefits AVs have within the logistics industry, which becomes even more important in the current times of the Covid-19 pandemic. Reviewing the existing literature in the areas of autonomous logistics vehicles (i.e., ADVs) it has been found that little attempts were made to explore the behavioural components of users' intention to use ADVs

(Marsden *et al.*, 2018; Kapser and Abdelrahman, 2020b). Therefore, this study uses a modified UTAUT2 model, which was developed for investigating user acceptance of ADVs (Kapser and Abdelrahman, 2020b) as a foundation and extends it with additional important constructs to investigate user acceptance. This is the first knowledge gap that will be filled within this research.

2.2. The role of user characteristics in technology acceptance research

It has been found in several technology-driven fields that user characteristics can play a significant role in the assessment of new technologies (Venkatesh *et al.*, 2012; Venkatesh *et al.*, 2003; Venkatesh *et al.*, 2016; Dwivedi *et al.*, 2019). Venkatesh *et al.* (2016) investigated how UTAUT and UTAUT2 were extended in several technology acceptance studies between 2003 and 2014 and found that user characteristics like age, gender, experience, and voluntariness have only been examined in a limited way. In other words, most studies have only investigated the main effects of the theory by ignoring the moderating effects of user characteristics. In a more recent study, Dwivedi *et al.* (2019) came to the same conclusion. Reviewing the specific literature of AVs acceptance, it can also be concluded that the studies investigating moderating effects are very limited (e.g., Hohenberger *et al.*, 2016; Madigan *et al.*, 2017). For instance, Madigan *et al.* (2017) investigated the user acceptance of autonomous shuttles and included age, gender, and experience as moderating variables. However, none of these moderators have been found influential. Thus, it is imperative to shed more light into the moderating effects in the area of autonomous vehicles acceptance, and specifically in the field of ADVs in last-mile delivery, which is the second knowledge gap that will be filled in this research. In doing so, this study explicitly focuses on gender as a moderating variable. Despite the fact that gender has already been studied extensively in several technology acceptance studies, it has often produced mixed findings (Sun and Zhang, 2006; Zhang *et al.*, 2014). Therefore, within this study gender has been selected as a key moderator in the context of ADVs acceptance to shed more light into this context.

3. Proposed framework and hypotheses development

As outlined before, within this study the UTAUT2 model is utilised to investigate user acceptance of ADVs. UTAUT2 is a theoretical synthesis of eight previous developed models that were used to investigate user acceptance (Venkatesh *et al.*, 2003; Venkatesh *et al.*, 2012) e.g., the Technology Acceptance Model by Davis *et al.* (1989) or the Theory of Planned Behaviour by Ajzen (1991). In doing so, Venkatesh *et al.* (2003) and Venkatesh *et al.* (2012) were able to summarise the current knowledge when it comes to technology acceptance. Thus, it is theoretically and practically justified to use UTAUT2 as a starting point within this study.

However, despite the fact that UTAUT2 has explicitly been developed for the investigation of consumer technologies, technology acceptance research has found that some constructs might not be as influential as others and therefore are not considered in this study. First, effort expectancy has been found in several technology acceptance studies not to be influential (Angelis *et al.*, 2017; Rahman *et al.*, 2018; Kapser and Abdelrahman, 2020b). For instance, in the field of ADVs, Kapser and Abdelrahman (2020b) argue that when people feel familiar with mobile apps, which are involved in the delivery process when using ADVs, they believe that the system is not effortful and thus not influential. Thus, effort expectancy was excluded in this study. Second, facilitating conditions are interlinked with effort expectancy. In other words, when people believe the use of a technology is not effortful, they are also likely to believe that they have all facilitating conditions available to use this kind of technology, which has been found in previous technology acceptance studies (Farah *et al.*, 2018; Arain *et al.*, 2019). Therefore, facilitating conditions was also excluded in this study.

Moreover, for some UTAUT2 constructs it was not possible to investigate them at the current point of time. First, besides the fact that habit has been proven a good predictor in technology acceptance research, it is not possible to investigate it in this study (Venkatesh *et al.*, 2012). This is based on the argument that for investigating habit participants need to have a broad knowledge about ADVs as well as have used this technology several times to build a habitual behaviour, which is not the case for ADVs since it has not yet fully been introduced to the German last-mile market. Second, following the same argument, price value could also not be investigated, because currently there is no price available nor is the consumer value for choosing this technology for last-mile delivery known. However, price has been found to be one of the most important aspects in the highly competitive last-mile delivery market in a previous ADVs acceptance study (Kapsler and Abdelrahman, 2020b). Therefore, price sensitivity which is related to the willingness to pay for a technology or service is used in this study to cover the price aspect. Finally, behavioural intention is the dependent construct in this study. The actual behaviour, which was also proposed in UTAUT2 was excluded because of the fact that ADVs are not regularly available in the German last-mile delivery market yet.

Furthermore, previous research has found that there are also some additional constructs highly relevant when investigating ADVs acceptance. These findings will be fully considered in this study. Therefore, perceived risk, which has been proven highly relevant not only in several technology acceptance studies in the area of autonomous vehicles (Liu *et al.*, 2019b; Liu *et al.*, 2019a; Choi and Ji, 2015) but also in a previous study conducted in the area of ADVs (Kapsler and Abdelrahman, 2020b), will be added to conceptual research model. Moreover, innovativeness, and trust in technology have been found to be of high importance in the field of AVs acceptance (Angelis *et al.*, 2017; Buckley *et al.*, 2018; Xu *et al.*, 2018; Zmud *et al.*, 2016) and are some of the most incorporated acceptance constructs in UTAUT2 (Tamilmani *et al.*, 2018). Importantly, both constructs have not been empirically studied in the specific field of ADVs in last-mile delivery yet (Kapsler, 2019). Thus, both constructs will be incorporated into UTAUT2 in this study. The final conceptual research model including the moderating effects proposed is presented in Figure 1. The figure shows in black the original UTAUT2 constructs, in blue the constructs that have previously be verified in the context of ADVs acceptance and in green the constructs as well as the moderator that has not been studied before.

