Towards Autonomous Driving: Developing a Framework for a Successful Transition

Masterarbeit

Zur Erlangung des akademischen Grades “Master of Science (M.Sc.)” im Studiengang Wirtschaftswissenschaft der Wirtschaftswissenschaftlichen Fakultät der Leibniz Universität Hannover

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Hannover, der 31.01.2018

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1 Introduction

1.1 Motivation and Relevance

"*I believe in horses. Automobiles are a passing phenomenon.*"
- German Kaiser Wilhelm II. (1905)

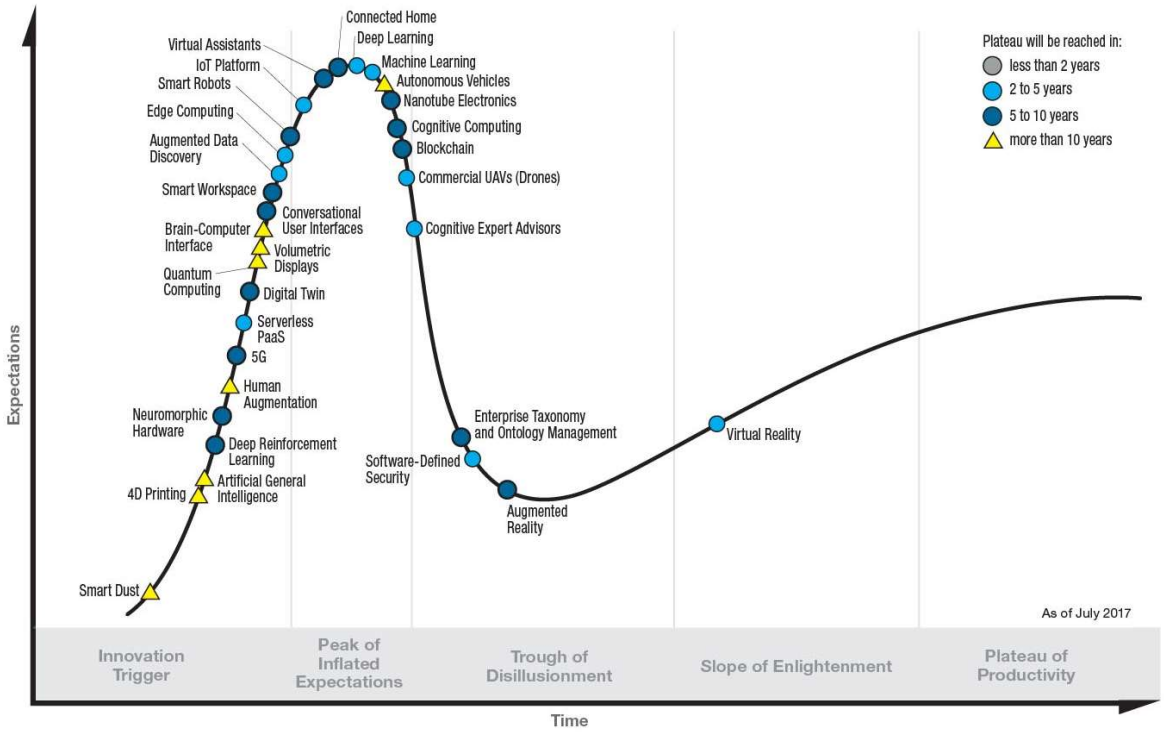
Similar to the transition from the horse to the automobile in the last century, the humanity is again facing a radical rethinking of mobility. As research and practice indicate, it is no longer a question of whether autonomous driving (AD) prevails, but of when it reaches the everyday life of the general public (Mahmassani, 2016). As the product of the ongoing computerization of vehicles, AD is attracting attention from a wide range of researchers, industries, and governments (Gordon and Lidberg, 2015). It is likely, that transportation is undergoing major disruptive influence regarding technology, players, and concepts (Mahmassani, 2016). As illustrated in the Gartner Hype Cycle for Emerging Technologies (Figure 1), there are enormous expectations of the new technology, that could "revolutionize transportation" (Levin et al., 2017). Autonomous vehicles (AV) could have the potential to reduce accidents, lower greenhouse emissions, provide individual mobility to the elderly and disabled, increase the efficiency in terms of energy and road capacity usage, and thereby reduce the travel time (Hult et al., 2016, Fagnant and Kockelman, 2014, Sparrow and Howard, 2017, Sherif et al., 2017).

