PAVING THE WAY FOR THE ADOPTION OF AUTONOMOUS DRIVING: INSTITUTION-BASED TRUST AS A CRITICAL SUCCESS FACTOR

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Abstract

Autonomous driving is a technology that could fundamentally change people’s lives, however, safety and liability concerns dominate public debates. For individuals, giving up control and trusting the car’s technology is an obstacle that has yet to be overcome.

To address this issue, we investigated the impact of institution-based trust on trust in autonomous vehicles and on the adoption process. Therefore, we built on the technology acceptance model and included the level of perceived uncertainty, anthropomorphism and individual disposition to trust.

A PLS-SEM (n = 286) shows that trust in technology is pivotal for the intention to use autonomous vehicles. We identify institution-based trust, more specifically the subdimensions perceived technical protection and situational normality, as the major drivers of trust in autonomous driving technologies. Furthermore, we find that uncertainty moderates the relationship between perceived technical protection and trust.

This article contributes to the academic discourse on the adoption of autonomous vehicles by highlighting the relevance of institution-based trust to overcome structural barriers in the adoption process. Furthermore, it highlights the interplay of institution-based trust with technical and individual antecedents of trust, thereby enlightens mechanisms of the trust building process and provides comprehensive empirical evidence on the relative importance of trust’s determinants.

Keywords: Autonomous driving, institution-based trust, trust in technology, technology adoption.
1 Introduction

“Automated or self-driving vehicles are about to change the way we travel and connect with one another.” - Elaine L. Chao, The U.S. Secretary of Transportation (Chao, 2018)

The emergence of autonomous vehicles (AVs) and their possible future application have been subject to numerous current debates. Mervis (2017) underlines key obstacles for future AV adoption, such as the question “how safe is safe enough”. Even though AVs are comparably safe, public acceptance levels are low and hesitation exists towards using AVs (Hulse et al., 2018). In his “Science” publication, Hutson (2017) claims that the biggest obstacle for the adoption of AVs is the consumers’ distrust in the technology, which highlights the outstanding importance of trust for the adoption process.

The research domain of autonomous driving technologies is an emerging field with only few studies providing empirical evidence on the technology adoption process. Those studies discussed the relevance of security, transparency, privacy, technical competence, anthropomorphism and experience for trust development towards AVs, as well as the impact of trust, perceived risk and disposition to trust on the willingness to use AVs (Choi and Ji, 2015; Kalra and Paddock, 2016; Osswald et al, 2012; Waytz et al., 2014). However, there is little evidence on the interplay of these individual factors.

With AVs being highly complex, most individuals will have difficulties in understanding and evaluating the technology itself. Hence, the decision to trust AVs is not an easy one. Furthermore, as AVs are not publicly available yet, users cannot evaluate actual features and characteristics based on their personal experiences. In such situations, people frequently base their decision to trust on things they can evaluate, such as the structures around the technology (McKnight et al., 2011). Thus, the institutional context in which the AVs are evaluated may be a key factor in the trust building process. When adequate structural support for using AVs exists, this may have a positive effect on the trust towards AVs.

However, literature on AVs has so far neglected this context effect. We argue that institution-based trust is a crucial factor for initial trust development. While this factor has been shown to be highly relevant in different domains, it lacks consideration in the process of AV adoption (Gefen et al., 2003; Kim et al., 2009; Liang et al., 2005; McKnight et al, 2002).

Consequently, this study investigates the role of institution-based trust in the adoption process towards autonomous driving technologies. To address this issue, we integrate trust in technology and institution-based trust into the well-established technology acceptance model (TAM; Davis, 1989). Furthermore, we include determinants of the individual and technological levels that have been shown to be relevant for technology adoption. Therefore, we contextualize the impact of institution-based trust on AV adoption within a comprehensive model.

Based on our theoretical considerations, we employ the partial least squares structural equation modelling (PLS-SEM) method on survey data of 286 respondents. We contribute to the literature on technology adoption by theorizing and providing empirical evidence on the role of institution-based trust as an enabler of the acceptance of AVs. We find that institution-based trust is context dependent and strongly influences trust towards technology. Hence, it is a key factor in the adoption process of AVs.

Furthermore, we contribute to the trust literature by advancing the empirical foundation. Our study highlights the influence of structural and situational institutional factors on trust development towards AVs and their interplay with well-established individual and technical determinants. Thus, we answer the call for a more nuanced understanding of the trust building process.

