The robot always rings twice - an empirical investigation of factors that influence trust towards robots in last-mile delivery

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Abbreviations

AGV= Autonomous ground vehicle

AVE=average variance extended

B2B= business-to-business

B2C= business-to-customer

CAGR= Compound annual growth rate

CEP= Courier, Express and Parcel

CO2= Carbon Dioxide

CSL= Crowd sourcing Logistics

FR=Factor reliability

HRI= Human-robot interaction

ICT= Information and communication technologies

IR= Indicator reliability

LMD= Last-mile delivery

PLS= Package pickup locations systems

TAM= Technology acceptance model

USD= United states dollar

1. Introduction

1.1 Motivation and subject matter

1.1.1 Last-Mile delivery

Overcoming the last mile has become a major issue for business-to-business (B2B) and business-to-customer (B2C) e-commerce retailers, and in particular for all concerned stakeholders, which are included in the delivery process (Punakivi et al., 2001). Major providers in the courier, express and parcel (CEP) market offering the delivery service are e.g. DPDHL, FedEx, and UPS (Orbis Research, 2018). But what exactly is last-mile delivery (LMD)? Orbis Research (2018) defines LMD as “the movement of […] goods from a transportation hub to a final delivery destination” (Orbis Research, 2018, p. 1). The destination is typically a personal residence (Datex, n.a.). In other words, CEP providers ensure the delivery of parcels, which consumers ordered before (e.g. from e-commerce retailers like Amazon) to the consumers’ residence or a determined location. The general fulfilment process for orders can be clustered into three general stages: 1. the order capture and promise, 2. order sourcing and assembly, and 3. order delivery (Campbell & Savelsbergh, 2005). Within the first stage, the consumer orders products from an e-commerce retailer. The e-commerce retailer confirms the order and promises to send the order to the consumer. Within the second stage the e-commerce player takes care of the sourcing and assembly of the ordered products. As a last step the order will be delivered to the customer’s residence or to a location determined by the customer. For most online retailers, the delivery option of home transportation is an additional service, which will be executed by a CEP provider e.g. DPDHL, FedEx or Hermes (Punakivi et al., 2001). Therefore, the LMD process is included within the third stage, the delivery of the order to the end-consumer. The present work is focusing on the last step and concerned stakeholders which are usually CEP providers.

1.1.2 Current trends and challenges

The international CEP market experiences an upswing in revenues and volumes. According to Orbis Research (2018), the global market size is expected to grow from a revenue of 30.2 billion USD in 2019 to 47 billion USD by 2024, which complies with a CAGR of 9.3%. The market is also characterized as highly dynamic, including growth rates from 7% to 10% (in 2015) in mature markets like Germany or the United States (McKinsey, 2016 a). In mature markets, the amount of delivered parcels is expected to double within the next ten years, resulting in 5 billion parcels in Germany and 25 billion parcels in the United States per year (McKinsey, 2016 a).

The expected enormous growth brings major challenges, which stakeholders of the market need to overcome like the increasing amount of orders, which need to be delivered to the recipient and the changing customer needs.

The reasons for the enormous growth are various. Current trends influence and disrupt the way stakeholder within the CEP market work currently, increase the competition on the market and create new challenges. One of the most important trends is the “e-commerce boom”, meaning the enormous ongoing growth of e-commerce sales, mainly within the B2C sector (AT Kearney, 2017). While in 2017, the e-commerce sales worldwide reached around 2.4 trillion USD, the number is expected to increase steadily, resulting in expected e-commerce sales of about 6.5 trillion USD in 2023 (Statista, 2019a). The largest sector is represented by the fashion segment, followed by electronics and media (Statista, 2019b). The growth of B2C e-commerce has also led to new consumer direct services models like grocery delivery services or home delivery services of mail-order pharmacies (Campbell & Savelsbergh, 2005). These upcoming businesses entering the market and confront delivery service providers with new challenges in the case of transportation. Groceries should be shipped under specific conditions, so that the food will not lose its quality (Campbell & Savelsbergh, 2005). Similar conditions are also needed for the delivery of medication. An example for the challenging new delivery service options is the mail-order pharmacy DocMorris, which promises customers the delivery of medication not later than 48 hours (DocMorris, n.a.). Furthermore, some medications need to be delivered under specific conditions e.g. an uninterrupted cooling chain (DocMorris, n.a.). All of these delivery promises have to be realized by CEP players, delivering the order to the end-consumer. In the future CEP players, which are able to deliver goods and services at a reasonable cost and on time as well as to the determined conditions of the e-commerce retailers are going to be successful (Lee & Whang, 2001).

In addition to the growing e-commerce sales, consumer demands are changing constantly, which directly affects CEP providers. Indeed, consumers require faster home delivery, including next day, same day or instant delivery, at a reasonable price or even for free (McKinsey, 2016 a). According to a study of McKinsey (2016 a) around 25% of consumers are already willing to pay more for same day or instant delivery, while at the same time 70% of consumers would prefer the delivery option with the cheapest cost or even for free. Many customers would also like the flexibility to shop in store and have items shipped to their home or to have the ordered items moved to a different location, such as an office, a self-service locker, or other pickup points (McKinsey, 2016 a). Next to the price of the product, online customers consider factors like the cost of home delivery, the variety of delivery options and the perceived quality of the delivery service, as key differentiators within the decision-making process (McKinsey, 2016 a). Furthermore, the customer also wants to receive predictive information about the expected delivery and the delivery status (Kennis DC Logistiek, 2017). Next to the customer, e-commerce retailers are triggering new customer demands, with the rise of new delivery services options (McKinsey, 2016 a). An example for that is the e-commerce retailer Amazons' subscription system "Amazon Prime". Amazon offers Prime-subscribers for a monthly price of about 7.99 €, a range of delivery options like premium delivery, same-day delivery, instant delivery or delivery within a specific timeframe, determined by the customer (Amazon, n.a.). Although Amazon is offering these options, CEP providers have to realize them. Based on the increasing consumer demands and new delivery service offerings, current CEP providers are confronted with increasing competition as more and more start-ups entering the market, which are focusing on new and more efficient ways of delivery (Hoffmann & Prause, 2018). This directly impacts companies within the CEP sector. In order to stay competitive, CEP companies need to act in a forward-thinking way, adapting last-mile services and offer customers more convenient options of delivery (AT Kearney, 2017).

While the market is going to grow tremendously, delivery companies are facing problems in fulfilling all the orders based on a lack of skilled employees (Manager Magazin, 2018). In order to handle the enormous e-commerce growth, the delivery sector is expected to have an additional need for at least 100,000 deliverers by 2025 in the German market (Manager Magazin, 2018). Although the demand of deliverers is quite high, delivery companies are facing huge problems to find skilled workers. Based on the demographic change, a low unemployment rate and a rather unattractive job profile, companies are confronted with huge problems in finding skilled deliverers (Manager Magazin, 2018). Furthermore, trends on the community level disrupt the LMD sector. Due to the ongoing climate change, more and more countries setting up clean air zones or low emission zones, banning high polluting vehicles from entering specific urban city centre locations. The city of London already set up low emission zones where high polluting diesel vehicles are not allowed to drive (Transport of London, n.a.). Another example can be found in Germany. A lot of cities like Stuttgart or Cologne already set up low emission or environmental zones (ADAC, 2019). Furthermore, every vehicle in Germany has an environmental badge, clustering the vehicle based on its pollutant emission (ADAC, 2019). Only vehicles with green badges (=zero or low emission) are allowed to enter environmental zones. The increasing amount of these zones force delivery companies to invest in building up a zero-emission fleet including electric mobility solutions or alternative emission free solutions (Kennis DC Logistiek, 2017).

Based on the described trends, the LMD sector is disrupted by new business models and the digitalization, including connectivity and new technologies, entering the market (McKinsey, 2016 a). In order to stay competitive, delivery companies need to think about innovative ways to fulfil orders in time and at a reasonable price, offer convenient delivery options and comply with low-emission zones.

1.1.3 Deployment of robots in LMD

The deployment of robots to deliver parcels is seen as one of the most promising and cost-effective options (McKinsey, 2016 a). Robots are able to solve the problem with clean air zones as they are electrified (Kennis DC Logistiek, 2017). Also new demands like same-day delivery or even instant delivery are easier to satisfy with robots (McKinsey, 2016 a). Furthermore, consumers are offered a more convenient delivery service, since the delivery with robots provides a specific delivery window of about 20 minutes, during which the consumer will be able to accept the parcel (Hoffmann & Prause, 2018). The delivery window can also be determined by the consumer.

Kennis DC Logistiek (2017) sees an ongoing robotization to be at "the heart of urban freight solution" in the future. McKinsey (2016 a) supports this opinion, and claims that in the future, urban deliveries will mainly be carried out by autonomous systems like ground robots with parcel lockers and drones, which are expected to cover around 80% of deliveries. The remaining 20% will be covered by traditional human delivery solutions (respectively 18%) and human-operated bike couriers (respectively 2%). The two human-operated delivery services will mainly be used by major B2B customers and for products with special delivery requirements, e.g. groceries, medications (McKinsey, 2016 a). Another indicator of the assumed success of delivery robots can be found in the start-up funding landscape. About 50% of all investments are favouring robotics start-ups, ranging from industrial robots to delivery robots (CB Insights, 2017). Start-ups, working on the deployment of delivery robots Starship Technologies, Marble, or Dispatch were able to obtain investments within the range of a couple of million Euro in 2017 (Balachandran et al., 2017). Furthermore, the delivery robot sector is expected to growth with an CAGR of 60% from 2017 till 2021 (Balachandran et al., 2017).

Regarding the LMD sector, service providers are already using robots within the downstream supply chain, fulfilling tasks like packaging, picking and storing of orders to enhance efficiency and to keep the integral door-to-door supply chain running (Kennis DC Logistiek, 2017). Within the delivery to the end-consumer and overcoming the last mile, different solutions around the world are currently tested and developed but haven't been fully rolled-out yet. Especially the automotive industry will take a disruptive influence on the sector, driven by large automobile companies (McKinsey, 2017). The range of possible autonomous solutions extends from unmanned technology solutions like drones or autonomous vehicles, through to human-robot-coexistences, a robot that will follow the delivery employee (Kennis DC Logistiek, 2017).

The implementation of robots comes along with a variety of benefits like increasing efficiency and productivity, reduction of errors, re-work and risk rates (Deloitte, 2017). It also has the potential to improve the safety of employees as well as create enhanced employee value by robots overtaking repetitive and mundane tasks, while employees can focus on more strategic tasks (Deloitte, 2017). As it can be seen in various other industries where robots are already implemented successfully, all of the benefits have the ability to result in a reduction of a company's direct and indirect operating costs, which will lead as a further step to a potential revenue growth (Deloitte, 2017). With the adaption of robots, CEP providers like DHL, UPS or FedEx can also counteract the increasing driver shortage (DPDHL, 2017).

1.1.4 Barriers a of successful robot deployment

According to a study of McKinsey (2016 a), consumers indicated that they are willing to pay more for faster delivery, but only a few participants were willing to accept orders from an unattended delivery solution like autonomous parcel lockers, even at reduced delivery costs. Therefore, it can be indicated, that consumers in LMD do not define their preference exclusively based on the lowest possible price. The results reveal, that there are underlying factors which explain the individuals' lack in an acceptance of robots. The individual's acceptance of a robot will ultimately determine the success of the robot's deployment (Groom & Naas, 2007). Therefore, delivery companies, which already consider the deployment of delivery robots, need to know why individuals might accept or not accept robots in order to integrate them in a successful way. Freedy et al. (2007) examined, that trust has been revealed as being an ultimately precursor, which directly affects an individual's acceptance of robots. Trust is of high importance for almost every relationship. It is necessary for private relationships, business relationships and trust it is also a critical element in interactive relationships between humans and robots (Hancock et al., 2011). The degree of trust is an important element of human-robot-interaction, and directly linked to the outcomes of such interactions like effectiveness and performance (Lee & See, 2004). It is one of the most important factors in designing reliable relationships between humans and robots but at the same time also the most difficult challenge to overcome (Groom & Nass, 2007). Every human-robot interaction needs the existence of trust, since an absence can impact the purpose of the interaction in a negative way (Billings et al., 2012). Furthermore, it is of high importance to examine the factor trust, since robots in general and delivery robots in particular, are not part of an individual's daily life yet. Individuals lack in a routine of interacting with robots and therefore aren't familiar with this type of autonomous systems. As Luhmann (1979) already revealed, familiarity is one of the main factors influencing the level of trust, since familiarity is an ultimate pre-condition for trust. Therefore, it could be assumed that individuals lack in trust towards delivery robots. Salo & Karjaluoto (2007) identified, that individuals are more likely to interact or work with a party they trust indeed, rather than a party with whom the individual has not developed a trust relationship at all. This effect increases within an unfamiliar environment or within an environment, which the individual cannot control (Salo & Karjaluoto, 2007). Delivery companies, considering a deployment of delivery robots need to know beforehand how to overcome an existing lack of trust and how to increase the trust, which individuals have in robots in order to deploy them successfully. Therefore, it is of high importance to identify factors, which are influencing the trust towards robots.

The deployment of robots in LMD represents a futuristic and highly innovative case for which the great majority of delivery companies still need to define and establish an approach focusing on the creation of trust in these autonomous systems (McKinsey, 2016 a). Companies lack in experience with the successful deployment and best practices within the specific area of delivery robots aren't existing yet. In order to take advantage of the deployment of delivery robots and to stay competitive within the changing market, the creation of a model focusing on trust creating factors, will offer valuable implications to delivery companies.

Furthermore, theoretical research in the area of trust towards robots is quite rare. Whereas research about trust towards manufacturing robots, service robots or even care robots already exists, the topic of trust in delivery robots has not been examined yet. As Li et al. (2010) already revealed, the level of trust towards robots also depends on the specific situation in which they are deployed. Therefore, theoretical knowledge and developed models concerning different kind of robots, could not be applicable to the case of delivery robots and should be examined further. As the topic of robots especially in the area of last-mile delivery is quite new, neither recommendations based on practical experience nor theoretical frameworks have been established yet. It is of high importance, to set up a theoretical framework and adapt theoretical trust models, in order to support companies in successfully launch the integration of delivery robots.

1.2 Problem statement

As elaborated within the previous chapter, the creation of trust is of paramount importance for delivery companies, considering the deployment of delivery robots, as trust is an ultimate precursor for consumers acceptance and therefore an ultimate factor for a successful implementation of these autonomous systems (Lussier et al., 2007). Companies need to know which factors are affecting the degree of trust in order to derive the best approach for a successful deployment. Therefore, the present paper is discussing the research question: which factors affect the level of trust towards robots in the area of last-mile delivery?

The present research is analysing trust creation in robots in the area of (LMD) out of the consumers' perspective, by focusing on the question, which factors are impacting the level of trust, that individuals have in delivery robots. The results of the analysis will help to make recommendations for managers of delivery companies in order to successfully integrate robots in the area of LMD.

The research methodology has been chosen based on a customer-based approach, taking into account the customer's intentions and feelings towards robots in the area of LMD. It is of high importance for service providers to act customer-centric, in order to effectively and efficiently offer services towards customers (Sheth et al., 2000). Customer-centricity is taking the customer as the focus of the whole business, rather than the product or service the company is offering in order to fulfil the needs and want of each individual customer.

The present research makes a contribution for companies, considering the implementation of delivery robots by identifying trust creating factors supporting the customers acceptance of these solutions and therefore promote a successful deployment. As robots and in particular delivery robots are not part of our daily lives yet, promising practices and established approaches are not existent. The present research closes this gap by analysing the creation of trust in robots and the identification of factors related to the consumers, the robot and the situational context. Based on the results related to the robot, companies will be able to design and develop robots in a way that consumers perceive them as being trustworthy, which will consequently result in an acceptance of these autonomous systems. Furthermore, the identification of trust creating factors regarding the customer, helps delivery companies to understand which personality traits increase trust and why consumers might mistrust robots. Based on the consumer-related results, companies will be able to derive implications for a promising implementation of the robot. This could help companies in successfully integrating the robot on the consumers' side of the delivery process. The evaluation of situational factors will help delivery companies to identify the most promising areas and product types for a successful deployment of robots.

Out of a theoretical point of view, the present research makes a contribution to the rare existent literature about trust in robots and delivery robots especially. While researchers already examined trust in robots in the context of social robots or manufacturing, trust in delivery robots has not been examined yet. Therefore, the research closes the gap by identifying trust creating factors in the special area of LMD. Furthermore, as concepts of existing research regarding trust in robots has been applied to the case of LMD within the study, the research validates existing trust theories about robots and examines if the theories are applicable to different situations.

1.3 Approach

In order to solve the research question, a comprehensive research was conducted, to get a fundamental understanding of theories about trust in general, trust development and creation. Furthermore, existing literature about trust in robots was examined to get a clear vision of possible factors, which have the ability to affect the trust level in robots. Additionally, literature about last-mile delivery solutions was examined. Based on the comprehensive review of the already existing literature, a model has been developed, with the aim to answer the research question. The related literature as well as the proposed model is reviewed in chapter 2. Based on the cause-effect-relationship of the proposed model, the derived hypotheses have been tested, using a quantitative methodology in the form of an online survey with consumer in the area of last-mile delivery. Chapter 3 includes all the information about the used methodology and the operationalisation. The results, which are reported in chapter 4, have been analysed by conducting Cronbach's alpha, factor loadings and a confirmatory factor analysis in order to test the validity and reliability of the model. Furthermore, a multiple regression analysis was conducted in order to analyse and identify factors, which have an actual impact on the level of trust in delivery robots. The results of the analysis were also applied to the practical context and discussed in order to derive managerial recommendations, within chapter 5. Furthermore, an ethical consideration about the deployment of delivery robots has been discussed. The results are included in chapter 6. Within the last chapter, managerial and theoretical implications were derived and limitations as basis for further research were identified.

2. Theoretical background and foundations

2.1 Trust

2.1.1 Definition of trust

"Trust is a basic fact of social life" (Luhmann, 1979, p. 4)

As Luhmann (1979) already stated, within a society trust is always existent since trust is a general need and necessary for an existing and working society. The individuals within a society have the ability to affect trust. Furthermore, trust is considered as the basis for deriving rules of proper conduct for the individuals within a society (Luhmann, 1979). Indeed, the existence of trust sets a framework for individuals' behaviour and decisions within a world which is marked by complexity and uncertainty.

Within the literature, the creation and existence of trust is an interdisciplinary research subject, as it has been studied by a range of researchers from several fields like social psychology (Deutsch, 1962), trust in evolutionary biology (Bateson, 1988), as well as trust in context with economics (Bruckner, 2016) to name just a few. As various as the research areas are, as various are the definitions of trust. One of the first widely acknowledged researchers in the area of trust is Morton Deutsch, who defines trust as a partial aspect of an individuals' personality (Marsh, 1994; Deutsch, 1962). Based on Deutsch's (1962) beliefs, trust is the actual result of an individual's choice among a range of possible behaviours within a specific trust situation. The trust choice is affected by an individual's perception of the actual situation and a consideration of the attached costs and benefits (Spaeth, 2007). The benefits need to outweigh the costs, leading an individual to decide to trust. The expected benefits of an efficient trust relationship are various. Existing trust leads to an easier cooperation (Argyle, 1991). Furthermore trust can increase the task performance in collaborations (Golembiewski & McConkie, 1975). The connected costs are represented by the degree of risk, that the trusted opponent misuses the received trust (Marsh, 1994). According to Deutsch (1962), the specific situation in which trust occurs is the foundation for the distinction of various types of trust. There are different kinds of trust in situations of social conformity, hope, innocence, confidence, despair, impulsiveness, virtue, masochism, faith or risk-taking (e.g. Golembiewski & McConkie, 1975; see Marsh, 1994 for an overview).