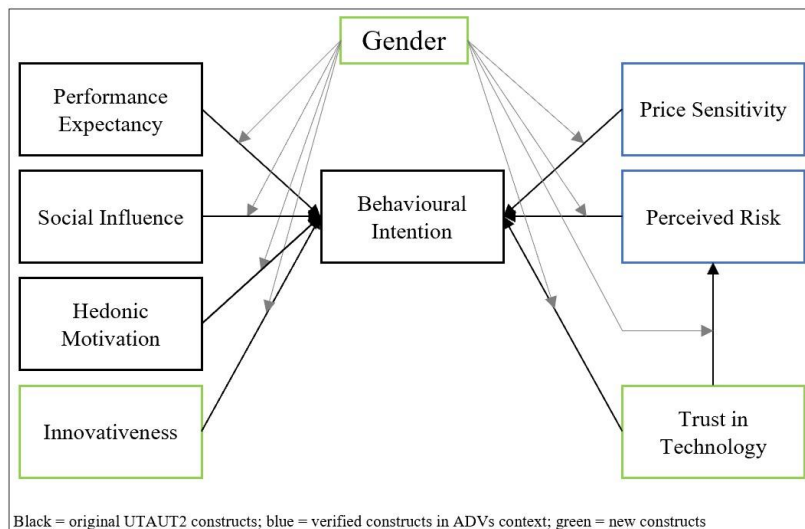


Figure 1: Modified and extended UTAUT2

In the following all proposed constructs will be presented in greater detail including the development of the hypotheses. Section 3.1 starts with the UTAUT2 constructs followed by section 3.2 which presents the previously verified as well as the new added constructs. Section 3.3 explicitly shows the moderating importance of gender in this context.

3.1 Original UTAUT2 constructs

Performance expectancy in this study “is defined as the degree to which using a technology will provide benefits to consumers” (Venkatesh *et al.*, 2012, p. 159). Not only has it been found to be the most important construct in technology acceptance research (Venkatesh *et al.*, 2003) but also has it been identified as a crucial construct in the explicit field of AVs (e.g., Moták *et al.*, 2017; Choi and Ji, 2015; Kapser and Abdelrahman, 2020b). ADVs are stated to be more consumer-centric (e.g., option to select the time of delivery) compared to its conventional counterpart (Joerss *et al.*, 2016). Especially in times of the Covid-19 virus, the usefulness of ADVs might be seen immensely higher. Therefore, performance expectancy is also been required for determining behavioural intention to use ADVs. Thus, the following hypothesis is proposed:

Hypothesis 1. Performance expectancy positively influences behavioural intention to use ADVs.

Social influence in this paper 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 identified as an important construct in the field of AVs (e.g., Madigan *et al.*, 2017; Panagiotopoulos and Dimitrakopoulos, 2018; Buckley *et al.*, 2018). Transferring this to the specific field of ADVs, it is believed that users will discuss with their social system before using the innovative delivery method. This leads to the following proposed hypothesis:

Hypothesis 2. Social influence positively influences behavioural intention to use ADVs.

Within this study, hedonic motivation can be defined as “the fun or pleasure derived from using a technology” (Venkatesh *et al.*, 2012, p. 161). Interestingly, Kapser and Abdelrahman (2019) found in their systematic literature review of technology acceptance studies that hedonic motivation has not often been studied in the UTAUT context. Nevertheless, Madigan *et al.* (2017) and Kapser and Abdelrahman (2020a) were able to prove the direct effect of hedonic motivation on behavioural intention. Within the field of ADVs, it is assumed that using ADVs is fun and enjoyable. Thus, hedonic motivation is proposed to be relevant when determining behavioural intention. Thus, the following hypothesis is suggested:

Hypothesis 3. Hedonic motivation positively influences behavioural intention to use ADVs.

3.2 Additional constructs for the context of ADVs acceptance

Price sensitivity can be defined as the “way in which buyers react to price changes” (Goldsmith *et al.*, 2005, p. 501). It has not been studied much in previous technology acceptance research (Goldsmith and Newell, 1997; Goldsmith *et al.*, 2005; Tsai and LaRose, 2015), nor has it been incorporated into the UTAUT2 model in other technology acceptance studies (Kasper and Abdelrahman, 2020b). In the field of ADVs, Kapser and Abdelrahman (2020a) found that it is the most important determinant of behavioural intention, which can be linked to the competitiveness within the last-mile delivery market. So, the following hypothesis is proposed:

Hypothesis 4. Price sensitivity negatively influences behavioural intention to use ADVs.

Perceived risk is defined as “potential for loss in the pursuit of a desired outcome” (Featherman and Pavlou, 2003, p. 454). Although, the use of new technologies like AVs has often been stated to be risky (Liu *et al.*, 2019a), the perception of risk has not been incorporated in any basic technology acceptance model (Koenig-Lewis *et al.*, 2015). However, following the argument by Cowart *et al.* (2008) it is important to study detractors since customers have a tendency to consider not only the incentives but also the fears. Within the context of AVs, the perception of risk has frequently been investigated (e.g., Choi and Ji, 2015; Kapsler and Abdelrahman, 2020b). Due to the newness of ADVs as well as its special characteristics (e.g., driving autonomously) there might be several potential risk sources involved (e.g., poor technology interaction or danger of accidents). Thus, it seems plausible that risk influences behavioural intention. Accordingly, this hypothesis is proposed:

Hypothesis 5. Perceived risk negatively influences behavioural intention to use ADVs.

Similar to the interpersonal context, trust in technology has been defined as “the general tendency to be willing to depend on technology [i.e., ADVs]” (McKnight *et al.*, 2011, p. 7). However, compared to the interpersonal context, comparatively little research exists on trust in technology (McKnight *et al.*, 2011). In particular, in the context of self-services (i.e., automated services), it has been argued to be of special importance due to the lack of personal interaction involved (Farah *et al.*, 2018). Thus, it is proposed that innovativeness influences behavioural intention. Thus, the following hypothesis is proposed:

Hypothesis 6. Trust in technology negatively influences behavioural intention to use ADVs.