From a practical view, our study helps manufacturers to better understand the importance of trust for the acceptance of AVs and to communicate the strengths of AV in a more targeted way. For policy makers, it shows opportunities to support the adoption process by setting the framework for improved AV testing and clarifying liability issues.
2 Theoretical Background and Hypotheses

2.1 Foundations and Literature Review

The definition of autonomous driving technologies is adapted from the taxonomy established by the Society of Automotive Engineers International. On the final level of autonomous driving, steering wheels or pedals are no longer necessary and there will be no possibility to recover control or challenge the car’s decisions (Inman, 2018).

Institution-based trust arises through supportive structures and mechanisms and can enable technologies to overcome adoption barriers (McKnight et al., 2011). It could facilitate initial trust in the beginning of the adoption process, as it is independent of actual interaction between user and technology (McKnight et al., 2002; Rousseau et al., 1998). Institution-based trust and its related constructs have been shown to enhance trust in different contexts, such as in mobile banking (Kim et al., 2009; Wang et al., 2015), online shopping (Gefen et al., 2003; Pavlou and Gefen, 2004), health care (Liang et al., 2005) and IT artefacts (Vance et al., 2008). Trust is especially relevant in risky or uncertain situations, such as the use of autonomous technologies, where the trustor cannot fully predict or control all possible outcomes. By providing beneficial structures, institution-based factors enable trust building. However, in the specific context of AVs, these relationships have only been partly examined by Kalra and Paddock (2016), who emphasized the importance of regulatory and liability topics. Following this direction, we specifically focus on how situational normality and institutional factors concerning technical, economic and legal protection mechanisms enhance trust in AVs.

Trust in technology has been established as an influential factor for technology adoption (Wu et al., 2011). Technology adoption literature has found support for a number of factors influencing trust in technology. On the individual level, disposition to trust, experience and self-efficacy have been shown to serve as antecedents to trust across a number of technologies (e.g. Gefen et al., 2003; Kim et al., 2009; McKnight et al., 2011). On the level of a specific technology, a diverse set of determinants to trust development has been identified. For example, information, service and system quality have been shown to be relevant for trust in technology (Kundu and Datta, 2015; Lee and Chung, 2009; Vance et al., 2008; Zhou, 2012; Zhou et al., 2016). Additionally, perceived privacy and perceived security have also shown to influence trust development by protecting customers’ interests (Lee and Turban, 2001; Susanto et al., 2013; Vejacka and Stofa, 2017). Previous studies have also investigated the influence of performance expectancy (Gu et al., 2016), relative benefits (Kim et al., 2009) and humanness (Lankton et al., 2015) on trust. On the organizational level, the firm’s reputation and its trustworthiness have been investigated (Chellappa and Pavlou, 2002; Kim and Park, 2013; Koufaris and Hampton-Sosa, 2004).

However, the AV context possesses unique characteristics that distinguish it from other areas. For example, while customer protection in mobile banking or online shopping is mainly of a financial or privacy nature, using an AV is also a matter of personal safety. An emerging stream of research has addressed the effects of trust on the adoption of AVs and included some of the aforementioned factors. For example, security, privacy, and technical competence have been shown to influence trust, which in turn has been shown to increase the willingness to use AVs (Choi and Ji, 2015; Kaur and Rampersad, 2018). Additionally, in an experimental setting, Waytz et al. (2014) exposed participants to autonomous vehicles with different levels of humanness and showed that anthropomorphism significantly increased trust. Gold et al. (2015) also used driving simulations to approximate participants’ experience with AVs to find that trust increased with the level of experience.

We build on these findings to capture the uniqueness of the AV context. Concerns regarding safety and protection are considered by the institution-based trust conceptualizations. On the individual level, we include disposition to trust technologies, as this factor has been shown to be an important factor for trust in technology in various settings (McKnight et al., 2011). On the technology level, we investigate the role of anthropomorphism, perceived uncertainty and components of the TAM.
2.2 The Role of Institution-based Trust

Institution-based trust comprises structural assurance and situational normality. Structural assurance reflects one’s beliefs that structures like guarantees, regulations, promises, legal resources or other procedures are in place to promote success of a given technology (McKnight et al., 2002). In this context, we distinguish between perceived vendor specific guarantees, perceived technical protection and perceived legal protection.

Product warranties can be seen as a signal for product quality. They allow recourse on the manufacturer and can thereby positively affect consumers’ trust in the product (Boulding and Kirmani, 1993). Investing in AVs could be risky, as most individuals will not be fully able to understand or evaluate its quality. At the same time, AVs are expected to be comparably expensive, making the investment particularly risky (Fagnant and Kockelman, 2015). Summarizing, in the context of AVs these warranties provide support for uncertain investments.