Trust can be defined as a psychological state, defining trust as a decision behaviour of an individual (Nooteboom, 2003). Furthermore, trust can be seen as a choice behaviour, implying that trust is a calculative and rational decision, based on the available information, which an individual has (Spaeth, 2007). This approach believes that an individual reflects information about the trust situation and the opponent and therefore decides whether to trust or mistrust, based on a rational behaviour approach (Spaeth, 2007).

Rousseau et al. (1998) defines trust as "a psychological state comprising the intention to accept vulnerability based upon positive expectations of the intentions or behaviour of another" (Rousseau et al., 1998, p. 395). Therefore, trust can be seen as a psychological condition of an individual, and that cognitive and affective processes are needed to develop trust. Adali (2013) also sees trust mainly as an underlying psychological condition, rather than a choice or behaviour. Based on the definitions of Rousseau et al. (1998) and Adali (2013), the level of trust also describes the willingness of an individual, to be vulnerable to some degree against the trusted opponent. The intention, to accept this vulnerability, is based on the individual's expectations towards the intentions and behaviour of the trusted opponent (Adali, 2013). If the individual believes that the trusted party behaves in the way which the individuals expects, the level of trust is quite high.

Most of established definitions, which can be found within existing literature share one common idea: that trust is associated with dependence and risk. Dependence in the context of trust means, that an individual is in an actual dependence relationship with the trusted party and he depends on something or someone (Nooteboom, 2003). A certain degree of risk is also always present in trust situations and relationships, as it is possible that an individual's expectations or hopes in the trust relationship won't be satisfied or the given trust is being misused by the trusted party. An individual can just assume the future outcome and behaviour of the trusted party to a certain degree, as future developments and actions can't be foreseen completely (Nooteboom, 2003). In every trust relationship, there are at least two parties involved: on the one side there's the trustor, which is the person who decides whether to trust or not. On the other side there's the trustee, a person, object or organization, which receives the trust from the trustor (Nooteboom, 2003).

2.1.2 Trust basics

The question of whether to trust or mistrust, arises based on a lack of information within a trust situation (Nooteboom, 2003). If an individual would be completely certain about future developments and the behaviour of the trusted counterpart, there wouldn't be the question about trust at all. In this case the individual would know exactly about the consequences, when he decides to trust. The existence of trust is also influenced by the base of the information, motives and competencies of individuals as well as on their observed or reported behaviour of the trusted person or object (Spaeth, 2007). Trust is also related to learning, which is based on knowledge and experience (Nooteboom & Six, 2003). This means, that an individual requires time and experience to identify the competencies and intentions of others, in order to know if an opponent can be trusted or not. It also takes time to understand value judgments and emotions (Nooteboom & Six, 2003). Therefore, the development and creation of trust is an ongoing, unsteady process and the value of trust is changing in the course of time. The actual level of trust differs over the time, by changes from the trusted opponent or even by changes of the individual itself (Pereitra, 2009). As trust also depends on the specific situation, it is possible, that the degree of trust varies over time when the conditions of the trust situation change (Marsh, 1994; Pereitra, 2009). In order to verify trust over time, Marsh (1994) established a simple notation: T(i,j,a). The notation can be read as: the individual i, trusts j in a specific trust situation a (Marsh, 1994). According to the findings of Marsh (1994), trust can be measured within a range from "-1" to "+1" (-1= mistrust; +1=trust; 0= uncertainty or ignorance).

It is of high importance to make a clear distinction between the factors, which lead to an individual's mistrust or trust. These terms are not just simple opposites, meaning that trust and distrust are not necessarily based on the same factors (Pereitra, 2009). Therefore, trust and distrust can be coexistent. The fact that a specific factor leads to higher trust, does not mean that an individual mistrusts an opponent, if the specific trust-creating factor is not existent within the trust relationship (Pereitra, 2009).

The process of an individual's trust creation can be described within three steps. First of all, an individual perceives subjectively the trustworthiness of the counterpart and further information about the situation, the connected risks and the level of dependence (Muethel, 2006). Based on the gathered perceived information, the individual decides whether to trust or not. As a result of the decision, the trust action follows as the last step. The actual trust decision can but doesn't have to result in a trust action (Muethel, 2006). For a better understanding, the trust creation process is depicted in figure 1.

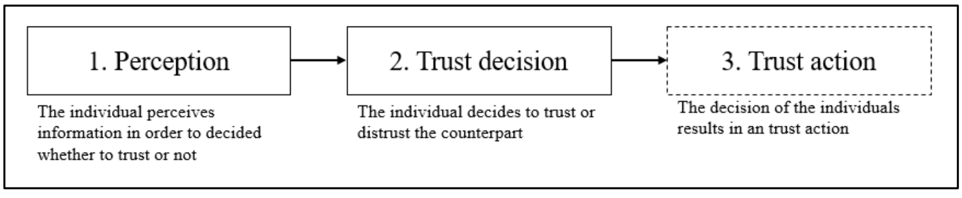

Figure 1: Trust creation process (according to findings of Muethel, 2006)[1]

[1] Source: own illustration

2.2 Trust Theory - The conditions of trust

Nooteboom (2003) established a widely applied model of interpersonal trust creation, which helps researchers to examine and identify trust levels. According to Nooteboom (2003) "the trustor trusts a trustee in one or more aspects of behaviour, under certain circumstances." (Nooteboom, n.a., p. 5). Based on Nooteboom's (2003) trust theory, in order to create trust, factors related to three different parameters need to be taken into account: the trustor (= the individual who trusts), the trustee (=the opponent, which can be a person or object, who receives the trust from the trustor), and the trust situation (=the situation in which the question whether to trust or mistrust, occurs). Therefore, factors connected to three parameters, are acting as explaining variables for an individual's trust level (Muethel, 2003). The personality of the trustor and the trustee, as well as the conditions of the specific situation in which the question of trust arises, are relevant factors, which are influencing an individual's decision towards trust or mistrust. Therefore, trust is contingent upon factors of the trustee, the trustor as well as the situation, indicating that the level of trust depends on both conditions, inside and outside (Muethel, 2003). Based on this statement, depending on the conditions a trustor will trust the trustee in a different way. The model can be applied in order to identify and explore the level of trust an individual has e.g. in organizations or people. Figure 2 depicts the findings of Nooteboom's trust theory.

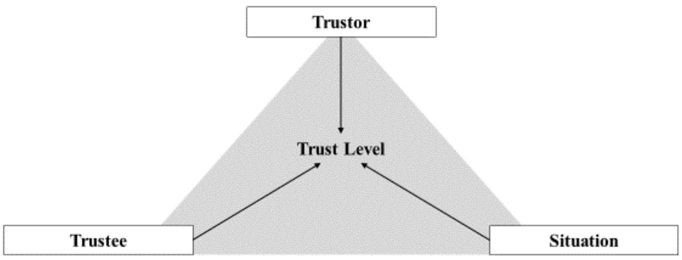

Figure 2: Trust theory – the conditions of trust (according to findings of Nooteboom, 2003)[2]

The trustor

The trustor is the partner in an interaction, who decides whether or not to trust the counterpart (=trustee) in a trust situation (Nooteboom, 2003). The trustor decides to trust or mistrust, based on the fact, that the decision towards trust is connected with a specific degree of risk. The most relevant factor, which is influencing the degree of trust regarding the trustor, is the trustor's own personality, including characteristics like loyalty, integrity and consistency (Muethel, 2006; Nooteboom, 2003). Next to the personality the individual's previous experiences in trust

[2] Source: Own illustration

relationships as well as experiences with the trustee are relevant factors. If the individual trusted the counterpart before, and the counterpart betrayed the individual's trust, the trust level within the next trust decision will be weaker based on the previous bad experience (Muethel, 2006). Furthermore, the trustor's tendency to take risks, is also a relevant factor as trust is always connected with risk, which is based on a lack of information. Therefore, individuals who are risk-loving tend to trust, compared to risk-averse individuals, who do not trust easily (Muethel, 2006).

The trustee

The trustee is the person or object who receives the trust from the trustor (Nooteboom, 2003). The trustor needs to make a risk-attached pre-decision, because the trustor is dependent on the trustee and if the trustee doesn't act in the expected way, the trustor can be harmed or effected negatively (Mayer et al., 1995). Therefore, before the trustor makes the decision whether or not to trust, he takes into account factors like the trustee's personality in order to assess subjectively the trustworthiness of the trustee (Muethel, 2006). Furthermore, factors like the trustee's characteristics and behaviour, can influence the level of trust, which he receives from the trustor (Muethel, 2006).

The trust situation

Factors regarding the specific situation also define the actual state and level of trust (Nooteboom, 2003). A factor regarding the situation is the time of the trust decision. As mentioned before, trust is a dynamic and adapting value, which is changing over time (Marsh, 1994). The trust value is increasing or decreasing in the course of time based on the preceding behaviour of the trustee within the situational context. Furthermore, factors like the culture of an individual are also assigned as situational factors (Lee & See, 2004).

2.3 Last-Mile delivery

2.3.1 Definition of LMD and the last-mile issue

Overcoming the last mile has become a major challenge nowadays. Esper et al. (2003) defines the last mile as "the delivery of the product to the consumer" (Esper et al., 2003, p. 177). Therefore, the logistical process within the last-mile describes the delivery service for the end-consumer. Although, companies are able to move an immense amount of goods all over the world, overcoming the last mile has been revealed as being the biggest issue in the CEP sector (Moroz, 2016). For most online retailers, the delivery option of home transportation is an additional service, which will be executed by a CEP provider e.g. DPDHL or Hermes (Punakivi et al., 2001). Companies, offering the delivery service for the customer are confronted with several issues like new delivery opportunities (e.g. same-day delivery, instant delivery) the expected exploding number of orders in e-commerce, and in particular the increase in small orders, especially in urban areas (Punakivi et al., 2001; WIK Consult, 2019). All of these factors make the fulfilment of the delivery service quite challenging for CEP providers, which is called the "last-mile issue" (Punakivi et al., 2001; Moroz, 2016).

2.3.2 Findings of current LMD solutions

As discussed in chapter 1, the case of LMD has become an issue of high importance in the last years. Current researches examine opportunities how to overcome and tackle the upcoming enormous and disruptive changes in the sector. Punakivi et al. (2001), assume that unattended delivery of orders has a high ability to solve the last-mile issue. The unattended delivery option can be divided into two main concepts: the reception box concept includes a parcel box, permanently fixed at the customer's home e.g. in the yard or garage, while the delivery box concept, includes the deployment of an insulated secure box, which is equipped with a specific docking mechanism and can be attached temporarily at the house of the recipient (Punakivi et al., 2001). As an actual investment and commitment of the recipient is needed in order to deploy unattended delivery solutions successfully, the authors see an actual success of this solution as being critical. Furthermore, McKinnon & Tallam (2003) mention a high lack of security within these solutions, as the authors identified within their research, that unattended systems are most vulnerable based on a missing proof of the delivery and increasing risks of thefts based on successive orders.

Iwan et al. (2015) discussed within their research, the deployment of parcel lockers to solve the issue of last-mile and reduce the heavy traffic of commercial vehicles within cities. Parcel lockers are also unattended systems, including reception boxes, which are deployed at a specific place (Iwan et al., 2015). The recipient receives a code in order to open a specific reception box in a specific machine. As the solution does not offer the possibility of at home delivery, a commitment and an effort to pick up orders is needed from the recipient. Therefore, these systems are only a promising opportunity, when installed in the proper location, e.g. close to the recipient's home or on the way to work (Iwan et al., 2015). Morganti et al. (2014) were also focusing in their research on alternative delivery services like automated parcels lockers and pickup points in France and Germany in comparison to at home delivery. As the results revealed, parcel lockers are quite common in Germany and established very well, while in France pickup points are the most popular alternative delivery service (Morganti et al., 2014).

Pickup points offer the recipient the ability that he can pick up the parcel when it is most suitable for him, as the time and place of the delivery can be determined by the customer (DPD, n.a.). Possible pick-up points are supermarkets, kiosks or service stations (Landmarkglobal, 2014). Deutsch & Golany (2017) also see the development of a parcel locker network as a promising solution in the area of last-mile delivery, out of a cost-related view. The successful deployment of such a system depends on the optimal amount of lockers, suitable locations and efficient sizes of locker facilities (Deutsch & Golany, 2017). As these concepts require an effort from the recipient's side, parcel lockers can only be deployed successfully, when the solution has a clear advantage over all other delivery solutions (Yuen et al, 2018). Furthermore, the self-picking concept needs to be integrated within the consumers' lifestyle, values and needs, in order to improve the intention of the end-users to pick up their orders. Moroz & Polkowski (2016) also discovered, that an actual reduction of carbon dioxide (CO_2) emissions, which comes along with the deployment of parcel lockers, does not lead younger consumers to accept these systems. Furthermore, it is also incapable to compete with other delivery options. Although, consumers would be willing to pay a little more for an emission-free delivery option, the willingness to pick up parcels, when using parcel lockers is quite low (Moroz & Polkowski, 2016).

Muñoz-Villamizar et al. (2015) examined with the use of mathematical modelling, the efficiency and success of collaborative logistics operations. This solution includes a horizontal collaboration of companies, operating at the same level of the supply chain, by sharing properties like trucks, customers and routes in order to increase the efficiency of the delivery task (Muñoz-Villamizar et al., 2015). As a result, various benefits of the solution have been quantified, revealing that the solution is quite promising in order to solve the last-mile issue.

Conway et al. (2011) discussed the challenges and opportunities of the deployment of freight-tricycles in Manhattan, New York. The discussed solution includes a privately or public-private operated logistic space, in which goods from multiple carriers are being delivered. Within the hub, the orders are being loaded on smaller and emission-free vehicles like electrically-aided tricycles, to be delivered to the recipient (Conway et al., 2011). Based on the results, the authors recommend the deployment of smaller and cleaner vehicles (like electric tricycles) in cities, in order to overcome the last mile. Tipagornwong & Figliozzi (2014) examined the competitiveness of tricycle solutions compared to current diesel vehicles out of a cost-related view. The authors see a huge potential, due to high cost advantages coming along with the deployment of tricycles, based on reduced driver's cost, speed limits and parking policies.

Suh et al. (2012) examined the efficiency of alternative package pickup locations systems (PLS) like kiosks or grocery stores. The results revealed, that the deployment of such systems within suburban and urban areas is only efficient if a social network using a mobile ICT platform is deployed in order to assist the pickup of the packages. Chen & Pan (2015) as well as Castillo et al. (2017) and Frehe et al. (2017) are discussing within their researches the effect of the ongoing sharing economy, and therefore examine the deployment of crowdsourcing solutions in the area of LMD. The solution of crowdsourcing is based on drivers with independent contracts, delivering orders in their own vehicles (Castillo et al., 2017). Chen & Pan (2015), propose a methodological approach for the application of crowdsourcing solution in the area of LMD. The theoretical framework of their solution recommends, to include taxi fleets in the delivery process and establish customer self-pickup facilities, e.g. in shops. The sensibility and performance of the system still needs to be proven. Castillo et al. (2017) suggest, that companies should implement crowdsourcing logistics (CSL), when the penalties for delayed deliveries are weak and the company's main focus is to increase the amount of total deliveries. Frehe et al. (2017) developed a business model concept, allowing logistic companies to implement crowd logistics services in a sustainable way. The authors see disadvantages of the solution within the maintenance of the customer and carrier crowd, as well as the high initial investments.

2.3.3 Deployment of robots in LMD

Scientific researches and in particular established methodologies for the application of robots in the area of last-mile delivery are still rare in the literature. McKinnon (2016) examined the deployment of drones in last-mile logistics. Based on his findings he identified a range of opportunities, enabling a successful deployment but the author proposes that an actual application in the future will remain limited based on factors like a weak scale of economics, and a restricted value addition. Goodchild & Toy (2018) evaluated the CO2 emissions, based on the deployment of unmanned aerial vehicle technology (=drones) compared with trucks. The authors identified, that drones outpaced trucks in the area of CO2 emissions by far. Only for longer delivery routes and for a huge amount of recipients, the truck has been revealed as being the more sustainable option. Based on the results, drones only offer a CO2 benefit if the service zones are close to the home base and when the delivery routes have a small number of stops (Goodchild & Toy, 2018).

Autonomous systems, deployed in the area of LMD, are in a quite early state currently, but expected to account for about 80% of deliveries in the future (McKinsey, 2016 a). According to a study of McKinsey (2016 a) the following solutions are expected to dominate the market of LMD as the most promising opportunities for the future:

Drones:
Drones are aircrafts without a human pilot on board, flying autonomously or coordinated by a pilot on the ground (McKinsey, 2016 a). Although the delivery of packages via drones is already available in selected Chinese cities, in Europe they are still under tight restrictions and haven't been deployed successfully yet (McKinnon, 2016). Agatz (2018) believes in the combination of trucks and drones, and therefore developed a scalable model, that calculates the most efficient route, including deliveries fulfilled by truck and also by drone. Applying drones to delivery trucks, can reduce the total delivery time on average by 30-38%, compared to the scenario, where the truck is used only (Agatz, 2018). Furthermore, drones have the ability to satisfy the increasing demand of same-day delivery of consumers (McKinsey, 2016 a).

Autonomous ground vehicles (AGV) with parcel lockers:
These systems consist of autonomous delivery vehicles (e.g. van or truck), including lockers, where customers can pick up their orders, without an interaction with a human employee (McKinsey, 2016 a). The vehicles drive autonomously to the recipient's home, where the end-consumer can pick up the parcel from a specified locker, which is attached at the autonomous delivery vehicle. Afterwards, the system will drive back to the hub. The solution is especially suitable for huge cities, with more than 50,000 inhabitants (McKinsey, 2016 a). AGVs are identified as being the most promising robot in particular for urban areas. Therefore, AGVs are expected to dominate the future LMD market, based on an anticipated cost advantage of at least 40% compared to traditional delivery options (McKinsey, 2016 a).

Semi-autonomous ground vehicles:
This solution combines an autonomous vehicle with a human employee within a human-robot collaboration (McKinsey, 2016 a). The robot is taking over tasks like driving and parcel organizing, while the human takes care of the scanning and arrival announcement. Therefore, the solution has the ability to help and support human deliverers through overtaking heavy and recurring tasks (McKinsey, 2016 a).

Droids:
Droids are small autonomous and slow vehicles, containing parcels in a box. These autonomous systems are using the pedestrian way instead of the street (McKinsey, 2016 a). Existing droids, which are deployed in the area of last-mile delivery are equipped with six wheels. The droids

can reach a maximum speed of four miles per hour and their battery lasts around two hours (Gaskill, 2017). The autonomous systems can carry about 20 pounds (Gaskill, 2017).

2.4 Trust in robots

According to Nooteboom's (2003) basic fundamentals of trust, the question of trust also arises in the context of the deployment of robots. As mentioned in chapter 2.1.1 the question of trust comes up, when there's a lack of information about future development and behaviour of the trusted opponent (Nooteboom, 2003). In the context of robots this means, that individuals also lack in foresights as robots are working autonomously (Schaefer et al., 2014). Individuals need to decide whether or not to trust the intentions and future behaviour of robots, since individuals, which are interacting with these systems can't be completely certain what the robot is doing next. Although the amount is limited and research about trust in robots in LMD are rare, there are papers discussing trust in robots deployed in other areas, which helps to understand what kind of factors lead to a higher level of trust in these autonomous systems.