Besides the influence of trust on behavioural intention, trust has also been proven as a major determinant of perceived risk in a service-based setting (Slade *et al.*, 2015; Koenig-Lewis *et al.*, 2010) as well as in the context of AVs (Choi and Ji, 2015). Indeed, perceived risk has been found as a major construct linked to trust, especially when it comes to the use of an automated system (Pavlou, 2003). Trust in technology is believed to reduce the perceptions of risk, which depends on the user’s expectations of negative situations (McKnight *et al.*, 2002). Following this, if users trust ADVs then they believe that the vehicle will perform as expected and thus reducing the perception of risks of a negative situation. Thus, the following hypothesis is proposed:

Hypothesis 7: Trust in technology negatively influences perceived risk.

In this research study, the innovation definition by Agarwal and Prasad (1998) is adopted. As such, innovativeness is defined as the willingness to try out ADVs as a delivery option. Despite the fact that innovativeness has been asserted as a key construct in a consumer’s willingness to adopt a new technology (Agarwal and Prasad, 1998; Rogers, 1983; Midgley and Dowling, 1978), it has not been incorporated in one of the major technology acceptance theories or models (Agarwal and Prasad, 1998; Slade *et al.*, 2015). Even the UTAUT or the UTAUT2, which claim to be the most comprehensive models, fail to recognize the importance of an individual innovativeness in the adoption process (Slade *et al.*, 2015; Dwivedi *et al.*, 2019). Despite the failure to include innovativeness in previous acceptance models, many studies incorporated innovativeness to understand individual differences in the acceptance of technology (Saprikis *et al.*, 2018; Giovanis *et al.*, 2018; Kim and Forsythe, 2008; Slade *et al.*, 2015). As a result, the following hypothesis is proposed:

Hypothesis 8: Innovativeness positively influences behavioural intention to use ADVs.

3.3 Moderating effect of gender

Several empirical studies have ignored investigating the effects of gender as a moderator despite its importance in technology acceptance research (Dwivedi *et al.*, 2019). Within this study it is proposed that all relationships are moderated by gender, which is based on previous literature.

Firstly, previous research showed that men tend to be more task-orientated than women (Morris and Venkatesh, 2000). Since performance expectancy is linked to task accomplishments, it has often been found that the effect is more salient for men than women (Wang and Shih, 2009). Secondly, Venkatesh *et al.* (2012) and Venkatesh *et al.* (2003) found that women have a tendency to be more led by opinions of others, which clearly might affect the effect of social influence on behavioural intention. Thirdly, in terms of innovativeness, it has been found previously that men tend often to be the innovators when it comes to new technologies. In other words, men are generally more willing to try new technologies in the early stages of introduction (Venkatesh *et al.*, 2012), which might increase the relative importance of hedonic motivation for men compared to their women counterparts. Fourthly, following theories in the area of social roles it has been found that women and men take different social roles. For instance, women usually consider more details in their adoption decision than men (Deaux and Kite, 1987). As a consequence, it is very likely that women take a closer look regarding the price. In other words, they will be more cost conscious than men (Venkatesh *et al.*, 2012). Fifthly, previous research provides evidence that men are more inclined to take risks than women (Sundheim, 2013). Reflecting this to the area of technology acceptance, women are more risk-averse than men, when adopting new technologies. Sixthly, in line with the argument that women are more risk-averse than men (Sundheim, 2013), it is proposed that the higher the trust of women in new technologies the higher its effect on their actual acceptance. Seventhly, following these arguments, women who have a higher trust in the use of ADVs as a last-mile delivery service, will also have lower risk perceptions of such services. This ultimately increased the overall behavioural intention to use ADVs. Finally, previous research showed that men tend often to be the innovators when it comes to new technologies and therefore try new technologies in the early stages of introduction (Venkatesh *et al.*, 2012). By examining the moderating effect of gender, this study will help not only theorists but also practitioners to better understand how gender influences the acceptance of ADVs for last-mile delivery.

4. Methodology

4.1. Research instrument development

Following previous user acceptance studies, a survey method was used; taking previously validated scales (see Table 1). The questionnaire used in this study included four parts (i.e., cover letter, demographic characteristics, information sheet on ADVs, and the measurement items ranging from 1 = strongly disagree to 7 = strongly agree.

Table 1: Constructs 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 <i>et al.</i> , 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 <i>et al.</i> , 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 <i>et al.</i> , 2012) |

| | | |
|----------------------------|--|----------------------------------|
| Price Sensitivity (PS) | PS1: I would not mind spending a lot of money for getting my orders delivered by autonomous delivery vehicles (<i>reverse</i>). PS2: 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 (<i>reverse</i>). PS3: A really great delivery option would be worth paying a lot of money for. | (Goldsmith <i>et al.</i> , 2005) |
| Perceived Risk (PR) | PR1: Using autonomous delivery vehicles as a delivery option would be risky. PR2: Autonomous delivery vehicles as a delivery option would be dangerous to use. PR3: Using autonomous delivery vehicles as a delivery option would expose me to an overall risk. | (Featherman and Pavlou, 2003) |
| Trust in Technology | TT1: I would trust autonomous delivery vehicles to be reliable. TT2: I would trust autonomous vehicles to be dependable. TT3: I would trust autonomous delivery vehicles. | (Choi and Ji, 2015) |
| Innovativeness | INO1: If I heard about a new technology, I would look for ways to experiment with it. INO2: Among my peers, I am usually the first to explore new technologies. INO3: I like to experiment with new technology. | (Agarwal and Prasad, 1998) |
| Behavioural Intention (BI) | BI1: I intend to use autonomous delivery vehicles as a delivery option in the future. | (Venkatesh <i>et al.</i> , 2012) |
| | 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. | |

To improve and enhance the validity of the questionnaire; pre-tests were conducted with 8 participants to correct any issues in advance to the data collection. Minor changes were suggested in the wording of the items to increase the easiness and additional information on ADVs were incorporated in the information sheet. Following this, the survey instrument was translated and back-translated by two translators (Brislin, 1970). The questionnaire translations were checked for any misunderstanding and mistranslations or any issues related to the meaning, which led to some minor changes of the German translation. Then, this version was also pre-tested (9 participants). Again, the feedback was incorporated in the final questionnaire. Following these procedures, the online questionnaire was developed on the online platform Qualtrics.