Nevertheless, barriers to mass-market penetration remain (Fagnant and Kockelman, 2015) and the widespread adoption of AV technology seems to be years away (Chen et al., 2017b, Gartner Inc., 2017). Previous research that investigated these barriers was focused mostly on examining the technical aspects and feasibility of AV (Haboucha et al., 2017). Several researchers as Beiker (2012) and Glancy (2015) evaluate legal challenges of AD. Also, the customer's adoption is discussed in several papers (Bansal and Kockelman, 2017, Daziano et al., 2017, Haboucha et al., 2017). Bagloee et al. (2016) summarize potential advantages and disadvantages of AV. Yun et al. (2016) focus on the interplay between business models, technology, and market based on interviews with Korean firms. Many other studies discuss the adoption and effect of new business models such as shared mobility as a service (Chen et al., 2016a, Fagnant and Kockelman, 2014, Krueger et al., 2016, Levin, 2017), ridesharing applications (Fagnant and Kockelman, 2016, Levin et al., 2017) and implications of connected AV (CAV) (Hobert et al., 2015, Hult et al., 2016). Fagnant and Kockelman (2015), however, state that "one of the most pressing needs is a comprehensive market penetration evaluation."

The present study aims to contribute to research by conducting a comprehensive analysis of the underlying mechanisms, obstacles, and stakeholders that influence the market penetration of AV. The overall objective is to develop a framework for a successful transition towards fully AD in public road traffic. Thereby, a transition to AD is considered as successful if benefits and

risks are balanced in terms of economic, social and environmental sustainability. Such a framework can demonstrate relationships between the relevant determinants and indicate further need for research and actions.

Figure 1: Gartner Hype Cycle for Emerging Technologies (2017)
Source: Gartner Inc. (2017)



1.2 Research Questions and Structure of the Thesis

The guiding research question (RQ) of this thesis is:

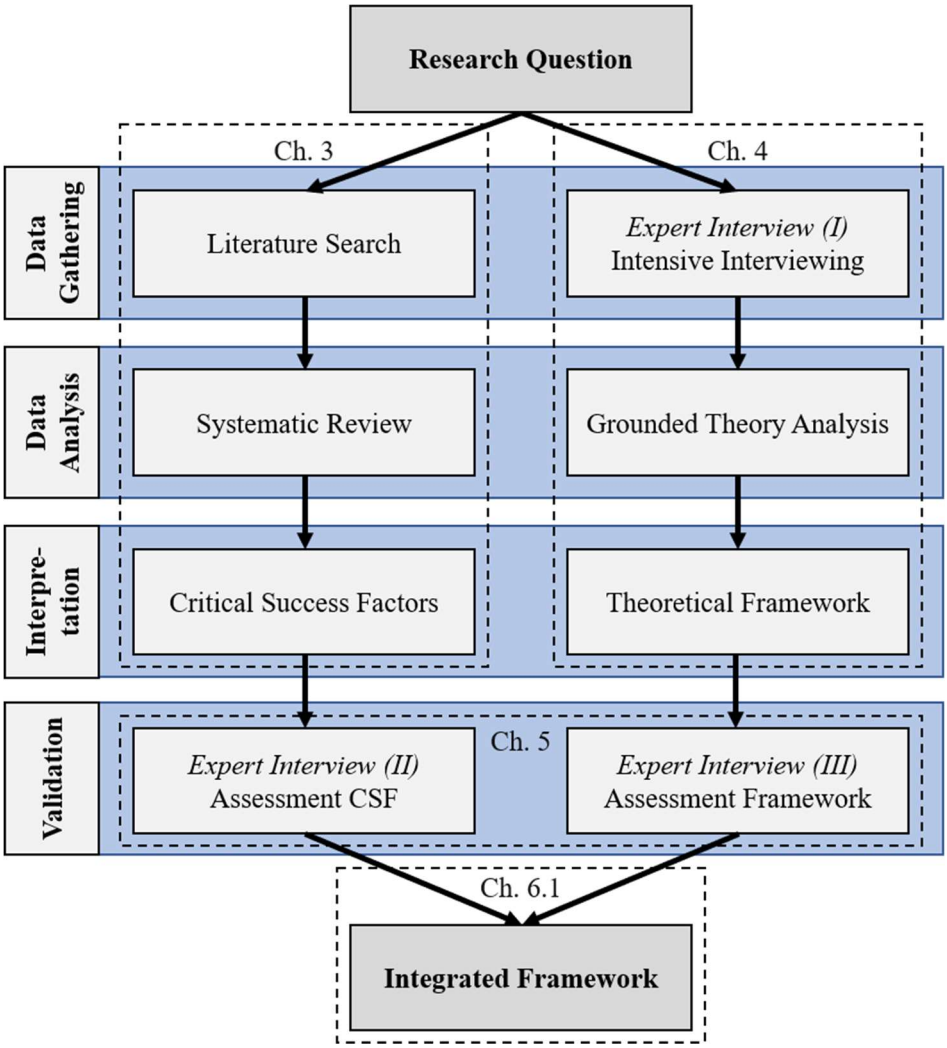
> *What are the determinants of a successful transition to AD in the public road traffic and how are they related?*