Closely related, institutional legal structures that allow punishment of inappropriate or opportunistic behaviors increase predictability and reduce the risk of unwanted outcomes (Sha, 2009; Zucker, 1986). Legal structures are also relevant for liability issues (Kalra and Paddock, 2016). Imagine a situation in which the car drives above speed limit or causes an accident. Since the car drove autonomously, the driver was not directly responsible for the incident. To what extent can the driver be legally prosecuted? Institutional legal structures would clarify these liability issues by establishing clear legal frameworks and consequently, increase trust in AVs. Previous research already provides evidence that legal bonds help consumers to trust in new technologies (Pavlou, 2002).

Perceived technical protection through safeguards as well as encryption of the programming code covers the effectiveness of the technology itself. The technology is a decisive factor for functioning but also safety of AVs. Therefore, in this context technological protection is especially important. Previous research suggests that safety is a key concern and thus barrier for AV adoption (Hutson, 2017; Mervis, 2017). Therefore, we assume that technological protection will serve as a key enabler. Utilizing technological security measures that are perceived as reliable should increase trust towards AVs (Wingreen and Baglione, 2005).

Situational normality reflects an individual’s belief that the environment is in proper order and success is likely because the situation is favorable (McKnight et al., 2002). Research provided strong support for the relationship between situational normality and trust (Gefen et al., 2003, McKnight et al., 2011). In the context of our study, situational normality represents the passengers’ feeling that traveling in an AV is comfortable and not worrying at all. This generally positive perception may result in trust in AVs. Therefore, we propose that:

**H1:** Institution-based trust, as represented by a) perceived vendor specific guarantee, b) perceived technical protection, c) perceived legal protection and d) situational normality, increases trust in AVs.

The more uncertain the perception of dealing with a technology is, the less people tend to trust it. Uncertainty is generally negatively related to trust and prevents individuals from engaging with a technology (Chen et al., 2015; Pavlou, 2003). In case of AVs, most individuals will have difficulties in understanding and evaluating this technology. Consequently, we assume that uncertainty concerning AVs will reduce trust towards them.

**H2:** Uncertainty decreases trust in technology.

Institution-based trust is especially relevant if the situation is ambiguous and only little information about the technology are available (McKnight et al., 2011). In situations of high uncertainty, structural and situational context factors, which an individual can rely on, can be of specific relevance (Hwang and Lee, 2012). Hence, we assume that the level of uncertainty moderates the relationship between institution-based trust and trust in technology:
**H 3:** Uncertainty positively moderates the relationship between trust in AVs and institution-based trust, as represented by **a)** perceived vendor specific guarantee, **b)** perceived technical protection, **c)** perceived legal protection and **d)** situational normality.

### 2.3 Trust in Technology and the Technology Acceptance Model

Trust in technology is the belief that a specific technology is able to perform a certain task as expected in situations where unfavorable outcomes could occur. This belief is based on the attributes of the technology, which are (1) functionality, (2) helpfulness and (3) reliability (Lankton et al., 2015; McKnight et al., 2011). In context of autonomous driving these factors imply that AVs (1) are capable to get their passengers safe to their destination, (2) will provide competent guidance, if necessary and (3) perform their services without unforeseen incidents, such as software errors. The importance of trust in technology in technology adoption has been highlighted in many studies (Wu et al., 2011).

Trust has an influence on the usage intention and on perceived usefulness. This could be shown, for example, for Enterprise-Resource-Planning systems implementations and recommendation agents (Benbasat and Wang, 2005; Gefen, 2004). Under uncertain conditions, such as those that apply to AV use, trust becomes a necessity to overcome barriers, as it reinforces the feeling that the technology will deliver what is expected. Trust increases the perceived benefit and subsequently the perceived usefulness (Gefen et al., 2003). In addition, if people trust a technology, they will believe in its capability or helpfulness, which will then lead to an increase in perceived usefulness as well as in intention to use it (Benbasat and Wang, 2005). While intention to use describes an individual decision, adoption refers to the process from getting familiar with a technology to using it (Choi and Ji, 2015; Kim et al., 2009).

We use them synonymously, as actual adoption is not possible without the availability of AVs.

**H 4:** Trust in AVs increases **a)** the intention to use them and **b)** their perceived usefulness.

We build on the TAM to incorporate technology-specific features, explain the predicted relationships and provide a well-established theoretical context (Davis, 1989; Venkatesh et al., 2007). Within the TAM, perceived usefulness and the perceived ease of use determine the intention to use a technology. We define perceived usefulness as the degree to which a person believes that AVs will have a positive effect for them overall. Perceived ease of use refers to one’s perception AVs can be used without much effort. Even though most people lack experience with AVs, available driving assistance systems can shape their perception. A technology, which is not easy to use might be perceived as less capable and consequently as less trustworthy (Gefen et al., 2003). For example, some people might not understand how driving assistance systems actually function and how to use them properly. By arguing vice versa we can expect perceived ease of use to influence trust in AVs positively.

