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Technology Acceptance and Critical Success Factors of Autonomous Driving from a Car Manufacturers' Perspective

Masterarbeit

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Abstract

The advent of autonomous driving constitutes a disruptive game changer of our transportation system and the epitome of future mobility. Although the number of technology acceptance studies in the field of self-driving vehicles is increasing rapidly, publications focusing on the fleet customer segment instead of private customers are still not present. As fleet customers will particularly benefit from autonomous driving, the present thesis investigates factors determining an individual's acceptance and resistance towards this technological innovation. In this context, seven interviews with experts in the field of autonomous driving, the fleet customer segment, and company car drivers are conducted. As an initial step literature on autonomous driving and existing acceptance studies, dealing with psychological aspects affecting behavior towards an innovation, are reviewed. Subsequently, based on the literature review and popular technology acceptance models discussed in the theoretical part, interviews are conducted and data obtained are analyzed in the spirit of grounded theory. Arising from the study's results, critical success factors of autonomous driving in the fleet customer segment will be derived. These relate to both company car drivers and fleet managers, representing major stakeholders within a company with respect to mobility. The findings are discussed in terms of implications for car manufacturers to enhance acceptance of both groups towards self-driving cars, before recommendations for further research are given.

Keywords: Autonomous Driving; Technology Acceptance; Critical Success Factors; Fleet Customer Segment; Business Models

1. Introduction

1.1 Motivation and Relevance

The advent of autonomous driving is considered a disruptive game changer of our transportation system (cf. Fagnant and Kockelman, 2015: 167). As cars have been incrementally equipped with automated technologies (e.g. anti-lock-brakes or rear view alarm system) for decades (cf. Schreurs and Steuwer, 2015: 152), autonomous vehicle technology has experienced a rapid maturation process, making highly automated driving on highways available in the near future (cf. Hars, 2015: 57; Fraunhofer IAO, 2015: 1). Even though autonomous driving has become a topic of great interest to the public, academic institutions, government, and industries (cf. Bazilinskyy, Kyriakidis and de Winter, 2015: 2535), leading to intense and emotional discussions in media coverage (cf. Maurer, 2015: 1), the idea of vehicle automation even dates back to the year 1937. In the context of the Futurama exhibit in New York an automated highway system, containing high-speed vehicles using dedicated freeways to comfortably travel across the country, was presented and planned to implement within 20 years (cf. van Loon and Martens, 2015: 3281). While Japanese researchers developed a driverless vehicle moving along by visually tracking white markers on the street in 1977, the DARPA grand challenge of 2005 constitutes the first milestone of autonomous driving activities in the 21st century. Volkswagen's modified self-driving Touareg was the first to complete the 211 kilometers course in less than seven hours reaching a maximum speed of 40 kilometers per hour (cf. Stanchev and Geske, 2016: 2).

Major benefits of autonomous vehicles being predominant in existing literature are increased safety, improvement of travel times by reducing congestion, and in this context enhanced fuel economy and CO2-emissions (cf. van Loon and Martens, 2015: 3281). As road accidents in Germany caused by human error amounted to 361,935 in 2014 and thus increased by 11,554 compared to 2013 (cf. Statistisches Bundesamt, 2015), driver failure is also empirically confirmed to be the main reason for traffic accidents (cf. Winkle, 2015: 372). Hence, in both public and scientific discourse autonomous vehicles are attested the potential to significantly lower traffic accidents by eliminating human sources of error (cf. Anderson et al., 2014: 4). Additionally, vehicle automation enables smoothing stop-and-go-effects in the traffic flow resulting in cars following each other more closely which, in turn, leads to an increase of the roadway's net capacity (Barth et al., 2014: 107f.). The authors also found that positive effects could be accomplished by platooning, which comprises a number of vehicles equipped with driver assistance systems and closely following the other. Keeping short distances to

preceding vehicles reduces the aerodynamic drag forces and reversely leads to lower energy consumption and emissions.