Different sectors have already appreciated the various advantages of robots and already implemented them successfully. Especially in the area of industry 4.0, manufacturing companies deploy robots in order to increase factors like efficiency and productivity (Mies & Zentay, 2017). Also, the deployment of "cobots" (=collaborative robots), supporting humans by taking over tasks like lifting heavy materials, are widely used to increase the outcome of the production, simplify tasks and ensure the physical integrity of fabric workers (Østergaard, n.a.). As various researchers examined, automation has been identified as a key dimension of a robot (Schaefer et al., 2014; Hancock et al., 2011). Therefore, the literature review includes researches about both, autonomous systems and robots.

2.4.1 Trust factors regarding the human

Regarding the human, who interacts with a robot, several factors have been revealed, which have the ability to influence the level of trust towards these autonomous systems. The effect of demographic factors towards trust in robots has been examined by various researchers. Scopelliti et al. (2005) identified, that older individuals significantly mistrust new technologies like robots more than adults and younger individuals, as elderly are lacking in familiarity with new technologies in general and furthermore underestimate the potential of autonomous machines. Additionally, as the authors identified, females expressed a greater scepticism about robots than males (Scopelliti et al., 2005). The influences of gender on the trust level is disputed. Some researches didn't find out any differences regarding the trust level of men and women (cf. Evers et al., 2008) while others were able to identify significant differences (cf. Scopelliti et al., 2005; de Graaf & Allouch, 2013). Furthermore, previous experience with autonomous systems or even robots lead to higher trust (Desai et al., 2007). Individuals, interacting with an automated robot for the first time, indicating a lower level of trust. Also, the human's characteristics like self-confidence have the ability to raise the trust level towards robots (Chen & Terrence, 2009). Furthermore, researchers deployed the technology acceptance model (TAM) in order to identify differences in trust in robots (cf. de Graaf & Allouch, 2013; Goudey & Bonnin, 2016). The technology acceptance model can be deployed in order to explain how individuals behave, when they are confronted with new technologies (Davis, 1989). The essential belief of the model is, that an individual's intention to use or not to use new technologies depends on two main factors, namely the perceived usefulness of the new technology and the perceived ease of use (Davis, 1989). The model claims, that individuals, who perceive new technologies as being useful and easy to use are more likely to accept them (Goudey & Bonnin, 2016). Ghazizadeh et al. (2012) identified the need of integrating trust in the technology acceptance model. Based on his findings, an individual's trust will be impacted based on the degree of the perceived usefulness and perceived ease of use. The resulting level of trust consequently impacts an individual's intention towards an actual use of the technology (Ghazizadeh et al., 2012). Furthermore, it has been revealed within previous studies, that the perceived usefulness of new technologies like robots, is determined by an individual's technological anxiety, meaning that the use of a robot leads to anxious or emotional reactions of the individual, which can have an impact on the level of trust (Heerink et al., 2010; Heerink, 2011).

Another human-related variable, which has the ability to impact the trust in robots, is an individual's attitude towards technology in general (Scopelliti et al., 2005). Individuals with a weak attitude towards new technologies are more likely to mistrust them. Especially elderly indicated emotional difficulties with new technologies in general, which leads to mistrust towards robots (Scopelliti et al., 2005). Individuals also trust robots more if they feel comfortable with them (Evers et al., 2008). Merritt & Ilgen (2008) also identified, that trust in automation is related to the level of initial trust in a system. The researchers compared the individual's perceptions on the characteristics of an autonomous system to the actual machine characteristic and identified that the level of initial trust and the actual trust in the autonomous machine are correlated (Merritt & Ilgen, 2008).

2.4.2 Trust factors regarding the robot

Hancock et al. (2011) claims that the robot's characteristics and especially the performance should be considered as being the most important driver of trust towards them. Humans mistrust robots based on their autonomous behaviour, which prevents individuals to foresee what the robot is doing next (Hancock et al., 2011). Also, the robot's lack of self-awareness leads to mistrust, especially in dangerous situations (Kidd & Breazeal, 2004). Therefore, the possibility to adapt or adjust the autonomous behaviour of a robot leads to higher trust, as an adjustment of automation offers some level of collaboration (Cai et al, 2012; Heerink et al, 2010). A possible adjustment of the robot's autonomous behaviour could be the opportunity to give commands to the robots. The possibility to give feedback to the robot also leads to higher trust towards them (Desai et al., 2007). Furthermore, a higher predictability of the robot's actions also results in a higher level of trust (Groom & Nass, 2007). If individuals know beforehand what the robot is doing next, the trust level increases. Desai et al. (2007) identified the effect, that individuals who have a high level of experience with automated robots, trust these systems more, only when the robot's level of automation is adaptable. Scopelliti et al. (2005) revealed, that individuals have more trust in robots, when there's a possibility to interact with them. This effect could only be found within the age group of younger participants. Elderly indicated, that they don't want to interact with a robot (Scopelliti et al., 2005). Furthermore, a higher level of reliability leads to higher trust in robots (Lee & See, 2004). If individuals perceive the robot and the robot's actions as being highly reliable, the level of trust increases. The reliability of the robot and therefore the level of trust decreases, when the robots makes a mistake or has a system break down (Desai et al., 2007). Also, a robot has to act as the individual expects him to act, in order to receive trust (Groom & Nass, 2007). The matching of expectations and actual behaviour will lead to a higher level of trust. Transparency has been revealed as being important in the case of human-robot interactions (Sanders et al., 2014). Within their examination, Sanders et al. (2014), identified, that participants reported higher levels of trust, when the robot provided information about upcoming actions constantly.

Also, the physical attributes of the robot, have an impact on the level of trust. As Charalambous et al. (2015) identified, individuals feel intimidated and worried by huge robots, which leads to distrust in these autonomous systems. Furthermore, several researchers are also focusing on anthropomorphism in context with trust in robots. Anthropomorphism is a combination of the Greek words anthropos (=man) and morphe (=form or structure) (Duffy, 2003). The term describes the tendency of individuals, to ascribe characteristics which are typical for a human, like behaviour or appearance, to an inanimate or nonhuman object (Duffy, 2003). The 'humanization' of nonhuman things is based on the theory "uncanny valley", which was originally established by Mori (1970). The hypotheses states, that a robot, which is more humanlike in its movements as well as its appearance, will create an increasingly positive affinity of an individual and will be perceived as being more trustworthy, since anthropomorphism and trust are correlated (Mori, 1970; Złotowski et al., 2015). The level of anthropomorphism needs to be chosen carefully. An individuals' positive affinity with a robot reaches its highest level when the robot becomes undistinguishable to a human person, while a clearly distinguishable but nearly perfect reproduction of a human person will lead to negative reactions of individuals (Złotowski et al., 2015). Furthermore, the degree of anthropomorphism depends on the situation where the robot is deployed, as different kinds of appearances create different kinds of expectations towards the robot (Bartneck et al., 2009). In the area of robots, deployed for the care of elderly, humanlike designs are applied very often in order to increase the level of trust (Duffy, 2013). Eyssel et al. (2012) identified, that individuals express different trust levels based on the gender of the robot. The authors examined, that male individuals feel closer to robots, speaking with a male voice and also trust them more, while females preferred the female voice of the robot (Eyssel, 2012). Furthermore, researchers mentioned, that robots should be able to express social behaviours e.g. emotional expressions like a human person, in order to be trustworthy (Bartneck et al., 2009). It is important to match the appearance of the robot with its abilities and tasks in order to create trust and to avoid to not fulfil expectations (Duffy, 2003). This also goes in line with Groom & Nass (2007) findings, that a robot needs to act as it is expected in order to create trust.

2.4.3 Trust factors regarding the environment

Lee & See (2004) identified different levels of trust in robots, based on the culture of individuals. In this case culture means the origin of individuals. Also, Evers et al. (2008) identified, that individuals from China have higher trust in robots than individuals from Western countries, especially the US. Furthermore, Chinese participants indicated a higher demand of controlling the robot and also preferred anthropomorphized robots, compared to participants from the US (Evers et al., 2008). Li et al. (2010) also examined trust level differences of service robots between German, Chinese and Korean participants. German individuals expressed a significantly lower level of trust towards robots, based on anxiety and concerns, whereas individuals from China or Korea perceive robots as being highly likeable and trustworthy. Furthermore, Chinese and Korean participants indicated a higher engagement with the robots

(Li et al., 2010). Based on the masculine culture and the individualism, countries like Germany prefer to control the robot and deploy the robot as a tool or machine rather than within service areas (Li et al., 2010). Another environmental aspect is the type of task, for which the robot is used for. Kidd (2003) examined, that the type of task influences the degree of trust, which the robot receives from an individual. Furthermore, in order to increase trust in robots, the task, assigned to the robot, must match the robot's appearance (Li et al., 2010).

2.5 Trust Factor-Model for robots in LMD

2.5.1 Development of the model

In order to identify factors impacting the level of trust in robots in the area of LMD, existing literature on trust creation in general, trust towards robots as well as trust in automation has been reviewed. Based on the analysis a conceptual model was defined. The trust factor model's aim is to identify, which factors are driving the level of trust in delivery robots. As the literature suggests, a range of factors have to be taken into account to identify trust creating factors for robots (cf. Schaefer et al., 2014). Therefore, several factors were tested and examined in order to identify main influencing factors.

Based on the trust theory of Nooteboom (2003) (see figure 2), the three-factor approach was applied as the framework for the model, including the three proposed trust antecedents: factors regarding the trustor, the trustee and the trust situation. The model has been applied to the context of trust creation in robots in the area of LMD. Therefore, the trust-factors model includes the three adjusted categories: robot-based factors (applied from trustee factors), human-based factors (applied from trustor factors) and situational-based factors. This approach also goes in line with the various results of existing research about trust creation towards robots. Most researchers define factors divided by the human, the robot and environmental based factors including situational factors (cf. Sanders et al. 2011; Hancock et al., 2011).

The variable "Trust towards robots in LMD" has been defined as the dependent variable, since the following analysis is focusing on the identification of factors, which influence the actual degree of trust, that individuals have in delivery robots. Therefore, the variables which are categorized in human-based, robot-based and situational factors have been assigned as independent variables. An illustration of the model, representing the causal relationship of the independent variables towards the dependent variable, as well as the connected hypothesis are illustrated in figure 3.

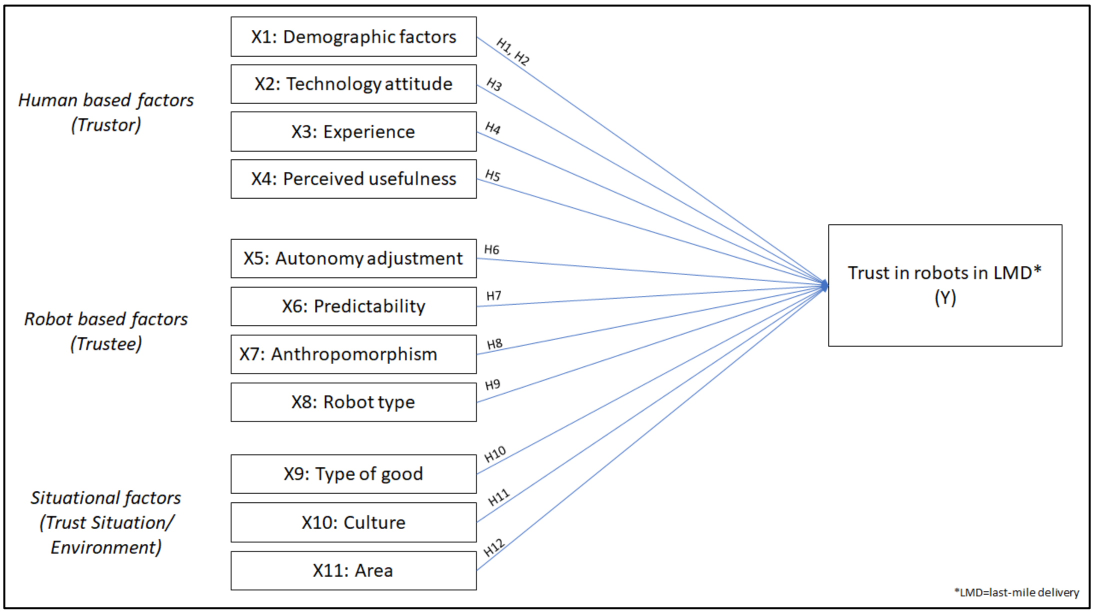

Figure 3: Trust-factor model[3]

2.5.2 Hypotheses

Human-based factors

In order to identify which kind of human related factors have an actual influence on the trust towards delivery robots, four independent variables have been defined.

To examine in which direction and to which extent, the age and gender of humans impact the degree of trust towards delivery robots, the independent variable X1 "Demographic factors" was implemented in the model. As previous researches already identified, elderly mistrust robots more than younger individuals and women have a greater level of mistrust in robots than men (cf. Scopelliti et al. 2005; de Graaf & Allouch, 2013). Therefore, the following two hypotheses have been derived:

H1: Younger individuals have a greater level of trust towards delivery robots compared to elderly

H2: Males trust delivery robots more than females do

Additionally, the variable "technology attitude", was implemented in the model. Scopelliti et al. (2005) claimed, that social robots gain greater trust if individuals have a higher attitude towards new technologies in general. Therefore, hypothesis H3 focuses on the effects of the individuals' technology attitude.

[3] Source: own illustration

H3: Individuals with a higher attitude towards new technologies have a greater level of trust in delivery robots

Furthermore, the effects of experiences with autonomous systems, has been revealed as being an important factor, impacting the level of trust in robots (Desai et al., 2007). Individuals with experiences with autonomous systems have higher trust in robots. Therefore, the variable "experience" has been implemented in the model, represented by hypothesis H4.
H4: With an already existing experience with autonomous systems, individuals have greater trust in delivery robots

De Graaf & Allouch (2013) identified within their research study about social robots, that individuals have greater trust in these technologies, if they perceive the robots as useful and enhancing for the task. Therefore, the dependent variable "perceived usefulness" was created, in order to test if an individual's perceived usefulness of delivery robots leads to a higher level of trust. Based on the assumptions, hypothesis H5 was derived.
H5: If individuals perceive the deployment of delivery robots as useful, they trust them more

Robot-based factors

As autonomy is one of the key dimensions of a robot, which distinguish the robot from a human, the level of automation has an impact on the level of trust towards the robot. Cai et al. (2012) and Heerink et al. (2010) examined within their studies, that individuals exhibit greater trust in autonomous systems, if the system provides a possibility to change the degree of autonomous behaviour, giving the human the intention that he can control the system. Therefore, the independent variable "automation adjustment" was implemented in the model, to test whether or not individuals trust robots more if they have the possibility to adjust the degree of autonomous behaviour.
H6: With the possibility to adjust the delivery robot's autonomous behaviour, individuals have greater trust in them

With the independent variable "predictability", influences on the level of trust towards delivery robots based on the predictability of the robots upcoming actions are examined. Groom & Nass (2007) already claimed that individuals have greater trust in robots, if they know beforehand what the robot is doing next. Applied to the case of last-mile delivery hypothesis H7 was derived.
H7: If the delivery robot's upcoming actions are more predictable, individuals have greater trust in them

Several researches examined the appropriate design of the robot, in order to create trust. Some researchers (e.g. Złotowski et al., 2015; Eyssel, 2012; Bartneck et al., 2009) claim, that individuals express a higher level of trust in humanoid robots compared to non-human robots. The effects of humanlike robots are of high importance, since most of the current delivery solutions are designed in a not-human way (cf. McKinsey, 2016 a). Therefore, the independent variable "anthropomorphism" was established in order to measure the effects on trust towards delivery robots, included in hypothesis H8.

H8: Individuals have greater trust in humanoid delivery robots, compared to non-human delivery robots

As McKinsey (2016 a) already identified the four most promising delivery robot solution, it is interesting to examine, if the different robot types, receive different levels of trust. As Charalambous et al. (2015) already assumed, the size of the robot has an impact on the level of trust. According to the authors' results, individuals express a higher level of trust towards smaller robots compared to larger ones. Furthermore, previous studies already revealed that drones might not be the best option, when it comes to the deployment of delivery robots, since individuals are afraid of them. Individuals fear those aircrafts based on security concerns as well as privacy concerns since these systems are equipped with cameras and sensors (DHL, 2014). Based on the described findings, individuals are expected to prefer smaller delivery robots like droids. Therefore, hypothesis H9 was derived, including the different kinds of delivery robots, identified by McKinsey (2016 a).

H9: Individuals have greater trust in droids than in autonomous ground vehicles

<u>Situational factors:</u>

As Kidd (2003) examined, the level of trust in a robot, depends on the type of task, for which it is deployed for. Therefore, the trust in robots, delivering different kinds of goods, represented by utilitarian goods and hedonic goods, have been implemented in the trust-factor model. Utilitarian goods are characterized as effective and helpful products, like cleaning products, or groceries while hedonic products are thrilling, enjoyable and delightful and linked to luxury, like buying a new laptop or piece of art (Lu et al., 2016). Smith et al. (2005) already identified, different trust expressions in online decision making, based on the distinction of hedonic and utilitarian goods. Therefore, it is interesting to identify if in the case of robots, individuals express different levels of trust, based on the type of good.

H10: Individuals have greater trust in delivery robots, delivering utilitarian goods compared to the delivery of hedonic goods

In the case of situational factors, the culture of individuals has been revealed within previous studies, as relevant factor, impacting the level of trust in robots (cf. Evers et al., 2008; Li et al., 2010). Based on previous studies, individuals from Asian countries have a higher level of trust in robots compared to individuals from Western countries. Therefore, differences in trust levels based on an individual's culture are expressed in hypothesis H11.

H11: Individuals from Asian countries have greater trust in delivery robots, than individuals from Europe

New solutions of LMD are focusing on urban areas in order to solve the last-mile issue as the problem is mainly existent within cities. Indeed, within urban areas, individuals have more opportunities to receive parcels, like parcel lockers or pick up points (WIK Consult, 2019). Furthermore, the postman's delivery quality, measured by factors like "delivery to agreed location" and "delivery on time" is significantly better in rural and suburban areas compared to urban areas (WIK Consult, 2019). Therefore, it could be assumed, that individuals living in rural areas, are actually quite satisfied with the delivery service and based on a lack of familiarity with new delivery solutions like parcel lockers, tend to express a lower level of trust in delivery robots, which is represented in hypothesis H12.

H12: Individuals living in urban areas have greater trust in delivery robots than individuals living in villages

3. Methodology

3.1 Choice of methodology

In order to answer the research question and explore the existence of the proposed hypotheses, a quantitative methodology in the form of a survey with end-consumers (=receiver of a parcel) in the area of last-mile delivery was conducted. Basically, quantitative research methodologies are object-related, meaning that their aim is to identify explanations and cause-effect-relationships, whereas a qualitative approach tends to investigate in a more interpretive and subject-related understanding of the research question (Lamnek, 2006). Quantitative methodologies are following a deductive approach. This means, that the methodologies aim to gather information about existing theories in order to identify new theories and hypotheses (Lamnek, 2006). The aim of a quantitative methodology is to collect information about opinions, values, motives and behaviour of the target group, count them, classify specifications and develop statistical models, in order to explain the observations (Neill, 2007). Additionally, quantitative methodologies come along with the advantage of enabling the testing of hypotheses but at the cost of missing the contextual detail (McCusker & Gunaydin, 2015).