**H 5:** Perceived ease of use increases the trust in AVs.

Situational normality reflects an individual’s belief that the environment is in proper order and success is likely because the situation is favorable (McKnight et al., 2002). Perceived ease of use indicates how effortful actual system usage is (Venkatesh and Davis, 2000). Accordingly, a favorable general situation will positively influence the perceived ease of use of a technology.

**H 6:** Situational normality of using AVs increases the perceived ease of use.

The relationships postulated within the TAM have been tested in many contexts and found wide support (Wu et al., 2011). Recently, they have also been shown to be relevant in the context of AVs (Choi and Ji, 2015). Therefore, we propose:

**H 7a:** Perceived usefulness of AVs increases the intention to use them.

**H 7b:** Perceived ease of use of AVs increases the intention to use them.

**H 7c:** Perceived ease of use of AVs increases the perceived usefulness.
2.4 Controls

To assess the role of institution-based trust within the context of commonly used determinants of trust in AVs, we include technical and individual control variables into our model. We control for perceived anthropomorphism as research has emphasized that it influences trust towards AVs (Waytz et al., 2014). The definition used in our study refers to anthropomorphism as the attribution of uniquely human characteristics, motivations, intentions, or emotions to the AV (Epley et al., 2007). We assume that the perception of the humanness of autonomous driving technology will influence trust towards AVs.

Regardless of any specific situation, individuals differ in their disposition to trust technology (Rotter, 1967). This disposition is the general tendency to be willing to depend on technology across a broad spectrum of situations and technologies (McKnight et al., 2011). We include this factor, since we assume that the individual trust in AVs is highly dependent on the general attitude towards technologies. Figure 1 illustrates our final research model.

Figure 1. Research model.

3 Methodology and Study Design

3.1 Participants

Data was gathered in the period from 09/07 to 31/08/2018 via an online survey. To get a broad set of responses we invited employees of local SMEs as well as a DAX company and contacted participants through a German professional online network. By addressing these people, we wanted to incorporate the age, education and income structure, but also the overall life circumstances of regularly employed people. Additionally, we invited graduate students to participate in our survey, as younger people frequently are early adopters of new technologies (Luo et al., 2010).
In the survey, we provided short pieces of textual information to clarify the definition of autonomous vehicles, the difference to driving assistance systems and the distribution of responsibilities between driver and machine. Examples of driving assistance systems were also given. After dropping incomplete datasets, the sample consisted of 286 participants, leading to a response rate of 56%. Of all participants, 40% were women, 59% men and two respondents did not answer this question. The average age was 40 years (range = 19 – 72 years) with peaks of respondents aged between 20-25 years, but also between 50-55 years. Additionally, 62% of the participants held a university degree.

3.2 Measures

The study is built on previously validated items to ensure a good quality of the measurement models. Since we measure the intention to use a technology that is not yet commonly possible to use, we provided detailed explanations on technology characteristics and examples. All items were measured on a 7-point Likert-scale ranging from (1) strongly disagree to (7) strongly agree.

Structural assurance. Constructs for perceived technical protection and perceived legal protection were adapted from the work by McKnight et al. (2002), while perceived vendor specific guarantee was adapted from a study by Sha (2009). Coefficient alphas were 0.93, 0.85 and 0.89 respectively.

Situational normality. To include situational normality, the scale used by McKnight et al. (2011) was adapted to measure perceived normality when using driving assistance systems, as autonomous driving technologies are not available yet. Situational normality was measured on a 4-items scale and had a coefficient alpha of 0.84.

Uncertainty. To measure the amount of uncertainty, we used the 2-items scale developed by Liang et al. (2005). Coefficient alpha was 0.83.

Technology trusting beliefs. To measure technology-trusting beliefs, items for functionality, reliability and helpfulness were all measured on 3-items scales taken from Lankton et al. (2015). Coefficient alphas were 0.87, 0.76 and 0.93 respectively.

Technology Acceptance Model. To measure perceived ease of use, perceived usefulness and intention to use as utilized in the TAM, we adapted the items provided by Venkatesh and Davis (2000). Perceived ease of use and perceived usefulness are measured on a 4-items scale and intention to use is measured on a 2-item scale. Coefficient alphas were 0.89, 0.88 and 0.97 respectively.

Disposition to trust. The measurement of disposition to trust is based on a 3-item scale developed by McKnight et al. (2002). Coefficient alpha was 0.83.