4.2. Sampling and analytical procedures

The overall goal of this study was to be as representative as possible for Germany to draw significant conclusions in this study. To be able to achieve this goal quota sampling was chosen as an appropriate sampling technique applying three quotas (i.e., gender, age, and monthly household netincome). To develop highly accurate quotas, statistical data from Destatis (2017) and Eurostat (2017) were used.

Within this study structural equation modelling (SEM) was applied, using AMOS version 26 (Maximum Likelihood Estimations). SEM combines multiple regression analysis with factor analysis and as such is a strong tool for analysing complex phenomena like user acceptance. Since covariance-based SEM need a high sample size for creating reliable estimates, the sample size was set to be minimum 500 respondents (Hair *et al.*, 2014). This was also used as the basis for the calculation of the quotas. To increase the representativeness of the sample, Germans (18 years and above) were randomly selected by Qualtrics panel partners. They were invited via electronic mail to take part in this survey. Data collection stopped automatically when the quotas were filled as intended. To increase the quality for data analysis only whole datasets were saved by the system, whilst incomplete datasets were automatically deleted. Moreover, the questionnaire included two quality checks that were used to identify outliers (>3 mins. minimum completion time; attention check). The data was collected within the timeframe of December 2018 and January 2019.

5. Results

5.1. Descriptive statistics

A total of 501 datasets were received and taken for data analysis. On average participants needed approximately 10 minutes to fill in the questionnaire. Following the analysis of the quotas, all were appropriately filled. So, by taking into consideration the quotas and the gathered data, it can be stated that the findings are representative of Germany in terms of age, gender as well as the monthly household net income (see Table 2).

Table 2: The Demographic Profiles and Familiarity with ADVs of Germans

| Variable | Category | Frequency (n=501) | Percentage | German characteristics (percentage) |
|----------------------------------|---|-------------------|------------|-------------------------------------|
| Gender | Male | 247 | 49 | 49 |
| | Female | 254 | 51 | 51 |
| Age | 18-24 years | 44 | 9 | 9 |
| | 25-34 years | 76 | 15 | 15 |
| | 35-49 years | 115 | 23 | 24 |
| | 50-64 years | 138 | 27.5 | 27 |
| | 65 + years | 128 | 25.5 | 25 |
| Monthly Household Net Income | < 900 € | 46 | 9 | 9 |
| | 900 € - below 1,300 € | 60 | 12 | 12 |
| | 1,300 € - below 1,500 € | 35 | 7 | 7 |
| | 1,500 € - below 2,000 € | 78 | 16 | 16 |
| | 2,000 € - below 2,600 € | 74 | 15 | 15 |
| | 2,600 € - below 3,200 € | 57 | 11 | 11 |
| | 3,200 € - below 4,500 € | 82 | 16 | 16 |
| | 4,500 € - below 6,000 € 6,000 € and above | 39 | 8 | 8 |
| Education | Secondary School Certificate or below | 224 | 45 | 52.9 |
| | High school degree University diploma | 109 | 22 | 39.1 |
| | Bachelor's degree | 46 | 9 | 12.8* |
| | Master's degree | 50 | 10 | 2.4* |
| | Doctorate No degree other | 48 | 10 | 1.6* |
| | | 5 | 1 | 1.2* |
| Employment status | Full-time employment | 4 | 1 | 4 |
| | Part-time employment | 15 | 3 | 4 |
| | Seeking work | 192 | 38 | 29 |
| | Retired | 60 | 12 | 18 |
| | Pupil | 28 | 6 | 6.2 |
| | Student | 163 | 33 | 21 |
| | Others | 5 | 1 | 10 |
| | | 29 | 6 | 3.5 |
| Heard about ADVs (,familiarity') | Yes | 245 | 49 | - |
| | No | 252 | 51 | - |

*Note: people with University Diploma, Bachelor's, Master's or Doctorates are also included in the statistic of high school degree; therefore, the sum is not 100%. References for the German characteristics: (Destatis, 2017; Eurostat, 2017; Statista, 2020f, 2020e, 2020d, 2020c, 2020b, 2020a)

5.2. Assessment of the measurement model

According to Hair *et al.* (2014), good and poor models cannot be differentiated by a single index. In accordance to this, it is suggested to calculate several fit-indices, which can be used to determine adequate model fit (Byrne, 2016). In general, it is recommended to complement the Chi-square statistic with at least one incremental fit index as well as one absolute fit index (Hair *et al.*, 2014; Hair *et al.*, 2010). Thus, in this study, the model fit was assessed with three commonly applied model fit indices: Tucker-Lewis index (TLI; ≥ 0.95), comparative fit index (CFI; ≥ 0.95), as well as the Root Mean Square Error of Approximation (RMSEA; ≤ 0.07) (Hair *et al.*, 2014; Hu and Bentler, 1999; Hair *et al.*, 2010). In addition, the beta coefficients (threshold > 0.60), the standardized residual covariances (range $|2,58|$), as well as the modification indices (high standardized regression weights) were further used to establish adequate model fit. The results are presented in Table 3.

Table 3: Model Fit Assessment (Measurement Model)

| Indices | χ^2 | df | RMSEA | TLI | CFI |
|-----------|----------|-----|-------------|-------------|-------------|
| Standards | - | - | ≤ 0.07 | ≥ 0.95 | ≥ 0.95 |
| Results | 514.677 | 247 | 0.065 | 0.960 | 0.967 |

Additionally, the assessment of the model fit was complemented with further analyses. These included the factor loadings, discriminant validity, convergent validity and internal consistency (see Table 4).