A quantitative methodology is applicable to the proposed test model, as the model aims to examine possible causes for differences within the trust levels of end-consumers. Hence, the model investigates a causal relationship of the independent variables towards the dependent variable. Based on the underlying cause-effect relationship, a quantitative methodology in the form of a survey has been used, in order to test and validate the already existing theories and assumptions about trust in robots, within the context of last-mile delivery.

In order to measure the subject matter of the research, the previously defined hypotheses have been converted into questions and answer categories. This step is called "operationalization" (Raithel, 2008). The usage of a quantitative methodology to measure a research construct offers a range of opportunities to capture the data. The quantitative methodology in form of a survey with the target group can be conducted personally, written, via telephone or even online (Fuehles-Ubach, 2013). The choice of the appropriate methodology highly depends on the target group and the expected sample size. Using the methodology of a written surveys the return of finished surveys is quite questionable, because the participant of the survey needs to make an effort to hand in the documents (Fuehles-Ubach, 2013). Therefore, it is hard to reach a valid sample and make valuable assumptions. Furthermore, it is difficult to analyse this kind of methodology, as the content needs to be digitized. The conduction of a survey via telephone or through personal interviews provides the major advantage that the interviewer can gain more insights than he actually wants to conduct with the survey, as the researcher is actually speaking to the participant. In this case, the researcher can ask further questions (Fuehles-Ubach, 2013). Furthermore, if participants are asked questions, most of the time they judge their answer and therefore can offer a lot more of valuable insights. Apart from the major advantage of gaining additional valuable insights, the methodology comes with significant efforts required to conduct interviews and digitize the data afterwards (Fuehles-Ubach, 2013). An online survey provides another potential methodology. It comes with the disadvantage that it is challenging to define the sample, but apart from that provides a number of advantages, as it offers an easy and fast conduction of various data sets (Fuehles-Ubach, 2013). Furthermore, using an online tool, offers the ability to reach a high amount of participants, as the link to the online survey can easily be shared. As the present research model also aims to identify trust differences between different cultures, the deployment of an online survey, can be seen as the most useful methodology, as the link to the survey can be easily send all over the world to reach all concerned groups (Fuehles-Ubach, 2013). The same counts for the examination of differences between participants, living in different areas, like villages, suburban and urban areas. Furthermore, the aim of the process step of data collection was to reach a high sample, in order to make valid and significant assumptions. Based on the range of advantages, the online survey has been chosen as the most suitable methodology in order to answer the research question.

3.2 Operationalisation

As explained in the chapter before, the process of operationalization, includes the convertion of the research topic into measurable questions and answers. Atteslander (1993) defines operationalization as "the process of assigning empirically identifiable, observable or required indicators to a theoretical term." (Atteslander, 1993, p.61). For the operationalization, various types of questions can be used like open questions, closed questions or semi-closed questions (Schnell et al., 1998). For the present survey design, closed questions have been implemented, since this type of question comes along with the advantage that participants don't get influenced by the interviewer himself or his formulation of the questions. Closed questions also offer the advantage that they are easier to answer, since the response options are already given (Schnell et al., 1998). The deployment of robots in the area of last-mile delivery is a quite new topic. As of today, robots haven't been deployed by delivery companies within their last-mile activities and processes yet. Therefore, individuals lack on an actual experience with them, which might lead to problems by formulating answers to open questions. Hence, closed questions have been chosen, in order to give participants a direction of answers and make the conduction for the participants easier.

3.2.1 Survey structure

The survey was structured in six sections. At the beginning, participants were asked for information about their general order behaviour as well as their usage usage of delivery options for ordered online goods. Prior to the publication of the questionnaire, two excluding criteria have been defined: participants who never received a parcel at home before and users who only use parcel lockers to receive orders. The excluding criteria have been deployed in order to avoid biased responses of participants, based on a lack of knowledge and experience with at home delivery services. Therefore, the questions have been included at the beginning of the survey as knock-out criteria for participants who only use parcel lockers all the time and participants who never received a parcel at their home before.

The second part started with an explanation about the term "last-mile delivery", a description of current disruptive trends within this sector and the possibility to deploy robots for the delivery task. Based on the description, the participants were asked to imagine the situation, that a robot would deliver their parcel at home, followed by five questions, measuring the dependent variable, the trust level in delivery robots.

The third part was designed in order to test the robot-based variables autonomy adjustment, predictability, anthropomorphism and robot type. For each variable, between three and five questions have been implemented, representing the items of every variable. In order to measure the effect of anthropomorphism, next to the general closed questions about humanlike robots, the participants were also confronted with seven different pictures, including robots with different degrees of humanlike designs. Participants were asked to select to most trustworthy version of a robot for the task of delivery. Within the fourth part of the survey, the variable "robot type" has been examined. The participants were shown pictures and a short description for the four kinds of future delivery robots, identified by McKinsey (2016 a): autonomous ground vehicles, drones, semi-autonomous ground vehicles and droids. Right after the description of each robot, the participants were asked to rank the four robot types based on the perceived trustworthiness for the delivery task. Within the fifth part, participants were asked regarding their trust on delivery robots in relation to different types of goods to be delivered. All questions, were expressed in the exact same way, only differing by examples of each four hedonic and utilitarian goods (e.g. "would you trust a robot to deliver a high-quality watch, that you ordered?”). The survey continued with questions to measure human-based factors as the fifth step and ended with the elicitation of the demographic data (age and gender), as well as the situational factors x10 “Culture” and x11 “Area”.

3.2.2 Scales & measurements

For implementing closed questions, it is useful to implement scales. "The process of scaling is about the construction of a measuring instrument whose result is a scale." (Fuehles-Ubach, 2012, S.186). Therefore, the closed questions have been connected with predetermined answer categories, like a grading system used in schools or a likert-scale, measuring the agreeableness to the statements and questions (Bibliotheksportal, 2016). The survey instrument was developed using existing scales from theories regarding trust development as well as technology acceptance.

The dependent variable “trust towards robots in LMD” was measured, using an adjusted version of the “Trust in Automation Scale”, a 7-point likert scale measuring trust towards automation (Jian et al., 2000). The questions have been adjusted for the special case of the deployment of robots in the area of last-mile delivery. The items regarding new technologies as well as autonomous systems were measured with the “web experience scale”, a 7-point likert scale proposed by Everard and Galletta (2014). The scale was adjusted to the context of new technologies in general, as well as the experience with autonomous systems. In order to measure the construct regarding “perceived usefulness”, scales from prior technology acceptance model (TAM) researches were used (Chin et al., 2008). The used scales were modified in an appropriate way to the context of delivery robots. Based on the amount of variables as well as to keep the length of the survey reasonable, between 3-5 items were created in order to measure each of the constructs. The typical items in previous instruments tended to indicate the agreeableness of participants. This approach was applied for the survey design, by implementing a 7-point likert scale ranging from “Highly disagree” to “Highly agree”. The design was used for almost every construct, expect for the items regarding the general order behaviour of the participants. In order to measure the sequences of orders and the frequency of using parcel lockers, a more suitable 7-point likert scale was implemented, ranging from “never” to “always”. A table including all questions and scales can be found in the appendix 1.

3.2.3 Conduction of the survey

The configuration of the questionnaire has been realized in the form of an eight-minute online-survey, which was created with the help of the online tool "questback"[4]. An English as well as a German version of the survey was created, in order to increase the potential audience and to ensure a diversified sample with the aim to identify differences between cultures, assumed in hypothesis 11.

Before the official attempt of the survey, a pre-test with 10 participants was conducted to ensure the functionality of the survey tool, gain feedback about the overall survey structure, length and comprehensibility of the questions. Before the pre-test, participants were instructed to answer the following questions after the conduction of the survey: does the design motivate to finish the survey? At which point might participants quit the survey and why? Are all questions mentioned in a clear way? Are the answer opportunities suitable for the questions? Is the structure of the survey clear? How long does it take to answer all questions? The feedback of the pre-test was implemented before the survey has been published.

3.2.4 Recruiting of participants

After the completion of the pre-test, the survey was shared within the population, by using different channels. In order to receive a significant sample, the link to the online survey was shared on professional platforms like LinkedIn and Xing. The aim of publishing on these platforms was to reach a diversified sample regarding the culture and age of participants. Furthermore, the intension was to achieve more technology-affine participants as well as participants with an already existing experience with autonomous systems in order to receive a diversified sample. The social platform Facebook was especially used in order to address younger participants, as well as participants from different cultures and areas. Further calls were made by sending emails to acquaintances and colleagues in order to reach a sufficient amount of participants from different areas of living, various cultures and age levels.

The survey was released for two weeks. Half the time, a reminder was sent out with an additional call for participation. The participation in the online survey was anonymous and voluntary. An incentive was given at the end of the survey, by offering participants the possibility to insert their contact details in order to receive a summary of the research results.

[4] Access: https://www.questback.com

3.3 Evaluation of the causal model

The causal model was analysed by using a multiple regression analysis in order to assess the proposed effects from the independent variables towards the dependent variable. This method was used to explain the assumed cause-effect relationship of the model. The methodology has the ability to examine the effect of one or more independent variables towards a single dependent variable (Backhaus et al., 2011). The examination aims to find a straight line, which describes the connection between the independent variables and the dependent variable preferably good.

Before the conduction of the multiple regression analysis, Cronbach's alpha as well as factor loadings have been analysed. These methodologies have been applied, in order to assess the validity of the latent constructs of the proposed model and to identify if the items are measuring the same construct (Schermelleh-Engel & Werner, 2007). Afterwards, a confirmatory factor analysis was conducted in order to identify the reliability of the proposed model and its latent constructs.

4. Results

4.1 Participants

The online survey was finished by 223 participants. 185 participants completed the German version, which corresponds to 51.86% of exhaustive data sets of this version. 38 participants took part in the English version, which corresponds to 34.69% of exhaustive data sets of the English version. With an amount of 117 (respectively: 52.47%), slightly more male participants answered the survey compared to 106 (respectively: 47.53%) female participants. When it comes to the age of the participants, it can be observed that the majority (respectively: 78.48%) of the participants is between 20 and 34 years old. The larger proportion with 212 participants is from Europe (respectively: 95.07%). With an amount of 149, more than half of the participants live in an urban area (respectively: 66.82%), followed by 45 participants from a village (respectively: 20.18%) and 29 participants from a suburban area (respectively: 13%). The results are shown in table 1. On average, participants often order goods online (mean=5.61[2]) and receive their parcels at home (mean=5.95[2]). Only a few participants use parcel lockers every once in a while (mean= 2.14[5]). As none of the participants indicated, that he or she never ordered anything before or only use parcel lockers all the time and never receives parcels at home, all of the data sets have been used for the further analysis.

Participants

Gender

Gender	*Amount*	*Amount in % (total)*
Male	117	52.47
Female	106	47.53
Other	0	0
Sum	**223**	**100**

Age

Age range	*Amount*	*Amount in % (total)*	*Amount in % (cumulated)*
20-24	72	32.29	32.29
24-34	103	46.19	78.48
35-44	22	9.86	88.34
45-54	15	6.73	95.07
>54	11	4.93	100
Sum	**223**	**100**	

Origin

Origin	*Amount*	*Percentage*
Europe	212	95.07
North America	5	2.24

Area of living

Area	*Amount*	*Amount in % (total)*	*Amount in % (cumulated)*
Urban	149	66.82	66.82
Suburban	29	13	79.82

5 within the range from 1='never' to 7='always'

South America	1	0.45	Village	45	20.18	100
Africa	0	0	Other	0	0	
Australia	0	0	**Sum**	**223**	**100**	
Asia	4	1.79				
Other	1	0.45				
Sum	**223**	**100**				

Table 1: Description of the participants of the study[6]

4.2 Results of Cronbach’s alpha

For the further analysis the statistical programs SPSS and IBM AMOS were used. The analysis was started, with the elicitation of Cronbach’s alpha, a test which identifies the internal consistency of a scale. The value is measuring to what extend the items of a variable are interrelated, meaning if the items actually measure the same construct (Schermelleh-Engel & Werner, 2007). The value of Cronbach’s alpha (α) has to be equal or higher than 0.7, indicating a good internal consistency of the items of a factor (critical value: $\alpha \geq 0.7$). The Cronbach’s alpha was tested for the dependent variable, and almost every independent variable. The results are presented in table 2. As the variables “type of robot”, “type of good”, “gender”, “area of living” and “culture” are not measured using scales, a Cronbach’s alpha wasn’t conducted. As shown in the table, the values of the variables “experience” (α=.834) and “predictability” (α=.863) reveal, that an internal consistency is already given. An adjustment of the related items isn’t necessary. For the dependent variable one item was deleted in order to achieve a higher Cronbach’s alpha and increase the internal consistency of the scale. It was also necessary to remove one item for each of the variables “perceived usefulness” and “anthropomorphism” to increase internal consistency. For the variable “autonomy adjustment” two items had to be removed, in order to reach the critical value of Cronbach’s alpha. In the case of the variable “technology attitude” it also had been necessary to exclude two items in order to reach the critical value for internal consistency. As examined within the later on performed factor analysis, it has been revealed, that the two items, which had to be eliminated based on the results of Cronbach’s alpha, are actually measuring the same construct. Therefore, a new variable was created, including the two items, which are measuring the participants interest in technology. Both of the new variables “technology attitude” and “technology interest” reach the critical value and are therefore indicated as internal consistent.

[6] Source: own illustration

Cronbach's alpha				
Variable	**Cronbach's alpha (initial result)**	**Initial items**	**Cronbach's alpha (with adjusted items)**	**Final items**
Dependent variable				
Y_Trust in robots	.897	5	**.922**	**4**
Independent variables				
X21_Technology Attitude	.796	4	**.853**	**2**
X22_Technology Interest			**.889**	**2**
X3_Experience	.834	3	**.834**	**3**
X4_Perceived Usefulness	.865	5	**.899**	**4**
X5_Autonomy Adjustment	.674	3	**.714**	**2**
X6_Predictability	.768	3	**.863**	**2**
X7_Anthropomorphism	.768	4	**.892**	**3**

Table 2: Results of Cronbach's alpha[7,8]

4.3 Results of factor loadings

As a next step a factor analysis was conducted. With the help of a factor analysis, items can be examined regarding their underlying factor structure. As a result, every item can be assigned to one factor. The factor loadings need to be equal or higher than 0.7 to be assigned to a factor (Homburg & Giering, 1996). The results of the factor analysis are shown in table 3. As it can be seen, the dark grey marked values didn't reach the threshold value (≥ 0.7) and therefore, had to be excluded. This confirms the results of the analysis of Cronbach's alpha. In the cases of the items "X3_Experience" (factor loading=0.68) and "X5_InteractionPossibility" (factor loading=0.61), which have been marked in light grey. The items have been included in the further analysis, as the factor loadings almost reached the critical value of 0.7. Furthermore, the aim was to await the results of the confirmatory factors analysis, which has been conducted as a next step, before excluding the items. In the case of "technology attitude" it has been revealed, that two of the items load high on another factor. This confirmed the results of Cronbach's alpha, which suggested before to exclude these two items. Based on the results, a new variable

[7] Values in bold represent the final results after the analysis of factor loadings and the results of the confirmatory factor analysis

[8] Source: own illustration

"technology interest" was created, including the two items "X2_LikeDealingwith Technologies" and "X2_UptoDate".

Factor loadings			
Variable	**Item**	**Factor Loading** *Factor 1*	**Factor Loading** *Factor 2 (if existing)*
Dependent Variable			
Y_Trust in robots	Y_ReliableTask	0,79	
	Y_ReliableRobot	0,92	
	Y_Dependable	0,84	
	Y_Trust	0,91	
	Y_2_Suspicious	0,56	
Independent Variables			
X2_Technology Attitude	X2_RobustSafeTechnologies		0,85
	X2_RelyonTechnologies	0,48	0,89
	X2_LikeDealingwithTechnologies	0,94	0,41
	X2_UpToDate	0,85	
X3_Experience	X3_UseInteractWithAS	0,75	
	X3_FamiliarAS	0,97	
	X3_OftenInformationAS	0,68	
X4_Perceived Usefulness	X4_TaskEnhancement	0,84	
	X4_QuickDelivery	0,82	
	X4_Useful	0,87	
	X4_Punctual	0,80	
	X4_2Postman	0,48	
X5_Autonomy Adjustment	X5_InteractionDuringDelivery	0,56	
	X5_RobotCommands	0,78	
	X5_InteractionPossibility	0,61	
	X5_Scared	0,40	
X6_Predictability	X6_Unpredictability	0,47	
	X6_WantToKnowBeforehand	0,86	
	X6_MoreSecureifInformationInAdvance	0,88	
X7_Anthropomorphism	X7_TalkLikeHuman	0,74	
	X7_TalkDuringDelivery	0,941	
	X7_TalkHumanVoice	0,90	
	X7_2HumanRobotPIC	.0	

Table 3: Factor Loadings[9]

[9] Source: own illustration

4.4 Results of the confirmatory factor analysis

Based on the results of the previous analyses, a confirmatory factor analysis was conducted using IBM AMOS in order to identify the values, which are needed to calculate the indicator reliability (IR), the composite reliability (CR) and the average variance extracted (AVE). The IR represents the proportion of the variance of the indicator (item) which is explained by the underlying variable. The value needs to be equal or higher than 0.4 (Homburg & Giering, 1996). Items, which do not reach the critical value (IR ≥ 0.4) should be excluded from the model. The CR is a measure of internal consistency and shows how well the latent variable is actually measured by the assigned items. The value of the CR needs to be equal or higher than 0.6 (Bagozzi & Yi, 1998). The AVE is a measure, that represents the percentage of the spread of the latent construct which is explained on average by the indicators. The value of AVE needs to be equal or higher than 0.5 (Fornell & Larcker, 1981). In order to identify the IR, FR and AVE, the formulas in figure 4 have been applied.

Composite reliability: $$rel(\xi_j) = \frac{\left(\sum_{i=1}^{k} \lambda_{ij}\right)^2}{\left(\sum_{i=1}^{k} \lambda_{ij}\right)^2 \phi_{jj} + \sum_{i=1}^{k} \theta_{ii}}$$

Indicator reliability: $$rel(x_i) = \frac{\lambda_{ij}^2 \phi_{jj}}{\lambda_{ij}^2 \phi_{jj} + \theta_{ii}}$$

Average variance extracted: $$\text{AVE}(\xi_j) = \frac{\sum_{i=1}^{k} \lambda_{ij}^2 \phi_{jj}}{\sum_{i=1}^{k} \lambda_{ij}^2 \phi_{jj} + \sum_{i=1}^{k} \theta_{ii}}$$

λij= factor loading, ϕjj= variance of the latent variable, θii= variance of the disturbance variable

Figure 4: Formulas for the calculation of psychometric criteria[10]

The values for IR have been calculated for every item and the values measuring CR and AVE were calculated for every factor (latent variable). The values, needed to calculate the key figures, have been extracted from the output of AMOS. A presentation of the developed model in AMOS can be find in appendix 2. For the calculation, an excel-file provided by the institute

[10] Source: own illustration

for corporate management and service management at the university of Hohenheim, Stuttgart[11], was used. A screenshot of the excel file is included in appendix 3. Table 4 represents the results of the confirmatory factor analysis. Observing the values for the items "X3_OftenInformationAS" and "X5_InteractionPossibility", which have been critical based on the results of the factor analysis before, within the confirmatory factor analysis the item "X5_InteractionPossibility" exceed the critical value for IR (IR ≥ 0.4), meaning that an sufficient proportion of the item's variance is explained by the underlying latent construct. As the value for "X3_OftenInformationAS" didn't reach the critical value of IR ≥ 0.4, the item was excluded from the further analysis. All of the other items reached the critical value for IR and thereby proved to be suitable to measure the related latent variables. Observing the composite reliability in the fourth column, it is also noticeable that all of the variables exceeded the critical value (CR ≥ 0.6), indicating a well internal consistency of the construct and that a sufficient amount of the variable's variance is explained by the related items. All variables also exceeded the critical value for AVE (AVE ≥ 0.5), indicating that more than 50% of each item's variance can be explained by the related latent variable. As the values reveal, all variables and the related items reached the critical values for IR, CR and AVE. Therefore, the model, which has been adjusted based on the results of Cronbach's alpha and the factor loadings, can be evaluated as being valid and reliable.