Anthropomorphism. This construct is based on Waytz et al. (2014) using four items resembling human capabilities such as asking, “how smart the car is”. Due to low factor loadings, one item was dropped from the analysis. Coefficient alpha is 0.71.

3.3 Data Analysis

To test our hypotheses, we assessed the measurement models and calculated the structural model in a second step. Both analyses were performed using PLS-SEM. PLS was chosen over CB-SEM, as it does not assume normal distribution, is particularly appropriate for complex models and its bootstrapping method increases robustness (Efron and Tibshirani, 1998; Hair, 2017).

To evaluate the measurement models’ internal consistency, convergent validity and discriminant validity were tested (Hair, 2017). Internal consistency can be assumed with Cronbach’s alphas above 0.7 (Cronbach, 1951). As the test of our measurement models showed, internal consistency is given for all factors. Convergent validity is assessed by analyzing the indicator reliability and the average variance
extracted (AVE). Indicator reliability reflects the amount of explained variance by the emerging factor for each indicator. A minimum value of 0.4 is required (Hair, 2017). AVE reflects the ratio of the explained variance of the construct and the variance of the error term. As the variance explained by the factor should be higher than the explained variance of the error term, a minimum requirement of 0.5 is expected (Hair, 2017). Results show sufficient values and confirm that convergent validity is given. To measure discriminant validity, the Fornell-Larcker Criterion was used to measure whether indicators of the same constructs are correlated stronger with themselves than with indicators of other constructs (Bagozzi and Phillips, 1982). Results show that discriminant validity can be assumed for all constructs. Additionally, the test for heterotrait-monotrait ratio did confirm discriminant validity for the measurement models.

Based on McKnight et al. (2011), trust in technology is a reflective-reflective second order construct and was analyzed using the repeated indicators approach in Smart PLS 3. This higher order model reduces the complexity of relationships and decreases multicollinearity due to the integration of the highly correlated dimensions in a higher order construct (Ringle et al., 2012). While discriminant validity is not relevant for second-order constructs, evaluation of this construct showed that reliability criteria are met. Accordingly, convergent validity and internal consistency reliability could be confirmed for all first and second order constructs.

## 4 Results

Table 1 shows the means, standard deviations and correlations between the main constructs. To rule out any challenges with the results, a PLS-SEM model is defined by its predictive value (Hair et al., 2017). We controlled for multicollinearity by testing the variance inflation factors. All values are below the threshold of 3.3 (Kock, 2015), indicating that multicollinearity is not an issue in this setting.

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>SD</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
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<th>9</th>
<th>10</th>
<th>11</th>
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<tbody>
<tr>
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<td>Functionality</td>
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<td></td>
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<tr>
<td>2</td>
<td>Helpfulness</td>
<td>4.94</td>
<td>1.19</td>
<td>0.70</td>
<td>0.76</td>
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<tr>
<td>3</td>
<td>Reliability</td>
<td>4.29</td>
<td>1.45</td>
<td>0.72</td>
<td>0.66</td>
<td>0.93</td>
<td></td>
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<tr>
<td>4</td>
<td>Legal protection</td>
<td>4.35</td>
<td>1.53</td>
<td>0.52</td>
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<td>0.59</td>
<td>0.85</td>
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<td>Vendor guarantee</td>
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<td>0.48</td>
<td>0.50</td>
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<td>Technical protection</td>
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<td>1.44</td>
<td>0.73</td>
<td>0.66</td>
<td>0.77</td>
<td>0.71</td>
<td>0.16</td>
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<td>Situational normality</td>
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<td>0.89</td>
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<td>9</td>
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<td>-0.29</td>
<td>-0.55</td>
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</tr>
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</table>

Table 1. Means, Standard Deviations, Correlations and Cronbach’s alpha of main constructs.

Results of the model as presented in figure 2 show partial support regarding hypothesis 1, which stated that institution-based trust, as represented by a) perceived vendor specific guarantee, b) perceived technical protection, c) perceived legal protection and d) situational normality, increases trust in AVs. Of the three representations of structural assurance, only technological protection shows a positive effect on trust (0.590, p < 0.001), while guarantees and legal protection do not (0.023, p = 0.642; 0.025, p = 0.609). Situational normality has a significant effect on trust (0.107, p < 0.05). Therefore, hypothesis 1b and 1d can be supported, while hypotheses 1a and 1c cannot. Uncertainty significantly affects trust negatively (-0.129; p < 0.01), so we can confirm hypothesis 2. Overall, trust reaches an $R^2$ value of 0.696, which shows that the modelled factors explain a large part of its variance.
Hypothesis 3 stated that uncertainty moderates the relationships between institution-based trust constructs and trust in technology. We find support for a moderating effect on the relationship between perceived technical protection and trust (0.102, p < 0.05). The interactions of uncertainty with vendor specific guarantees, perceived legal protection and situational normality do not show any significant effects (-0.050, p = 0.192; -0.006, p = 0.886; -0.002, p = 0.642). Therefore, we find support for hypothesis 3b but not for hypothesis 3a, 3c and 3d.