Apart from that, public interest in autonomous driving activities has significantly increased in recent years. In this context, Figure 1 illustrates the development of Google search queries related to *Autonomous Car* (blue line), *Driverless Car* (red line) and *Autonomous Driving* (yellow line) from 2008 to 2016. The dashed black line, moreover, shows the trend from 2012 to 2016, indicating a sharply growing interest in self-driving vehicle activities.

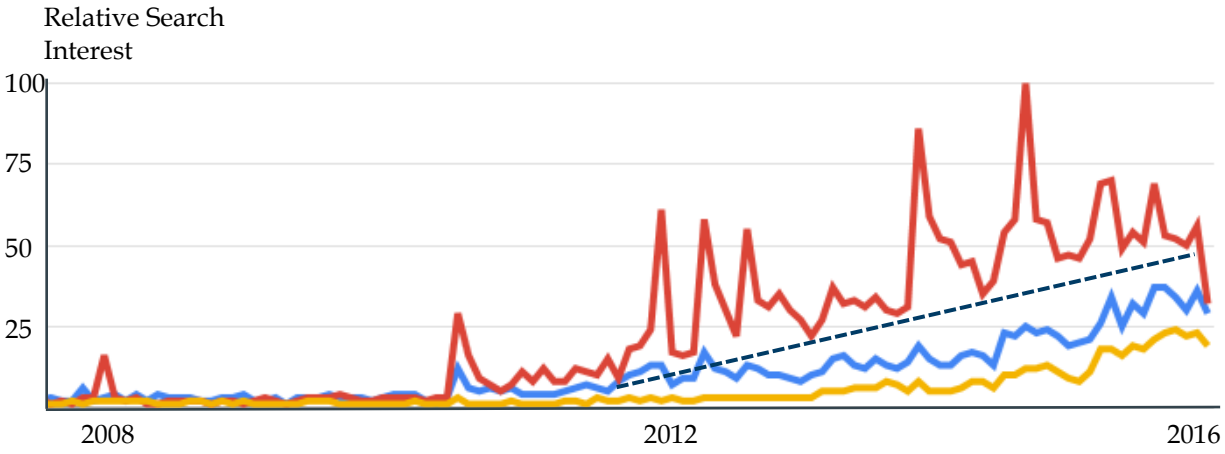

Figure 1: Google Search Queries for Autonomous Driving 2008-2016
Own illustration based on Google Trends, 2016

In the meantime, research has recognized the importance of autonomous driving and increasingly taken up the issue. Besides a rapid growth of general publications on benefits and challenges (e.g. Anderson et al., 2014) as well as of technical nature, particularly studies assessing the acceptance of society and future customers have become popular in research on vehicle automation. These studies reveal that public opinion on autonomous driving still varies strongly. For instance, according to Detecon (2016), 50.9% of participants can imagine to use autonomous vehicles for private purposes, whereas 32.2% are not willing to do so. While 65.5% consider the technical risk of driving such cars as too high (cf. Detecon, 2016: 16), another study revealed that German citizens are convinced of autonomous driving to reduce traffic accidents and to assist drivers in stressful and monotonous situations (cf. Continental Mobility Monitor, 2015: 26). However, as there is a multitude of work investigating technology acceptance of private customers, none of these studies take fleet customers into account, even though company car drivers will benefit most from vehicle automation (e.g. higher productivity). Furthermore, companies are also likely to benefit from higher productivity of their employees on the one hand and are enabled to reduce costs (e.g.

fuel costs) on the other hand. Against this backdrop, analyzing technology acceptance and determining critical success factors of autonomous driving in the context of fleet customers, respective fleet managers and company car drivers, is of great importance.

1.2 Objectives and Structure of the Thesis

Many studies investigating private customers' opinions on autonomous driving have been published in recent times (e.g. Detecon, 2016 or Automobil-Club Verkehr, 2015).