Confirmatory factor analysis		**Indicator reliability (IR) ≥0.4**	**Composite reliability (CR) ≥0.6**	**Average variance extracted (AVE) ≥0.5**
Y_Dependent variable	Y_ReliableTask	0.64	0.86	0.60
	Y_ReliableRobot	0.85		
	Y_Dependable	0.70		
	Y_Trust	0.83		
X21_Technology Attitude	X2_RobustSafeTechnologies	0.57	0.87	0.77
	X2_RelyonTechnologies	0.98		
X22_Technology Interest	X2_LikeDealingwithTechnologies	0.83	0.89	0.8
	X2_UpToDate	0.77		
X3_Experience	X3_UseInteractWithAS	0.54	0.86	0.76
	X3_FamiliarAS	0.98		
X4_Perceived Usefulness	X4_TaskEnhancement	0.74	0.9	0.69
	X4_QuickDelivery	0.64		

[11] https://uf-lehre.uni-hohenheim.de/en/74770

	X4_Useful	0.74		
	X4_Punctual	0.64		
X5_Autonomy Adjustment	X5_RobotCommands	0.46	0.72	0.57
	X5_InteractionPossibility	0.68		
X6_Predict-ability	X6_WantToKnowBeforehand	0.81	0.86	0.76
	X6_MoreSecureifInformationInAdvance	0.71		
X7_Anthropo-morphism	X7_TalkLikeHuman	0.55	0.9	0.75
	X7_TalkDuringDelivery	0.89		
	X7_TalkHumanVoice	0.80		

Table 4: Results of the confirmatory analysis[12]

In order to measure the fit of the new model, various key figures have been analysed, using the output of AMOS. The Root Mean Square Error of Approximation (RMSEA), with a value of 0.06 indicates a good model fit as it is equal to the critical value RMSEA ≤ 0.06 (Brown & Cudeck, 1993). The comparative fit indices (CFI) compares the model with a "null model", indicating within the null hypothesis, that all variables are not correlated. With the model's CFI=.958, the critical value (CFI ≥ 0.95) has been exceeded (Carlson & Mulaik, 1993). Therefore, it can be assumed that correlations in the model are existent. The Tucker-Lewis Index (TLI) compares the model with a basis model, including non-correlated variables. With an TLI=.945 the critical threshold (TLI ≥ 0.9) has been exceeded, indicating an adequate model fit (Homburg & Baumgartner, 1995). The Goodness of Fit index (GFI) with a value of GFI=0.893 did not reach the critical threshold (GFI ≥ 0.9), indicating an unsatisfying model fit as the minimum amount of variance explained by the model hasn't been reached. The evaluation of the overall model can be indicated by chi square to df ratio. For the specific model, a $Chi^2/df = 2.07$ has been reached. Since the value does not transcend the critical threshold ($Chi^2/df < 2.5$), it can be assumed that the overall model has a good fit (Homburg & Baumgartner, 1995).

As a last step the whole construct was tested for discriminant validity using the Fornell/Lacker-criteria, which indicates that within each possible pairs of constructs, the shared variance (=squared correlation) observed should be lower than the minimum of their AVEs, evidencing the discriminant validity (Fornell & Larcker, 1981). The empty cell indicates a non-admissible correlation which has been set to 0. As it can be seen in table 5, discriminant validity is given for the model.

[12] Source: own illustration

	Trust in Robots	Techno-logy Attitude	Techno-logy Interest	Expe-rience	Perceived Usefulness	Autonomy Adjust-ment	Predict-ability	Anthro-pomor-phism
TrustinRobots	**0.775**							
TechnologyAttitude	0.879	**0.877**						
TechnologyInterest	0.484		**0.894**					
Experience	0.374	0.313	0.630	**0.872**				
PerceivedUsefulness	0.499	0.609	0.446	0.344	**0.831**			
AutonomyAdjustment	0.054	0.007	0.031	0.074	0.134	**0.755**		
Predictability	0.080	-0.148	-0.072	-0.073	0.015	0.513	**0.872**	
Anthropomorphism	0.218	0.017	0.124	0.127	0.133	0.377	0.542	**0.866**

Table 5: Discriminant validity table[13]

4.5 Multiple regression analysis

4.5.1 Preparation

To measure the impact and effect size of the independent variables, a multiple regression analysis was conducted. The underlying multiple regression equation is depicted within figure 5.

$$\hat{Y} = b_0 + b_1 x_1 + b_2 x_2 + \ldots + b_j x_j + \ldots b_J x_J$$

Y= dependent variable; b_0= constant; b_J=independent variables; J= amount of independent variables (j=1,2, …, J)

Figure 5: Underlying multiple regression equation[14]

The regression parameters “b_J” have been determined within the multiple regression analysis, which has been conducted as a next step. The parameters indicate the actual impact of each independent variable (X) towards the dependent variable (Y).

The proposed regression equation for the present model can be comprehended in figure 6.

$$\hat{Y} = b_0 + b_{12}*X_{12}\_Age + b_{13}*X_{13}\_Gender + b_{21}*X_{21}\_TechnologyAttitude + b_{22}*X_{22}\_TechnologyInterest + b_3*X_3\_Experience + b_4*X_4\_Perceived\ Usefulness + b_5*X_5\_AutonomyAdjustment + b_6*X_6\_Predictability + b_7*X_7\_Anthropomorphism + b_8*X_8\_TypeofRobot + b_9*X_9\_TypeofGood + b_{10}*X_{10}\_Culture + b_{11}*X_{11}\_Area$$

Figure 6: Proposed regression equation for trust in delivery robots[15]

At the beginning, in order to run the regression analysis, new variables were created representing the means of all metric variables, including their related items. Therefore, the variables for technology attitude (X21), interest in technology (X22), experience (X3),

[13] Source: own illustration
[14] Source: based on findings of Backhaus et al., 2011; own illustration
[15] Source: own illustration

perceived usefulness (X4), autonomy adjustment (X5), predictability (X6), anthropomorphism (X7) and urbanity (X11) were transformed into new variables. Furthermore, to analyse the effects of the age of the participants, a new variable was created and recoded with a value from 1 to 5, as shown in table 6. Thus, the assigned value represents the "extent" of the age of the participant. Transforming the variable "Age" in the described way, enables the inclusion in the regression analysis.

Age range (in years)	*Recoded variable value*
18-24	1
24-34	2
35-44	3
45-55	4
>55	5

Table 6: Transformation table of the variable "Age"[16]

Additionally, the variable "Type of Robot" was transferred in order to measure the impact on the dependent variable Y. The variable measures the most trustful type of robot, used for the task of delivery. As participants were asked to rank them, the items of all robot type include measures from 1 to 4 (1=most trustworthy, 4=least trustworthy). For the following analysis, every item was converted indicating if it was ranked as first one (most trustworthy) or not. Therefore, the values of the four different items were replaced, each by two values. If the item was set as the most trusted, each item received a defined value, represented in table 7. When the item was set on stage 2, 3 or 4 it was replaced by 0. At the end, a new variable was created, including the sum of the adjusted four items for "Type of robot". Therefore, the new variable indicates which item was ranked as the most trusted. As an example, in the case of a value equal to "3", the figure indicates, that the participant perceives semi-autonomous ground vehicles ("X8_SemiAutonomousGroundVehicles) as most trusted next to the three other options. The values have been chosen, based on hypothesis H9. As the hypothesis proposes droids and semi-autonomous ground vehicles should be perceived as the most trusted, the items were assigned with the values 4 and 3.

[16] Source: own illustration

Item	*Value, when ranked as number 1 "most trusted"*	*Value, when ranked as second, third or least "most trusted"*
X8_Droids	4	0
X8_SemiAutonomousGroundVehicle	3	0
X8_AutonomousGroundVehicle	2	0
X8_Drones	1	0

Table 7: Transformation table of the variable "Type of robot"[17]

After the preparation of the variables and items, the regression analysis was conducted, including all items and variables which haven't been replaced or excluded within the analysis of the quality criteria.

4.5.2 Results multiple regression analysis

Within the descriptive statistics table, the means of the values is presented. As it can be seen, on average, participants answered 4.9 (SD=1.47) (mentioned in 7 point likert-scale="slightly agree"), indicating that participants on average already have trust towards robots. On average, participants have a quite positive attitude towards new technologies in general (mean=4.48; SD=1.476) and are also interested in them (mean=5.04; SD=1.57). It can be seen, that on average participants aren't really familiar with autonomous systems (mean=3.77; SD=1.61) but actually perceive delivery robots on average as useful for the task of delivery (mean=5.09; SD=1.46). Participants on average, are undecided, if they want to interact with the robot during the delivery task (mean=4.28; SD=1.63). When it comes to more predictability, participants on average have a slight preference towards an enhanced predictability of the robot's actions (mean=4.43; SD=1.67). When it comes to human-like behaviour, participants on average slightly disagree on the possibility to talk and interact with the robot like with a human person (mean=3.41; SD=1.71). On average, participants, perceived autonomous ground vehicles as the most trusted robot, deployed for the task of delivery (mean=2.67; SD=1.05).

The model summary table represents important values about the overall success of the analysis and the goodness of the estimated regression equation. The central measure is given by R^2 of the model, which is the result of the quotient from declared variance and total variance. Resulting from the regression analysis the estimated model achieves an adjusted R^2 =.469 with R^2=.497. As R^2 lies between 0 and 1, the value .497 means, that the linear regression explains 49.7% of the variance in the data. Aligned to the context, the value indicates, that 49.7% of trust towards robots in last-mile delivery, can be explained by the included variables. The Durban-

[17] Source: own illustration

Watson value is given by d=1.598, which fits between the two critical values $1.5 < d < 2.5$, therefore it can be assumed, that there is no first order linear auto correlation in the data. The values of the ANOVA table are indicating to what extent the available data suggest that there is indeed a correlation between the independent variables and the dependent variable in the population, including the F-Test. The linear regression's F-test sets the null hypothesis, that the model explains 0% of the variance of the dependent variable. If the null hypothesis would be supported, this would indicate that $R^2=.0$. As it can be seen in the table, the F-Test is highly significant, with p= .000 ($p<.001$). Therefore, it can be assumed, that the linear regression model explains a significant amount of the variance of trust towards robots in last-mile delivery. For the following analysis of the variables, the results of the t-test were examined, analysing the critical t-value $t > |1.96|$ on a 5% significance level. Furthermore, in order to analyse the correlation between the variables, the Pearson correlation r was used, to measure the strength and direction of the linear relationship between the variables. The results of Pearson correlation were combined with the population correlation coefficient p ("rho), which represent the statistical evidence of the identified linear relationship among the same pairs of variables within the population (Cohen, 1988). In order to analyse the Pearson correlation values, the categories proposed by Cohen (1988) have been used. A table including the categories can be seen in table 8.

r-value	Interpretation
-1	Perfectly negative linear relationship
0	No correlation
+1	Perfectly positive linear relationship
.1 < |r| > .3	Small/ weak correlation
.3 < |r| > .5	Medium/ moderate correlation
.5 < |r|	Large/ strong correlation

Table 8: Pearson correlation categories and interpretation[18]

<u>*Human-based factors*</u>

H1: Younger individuals have a greater level of trust towards delivery robots compared to elderly

Based on the results of the regression analysis, the Pearson correlation coefficient (r=-.235) indicates that the relationship between age and trust towards robots is slightly negatively

[18] Source: own illustration

correlated. Applied to the context, this means that the younger the participants are, the more they trust robots in the area of last-mile delivery. The correlation is highly significant p=.000, meaning that the null hypothesis, that age and trust towards delivery robots aren't correlated, has been rejected.

The t-test indicates whether or not the null hypothesis, that a coefficient is equal to 0, can be rejected. For the relationship between age and trust towards delivery robots, the t-test with a value of t=-.574 (< |1.96|) and a significance level indicates, that the null hypotheses can't be rejected. This means, that in the population, there isn't a real relationship between the tested dependent variable "trust towards robots" and the independent variable "age", i.e. the explaining variable „age" isn't suitable to explain the properties of the dependent variable. Therefore, hypothesis H1 has been rejected.

H2: Males trust delivery robots more than females do

The analysis revealed, that the relationship between the variable "gender" and the dependent variable is slightly negatively correlated and highly significant on a 5% significance level (r=-.213; p=.001). This indicates, that there is a slight tendency towards men having more trust in delivery robots. Based on the results, the null hypothesis, that gender and trust towards robots aren't correlated, has been rejected.

The t-test with t=-.727; p=.468 (< t=|1.96|), implies that the null hypothesis can't be rejected. This indicates that there isn't an actual relationship between the gender and trust towards delivery robots in the population. Based on the results, hypothesis H2 has to be rejected.

H3: Individuals with a higher attitude towards new technologies have a greater level of trust in delivery robots

Based on the previous evaluation of validity and reliability of the model, the variables for measuring the third hypothesis have been separated in two constructs, "technology attitude" and "technology interest". Within the results it can be indicated, that technology attitude with r=.554 (p=.000) is strongly positively correlated with trust towards robots and the relationship is significantly. The same examination can be observed for "technology interest", which identifies also a moderate positively correlated and significant relationship (r=.459; p=.000) with trust in delivery robots. Therefore, the null hypothesis for both relationships can be rejected, indicating that higher interest towards new technologies as well as higher technology attitude leads to higher trust towards delivery robots.

Indicated by the analysis results for the t-test, both variables “technology attitude” with a t-value=5.32 (>|1.96|); p=.000 as well as “technology interest” with a t-value=2.07 (>|1.96|); p=.040 have a real relationship towards trust in delivery robots in the population. The null hypothesis of the t-test for both variables can be rejected. Based on the results hypothesis H3 has been supported.

H4: With an already existing experience with autonomous systems, individuals have greater trust in delivery robots

Based on the correlation results r=.319 (p=.000), the experience with autonomous systems is moderate positively correlated with trust towards robots and significant. Therefore, the null hypothesis can be rejected. This implies, that with a higher experience with autonomous systems, participants trust delivery robots more.

Observing the t-test with a t-value=-.206 (<|1.96|); p=.837 the null hypothesis, indicating that the variable “experience with autonomous systems” has no real relationship towards the dependent variable in the population has been approved. Therefore, hypothesis H4 has been rejected.

H5: If individuals perceive the deployment of delivery robots as useful, they trust them more

Implied in the Pearson-coefficient value r=.573 (p=.000), the perceived usefulness of delivery robots is strong positively related with trust towards the robot. The relationship is significant. Therefore, it can be assumed that if participants perceive the deployment of delivery robots as useful, they trust them more. The null hypothesis, implying that perceived usefulness and trust towards delivery robots aren’t correlated, can be rejected.

The t-value=5.399 (>|1.96|); p=.000; indicates that the perceived usefulness of the deployment of delivery robots actually have an impact on the trust towards these robots. This relationship is significant. Therefore, the null hypothesis of the t-test can be rejected. The hypothesis H5 has been supported.

<u>Robot-based factors</u>

H6: With the possibility to adjust the delivery robot’s autonomous behaviour, individuals have greater trust in them

Based on the analysis of the correlation between the autonomy adjustment and trust towards robots, the results r=-.043; p=.277 indicate, that there’s no significantly correlated relationship.

The null hypothesis, indicating that autonomy adjustment and trust towards delivery aren't correlated, has been supported.

The results of the t-test, t-value=.076 (<|1.96|); p=.94 lead to the assumption, that there's no connection between the adjustment of the delivery robot's behaviour and the trust towards them. The null hypothesis for the t-test has to be approved. Based on the results, hypothesis H6 has been rejected.

H7: If the delivery robot's upcoming actions are more predictable, individuals have greater trust in them

Based on the analysis, the predictability and trust towards delivery robots are slightly negatively correlated, indicated by the Pearson-value r=-142; p=.024. This relationship is significant. The items, which measure the predictability of the robots, are asking in general if participants would trust them more when delivery robots would act more predictive. Therefore, it can be concluded, that a more predictable delivery robot has the ability to increase the trust towards robots. Applied to the context, this indicates, that participants who have less trust in robots, want the delivery robot to be more predictable.

The t-test with t=-2.022 (>|1.96|); p=.045, implies that predictability and trust in delivery robots, are actually connected within the population. This relationship is significant. Therefore, the null hypothesis of the t-test can be rejected. Hypothesis H7 is supported, since predictability and trust in delivery robots are correlated.

H8: Individuals have greater trust in humanoid delivery robots, compared to non-human delivery robots

The results of the correlation matrix using Pearson correlations, indicate that anthropomorphism and trust towards robots aren't correlated (r=-.006; p=.465). Therefore, the null hypothesis is supported, indicating that humanlike robots aren't correlated with the trust they receive.

Also, the null hypothesis for the t-test has to be approved for t=-.053 (<|1.96|); p=-.818. The results indicate, that a humanly delivery robot doesn't influence the trust towards them in the population. Based on the results, hypothesis H8 has been rejected.

H9: Individuals have greater trust in droids than in autonomous ground vehicles

The results reveal, that with a Pearson coefficient r=-.036; p=.306, there's no correlation between the specific type of robot and trust towards them. Therefore, the null hypothesis has been approved.

The same effect can be observed within the t-test. The value t=1.053 (<|1.96|); p=.294 leads to the assumption that the null hypothesis of the t-test needs is supported, implying that the type of robot and trust towards delivery robots don't have a real connection in the population. Therefore, the hypothesis H9 has been rejected.

Environmental factors

H10: Individuals have greater trust in delivery robots, delivering utilitarian goods compared to the delivery of hedonic goods

Hypothesis H10 compares the trust towards delivery robots based on different goods. In order to examine if the trust levels for hedonic goods are different from trust towards utilitarian goods, the data set was as a first step, separated into two parts. The first data set included participants with weak trust towards robots (mean (Y_trust towards robots) < 3.5), the second data set included participants who trust robots (mean (Y_trust towards robots) > 4.5). Afterwards, regression analyses have been conducted for both sets.

- *Group 1: weak trust in delivery robots*

Based on the analysis, hedonic goods and little trust towards robots are moderate positively correlated r=.386, p=.004. This means, that participants with less trust in robots, don't trust them to deliver hedonic goods. The correlation between utilitarian goods and trust towards robots is not significantly correlated (r=.386; p=.494).

In order to observe differences, a t-test has been calculated. The means of both products indicate that there is a difference between hedonic goods and utilitarian goods with the mean=2.45[19] for hedonic goods and the mean=4.38[16] for utilitarian goods. As the significance for both products is p=.000 it can be assumed, that the difference can be found within the population. Meaning that participants with a weak trust in delivery robots, would rather trust robots to deliver utilitarian goods rather than delivering hedonic goods.