Table 4: Factor loadings, construct reliability, AVE, item means, and standard deviations

| Construct | Item | Factor loading | CR | AVE | Mean (total) | SD (total) | Mean (female) | SD (female) | Mean (male) | SD (male) |
|------------------------|------|----------------|-------|-------|--------------|------------|---------------|-------------|-------------|-----------|
| Performance Expectancy | PE1 | 0.887 | 0.948 | 0.820 | 4.66 | 1.78 | 4.61 | 1.83 | 4.72 | 1.74 |
| | PE2 | 0.943 | | | 4.47 | 1.83 | 4.54 | 1.80 | 4.39 | 1.86 |
| | PE3 | 0.914 | | | 4.05 | 1.91 | 4.09 | 1.88 | 4.00 | 1.93 |
| | PE4 | 0.876 | | | 4.48 | 1.87 | 4.52 | 1.88 | 4.43 | 1.87 |
| Social Influence | SI1 | 0.944 | 0.968 | 0.910 | 4.03 | 1.75 | 4.03 | 1.79 | 4.02 | 1.70 |
| | SI2 | 0.966 | | | 3.98 | 1.76 | 3.94 | 1.83 | 4.02 | 1.69 |
| | SI3 | 0.952 | | | 3.88 | 1.72 | 3.90 | 1.75 | 3.87 | 1.69 |
| Hedonic Motivation | HM1 | 0.939 | 0.966 | 0.904 | 4.67 | 1.83 | 4.64 | 1.92 | 4.71 | 1.75 |
| | HM2 | 0.979 | | | 4.54 | 1.81 | 4.47 | 1.91 | 4.62 | 1.70 |
| | HM3 | 0.935 | | | 4.50 | 1.81 | 4.45 | 1.87 | 4.54 | 1.74 |
| Price Sensitivity | PS1 | 0.908 | 0.902 | 0.755 | 5.58 | 1.73 | 5.56 | 1.75 | 5.60 | 1.71 |
| | PS2 | 0.820 | | | 5.25 | 1.74 | 5.15 | 1.78 | 5.36 | 1.70 |
| | PS3 | 0.877 | | | 5.29 | 1.79 | 5.19 | 1.81 | 5.39 | 1.77 |
| Perceived Risk | PR1 | 0.943 | 0.942 | 0.845 | 4.37 | 1.56 | 4.42 | 1.58 | 4.33 | 1.53 |
| | PR2 | 0.965 | | | 4.26 | 1.61 | 4.27 | 1.63 | 4.26 | 1.60 |
| | PR3 | 0.845 | | | 4.03 | 1.63 | 4.08 | 1.61 | 3.98 | 1.64 |
| Trust in Technology | TT1 | 0.937 | 0.969 | 0.912 | 4.33 | 1.61 | 4.30 | 1.60 | 4.37 | 1.62 |
| | TT2 | 0.972 | | | 4.32 | 1.64 | 4.32 | 1.68 | 4.32 | 1.60 |
| | TT3 | 0.955 | | | 4.24 | 1.70 | 4.20 | 1.72 | 4.28 | 1.68 |
| Innovativeness | INO1 | 0.903 | 0.909 | 0.769 | 4.48 | 1.59 | 4.33 | 1.69 | 4.63 | 1.48 |
| | INO2 | 0.886 | | | 3.62 | 1.86 | 3.51 | 1.90 | 3.74 | 1.82 |
| | INO3 | 0.841 | | | 4.59 | 1.68 | 4.51 | 1.73 | 4.68 | 1.62 |
| Behavioural Intention | BI1 | 0.939 | 0.967 | 0.908 | 3.83 | 1.81 | 3.87 | 1.79 | 3.79 | 1.83 |
| | BI2 | 0.957 | | | 3.86 | 1.78 | 3.87 | 1.76 | 3.84 | 1.80 |
| | BI3 | 0.962 | | | 3.94 | 1.77 | 3.93 | 1.74 | 3.96 | 1.81 |

The factor loadings (betas) were all higher than the recommended threshold of 0.7 (Hair *et al.*, 2014), ranging from 0.820 – 0.979. Furthermore, the average variance extracted (AVE) was also higher than the required value of 0.5 (Fornell and Larcker, 1981). As a matter of fact, convergent validity within this study is supported. Moreover, the square roots of the AVE for each individual construct was larger than the construct correlations (see Table 5), which supports discriminant validity. Finally, following the recommendation of the threshold of the composite reliabilities (CR) (> 0.70) by Hair *et al.* (2014), internal consistency is supported (see Table 4).

Table 5: Discriminant Validity of Measures, Inter-Correlation Matrix, Means and Standard Deviations

| | PR | HM | PS | TT | PE | SI | INO | BI | Mean (total) | SD (total) | Mean (female) | SD (female) | Mean (male) | SD (male) |
|-----|--------------|--------------|--------------|--------------|--------------|--------------|--------------|-------|--------------|------------|---------------|-------------|-------------|-----------|
| PR | 0.919 | | | | | | | | 4.22 | 1.60 | 4.25 | 1.61 | 4.18 | 1.59 |
| HM | -0.420 | 0.951 | | | | | | | 4.57 | 1.82 | 4.51 | 1.90 | 4.62 | 1.73 |
| PS | 0.198 | -0.497 | 0.869 | | | | | | 5.37 | 1.75 | 5.30 | 1.78 | 5.44 | 1.73 |
| TT | -0.633 | 0.707 | -0.497 | 0.955 | | | | | 4.30 | 1.65 | 4.27 | 1.67 | 4.32 | 1.63 |
| PE | -0.373 | 0.770 | -0.406 | 0.641 | 0.905 | | | | 4.42 | 1.85 | 4.43 | 1.85 | 4.38 | 1.85 |
| SI | -0.368 | 0.761 | -0.505 | 0.659 | 0.705 | 0.954 | | | 3.96 | 1.74 | 3.95 | 1.79 | 3.96 | 1.70 |
| INO | -0.343 | 0.714 | -0.531 | 0.573 | 0.590 | 0.668 | 0.877 | | 4.32 | 1.71 | 4.11 | 1.77 | 4.35 | 1.64 |
| BI | -0.502 | 0.793 | -0.662 | 0.776 | 0.720 | 0.766 | 0.756 | 0.953 | 3.90 | 1.79 | 3.89 | 1.76 | 3.86 | 1.82 |