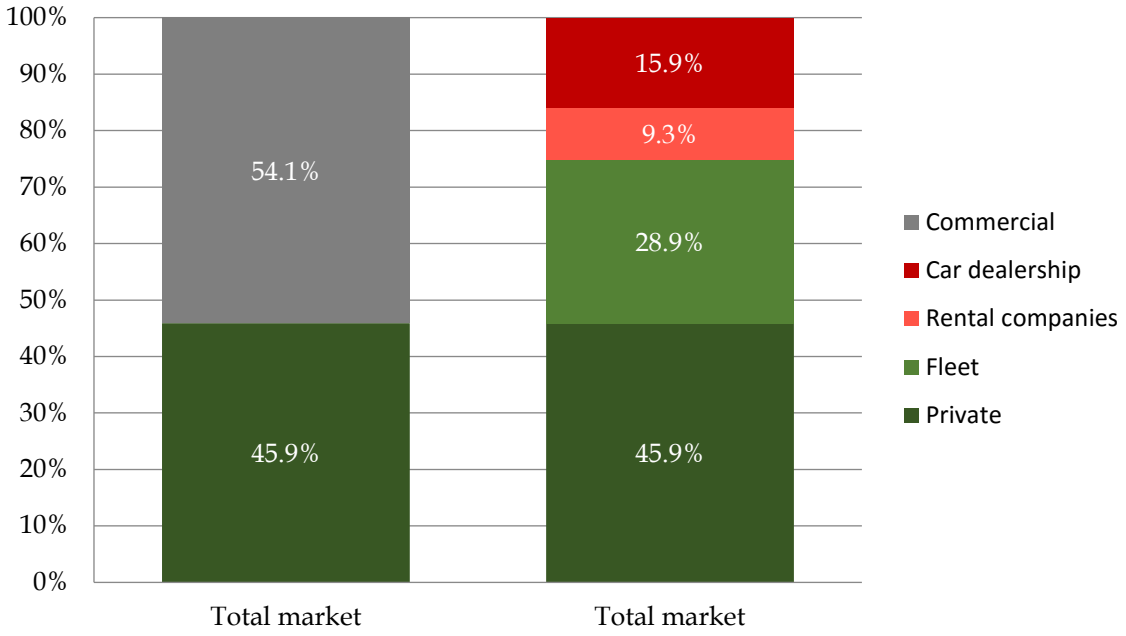

Figure 2: Sales Channels of New Car Registrations in Europe (2015)
Own illustration based on Volkswagen Group Fleet International, 2016b

However, as Figure 2 illustrates, 54.1% of total vehicle sales recorded in Europe in 2015 (EU16 countries) came from commercial customers, whereas private customers' share amounts to 45.9%. Despite the significance of fleet customers in total vehicle sales, there is no study solely focusing on technology acceptance of autonomous driving in the fleet customer business. Hence, this paper aims to close this research gap by investigating technology acceptance and critical success factors. Moreover, recommendations for action Volkswagen Group should take into account to raise or ensure acceptance towards self-driving vehicles are also in the focus of the present thesis. Against this backdrop, two research questions are derived:

- Which factors influence technology acceptance of autonomous driving in the fleet customer business?

difficult to reliably determine the level of acceptance. Individuals have not had the possibility to drive autonomously yet, wherefore they have not gained any experiences with self-driving cars and cannot assess their functionality properly. Therefore, even if participants expressed several benefits and pleasant anticipation towards self-driving cars, this could change after a first ride with an autonomous vehicle. It can be assumed, that reliable statements concerning an individuals' acceptance or resistance can be made only after repeated usage.

6. Conclusion and Outlook

The aim of the thesis was to determine factors influencing technology acceptance of autonomous driving in the fleet customer business. Furthermore, the study focused on critical success factors derived from these contributing factors. In order to gain a fundamental understanding of the investigation's objects, the fleet segment's relevance for car manufacturers was pointed out, before gradually elucidating five levels of driving automation. Subsequently, different acceptance models were discussed, forming the later basis of the empirical part. In order to identify aspects being prevalent in existing publications on autonomous driving and considered as influencing factors towards acceptance, a literature review was conducted. In this context, only determinants that may particularly be of importance for fleet customers were included. In order to verify these aspects and to create new knowledge on that topic, a qualitative research in the form of interviews with both experts and generalists was carried out. Within this research, two experts in the field of autonomous driving, two experts regarding the fleet customer segment, and three company car drivers, representing the eventual users of autonomous company cars, contributed information to the empirical part. Following a comprehensive analysis of the data collected from the interviews, a comparison between results and the preceding literature research was made to verify the aspects. Based on the findings of the interviews five critical success factors, car manufacturers should take into account for future business models in order to successfully establish autonomous driving in the fleet customer business, were derived. In the course of the fourth chapter the research questions were discussed in the light of the results. Additionally, in chapter five implications were discussed and related recommendations given, before limitations of the study were addressed.