[19] within the range from 1='very low level of trust' to 7='very high level of trust'

- *Group 2: strong trust in delivery robots*

The regression analysis for Group 2, indicates, that hedonic goods are moderate positively correlated towards trust in delivery robots (r=.415; p=.000), the relationship is significant. For utilitarian goods with the results r=.404; p=.000 the same effect has been identified, that utilitarian goods are also moderate positively correlated with trust towards delivery robots. The relationship is also significant.

The second t-test, observing the results for participants with strong trust in robots, reveals that there is not a major difference between the two goods with a mean=4.9[16] for hedonic goods and the mean=5.8[16] for utilitarian goods. As the significance for both products is p=.000 it can be assumed, that the difference can be found within the whole population. Therefore, hypothesis H10 is supported.

H11: Individuals from Asian countries have greater trust in delivery robots, than individuals from Europe

The results indicate that there do not exist any significant culture-based influences towards trust in delivery robots (r=.025; p=.362). The null hypothesis, indicating that culture and trust in delivery robots are not correlated has to be approved.

Observing the t-test, reveals the same results, as the t-value t=-.633 (<|1.96|); p=.527 indicates, that the variable doesn't have a real relationship in the population. The null hypothesis had been approved. Based on the results hypothesis H11 has to be rejected.

H12: Individuals living in urban areas have greater trust in delivery robots than individuals living in villages

Based on the analysis, a slightly significant influence can be observed regarding the area of living. The correlation value r=.162; p=.012 indicates, that there's a slightly positive correlation between the area of living and the trust towards robots. This indicates, that individuals, living in urban areas have higher trust in delivery robots. Therefore, the null hypothesis can be rejected.

The analysis reveals t-values of t=-.565 (<|1.96|); p=.573 for the relationship between the area of living and trust in delivery robots. Based on the results, the null hypothesis of the t-test had been approved indicating that there's no real connection between area of living and trust towards delivery robots. Based on the results, hypothesis H12 had to be rejected.

An overview of the hypotheses, the values of correlations and the t-test as well as the information about the rejection or support of the hypotheses are included in table 9. The correlation table is included in appendix 4.

Hypothesis	Variable	r	p	t-test	p	Results
H1	Age	-.235	.000**	-.574	.567	Rejected
H2	Gender	-.213	.001**	-.727	.468	Rejected
H3	Technology Interest	.554	.000**	5.32	.000 **	Supported
H3	Technology Atttitude	.459	.000**	2.07	.040*	Supported
H4	Experience	.319	.000**	-.206	.837	Rejected
H5	Perceived Usefulness	.573	.000**	5.399	.000**	Supported
H6	Autonomy adjustment	-.043	.277	.076	.94	Rejected
H7	Predictability	-.142	.024*	-2.022	.045*	Supported
H8	Anthropomorphism	-.006	.465	-.053	-.818	Rejected
H9	Type of robot	-.036	.306	1.053	.294	Rejected
H10	Type of good	-	-	-	.000*	Supported
H11	Culture	.025	.362	-.633	.527	Rejected
H12	Area of living	.162	.012*	-.595	.573	Rejected

*significant on a 5% level, **significant on a 1% level

Table 9: Results of the proposed hypotheses[20]

Regression coefficients

The regression coefficients indicate the loading of each independent variable compared to all other independent variables. Higher regression coefficients are more important than lower ones concerning the dependent variable.

Based on the analysis, it can be assumed that with a regression coefficient of b_{21}=.349 for "technology interest" and b_4=.347 for the "perceived usefulness", these two variables are the most important ones in the multiple regression equation, followed by "technology attitude" with b_{22}=.176 and "predictability" with b_6=-.134.

[20] Source: own illustration

5. Discussion

5.1 Human-based factors

As the results of the regression analysis revealed, two out of five hypotheses regarding the human-based factors are supported. Therefore, the attitude towards new technologies in general as well as the perceived usefulness are significantly correlated with trust towards delivery robots. The variable, measuring the attitude towards new technologies was separated at the beginning of the analysis in the two variables “technology attitude” and “technology interest”. Both of the variables are significantly moderate positively correlated with trust towards delivery robots.

As delivery robots are not part of our daily lives yet, it is quite surprising that the participants already perceive them as being quite useful for the delivery task (on average X4=5.5 [21]). A reason for the strong perceived usefulness could be found within the individuals’ attitude towards new technologies. The individuals’ technology attitude (r=.465; p=.000) as well as technology interest (r=.367; p=.000), are moderate positively correlated with perceived usefulness. This indicates that participants who think that new technologies are robust, safe and reliable also perceive delivery robots as useful.

Furthermore, the technology attitude is significantly positively correlated with trust towards robots. Possibly a positive spill-over effect can be observed in this case. A spill-over effect in general means, that the activities of an area also have impacts on other connected areas (Springer Gabler, 2018). The term is used in a variety of fields like marketing or economy policy. An example of a spill-over effect in marketing could be, that a company is launching a new product, which benefits from the image and popularity of the producer. Applied to the context, a positive spill-over effect would mean, that participants transfer the actual positive feelings towards new technologies in general and apply them on delivery robots. This could explain the strong correlation towards the perceived usefulness of delivery robots as well as the trust towards robots in the area of last-mile delivery.

The effect of the technology attitude towards trust in delivery robots could be strengthened by technology interest, as the variable is also significantly positively correlated with trust in delivery robots and also with technology attitude (r=.400; p=.000). With a higher attitude and interest in technologies, individual’s might be more familiar with these new technologies. As

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[21] within the range from 1=’not at all useful’ to 7=’very useful’

Luhmann (1979) already stated, familiarity is a precursor of trust. Therefore, it could be assumed that based on a higher familiarity with new technologies, individuals trust them more and furthermore apply these feelings to delivery robots, according to the described spill-over effect.

The results for age and the influence on trust towards robots revealed, that an actual positively and significant correlation with trust towards delivery robots is existent within the sample, but the relationship is not representative within the population. A reason for the missing significance for the population could lie in the actual unilateral sample, as elderly are not represented in a sufficient amount. As there is an actual relationship in the sample, it might be interesting to identify the factors influencing this effect. The age of the participants is slightly negatively correlated with the perceived usefulness (r=-.294; p=.000) and technology interest (r=-286; p=.000). Therefore, younger participants tend to be more interested in technologies in general and are already aware of the advantages of delivery robots. This could be the reason for the different trust levels of younger and elderly, although it is not representative for the population.

Also, the gender of the participants has been revealed as being slight significantly correlated with trust towards delivery robots, but the relationship is not representative within the population. The results represent the actual disagreement upon researchers within the area of robots. There’s no clear and uniform general opinion if the gender has an actual influence on trust towards robots or not. Within the sample, it can be observed, that gender and technology interest are moderate significantly negatively correlated (r=-.432; p=.000). This indicates, that men express a stronger interest in new technologies than women. The same effect can be observed for the familiarity with autonomous systems (r=-.379; p=.029). Therefore, it could be assumed that women are less familiar with new technologies in general, as well as with autonomous systems. This could be a reason for the weaker level of trust women have in delivery robots. As the correlations are existent but cannot be applied to the population, this effect cannot be assured.

The hypothesis, that participants with an actual experience with autonomous systems have higher trust in delivery robots, has been rejected. Indeed, within the sample a significantly positively moderate correlation has been revealed, but the effect can’t be applied to the overall population. A reason for that could be, that only two items were identified as being reliable since another item had to be excluded at the beginning of the analysis. Therefore, the remaining two items might not have a satisfying validity, in order to represent the variable of experience with autonomous systems in a proper way. Nevertheless, the regression analysis also revealed, that experience with autonomous systems is significantly strongly positively correlated with interest in new technologies. This indicates, that participants with low interest in technology also have less experience with autonomous systems and vice versa. This could indicate a moderating effect, meaning that participants who are not interested in new technologies in general, are also not interest in autonomous systems, therefore lack of experience with them and consequently have lower trust in delivery robots. Another reason for the rejection of the hypothesis could be, that an actual experience with autonomous systems does not lead to higher trust eventually, based on the kind of experience. It could be possible, that participants already had a bad experience with an autonomous system and based on that, do not trust such systems anymore. A proof for this assumption has not been revealed in the sample since the focus was to identify correlations with experience with autonomous systems in general and not the kind of experience.

5.2 Robot-based factors

Regarding the hypotheses testing robot-based factors, it can be observed that one hypothesis out of four has been supported. Therefore, an increasing predictability of the delivery robots, has an influence on the degree of trust.

Based on the results it can be assumed, if the delivery robots upcoming actions are more predictable to the recipient, the trust in the robot increases. Within the sample, the predictability of the robot and the possibility to adjust the level of automation are positively correlated (r.=.429; p=.000). This means, that participants who want the robot to be more predictive in its actions, also want the robot to be less autonomous or have at least the possibility to interact with the robot and give commands.

The possibility to adjust the delivery robot's autonomous behaviour, is not significantly correlated with trust towards delivery robots. A reason for that could be, that only two items have been revealed as being reliable while two other items had to be excluded at the beginning of the analysis. Therefore, the missing two items, might not have enough validity to represent the variable of autonomy adjustment in a proper way. Next to the participants opinion on the adjustment of the autonomous behaviour of the robot, they have been asked in which form they would like to interact with the robot. The participants were allowed to give multiple answers. The majority of 64.6% of the participants prefers to interact with the robot via smartphone or application, followed by the interaction via a display, attached at the robot (respectively: 61.4%). 40.4% of the participants would like to talk to the robot via voice commands and 22.4% of the participants would like to speak to a human employee via phone or video call. Only a small amount of participants indicated that they prefer no interaction at all (respectively: 8.1%).

In the case of anthropomorphism, the hypothesis that delivery robots have to be humanoid, has been rejected. Surprisingly, 61.9% of the participants answered the question about their preferences regarding conversations with the robot on average with 3.67, indicating that participants don't want to talk to the robot like to a human person. During the first analysis, the question regarding the humanoid design of the robot had to be excluded, based on the weak factor loading. Observing the descriptive statistics of the excluded item, it can be evaluated, that the majority of the participants prefer non-humanlike robots rather than humanoid robots. 41.7% of the participants preferred the totally non-human robot (parcel box), followed by the second one, a non-human parcel box (droid), which has a slight humanoid tendency since a face has been attached on it. Therefore, it can be assumed that in last-mile delivery, the deployment of humanlike robots wouldn't be the right way to increase the trust towards them. Already existing companies in this area like Starship, already following the approach of non-human designed robots, as currently tested solutions focus on a purpose-built design (Starship, n.a.).

Furthermore, a reason for the rejection of the hypothesis could lie in the actual delivery situation, because participants also indicated, that they do not see a clear necessity towards an interaction with a delivery robot during the delivery process. Compared to e.g. a social robot used for the care of elderly, it can be seen, that these two situations are completely different. In the case of care robots, the autonomous systems' task is to take care of the human individual. Therefore, social robots are actually "working" with humans, whereas in the case of delivery robots, the robot's task comprises the delivery of the ordered parcel. A direct contact with the human is not necessary in the case of delivery, while in the case of care robots it is inevitable. Indeed, in the case of care robots, the centre of activity and attention is the human person, whereas in LMD the focus lies on the parcel and not the human. Furthermore, the perceived usefulness of robots for the task of delivery was also ranked quite high, which could be an explanation for the preference towards purpose-built robots rather than humanoid robots. It could be assumed, that the majority of participants already realizes the advantages, which come along with the deployment of robots and based on that consider them as suitable for the task. As another result, it can be observed, that participants do not see the necessity of a human delivery person to execute the delivery process. This also goes in line with the fact, that participants do not see any kind of interaction during the delivery task as necessary. Furthermore, the majority (respectively 60.1%) of the participants answered that they would not prefer a postman for the task of delivery even if it takes longer.

Surprisingly, the majority of 39.9% of the participants chose the autonomous ground vehicle as the preferred robot type for the delivery task, followed by the semi-autonomous ground vehicle with 35.4%. Only 19.3% have chosen droids as the preferred delivery robot and the minority with 5.4% percentage would like to receive parcels via drone. The results are quite surprising, since researchers assumed, that individuals are afraid of objects which are huger than themselves (Charalambous et al., 2015). Obviously, participants preferred the two largest robots rather than the small ones. It could be assumed, that the size of the robot is actually important for the participants, since they see a higher efficiency in their deployment. Maybe, participants think that huger robots are actually more efficient and suitable for the delivery task, since they can carry more parcels at the same time. This goes in line with the result, that participants already perceive robots as being useful for the task of delivery. Another reason why participants do not prefer droids might be that participants are afraid that someone could damage them and possibly steal their order. This assumption cannot be explained within the results of the analysis.

5.3 Environmental factors

Regarding the environmental factors the results reveal, that one out of three hypotheses is supported. Participants have different kinds of trust in the delivery robot, based on the type of good.

Therefore, participants, which expressed a high level of trust, were likely to trust the robot in delivering hedonic goods as well as utilitarian goods. Participants with a lower level of trust, trusted the robot to deliver utilitarian goods but expressed scepticism when it comes to the delivery of hedonic goods. One reason for that could be the actual value of the delivered good. Participants with only small trust in robots, might think that when it comes to the delivery of hedonic goods like piece of art, a new premium watch or a new laptop, it might be too risky to get the parcel delivered by a robot. Furthermore, participants might think when it comes to the delivery of hedonic goods, that an explanation of the good or an assembly is necessary. An example could be the case of a furniture delivery. If the ordered furniture piece isn't already set up, it would be useful if the robot is accompanied by a human who overtakes the task of the assembly. In these cases, a human-robot cooperation would be a more suitable approach. A proof for these assumptions cannot be found within the sample.

Within the analysis, it has been revealed that trust towards delivering hedonic goods is significantly moderate positively correlated with technology attitude (r=.355; p=.000) technology interest (r=.412; p=.000), experience with autonomous systems (r=.447; p=.000), and perceived usefulness (r=.415; p=.000). These effects could be the reason for the revealed trust towards robots delivering hedonic goods. As the correlations reveal, with a greater attitude towards new technologies in general as well as interest in them, participants would trust them to deliver hedonic products. Hedonic goods are also slightly negatively correlated with the age (r=-.226; p=.001) and gender (r=-.219; p=.001) of the participants. This indicates, that younger participants have greater trust in robots to deliver their hedonic goods than elderly have. As it was explained before within the results for the participants' age, the sample revealed an actual relationship between the age and technology interest as well as perceived usefulness. This could also explain the fact, that elderly have less trust in receiving hedonic goods delivered by a robot, since the group of elderly don't perceive the deployment of robots as being useful, based on the lack of interest in technology.

The hypothesis, that participants from Asian countries have more trust in delivery robots was rejected. Based on the weak presence of participants outside Europe, it was not possible to derive any significant assumptions.

Also, the hypothesis, that participants living in an urban area have more trust in delivery robots compared to participants living in a village was rejected. A significant slight positively correlation has been revealed, but the relationship cannot be applied to the population. A reason for that can be found within the weak sample, which is representing the areas of living in an inconclusive amount. Participants living in an urban area (respectively: 66.82%) are represented three times higher as the number of participants from villages (respectively: 20.18%). Therefore, the results can hardly be applied to the population, as they are not representative. Within the sample, urbanisation is slight positively correlated with interest in technologies in general (r=.271; p=.000) and experience with autonomous systems (r=.242; p=.000). A slight negatively correlation could have been found with the age of the participants (r=-.254; p=.000). As it has been discussed before, technology interest is significantly correlated with the age of the participants. Furthermore, it can be revealed that within the sample, participants living in a village are older than participants living in a city, which slightly represents the ongoing demographic change in villages. As a result, it could be assumed, that participants living in villages are older and not that interested in new technologies in general as well as less familiar with autonomous systems. Compared to cities, small villages lack of not only autonomous systems, but also self-service technologies (SST). Meuter et al. (2000) defines SST ‘‘technological interfaces that enable customers to produce a service independent of direct service employee involvement’’ (Meuter et al., 2000, p.50). Due to the absence of an employee, SSTs can already be seen as a precursor of autonomous services in which the customer has to overtake tasks independently as part of the service process. An example for such a system is an automatic teller machine (ATM) (Meuter et al., 2000). Running an ATM costs the financial prover around 20.000 to 25.000 € per year and is therefore not profitable in smaller cities and villages (Stern, 2018). Based on that it can be observed that within villages the amount of ATMs is quite low in comparison to urban areas, where ATMs could be find at almost every corner (Stern, 2018). Therefore, it could be assumed, that individuals living in cities are actually more familiar with new technologies such as autonomous systems and SSTs. As Scopelliti et al. (2005) already examined, the familiarity with new technologies leads to higher trust towards them. This phenomenon could explain the weaker trust in delivery robots for participants from villages, since they are weakly familiar with these systems.

6. Implications of the results

6.1 Managerial implications

The results show that factors related to the human have the highest influence on an individual's level of trust. Human-based factors are characterized by the fact, that they are quite difficult to found within the individual's attitude and interest towards new technologies in general (Hancock et al., 2011). It is hard for a company to change an attitude or interest of an individual, but the cognitions can help to understand the origins of weak trust in delivery robots and helps delivery companies to derive appropriate actions in order to overcome it.

As individuals with a lower technology attitude and weaker technology interest also prove to have less trust in delivery robots, delivery companies should adjust the design of the robot towards a user-oriented and non-technology-affine way. The robot and its functions should be designed in a way, that an individual with no experience with technologies at all, should be able to handle the delivery process without any problems. One option to realize such a design could be the deployment of non-digital opening systems for the robots like combination lockers. A weak level of trust, based on human characteristics like weak technology attitude and interests, can be overcome by implementing trainings, in order to increase the technology attitude and therefore the trust in delivery robots (Sander et al., 2011). Hence, delivery companies considering the deployment of delivery robots should take into account the deployment of a human-robot cooperation (e.g. semi-autonomous ground vehicles) at the beginning, in order to create a shallow transition from human employees delivering parcels towards delivery robots. The human-robot cooperation approach offers delivery companies the opportunity to already implement a robot for the task, while the human employee accompanies the robot. As kind of a training for the individual's, the employee's task could include the explanation of the system to the recipient and support when it comes to problems. The approach of a rather slow transition towards delivery robots would also offer the possibility to increase the recipients' familiarity with the robot. This approach would go in line with Luhman (1979), who already claimed, that familiarity is a highly important precondition for the development of trust.

As the results revealed, participants have higher trust in delivery robots, if they perceive them as being useful for the delivery task. Therefore, delivery companies should focus their marketing activities in a way that supports the declaration, that the deployment of robots is the most efficient way for the task of delivery and constitute the disadvantages of current last-mile delivery solutions. Furthermore, delivery companies need to make sure, that the deployment of robots comes along with an enhancement of the delivery task, like more efficiency in the delivery process, flexible booking of specific delivery time slots and punctual deliveries. Not holding the promises that the deployment of delivery robots comes along with advantages could weaken the trust towards robots. This means, that the robot's technology needs to be on an already advanced level, in order to reduce the risk of failures and mistakes by the robot to a low level. With the aim to avoid weak trust levels based on failures or mistakes of the robot, delivery companies should also consider a human-robot cooperation within the first stage of implementation or within the pilot phase of the robot, when the robots technology is not yet at an advanced level. The human employee can overtake the tasks whenever the robot breaks down or doesn't work in a proper way. The employee could also act as an "ambassador" for the robots, explaining the technology and usage to the recipients. Furthermore, the human-robot approach could also lead to a higher level of trust, since the recipient already observes the human employee working with the robot, which could take away the fear of interacting with the robot. This goes in line with the logic of reciprocity, meaning that individuals observing others in a specific behaviour, also contribute in this specific behaviour (Kahan, 2002).