Hypothesis 4 stated that trust in technology positively influences a) the intention to use autonomous vehicles and b) perceived usefulness. Results show a significant effect on intention to use (0.411, p < 0.001) and perceived usefulness (0.733, p < 0.001), supporting hypothesis 4a and 4b. Perceived ease of use has no significant effect on trust in technology (0.030, p = 0.449), leading to a rejection of hypothesis 5.

Hypothesis 6 stated that situational normality has a positive effect on perceived ease of use. Results support the hypothesis with a significant effect (0.532; p < 0.001). By this, situational normality explains 28.0% of the variance of the latter.

The intention to use autonomous vehicles is significantly influenced by the perceived usefulness (0.374, p < 0.001), but not by the perceived ease of use (-0.012, p = 0.817). Moreover, perceived usefulness was not significantly influenced by perceived ease of use (0.021, p = 0.449). Thus, hypothesis 7a can be supported, while hypothesis 7b and 7c have to be rejected. Perceived usefulness reaches an R² value of 0.547 and intention to use of 0.525, which can be considered as medium to substantial.

Furthermore, anthropomorphism and disposition to trust also showed significant influences on trust (0.079, p < 0.05; 0.084, p < 0.05).

All dependent variables show a Q² above zero, indicating that predictive relevance is given for all these constructs. The q² values show that perceived legal protection, vendor specific guarantees, situa-
tional normality, uncertainty and controls only have a small predictive relevance for trust ($q^2 < 0.02$), while perceived technical protection has the highest predictive relevance for trust ($q^2 = 0.104$). Perceived usefulness and trust have a medium predictive relevance for intention to use ($q^2 < 0.15$), while perceived ease of use has little relevance ($q^2 < 0.02$). Furthermore, trust has a large predictive relevance regarding perceived usefulness ($q^2 = 0.500$). Last, situational normality has a large predictive relevance regarding perceived ease of use ($q^2 = 0.241$).

As suggested by Hair et al. (2017), we also analyzed the total effects in the model. Total effects are the sum of the indirect effect through a mediator construct and the direct effect (Baron and Kenny, 1986). Overall, the total effects support the conceptualization of our model and do not challenge individual relationships between variables by suggesting that significant relationships are not considered. An overview of total effects on intention to use is provided in table 2.

<table>
<thead>
<tr>
<th>Independent Variables</th>
<th>b</th>
<th>sd</th>
<th>t values</th>
<th>p values</th>
<th>95% confidence intervals</th>
<th>significance (p &lt; 0.05)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technical protection</td>
<td>0.397</td>
<td>0.052</td>
<td>7.839</td>
<td>0.000</td>
<td>0.295 - 0.489</td>
<td>Yes</td>
</tr>
<tr>
<td>Legal protection</td>
<td>0.021</td>
<td>0.033</td>
<td>0.515</td>
<td>0.607</td>
<td>-0.043 - 0.086</td>
<td>No</td>
</tr>
<tr>
<td>Vendor guarantee</td>
<td>0.018</td>
<td>0.033</td>
<td>0.464</td>
<td>0.643</td>
<td>-0.045 - 0.088</td>
<td>No</td>
</tr>
<tr>
<td>Situational normality</td>
<td>0.084</td>
<td>0.037</td>
<td>2.242</td>
<td>0.025</td>
<td>0.011 - 0.156</td>
<td>Yes</td>
</tr>
<tr>
<td>Uncertainty</td>
<td>-0.089</td>
<td>0.032</td>
<td>2.750</td>
<td>0.006</td>
<td>-0.150 - -0.027</td>
<td>Yes</td>
</tr>
<tr>
<td>Interaction Effects</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Technical protection x Uncert.</td>
<td>0.069</td>
<td>0.035</td>
<td>1.993</td>
<td>0.047</td>
<td>-0.008 - 0.134</td>
<td>Yes</td>
</tr>
<tr>
<td>Legal protection x Uncert.</td>
<td>-0.004</td>
<td>0.030</td>
<td>0.145</td>
<td>0.885</td>
<td>-0.066 - 0.054</td>
<td>No</td>
</tr>
<tr>
<td>Vendor guarantee x Uncert.</td>
<td>-0.033</td>
<td>0.026</td>
<td>1.304</td>
<td>0.193</td>
<td>-0.079 - 0.021</td>
<td>No</td>
</tr>
<tr>
<td>Situational normality x Uncert.</td>
<td>-0.005</td>
<td>0.027</td>
<td>0.044</td>
<td>0.965</td>
<td>-0.062 - 0.041</td>
<td>No</td>
</tr>
<tr>
<td>Control Variables</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anthropomorphism</td>
<td>0.054</td>
<td>0.026</td>
<td>2.067</td>
<td>0.039</td>
<td>0.006 - 0.109</td>
<td>Yes</td>
</tr>
<tr>
<td>Disposition to trust</td>
<td>0.057</td>
<td>0.023</td>
<td>2.490</td>
<td>0.013</td>
<td>0.015 - 0.104</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Table 2. Total Effects on the dependent variable intention to use.