In conclusion, nine superior categories consisting of several subordinate concepts, impacting behavior towards autonomous driving, were identified. Although a good feeling with regard to self-driving cars became apparent, this technological innovation is still associated with

uncertainty, potential risks of failure, and perceived technical immaturity. Moreover, company car drivers in particular reported a willingness to drive manually in specific situations, since driving is considered as enjoyment. Despite good experiences in the past, a perceived loss of control associated with autonomous driving was reported. In this context, more than half of the participants view a scalability or possibility to disable autonomous system functions as a prerequisite to this. Major benefits of autonomous driving mentioned are a comfort and safety benefits, support in monotonous and pesky driving situations, and high convenience at destination. Particularly the latter was associated with no longer having to search for free parking space, coming along with gain in time for the company car driver. Furthermore, the majority of interviewees, especially experts in the fleet segment, reported cost savings respectively fuel savings as a benefit for companies and fleet managers. However, autonomous cars also involve high initial costs, considered as a potential reason preventing fleet managers from acquiring such vehicles. Once self-driving cars have been introduced to a company's fleet, both fleet managers and company car drivers appreciate the possibility to work during travel leading to an increase of productivity (along with increasing appointments' quality), or to relax before meetings and after strenuous working days. Moreover, especially company car drivers reported a prevalent distrust in autonomous technology at the beginning but also familiarization with it after using it repeatedly. Based on the results, critical success factors derived relate to, for instance, providing the possibility of trying out the technology before market launch, a higher transparency of the stage of development, scalability of system functions, and an onboard working and relaxation environment. Autonomous driver trainings and test fleets for customers on-site would increase transparency of the current level of development on the one hand and would enable company car drivers reducing fears and getting familiar with as well as gaining trust in the technology on the other hand. Furthermore, scalability of autonomous functionalities in the form of an on-demand approach would lower customers' costs and, in turn, increase acceptance. This also relates to enhanced in-car multimedia systems giving the opportunity to pursue daily work during travel, including videoconferences and preparation of presentations. The company's fleet manager and the company car driver would therefore benefit from an increased productivity. Besides, in-car user interfaces offering access to movies, series, or a selection of music, as already known from long-haul flights, are likely to increase acceptance towards autonomous cars by ensuring a relaxation environment.

With regard to further research needs, a high potential of investigation relating to the present topic can be stated. As elucidated in chapter five, the timeframe of the present study does not

allow investigating development of acceptance over time, whereas merely behavior towards self-driving cars at the present moment is reflected. This is compounded by the fact that autonomous vehicles have not been introduced to the market yet, wherefore only expected behavior is investigated. Future research should follow up on that and examine dynamic developments of acceptance. In this context, a longitudinal research design to check for changes in behavior towards autonomous driving could be established. Once autonomous driver trainings and test fleets for customers have been introduced and led to an increased observability and trialability of the technology, changes in acceptance towards self-driving cars could be analyzed and related triggers determined. Apart from that, future research on autonomous driving should focus on qualitative rather than quantitative approaches. This is due to the fact that quantitative methods do not provide helpful insights for practice, as no concrete recommendations can be derived from numerical data. Qualitative research instead offers the possibility to get a deep understanding of an individual's reasons affecting acceptance or resistance towards autonomous driving. To conclude, future research on autonomous driving should more engage in investigating acceptance of fleet customers instead of private customers. As the fleet customer segment is more likely to immensely benefit from autonomous cars and is thus more willing to pay for it, this customer group will be the first to deal with the subject and to eventually adopt this technological innovation.