For delivery companies considering the deployment of robots, a robot-design triggering consumers to perceive the robot as being trustworthy would potentially increase consumer trust. Based on the results companies should consider the attachment of a screen or display, including information about the robot's upcoming actions, when designing the robot. The results revealed, that the predictability of the robot's upcoming actions is very important for the participants' trust development towards robots. If the robot's upcoming actions are more predictable, participants have higher trust in them. Based on that, participants prefer to interact with the robot via an application on the smartphone or a display, that is attached at the robot. This will enable consumers to be aware of the robot's upcoming actions during the actual delivery, which will lead to a higher level of trust in the robot consequently. When it comes to the design of the robots, the results revealed, that companies like Starship are already following the right approach by designing the delivery robots in a purpose-built way, rather than in a human-like way (Starship, n.a.). The results approved this approach, as participants don't want to talk to the robot and preferred a non-human design. This derivation is further proven by the fact, that the humanoid robot form was considered significantly less trustworthy. When it comes to the relevance and preferred type of interaction, participants do not prefer to interact in a human-wise way as they are currently doing with a delivery person. Instead of an human employee, participants rather prefer the possibility to interact with and give commands to the robot via a smartphone app or via a display attached to it. When it comes to the different kinds of delivery robots, participants preferred to receive orders via autonomous ground vehicle or a semi-autonomous ground vehicle. Therefore, delivery companies should focus on the implementation of these kinds of robots, rather than droids and drones since participants perceive them as being less trustworthy. In particular, the implementation of drones should be refrained by delivery companies as the majority of participants does not perceive them as being trustworthy.

The analysis also revealed, that participants have different levels of trust, depending on the kind of product, delivered by the robot. Participants with low trust in robots, would only trust the robot to deliver utilitarian goods but not hedonic goods, while participants with higher trust in robots would trust them to deliver both. Delivery companies planning on deploying robots, should consider a multimodal and demand-oriented approach, by offering consumers the possibility to choose a delivery via robot or with a semi-autonomous system. Furthermore, companies which produce hedonic goods, should consider the deployment of solutions with a human-robot-coexistence.

6.2 Theoretical implications

This research makes a contribution to the existing research about the deployment of robots as it examines the specific case of last-mile delivery, which hasn't been examined before. Furthermore, the results contribute to existing literature about LMD where new solutions have been examined but mainly out of cost-related and efficiency-related view. Within previous researches about LMD solutions, an examination of new solutions out of a customer-oriented view are quite rare.

Additionally, actual theories about trust towards robots have been applied within the context of LMD. Therefore, this research makes a contribution as existing theories e.g. about social robots, have been applied within a new context, identifying if established theories can easily be applied to different kinds of robots. Some hypotheses based on existing theories have been approved and can be applied for the context of delivery robots whereas others don't. The age of the participants did not prove to have an actual influence towards trust robots, which rejects the assumption of various researchers like Scopelliti et al. (2005). Furthermore, the gender of participants has not been observed as being relevant for the creation of trust towards delivery robots. Surprisingly, the possibility to adjust the delivery robot's autonomous behaviour also has no significant influence on the trust towards them, as being suggested by previous researchers (cf. Cai et al, 2012; Heerink et al, 2010). Participants do not want the robots to have a humanlike design or even speak to them. Furthermore, when it comes to the possibility to interact or give commands to the robot, only a minority of participants want to talk to an employee as an interaction possibility. The finding that an actual human interaction hasn't been revealed as being necessary in order to create trust contributes to the discussion whether robots need to be designed human-like or not. As being revealed within this research, for the actual task of delivery, participants prefer to receive orders by purpose-built robots rather than humanoid robots.

Furthermore, the review of the selected hypotheses reveals, that the actual three-categories-approach of Nooteboom (2003) can be applied to further examinations of trust in robots. A minimum of one hypothesis within each category has been revealed as being relevant for the development of trust in robots. It can be summarized that the combination of human-based factors (=trustor) as well as robot-based factors (=trustee) and environmental factors provide the ability to explain the trust creation towards robots.

7. Ethical reflection

7.1 Ethical basics

Discussing the deployment of robots to assume human tasks always raises the question, about the ethical justification. While the deployment of robots in our daily lives comes along the advantage that it makes many tasks much easier and more efficient, it is at the same time also questionable based on ethical point of views, which managers need to take into account, when deciding to implement robots in a company's environment. An ethical reflection on this topic is relevant and necessary mainly because of two interlinked reasons: (1) the impact of certain technologies like robots isn't included in actual laws and regulations yet, while (2) ethical issues can have an impact to reform laws (Leveringhaus, 2018). In order to set suitable regulations and laws it is of high importance to take into account the ethical side.

Before discussing the ethical consequences of the deployment of robots, the subject "ethic" and its spheres should be examined and defined further. Bendel (2018) defines ethic as part of morality philosophy and sciences, which should be clearly differentiated from ethic as morality theology. The aim of philosophical ethic is to outline, question and justify morality and immorality (Bendel, 2018). Hoeffe (2008) claims, that morality sets the constitutive and normative frame for an individual's behaviour, in particular next to fellow humans, the environment and himself. Therefore, ethic is creating in a former sense, a complex of rules of action, value standards and spirit imaginations, which are free from the randomness of individuals. As part of philosophical ethic, Bendel (2018) identifies "information ethic", as the morality, which information and communication technologies (ICT) are offering and using. Therefore, information ethic examines how individuals, groups and organizations should act out of a moral point of view.

The definition and differentiation of philosophical ethic and especially information ethic, was taken as a basis for the upcoming discussion of the deployment of robots for the delivery task. In the case of delivery robots, ethical questions arise from three different sides: the employees, the customers and the environment (Bendel, 2018). The ethical problems regarding these three groups, will be discussed in the following.

7.2 Employees

The first issue almost always arises when talking about new autonomous technologies like robots, is the increase of unemployment (McKinsey, 2016 b). When deploying robots, the labour is primarily concerned, as former manual tasks, fulfilled by a human are now automated, which makes the job of the human employee substitutable. According to McKinsey (2016 b), 78% of predictable physical work (meaning: physical work activities, performed in an predictable environment) like welding, soldering on assembly lines, as well as the preparation of food and packaging objects could be automated currently and the figure is expected to increase in the future with the development of new and smarter technologies. In the area of last-mile delivery, the deployment of robots would mean, that many postmen could soon be replaced by delivery robots.

It is not only the question about the unemployed individuals itself, there are also concerns about the unequal distribution of wealth, coming along with the replacement of the workforce by robots. The economic environment is based on compensation, meaning that employees, making a contribution to the company and the economy, are being compensated mostly assessed by an hourly wage (World Economic Forum, 2016). Using robots, to fulfil human tasks, could enable companies to drastically cut down the human workforce and therefore the overall costs for wages. Furthermore, with a reduced workforce, the created revenue of a company will consequently be distributed to fewer individuals (World Economic Forum, 2016). As a result, a larger part of the earnings will be accounted by the company's owners, carried out on the back of the former employees, who got replaced by robots. Out of an ethical point of view this is ethically unacceptable and raises the question how companies can distribute the wealth created by machines in an ethical and fair way.

Next to the disadvantages, the deployment of robots also carries advantages and opportunities for employees. One huge opportunity is the possibility for employees to educate further with the implementation and development of human-robot-collaborations (Forbes, 2018). The deployment of robots also means, that humans need to take care of the algorithms and software behind these autonomous systems. Employees are needed to take care of the maintenance and to enhance the systems further (Forbes, 2018). In the area of last-mile delivery, this could mean, that postmen get educated in taking care of the delivery robots, which enhances their skills and making their professional profile more attractive for the future labour market. Furthermore, employees don't necessarily have to be replaced by robots completely. The described human-robot-coexistence in chapter 2.3.3, namely semi-autonomous vehicles, offer a great opportunity for postmen. In this case, robots would be able to take care of inconvenient, recurring and heavy tasks, like the driving and sorting of the parcels, which relieves the human employee. The postman can, at the same time, take care of administrative tasks like the scanning of the parcels, or announcing the upcoming arrival to the recipients, as well as the contact to the customer

(McKinsey, 2016 b). This form of collaboration could relieve the postman in the physical tasks and could increase the ergonomics at the workplace.

While the replacement of humans and automatization of human tasks might seem unacceptable out of an ethical view, at some point it might be unavoidable and the only way to keep the company working. Based on an analysis of McKinsey (2016 a), one out of many industries which are most likely to be automated, will be manufacturing. But currently this sector is at the same time confronted with a huge problem – the increasing workforce shortage (Industry Week, 2018). Based on an analysis of the European Centre for the development of vocational training (2015), between half and two thirds of European firms have difficulties to find skilled workers, not only based on a lack of skills of applicants, but mostly based on unattractive job offers. The trend which is disrupting the area of manufacturing, can also be seen in the delivery industry. Industry leaders like DHL, GLS, Hermes or DPDHL are desperately looking for skilled workers (Manager Magazin, 2018). Based on the enormous e-commerce growth, the delivery sector is expected to have an actual need of at least 100.000 additional deliverers by 2025 in the German market, while delivery companies are facing huge problems to find skilled workers (Manager Magazin, 2018). The demographic change as well as the low unemployment rate are just two reasons for the trend, but the hugest part creating the problem is mainly caused, based on unattractive job offers. The job of a deliverer is marked by an immense workload. Deliverers are carrying three to five tons of parcels per day and are set under huge time pressure, e.g. DHL deliverers need to deliver at least 20 parcels per hour (Zeit Online, 2013). Next to the physical demanding work conditions, deliverers are also underpaid. In Germany, deliverers are mostly not tariff-bounded and therefore only compensated with the minimum wage (Manager Magazin, 2018). These conditions make the job profile of deliverers less attractive, which represents a major reason for the increasing skills shortage. In order to handle the upcoming e-commerce boom and to stay competitive, delivery companies are forced to take action and find alternative ways. One solution could be the deployment of robots for the task of the delivery to compensate the skills shortage and keep the delivery process efficient. But not only a replacement of humans by robots could be beneficial, also the enhancement of human-robot-collaborations could increase the attractiveness of the deliverers job. As described in the paragraph before, semi-autonomous ground vehicles could simplify the physical demanding part of the delivery task and therefore make the job more attractive to applicants. In this case, the deployment of robots can be seen as a great opportunity.

7.3 Customers

In the case of the customer, the first approach should be, that the protection of human rights needs to be central to the development of robots. In this case, the central question is if the deployment of robots enhances or undermines human rights in any way, e.g, if a robot is specially built to steal the data of customers, this would violate the individual's right on privacy, meaning it would be immoral to deploy the robot for the task (Leveringhaus, 2018). Thinking about robots to deliver parcels, this would mean, that recipients can receive their parcels faster, more efficient and maybe even on the same day could be possible (McKinsey, 2016 a). These robots aren't built to harm humans, their only purpose is to deliver parcels. Therefore, the deployment of robots can be seen as beneficial for the customers, as they are enabled to gain from new and more convenient delivery service options and a more efficient delivery process.

Furthermore, the right of self-determination of humans can be enhanced by the deployment of robots. Currently, when ordering a parcel, individuals are dependent on the postmen, and at which time he arrives at the recipient's location. Mostly this is the case at a specific spot during the day, as deliverers have specific routes, where they have to take care of everyday (Manager Magazin, 2018). If an individual orders something, he needs to think about the expected time of delivery, in the case he wants to receive his orders at home. The deployment of robots on the other side, offers the opportunity to set specific time frames, during which the recipient wants to receive the parcel. This gives the recipient more control about the expected delivery time and makes him more independent.

Another point can be found in the undermining of individual's dignity by the lack of human emotions. An example for that can be found in robots, deployed in social care. Deploying robots in that area suggests that the task of a carer could be done by a machine, ignoring the fact that many carers also invest emotions and feelings in their work with elderly (Bendel, 2008). The deployment of robots for this task therefore could lead to a dehumanisation of the patients (Leveringhaus, 2018). This could also be the case for the deployment of robots to deliver parcels. Many individuals live alone, and mostly elderly are living a quite isolated life (Leveringhaus, 2018). By a replacement of human employees, recipients are taken away a valuable opportunity for social interaction. Next to the social interaction, the human emotions and reactions of the deliverer are highly important values, which can hardly be replaced by a robot. Many postmen know the recipients quite well and know, where to leave the parcel when the recipient is not at home, e.g. hide the parcel in the garage, or backyard or pass it to a neighbour, from whom the postman knows that he is at home currently (Manager Magazin, 2018). They might also know, e.g. that the recipient in the fourth floor is an old lady and that she needs help to carry the parcel up to her apartment. These tasks could hardly be fulfilled by a robot as they have a lack of human intention and emotions (Leveringhaus, 2018). Also, current prototypes of delivery robots are mainly designed to fulfil the delivery task efficiently and not as a replacement for humans.

7.4 Environment

The deployment of delivery robots should also be considered out of an environmental-based point of view. Within cities, the traffic is increasing rapidly based on an increasing number of vehicles on the street. This results in a higher CO2 emission. The traffic sector is said to account about one fifth of the global greenhouse gas emission (Wirtschaftswoche, 2013). Furthermore, the emission in cities is expected to increase based on trends like urbanisation and a decreasing value of walking and cycling (Wirtschaftswoche, 2013). Since all of the robots proposed by McKinsey (2016 a) namely autonomous ground vehicles, semi-autonomous ground vehicles, drones and droids, are equipped with batteries as propulsion, these solutions are very environmentally friendly. Goodchild & Toy (2016) already examined the deployment of drones compared to common solutions including a gasoline-driven truck. Obviously, drones outpaced trucks regarding the CO2 emissions by far. Therefore, delivery robots can overtake delivery tasks, which are fulfilled by gasoline vehicles currently. The deployment of robots not only helps to reduce the CO2 emission it also enables to reduce the traffic within cities. Droids and drones are not using streets to delivery orders since drones are autonomous aircrafts and droids are using the pedestrian way (McKinsey, 2016 a). Furthermore, an increasing amount of countries are building up low emission zones in cities, where gasoline vehicles are not allowed to drive (Kennis DC Logistiek, 2017). For delivery companies this means, that at some point they might be forced to implement an alternative in order to fulfil orders in these areas. The deployment of robots therefore offers a huge possibility as it corresponds to the emission regulations. Out of an environmental point of view, the deployment of delivery robots is highly recommended.

7.5 Conclusion ethical reflection

Summarized, it can be seen that the deployment of robots offers a range of advantages especially in the context of sustainability and environmental protection. When it comes to human-related stakeholders, namely the customers and employees it is questionable to deploy robots out of an ethical point of view. Especially the replacement of employees by robots only to stay competitive shouldn't be the right approach for delivery companies. In point of fact, a human-robot collaboration should be one of the most favoured solutions out of an ethical context. The human employee could take care of the customer interaction and strategic tasks of the delivery process, while the robot could overtake repetitive and heavy tasks like the organizing and moving of parcels. Applying this approach, would integrate the employee within the new solution rather than replacing him. Furthermore, customers would not lose the contact to a human person. Therefore, the deployment of human-robot collaborations represents a quite promising approach out of an ethical point of view.

8. Conclusion & further research

8.1 Limitations & further research

The present research has some limitations, which should be examined within further researches. Reasons for the fact, that a limited number of variables have been revealed as having a significant influence on trust towards robots in last-mile delivery can be found within the sample. The unilateral character of the survey participants lead to a lack of significance. First of all, the sample is characterized by a unilateral age distribution with the majority of participants being 25 to 34 years old. Only 6.73% of the participants are between 45 and 54 years old, and only 4.93% of the participants are older than 54 years. Therefore, the preferences of middle-aged and elderly couldn't be depicted properly. Further research should focus especially on these age groups, as the demographic change and the aging population force companies to integrate the needs and expectations of elderly into their actions. Furthermore, the majority of older participants within the sample are quite technology affine, indicated by a medium to high level of interest in new technologies and a medium to high level of technology attitude. Further researches should select a sample not only representing elderly with high affinity towards new technologies but also with weak technology attitudes in order to examine differences in the level of trust towards robots for the group of elderly.

Next to the age, also different cultures are not represented in a sufficient way which would allow the derivation of expressive assumptions, as the great majority is from Europe. Almost all of the participants are actually from Europe (respectively 95.07%).

As differences in the type of good (hedonic vs. utilitarian good) have been conducted, it might be interesting to further investigate the reasons for the lower level of trust in robots delivering hedonic goods. As some studies already revealed, individuals are afraid of system crashes and worried about the risk that robots being hacked (McKinsey, 2017). Furthermore, individuals are afraid that someone could steal their order from the robot or even the robot itself (McKinsey, 2017). A more specific approach should be conducted, regarding the different types of delivery robots, as consumers might have more trust in AGVs delivering a hedonic good than delivered by a droid or a drone. It would be also interesting to see, if individuals would feel more secure, when a semi-autonomous ground vehicle would deliver the hedonic good. Maybe with the presence of a human, the trust towards the delivery robot could increase. This should be examined within further research.

The analysis revealed some small tendencies towards consumers preferring purpose-built robots rather than humanoid robots. This should further be examined in order to find the underlying reasons for that. Many researchers suggest to design robots in a humanoid way which has not been approved within the present research. The deployment of robots in the area of LMD differs from other research areas like social robots mainly in the actual trust situation, where the robot is not in direct contact with the customer. Further research should therefore focus on different deployment scenarios of robots and the need of individuals to design the robot in the specific situation humanoid or not.

Further research should also focus on the variables that have been revealed as being correlated and significant within the sample but based on the t-test result were not able to be applied to the population, namely the age and gender of individuals, the previous experience with autonomous systems as well as the area of living.

8.2 Summary

This research aimed to identify factors impacting an individual's level of trust in robots, deployed in the area of LMD. The results of the research had the aim to derive recommendations for companies, considering the deployment of delivery robots. Furthermore, the present research paper has the focus to extend current researches about trust development in robots, by examining influencing factors within the special case of the deployment of robots in the area of last-mile delivery.

In order to answer the research question, a causal model has been developed, reflecting the assumptions of Nooteboom's (2003) trust theory, that the level of trust is a three-sided property. Therefore, several factors have been examined, within the three categories: human-related factors, robot-related factors and situational factors. Previous researches already examined several individual factors. 11 of them, had been applied to the context of delivery robots and had been included in the model.

Based on a quantitative analysis in the form of an online survey with end-consumers in the area of LMD, it can be concluded that a range of factors impact the level of trust in delivery robots. Factors regarding the human (e.g. perceived usefulness, individual's technology attitude) have the highest influence towards the degree of trust towards delivery robots as most human-related factors had the ability to impact the individuals' level of trust. Therefore, an individual's technology interest, technology attitude as well as the perceived usefulness of the deployment of the robot for the delivery task, are the main factors explaining why individuals have strong or weak trust in delivery robots. Individuals with higher technology interest and attitude also have a higher level of trust. Indeed, if an individual perceives the deployment of the robot for the task of delivery as being useful, the trust level increases. The robots-based factor which has been revealed as being important is the predictability of the delivery robot's actions. This means that individuals express higher trust, when they know beforehand what the robot is doing next. Regarding the environmental factors, it has been revealed that individuals would trust a robot to deliver utilitarian goods, while they are more sceptical when it comes to the delivery of hedonic goods.