## 5 Discussion

### 5.1 Institution-based trust and the adoption of AVs

Using a PLS-SEM, this study investigates the role of institution-based trust on trust in technology and on the technology adoption process of AVs. We find mixed results concerning the influence of institution-based trust.

Of the structural assurance factors, only perceived technical protection is significant. However, its influence is very strong, in fact, over five times higher compared the next highest factor. Consequently, perceived technical protection is the dominant factor for people to trust an AV.

In other studies, perceived legal protection has been found to be a strong aspect of institution-based trust (McKnight et al., 2011). However, in this context legal protection and vendor specific guarantees are not sufficient to increase customers’ trust in AVs. A possible explanation is that using AVs involves a different risk than the use of other technologies, as the risk of being physically injured or even killed is much more severe than possible economic losses. Statistically, the car remains the most dangerous and deadly means of transportation today (Vorndran, 2010). The associated safety concerns
when using an AV seem to dominate individuals’ perceptions and put economic uncertainties into a subordinate role. Some participants may have difficulties to imagine the rather abstract legal and economic issues. This might be the reason why perceived technical protection has a higher relevance for building trust than vendor specific guarantee and legal protection. However, if safety considerations diminish, the relevance of vendor specific guarantee’s and legal protection’s influences might increase. Consequently, the relative importance of the institutional-based trust factors seems to be context dependent.

Situational normality has a strong positive effect on trust, which underlines the importance of the situational context. The more comfortable people feel while using AVs, the more willing they are to trust them. The strong effect situational normality exerts on perceived ease of use supports this notion.

Furthermore, results show a negative relation between uncertainty and trust. Uncertainty moderates the relationship between perceived technical protection and trust, so that it is stronger under high uncertainty. Generalizing, the moderating effect shows that under high uncertainty, institutional factors seem to be a legitimate path to build trust in AVs.

To examine whether the effects of perceived legal protection and vendor specific guarantees are mitigated by perceived technical protection, we conducted a post hoc analysis and excluded perceived technical protection. The $R^2$ of trust dropped from 0.696 to 0.590. Without the surpassing effect of perceived technical protection, legal protection shows a significant effect on trust (0.229, $p < 0.001$), and also vendor specific guarantees and situational normality have significant effects (0.187, $p < 0.01$; 0.142, $p < 0.01$). Results indicate that all examined institutional factors are relevant for trust development towards AVs, but technical protection is the key determinant to cope with the specific security needs associated with the use of AVs at the current stage of adoption.

Additionally, we performed subgroup analyses to explore the insignificant effects of legal protection and guarantees across demographic determinants. As the perception of AVs differs across age and gender, we tested the model based on these subgroups (Hulse et al., 2018). For female participants uncertainty has a negative effect on trust in AVs (-0.231, $p < 0.01$), while the disposition to trust is not significantly related to trust (-0.006, $p = 0.912$). Technical protection is the only other significant determinant of trust in AVs (0.715, $p < 0.001$), which is also moderated by uncertainty (0.160, $p < 0.05$). This indicates that safety issues regarding the use of AVs exceeds all other institutional factors.

Contrasting, for male participants the effect between uncertainty and trust is not significant (-0.093, $p = 0.108$), but disposition to trust has a positive effect on trust (0.132, $p < 0.05$). For this group, the influence of technical protection is significant but comparably weaker (0.483, $p < 0.001$). In addition, vendor specific guarantees also affect male participants’ trust (0.147, $p < 0.01$). These findings confirm that the impacts of other structural factors on trust get more relevant, if the effect of perceived technical protection is weaker. By these results, we find that the perception of AVs does indeed differ across groups. Especially the strengths of the relationship between technological protection and trust differ across genders. Additionally, while for female participants trust is negatively affected by uncertainty, male participants’ trust is positively affected by guarantees.