Note: SD = standard deviation; PR = perceived risk; HM = hedonic motivation; PS = price sensitivity; TT: trust in technology; PE = performance expectancy; SI = social influence; INO = innovativeness; 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. Assessment of the structural model

For the structural assessment of the extended UTAUT2, the same steps were conducted as within the measurement model assessment. As such, the structural model provided also adequate fit to the data (χ^2 : 1054.738; CFI: 0.95; TLI: 0.94; RMSEA: 0.07). In a next step, the structural paths of the model were calculated. This procedure was twofold. First, the total sample was used to calculate the beta coefficients of the total model (i.e., global model). This step was conducted to be able to reach the first goal of this paper, i.e., extending UTAUT2 with additional and important constructs for the field of ADVs. Second, since the second goal of this paper was to identify the differences of user acceptance of ADVs when it comes to gender the data is divided into two subgroups i.e., men ($n=247$) and women ($n=254$) and the structural paths were calculated again (see Table 6 and 7). Moreover, a Chi-square difference test was calculated to provide statistical evidence of the differences of men and women.

Figure 2: Path Diagram (global sample)

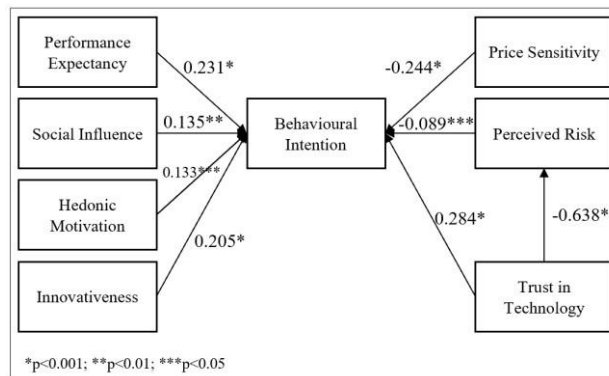


Table 6: Summary of Results of Structural Relationships

| Hypothesis | Path | Proposed effect | Estimate (n=501) | Significance | Result |
|------------|----------|-----------------|------------------|--------------|-----------|
| H1 | PE → BI | + | 0.231 | <0.001 | supported |
| H2 | SI → BI | + | 0.135 | 0.004 | supported |
| H3 | HM → BI | + | 0.133 | 0.013 | supported |
| H4 | PS → BI | - | -0.244 | <0.001 | supported |
| H5 | PR → BI | - | -0.089 | 0.011 | supported |
| H6 | TT → BI | + | 0.284 | <0.001 | supported |
| H7 | TT → PR | - | -0.638 | <0.001 | supported |
| H8 | INO → BI | + | 0.205 | <0.001 | supported |

Note: PE = performance expectancy; PR = perceived risk; SI = social influence; HM = hedonic motivation; BI = behavioural intention; PS = price sensitivity; TT = Trust in Technology; INO = Innovativeness.

Based on the statistical analysis all proposed hypotheses could be supported by the underlying data (see Table 6 and Figure 2).

Table 7: Summary of Results of Structural Relationships including Moderating Effects

| H | Path | Estimates women (n=254) | Significance (women) | Estimates men (n=247) | Significance (men) | Difference Estimates | Significance Chi-square difference test | Significant | Result |
|----|----------|-------------------------|----------------------|-----------------------|--------------------|----------------------|---|-------------|----------------------------|
| H1 | PE → BI | 0.153 | 0.011 | 0.332 | <0.001 | 0.179 | 0.519 | No | No statistical difference |
| H2 | SI → BI | 0.163 | 0.007 | 0.101 | 0.160 | -0.063 | 0.544 | No | Only significant for women |
| H3 | HM → BI | 0.144 | 0.041 | 0.091 | 0.296 | -0.053 | 0.708 | No | Only significant for women |
| H4 | PS → BI | -0.275 | <0.001 | -0.200 | <0.001 | 0.075 | 0.295 | No | No significant difference |
| H5 | PR → BI | -0.106 | 0.020 | -0.075 | 0.158 | 0.031 | 0.710 | No | Only significant for women |
| H6 | TT → BI | 0.255 | <0.001 | 0.312 | <0.001 | 0.056 | 0.635 | No | No significant difference |
| H7 | TT → PR | -0.633 | <0.001 | -0.645 | <0.001 | -0.012 | 0.519 | No | No significant difference |
| H8 | INO → BI | 0.253 | <0.001 | 0.178 | 0.003 | -0.076 | 0.769 | No | No significant difference |

Note: PE = performance expectancy; PR = perceived risk; SI = social influence; HM = hedonic motivation; BI = behavioural intention; PS = price sensitivity; TT = Trust in Technology; INO = Innovativeness; Significance *** p < 0.001; ** p < 0.01; * p < 0.05

Figure 3: Path Diagram Female Sample

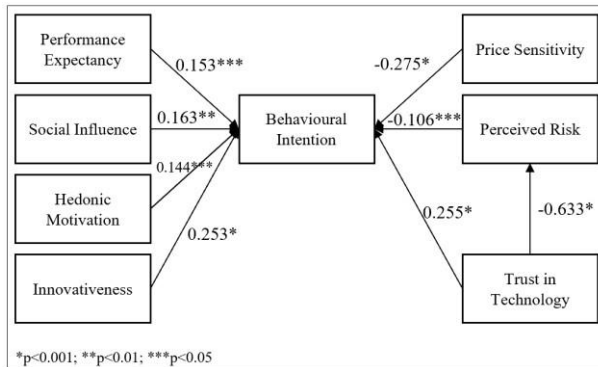
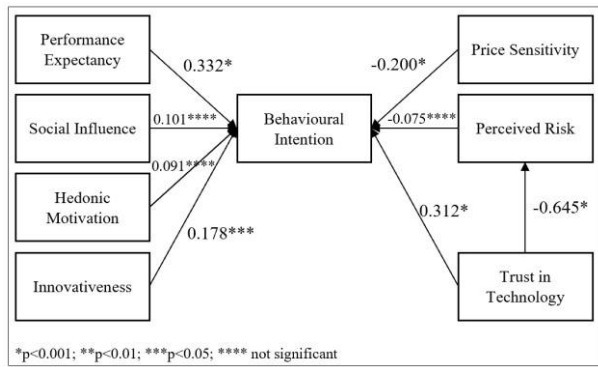