Established theories about robots have been tested but had to be rejected. Therefore, in contrast to findings of Duffy (2013) and Złotowski et al. (2015), anthropomorphism has not been revealed to have an impact on the level of trust. Individuals' prefer purpose-built delivery robots rather than humanoid robots. Furthermore, previous experiences with autonomous systems have not been revealed as important factor in the trust creation in robots, contrary to Luhmann's (1979) assumption, that with a higher level of experience trust increases consequently.

The deployment of robots for the task of delivery is an emerging concept based on disruptive trends like the enormous e-commerce sales on the market and rapidly changing customer demands. This paper is one out of the first exploring this topic and the very first one which examined trust in robots deployed in the area of last-mile delivery. The results of this study include a range of implications and best practices for robot manufacturers and delivery companies, considering the deployment of delivery robots, as it gives recommendations how to build and design delivery robots triggering consumers to perceive the delivery robot as being trustworthy as well as suggested approaches like human-robot collaborations in order to overcome human-related trust issues. The topic of trust is of high importance in the area of delivery robots as trust is an ultimately precursor of acceptance and usage of these systems (Freedy et al., 2007). Therefore, trust is a main component impacting the successful deployment of robot in the area of last-mile delivery in the future.

Within the upcoming years, robots might be deployed within the delivery process of companies and maybe in the future, it might be a robot instead of a postman who will ring twice at the door - as the robot always rings twice.

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Appendices

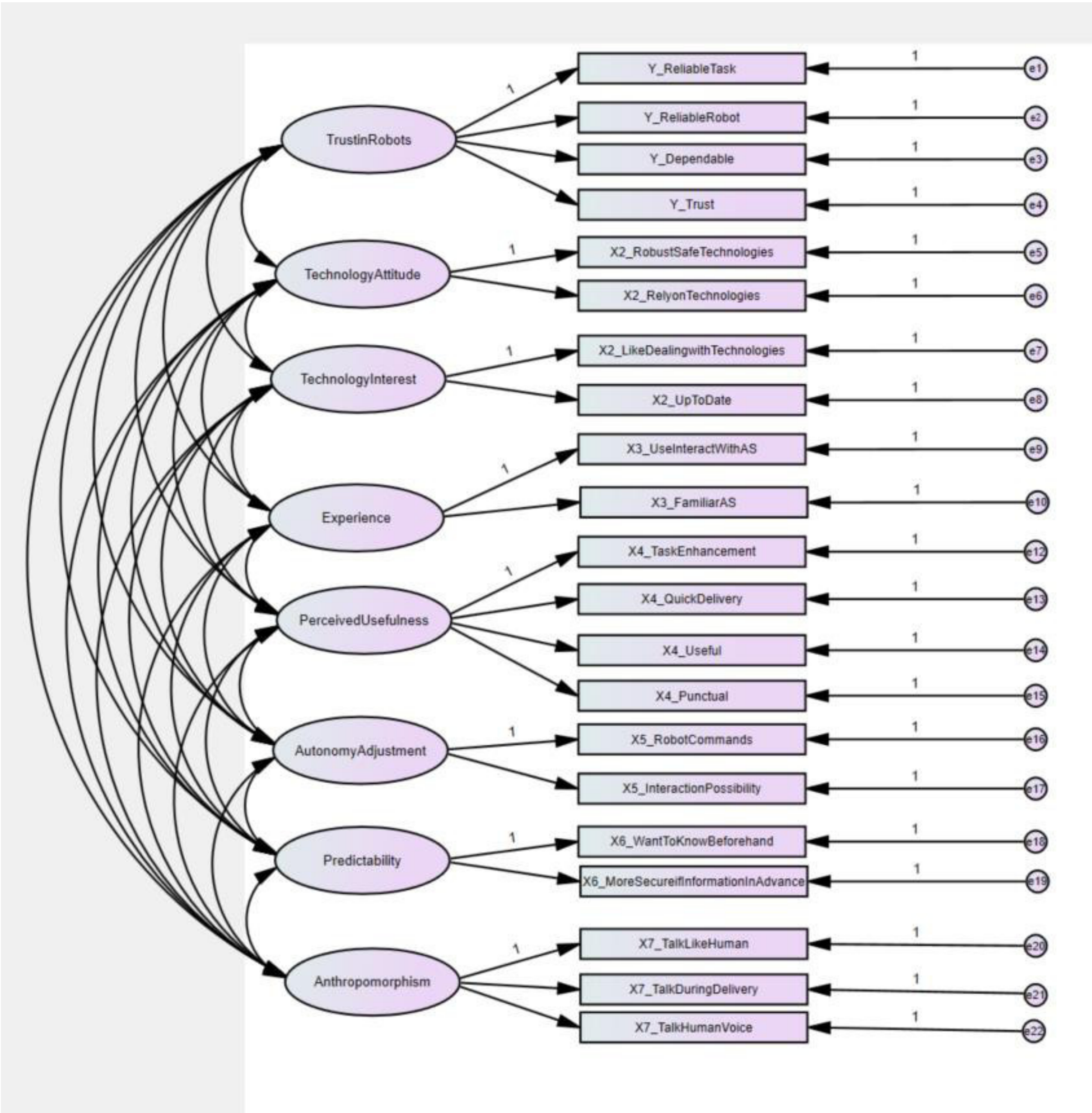
Appendix 1: Questions and scales used for the online survey

Variable	Items	Measurements
Order behaviour	I often order goods in online shops In general I receive the parcels I ordered at home I use parcel lockers	7-point likert scale: "Never" to "Always"
Trust In robots in LMDs	I can rely on a delivery robot to execute the delivery task reliably In my opinion a delivery robot is very reliable I think a delivery robot is dependable I can trust a delivery robot I am suspicious of a delivery robot's intent, action and output	7-point likert scale: "Highly disagree" to "Highly agree"
Perceived Usefulness	I think using robots to deliver orders enhances the effectiveness of the delivery task I think using robots allows me to receive orders more quickly I think a robot is useful for the delivery taks I would prefer to receive orders delivered by a postman, even if it takes longer I think using a robot will enable me to receive orders more punctual and/or at a specific time (determined by myself)	7-point likert scale: "Highly disagree" to "Highly agree"
Autonomy Adjustment	I think that a way of interaction while receiving a parcel is necessary I would feel more secure when there's a possibility to give commands to the robot I would like to have the possibility to interact with the robot I am scared of the robot's autonomous behaviour	7-point likert scale: "Highly disagree" to "Highly agree"
	I would like to interact with the robot in the following way:	Via display, attached at the robot/ Via Smartphone or app/ Via voice commands/ Via voice or phone call with an employee/ None
Predictability	I feel uncomfortable about the unpredictability of the robot	7-point likert scale: "Highly

	I want to know beforehand what the robot is doing next (e.g. by voice assistant, display/app notifications etc.) I would feel more secure if I'd be known beforehand what the robot is doing next	disagree" to "Highly agree"
Anthropo-morphism	I want to talk to the robot like to a human person I would feel more comfortable, if the robot would talk to me during the delivery task I would feel more secure, if the robot would actively talk to me with a human voice Which one of the following robots would you prefer to deliver your parcel?	7-point likert scale: "Highly disagree" to "Highly agree"
Type of Good	I'd feel comfortable receiving electronic devices (e.g. new laptop, smartphone) delivered by a robot I'd feel comfortable receiving cleaning products delivered by a robot I'd feel comfortable receiving furniture delivered by a robot I'd feel comfortable receiving groceries delivered by a robot I'd feel comfortable receiving paintings/art delivered by a robot I'd feel comfortable receiving clothes delivered by a robot I'd feel comfortable receiving prepared food delivered by a robot I'd feel comfortable receiving a high-quality watch delivered by a robot	7-point likert scale: "Highly disagree" to "Highly agree"
Type of Robot	Rank the following robots, considering they would deliver your parcel. Which one do you think is the trustworhtiest (First=most trustworthiest, Last=least trustworthiest)?	AGV/ Drones/ SAGV/ Droids
Technology Attitude	I believe that in general new technologies are robust and safe I always feel confident and that I can rely on new technologies I like dealing with new technologies I am always up-to-date regarding new technologies	7-point likert scale: "Highly disagree" to "Highly agree"
Familiarity with autonomous systems	I often use and/ or interact with autonomous systems I am familiar with autonomous systems I often obtain information about autonomous systems	7-point likert scale: "Highly disagree" to "Highly agree"
Demographic data	Gender Age	Male/ Female/ Other Input field

Culture	I am from..	Europe/ North America/ South America/ Africa/ Australia/ Asia/ Other
Area	I live in ..	An urban area/ a suburban area/ a village/ other

Appendix 2: Tested model[22]



[22] Source: Amos output

Appendix 3: Excel-file for the calculation of IR, AVE and CR[23]

Kommunikation		Ergebnisse der KFA und SPSS Analyse									Konvergenzvalidität (Berechnungsbasis stand. FL)		
Faktor	Indikator	Faktor-ladungen (stand.)	t-Wert der Faktor-ladung	Faktor-ladung (unstand.)	Varianz Messfehler des Indikators	Item to Total Korrelation ≥ 0,7	Cronbach´s Alpha ≥ 0,7	Varianz des Faktors	Ladungs-quadrate	Fehler-varianz	Indikator-reliabilität ≥ 0,4	Faktor-reliabilität ≥ 0,6	DEV ≥ 0,5
(Varianz: 1,0)	Item 1	0,780	48.413,000	1,000	0,103		0,922	1,000	0,608	0,392	0,61	0,86	0,60
	Item 2	0,924	46,091	1,218	0,106			1,000	0,854	0,146	0,85		
	Item 3	0,836	47,437	1,093	0,105			1,000	0,699	0,301	0,70		
	Item 4	0,913	44,072	1,236	0,109			2,000	0,834	0,166	0,83		
	Item 5							1,000	0,000	1,000	0,00		
	Summe	*3,453*							*2,995*	*2,005*			
	Quadrate	*11,923*											

[23] Source: institute for corporate management and service management at the university of Hohenheim, Stuttgart https://uf-lehre.uni-hohenheim.de/en/74770

Appendix 4: Multiple regression analysis – correlations table[24]

Korrelationen

		Y_Trust_MV	X21_TechnologyAttitude_MV	X22_TechnologyInterest_MV	X3_Experience_MV	X4_PerceivedUsefulness_MV	X5_AutonomyAdjustment_MV	X6_Predictability_MV	X7_Anthropomorphism_MV	Age	X11_Urbanisation	X1_Gender	X10_Culture	X8_RobotRanking	X9_HedonicGoods	X9_UtilitarianGoods
Korrelation nach Pearson	Y_Trust_MV	1,000	,554	,459	,382	,573	-,043	-,142	-,006	-,235	,162	-,213	,025	-,036	,555	,456
	X21_TechnologyAttitude_MV	,554	1,000	,400	,367	,465	,020	,035	,185	-,131	,189	-,118	,186	-,171	,355	,280
	X22_TechnologyInterest_MV	,459	,400	1,000	,723	,367	,036	-,038	,085	-,286	,271	-,432	,102	-,019	,412	,321
	X3_Experience_MV	,382	,367	,723	1,000	,347	,026	-,048	,152	-,136	,242	-,379	,152	-,010	,447	,320
	X4_PerceivedUsefulness_MV	,573	,465	,367	,347	1,000	,060	,037	,106	-,294	,178	-,119	-,055	-,052	,415	,365
	X5_AutonomyAdjustment_MV	-,043	,020	,036	,026	,060	1,000	,429	,325	,196	-,057	,034	,115	,064	-,181	,056
	X6_Predictability_MV	-,142	,035	-,038	-,048	,037	,429	1,000	,519	,068	-,074	,110	,019	,082	-,185	,025

[24] Source: SPSS output

	X7_Anthropomorphism_MV	-,006	,185	,085	,152	,106	,325	,519	1,000	,093	-,033	-,056	,050	-,003	-,062	-,046
	Age	-,235	-,131	-,286	-,136	-,294	,196	,068	,093	1,000	-,254	,023	,038	,092	-,226	-,092
	X11_Urbanisation	,162	,189	,271	,242	,178	-,057	-,074	-,033	-,254	1,000	-,046	,087	-,013	,163	,094
	X1_Gender	-,213	-,118	-,432	-,379	-,119	,034	,110	-,056	,023	-,046	1,000	-,075	-,050	-,219	-,017
	X10_Culture	,025	,186	,102	,152	-,055	,115	,019	,050	,038	,087	-,075	1,000	,037	,041	-,004
	X8_RobotRanking	-,036	-,171	-,019	-,010	-,052	,064	,082	-,003	,092	-,013	-,050	,037	1,000	-,120	-,071
	X9_HedonicGoods	,555	,355	,412	,447	,415	-,181	-,185	-,062	-,226	,163	-,219	,041	-,120	1,000	,559
	X9_UtilitarianGoods	,456	,280	,321	,320	,365	,056	,025	-,046	-,092	,094	-,017	-,004	-,071	,559	1,000
Sig. (1-seitig)	Y_Trust_MV	.	,000	,000	,000	,000	,277	,024	,465	,000	,012	,001	,362	,307	,000	,000
	X21_TechnologyAttitude_MV	,000	.	,000	,000	,000	,392	,314	,005	,034	,004	,051	,005	,009	,000	,000
	X22_TechnologyInterest_MV	,000	,000	.	,000	,000	,308	,298	,119	,000	,000	,000	,078	,397	,000	,000
	X3_Experience_MV	,000	,000	,000	.	,000	,359	,252	,017	,029	,000	,000	,017	,444	,000	,000

	X4_PerceivedUsefulness_MV	,000	,000	,000	,000	.	,201	,306	,071	,000	,007	,049	,222	,238	,000	,000
	X5_AutonomyAdjustment_MV	,277	,392	,308	,359	,201	.	,000	,000	,003	,214	,317	,055	,186	,006	,220
	X6_Predictability_MV	,024	,314	,298	,252	,306	,000	.	,000	,173	,154	,064	,398	,127	,005	,366
	X7_Anthropomorphism_MV	,465	,005	,119	,017	,071	,000	,000	.	,098	,324	,220	,246	,483	,194	,263
	Age	,000	,034	,000	,029	,000	,003	,173	,098	.	,000	,376	,299	,101	,001	,101
	X11_Urbanisation	,012	,004	,000	,000	,007	,214	,154	,324	,000	.	,261	,114	,431	,011	,096
	X1_Gender	,001	,051	,000	,000	,049	,317	,064	,220	,376	,261	.	,149	,244	,001	,405
	X10_Culture	,362	,005	,078	,017	,222	,055	,398	,246	,299	,114	,149	.	,305	,286	,480
	X8_RobotRanking	,307	,009	,397	,444	,238	,186	,127	,483	,101	,431	,244	,305	.	,048	,164
	X9_HedonicGoods	,000	,000	,000	,000	,000	,006	,005	,194	,001	,011	,001	,286	,048	.	,000
	X9_UtilitarianGoods	,000	,000	,000	,000	,000	,220	,366	,263	,101	,096	,405	,480	,164	,000	.
N	Y_Trust_MV	194	194	194	194	194	194	194	194	194	194	194	194	194	194	194
	X21_TechnologyAttitude_MV	194	194	194	194	194	194	194	194	194	194	194	194	194	194	194

X22_TechnologyInterest_MV	194	194	194	194	194	194	194	194	194	194	194	194	194	194	194
X3_Experience_MV	194	194	194	194	194	194	194	194	194	194	194	194	194	194	194
X4_PerceivedUsefulness_MV	194	194	194	194	194	194	194	194	194	194	194	194	194	194	194
X5_AutonomyAdjustment_MV	194	194	194	194	194	194	194	194	194	194	194	194	194	194	194
X6_Predictability_MV	194	194	194	194	194	194	194	194	194	194	194	194	194	194	194
X7_Anthropomorphism_MV	194	194	194	194	194	194	194	194	194	194	194	194	194	194	194
Age	194	194	194	194	194	194	194	194	194	194	194	194	194	194	194
X11_Urbanisation	194	194	194	194	194	194	194	194	194	194	194	194	194	194	194
X1_Gender	194	194	194	194	194	194	194	194	194	194	194	194	194	194	194
X10_Culture	194	194	194	194	194	194	194	194	194	194	194	194	194	194	194
X8_RobotRanking	194	194	194	194	194	194	194	194	194	194	194	194	194	194	194
X9_HedonicGoods	194	194	194	194	194	194	194	194	194	194	194	194	194	194	194
X9_UtilitarianGoods	194	194	194	194	194	194	194	194	194	194	194	194	194	194	194

Declaration

I,

Hofmann Tina

Born on **12.02.1991**

Student ID **s184604**

Academic year: **2018/ 2019**

hereby declare on my honor that the work attached to this declaration

□ Homework/Presentation

□ Bachelor Thesis

x Master Thesis

□ Diplom Thesis

has been independently prepared, solely with the support of the listed literature references, and that no information has been presented that has not been officially acknowledged. All parts of this work that were taken verbatim or in spirit from publications or outside communications are individually marked as such.

Supervisor:
Simon Hazée

Thesis topic:
The robots always rings twice - an empirical investigation of factors that influence trust towards robots in last-mile delivery

I declare herewith, that I have transferred the final digital, not write-protected text document (in the format doc, docx, odt, pdf, or rtf) to my mentoring supervisor and that the content and wording is entirely my own work. I am aware that the digital version of my document can and/or will be checked for plagiarism with the help of an analyses software program.

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Liège, 13.08.2019

Executive summary

The last-mile delivery market is characterized by disruptive changes and trends, like the unstoppable enormous growth of e-commerce orders in the upcoming years as well as changing customer needs, demanding new delivery services like same-day or instant delivery. Based on these profound transformation of the market, new technologies are on the rise changing the area of overcoming the last mile– the delivery service to the customer's home. One out of the most promising solutions is the usage of robots for the task of delivery. For a successful deployment of delivery robots, the end-consumer acceptance is of crucial importance. The acceptance and usage of the robot is mainly impacted by an individual's trust towards them. Therefore, examining the creation of trust in delivery robots is of high importance for delivery companies, considering the implementation of such autonomous systems.

The aim of the present research is to identify factors which influence an individual's trust in delivery robots. Therefore, the following research question has been defined: which factors affect the degree of trust towards robots in the area of last-mile delivery?

Based on the trust theory, claiming that an individual's level of trust depends on factors related to the trustor, the trustee and the trust situation, a research model has been developed, including several trust creating factors divided within the three overall categories. The categories have been adjusted to the case of last-mile delivery, namely: human-related factors, robot-related factors and situational factors.

In order to answer the research question, an online survey has been conducted with end-consumers in the area of last-mile delivery. The participants responses have been analysed using a multiple regression analysis. The results revealed, that all of the three defined categories have an impact on the level of trust towards delivery robots. Individuals trust delivery robots more if they already perceive them as being useful for the task of delivery. Furthermore, a positive attitude towards new technologies in general supports the individuals trust in delivery robots. Individual's also express a higher level of trust in delivery robots, when their upcoming actions are more predictable. Finally, individuals tend not to trust delivery robots to deliver hedonic goods, while they trust them to deliver utilitarian goods.

Delivery companies considering the deployment of delivery robots should take into account the deployment of human-robot collaborations as well as implementing an opportunity to reveal the robots upcoming actions in order to overcome trust issues. Further research should focus on examining factors like gender, age, experience with autonomous systems and the area of living.