We also split the sample at the median age of 36 years and find that among the older participants, situational normality significantly influences trust towards AVs (0.166, $p < 0.05$) while this effect is not significant for the younger participants (0.061, $p = 0.301$). Furthermore, anthropomorphism also increases trust among the older group (0.117, $p < 0.05$), but is not significant for young participants. These effects might occur because older participants are more accustomed to conventional cars, so that the adoption of AVs can be fostered through familiar interaction patterns and normality.

Summarizing, we find that the relevance of structural context factors differ across genders. Contrarily, situational factors differ between age groups. Thus, institution-based drivers of trust do not only vary based on the technological context of AVs, but also on the individual level.

Consistent with previous findings from other domains, our results show that trust in technology strongly influences the intention to use AVs directly and indirectly through perceived usefulness.
Concerning the TAM, we find evidence for the positive effect of perceived usefulness on intention to use. Autonomous driving technologies might for example be useful as they could reduce crash rates and enhance passengers’ safety. The low relevance of perceived ease of use might be rooted in the fact that participants had no prior hands-on experience with AVs (Venkatesh and Davis, 1996). Right now, the construct might mainly cover the participants’ general tendency to regard technologies easy to use.

Regarding control variables, we confirm the relevance of anthropomorphism for building trust in AVs (Epley et al., 2007; Waytz et al., 2014). Its positive influence might stem from an increased familiarity with the technology or provision of helpful features to simplify communication, as we have also found support for this argument in the subgroup analysis. Disposition to trust did also show a significant influence, which indicates that a positive attitude towards technology is beneficial for trusting and subsequently using AVs.

5.2 Limitations and Outlook

Like any other study, our research is subject to certain limitations. Continuous trust development builds on repeated interactions between trustee and technology, which we could only approximate by driving assistance systems due to the lacking availability of AVs. The conceptualizations of situational normality and perceived ease of use refer to driving assistance systems as well. Therefore, our results may be specifically relevant for initial trust development. Nevertheless, also driving assistance systems require trust and can be seen as a highly related preliminary stage of autonomous driving. Finally, the generalizability of our findings might be limited due to cultural aspects and sample characteristics. For example, the participants have a relatively high educational level and the age structure is not fully representative.

Based on these limitations and our findings, we provide guidance for future research. Surveys show that consumers specifically fear hacker attacks in relation to AVs (Hutson, 2017). Hence, future research should further explore technical protection regarding software stability and encryption. Furthermore, studies could gather longitudinal data at the transition from one level of autonomous driving to the proceeding one to analyze if the relevance of institutional factors changes along the adoption process (Venkatesh et al., 2003). Finally, we encourage researchers to further specify the referents of trust when investigating AVs. As a wide range of entities work together to create AVs and set the structural framework, researchers should be precise at whom trust is directed.

6 Contributions and Implications

This study provides important insights on the relevance of trust in technology for the adoption of autonomous driving technologies, emphasizing the role of institution-based trust. While recent studies have started to investigate trust in the adoption process of AVs, the role of institution-based trust has largely been overlooked. Thus, we contribute to the literature on AV adoption by integrating institution-based antecedents to trust in technology and placing them in the context of established factors originating from current research streams. The strong positive effects of perceived technical protection and situational normality highlight the relevance of institution-based trust. Consequently, this work adds to the understanding of the paradox of high initial trust levels (McKnight et al., 1998). Our results encourage further consideration of institution-based trust as a key factor for the research domain of technology adoption and initial trust formation in new technologies.

Furthermore, we shed light on the interplay between institutional factors and well-established individual and technical antecedents of trust, such as disposition to trust technologies and humanness of the
technology. We also examined the impact of institution-based drivers of trust for different demographic groups and find that their relevance differs for age and gender. Results show that the role of institutional factors is very relevant to the AV context, but has different consequences that vary depending on the characteristics of the individual. These findings add to the understanding of the mechanisms of the trust building process.

Additionally, this study makes important contributions to organizations and agencies involved in promoting AVs. Manufacturers and governments should provide structural assurance to customers. The latter can enhance trust development through designing laws and regulations that enable further technical development by manufacturers, e.g. by allowing data collection in public traffic, but also by specifying liability directives and mandatory settings to strengthen the perceived legal protection of potential users (Gogoll and Müller, 2017).

At the current stage of adoption, manufacturers should take initiative to increase the perceived technical protection of AVs, e.g. through advanced software encryption. In addition, humanness of AVs will support older customers’ trust, while warranties will primarily benefit male customers in building trust. Thus, benefits of AVs should be communicated tailored to the specific target groups.
References