Figure 4: Path Diagram Male Sample



Surprisingly, when dividing the sample into a women and a men sample, the findings show that all paths proposed are relevant for women; however, the structural results for the men sample shows that there is no significant effect of social influence, hedonic motivation and perceived risk on behavioural intention (see Table 7, Figure 3 and 4). Interpreting the Chi-square difference test; it shows that there is no significant difference in the women and men sample except for social influence, perceived risk, and hedonic motivation (see Table 7). These differences show that gender aspects are important to consider in studying the user-acceptance regarding ADVs for last-mile delivery.

6 Discussion

New delivery practices are needed more than ever to stop the spread of Covid-19 or any other virus in the future. ADVs have been proposed as a possible contactless delivery solution, which has the potential to revolutionize the whole logistics industry and make the last-leg of the delivery not only more efficient, sustainable, but also more customer-centric (Kapsler and Abdelrahman, 2020a, 2019, 2020b). Moreover, due to the ‘contactless’ delivery, ADVs are perfectly suited to help in the current virus-crisis situation and reduce the human contacts. It is important to mention again that the findings of this study are representative of Germany in terms of age, gender, and monthly household income. Therefore, the findings can be used by practitioners and policymakers immediately to help develop and adopt ADVs in a way that is actually accepted by the German population.

Interestingly, it seems that the participants in this study did not develop any attitude towards the use of ADVs as a delivery option for last-mile services yet. Statistically speaking, the scores of the mean of behavioural intention, which is defined as user acceptance in this study, to use ADVs were smaller than the mid-point 4 of the scales used (7-point scales) (see Table 4 and Table 5). Nevertheless, when it comes to disruptive and emerging technologies the public often holds a neutral opinion in the beginning, which holds also true in the field of AVs (Liu *et al.*, 2019a). The reason is seen in the fact that the public still needs to build an opinion. However, the current situation of Covid-19 will be helpful to increase the willingness for the adoption of a new delivery option immensely. Therefore, the findings can now be incorporated into the design and development of ADVs, which will very likely increase its general acceptance in the German population.

6.1. The extended UTAUT2 model and the moderating effect of gender

This study investigated an extended UTAUT2 including the moderator of gender in the context of ADVs and has generated two key observations. Firstly, this study empirically validated all proposed effects: performance expectancy to behavioural intention (supporting H1); social influence to behavioural intention (supporting H2); hedonic motivation to behavioural intention (supporting H3); price sensitivity to behavioural intention (supporting H4); perceived risk to behavioural intention (supporting H5); trust in technology to behavioural intention (supporting H6) trust in technology to perceived risk (supporting H7); and innovativeness to behavioural intention (supporting H8). As such, two further important behavioural components of user acceptance of ADVs in last-mile delivery that have not been studied in the ADVs field before (i.e., trust in technology and innovativeness) were validated. Moreover, the effect of trust in technology on perceived risk that has also not been studied in the ADVs acceptance field were also validated. Therefore, this study not only incorporated existing knowledge of AVs and ADVs acceptance into a modified UTAUT2 but also extended it successfully. This clearly shows the need to continuously improve technology acceptance models and modify them to the specific underlying context.

Secondly, it has been found that only few studies in the context of AVs have investigated moderator variables (Hohenberger *et al.*, 2016; Madigan *et al.*, 2017; Leicht *et al.*, 2018), despite its strong evidence from previous studies in general consumer research (Venkatesh *et al.*, 2003; Venkatesh *et al.*, 2012). In the AVs context, for instance, Hohenberger *et al.* (2016) investigated the effects of age, gender, education, and household. However, they could only find a negative influence of age on the effect of biological sex on behavioural intention. Madigan *et al.* (2017) investigated the effects of age, gender, experience, and income in the UTAUT model. Yet, they could not find any moderating effect at all. Concluding that moderators might not be of relevance in the AVs context. Leicht *et al.* (2018) were able to support the moderating effect of innovativeness in the UTAUT model. Thus, this study is not only among the first studies that shed light into the moderating effect

of gender in the field of AVs acceptance research, but also is the first that investigates moderating effects of autonomous vehicles for logistical purposes (i.e., ADVs).

Interestingly, no effect of gender was found on the following effects: performance expectancy to behavioural intention; price sensitivity to behavioural intention; trust in technology to behavioural intention; innovativeness to behavioural intention; and trust in technology to perceived risk. However, the findings also indicate that there are also three structural paths were the overall effect is only significant for women: social influence to behavioural intention; hedonic motivation to behavioural intention and perceived risk to behavioural intention. This clearly shows that women are more dependent on their peers than men; women value the enjoyment of using ADVs as a delivery option higher than men as well as women are highly influenced when it comes to potential risk when using ADVs, whereas men seem to not be influenced by risk perceptions. As a result, it can be concluded that there are effects of gender on some of the verified behavioural constructs, however, the effects were not as previous literature stated, which show the need to further investigate gender as a moderating variable in the field of AVs. This is especially important when the maturity of such technologies grows because the effects might change.

6.2. Theoretical and Managerial Contributions

This study enriches the literature in the fields of last-mile delivery specifically but also in general the technology acceptance literature. It also gives insights in how ADVs should be promoted by logistics service providers to the public to increase the likelihood of consumer adoption when introduced to the last-mile delivery market in Germany.

Theoretically speaking, this study is among the first that empirically investigates user acceptance of ADVs in last-mile delivery in the German context. In doing so, an extended UTAUT2 model was applied. In this regard, this study not only provided evidence for two new constructs in the field of ADVs acceptance (i.e., trust in technology and innovativeness) but also showed that trust in technology statistically influences perceived risk, which has not been studied in the context of ADVs before. Extending the UTAUT2 provided, therefore, further evidence that there is a need to continuously further develop existing technology acceptance models. Second, this study is the first that investigated the moderating effects of gender in the context of ADVs acceptance in last-mile delivery on the relationships of the extended UTAUT2 on behavioural intention.

From a managerial perspective, there are also several contributions. Firstly, trust in technology has been found to be the most imperative construct. Therefore, trust in technology is an important precondition for users to accept and adopt ADVs. Secondly, price sensitivity could be determined as the second most important predictor of ADVs acceptance. Thus, it is important to consider the pricing of this delivery system sensibly. Third, utilitarian benefits were found to also play a major role. As a matter of fact, developers and marketers should focus the development of ADVs as well as the promotional activities on the performance expectancies (e.g., higher flexibility, higher convenience, etc.) in comparison to conventional delivery options. Fourth, innovativeness also plays an important role. Following the theory of innovation and diffusion by Rogers (1983), innovators (2.5%) and early adopters (13.5%), who are generally considered to be highly innovative, will try this new delivery technology first. Therefore, it is recommended to marketers of logistics services that ADVs are introduced as an innovative delivery technology to the public. Importantly, when marketing ADVs the marketing activities regarding the effects of social influence, hedonic motivation, and perceived risk should be tailored to the needs of women. For instance, ADVs should explicitly be endorsed as a safe last-mile delivery option.

6.3. Policy Implications

The research presented in this study has not only theoretical and managerial implications, but also relevant implications for policymakers, especially for those countries that want to pioneer in the area of autonomous vehicles like Germany (BMVI, 2021). In other words, by considering the findings of this study policymakers and local authorities can positively contribute to the further development and introduction of ADVs as a last-mile delivery option, which might help to stop the further spread of the Covid-19 virus.

First, within this study price sensitivity (H4) has been identified as an important aspect of user acceptance. If shipment costs are too high due to the use of expensive automation technology, there will be little acceptance in the population and advantages of ADVs as a contactless delivery option will be missed out. Therefore, policymakers are asked to support the acceptance and use of ADVs for last-mile delivery through subsidising this kind of delivery solution. Not only could they help developers by providing research funding to make the ADV development more economically feasible, which has a direct effect on the pricing strategy of that service, but also could they directly subsidise the price for the actual delivery with ADVs in the introduction stage until a broader market maturity has been reached.

Second, our research found that perceived risk (H5) plays a central role in the acceptance formation for potential female users. Thus, policymakers can help promoting ADVs as a responsible, safe, and innovative delivery solution. As a first step, governments could publicly communicate the partnerships and funding provided for the development and trial projects of ADVs including its underlying benefits for society as well as the individual user. The innovative trials can then be used by governments to closely monitor and evaluate the technology as well as assess the underlying risk in a realistic manner. This will ensure that ADVs will have incorporated all necessary features to enhance public security and safety. Following this transparent and openly communicated process will likely reduce the perceived risks by potential users and ultimately increase their behavioural intention.

Third, our findings show that citizens in Germany have not yet build a clear attitude towards ADVs and the use of ADVs is highly determined by the underlying advantages of potential users (H1). In this sense, governments and local political authorities might be able to support the development of a positive attitude by engaging citizens in urban vision planning. In this regard, it might be crucial to have an open dialog and debate about the underlying opportunities. Whilst the pure introduction of ADVs might not be highly accepted by a broader population, it might, however, be more acceptable if the solution is introduced as a part of a policy package. For instance, if private vehicles are banned from urban spaces to decrease air pollution, which ultimately results in, for instance, more walking and cycling spaces, a larger number of citizens might develop a positive attitude and accept ADVs, which can provide the household essentials like groceries to the doorstep (Milakis *et al.*, 2020).

6.4. Limitations and Further Research

This study also has some limitations that should be considered. First, half of participants (51 percent) in this study stated to have ‘never heard about ADVs’ after having read the information sheet provided in the questionnaire. Even though this rating is not surprising as this delivery technology is not yet available in Germany on a regular basis, it needs to be carefully considered that half of the participants impressed their perceptions based on the information provided in the questionnaire. As ADVs become more mature as a delivery option in the market of last-mile delivery, further research should explicitly target actual users to identify the differences in users’ behavioural intention but also to investigate actual use behaviour, which was not possible in this study. Second, a cross-sectional approach was conducted in 2019 before the outbreak of the Covid-19 virus. However,

consumer behaviour is problematic to capture and altering endlessly, further studies should take a longitudinal approach and should collect data now to compare the findings before and after the virus outbreak especially because of the higher focus of the public on home delivery during the virus-crisis. Third, the results cannot be generalised completely since only age, gender, and household income are representative of the German population. Further research should take a larger sample as well as the geographical regions into consideration to enhance the representativeness of the study. Finally, the research was conducted in the specific domain of ADVs. Obviously, the findings are not generally applicable to other forms of autonomous vehicles (e.g., general cars). Thus, future research should apply the verified framework in this study to show its importance on the acceptance of other AVs.

7. Conclusions

This study provides a deeper insight into the user acceptance of ADVs in Germany and presents a clear option of contactless delivery, which is inevitable to stop the spread of Covid-19. The findings not only add valuable insights to the literature of innovations in last-mile logistics but also in a more general context of technology acceptance research. An extended version of UTAUT2 was investigated for both genders separately, which clearly provided evidence for some differences in genders. Overall, the findings of this study offer valuable knowledge not only to theorists but also to practitioners in logistics and policymakers to increase ADVs acceptance and implement this innovative last-mile delivery solution successfully in the near future.

Declaration of Competing Interest

No Conflict of Interest.

Appendix A: 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.

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