The objectives are fourfold: (1) to provide a thorough literature review on critical success factors (CSF) for the AD, (2) to integrate the findings of a qualitative analysis to a theoretical framework, (3) to validate both findings, (4) to contextualize the CSF in the theoretical framework and to derive implications for practice and research accordingly.

Figure 2 demonstrates how an achievement of these objectives is sought and how the thesis is structured. Chapter 2 provides background definitions and information on AD. To investigate the RQ, two different approaches were chosen. Chapter 3 provides a literature review resulting in CSF for AD, i.e. things that must go well to ensure success (Boynton and Zmud, 1984). Chapter 4 concerns the development of a theoretical framework for a successful transition to

AD. For this purpose, expert interviews are conducted and analyzed using the grounded theory method (GTM). Chapter 5 yields the validation of the CSF and the theoretical framework, assessed in further expert interviews. Chapter 6 provides a discussion and contextualization of the validated results, gives implications for research and practice, and points out the limitations of the thesis. Finally, the conclusions and an outlook are given in Chapter 7.

Figure 2: Structure of the Thesis
Source: Own Illustration



7 Conclusions and Outlook

Within this thesis a comprehensive framework for a successful transition to fully autonomous vehicles in public road traffic is developed. Thereby, a transition to AD is considered as successful if potential benefits and risks are balanced in terms of economic, social and environmental sustainability. Two approaches are chosen to answer the RQ. To provide an overview of key concepts and to identify major relationships in the research on AD in the road traffic, a structured literature review according to Webster and Watson (2002) is conducted. Thereby, a fundus of 53 relevant papers is identified. Due to the described search and evaluation criteria, the identified concepts can be considered as CSF for AD in the road transport, namely *Accident Safety* (CSF1), *Data Handling* (CSF2), *Legislation & Liability* (CSF3), *Business Models* (CSF4), *Fuel Consumption* (CSF5), *Perception of the Environment* (CSF6), *V2X Communication* (CSF7), *Passenger's Experience & Interaction* (CSF8) and *Road User Extension* (CSF9). An expert assessment revealed that CSF1 *Accident Safety* and CSF3 *Legislation & Liability* can both be considered as critically important.

As a second methodology, a qualitative research approach is chosen, because a comprehension of the contextual circumstances of AD is sought rather than a quantitative verification of existing practices. The GTM is established in the IS and transportation research and used in this thesis to construct theory by identifying, developing and integrating concepts. The data collection follows the intensive interviewing approach of Charmaz (2014) and Charmaz (2006), while the open, axial and selective coding is based on Strauss and Corbin (1998). Experts from leading companies in the automotive and technology sector, consulting agencies, an insurance company, and a government-related organization located in Germany, the U.S., Malaysia, and Singapore are conducted. Within the data collection and analysis, theoretical sampling and the constant comparative method are applied, and memo-writing is used as a supportive tool. The development of a theoretical framework results in the identification of the core category *Requirements for the Transition to AD* which is characterized by the interplay between the subcategories *Support*, *Supply*, and *Demand*. The core category, however, impacts the *Consequences* of a transition to AD and is influenced by *Underlying Forces* and *Driving Stakeholders*. The findings are summarized in key propositions (*P1-P9).* Two validation strategies are successfully applied. Within a discussion of the results, both findings are contextualized. It can be summarized that research and practice agreed in almost all respects. The thesis reveals research needs in all relevant areas. Recommendations for action are derived according to potential consequences that are identified in this thesis. Furthermore, limitations of the thesis are discussed.

In summary, it can be stated that the positive expectations in the technology of AD are largely justified. Potential benefits such as an increased safety, a reduction of pollution, the inclusion of currently underserved people, and a more efficient traffic, are discussed and confirmed in

the literature. However, to realize these benefits, action must be taken. This work contributed to reveal many ambiguities and barriers on the way to a sustainable transition to AD in the public road traffic. Also, relevant stakeholders were identified and the overall complexity of an introduction of AV into the market was shown. The next step should now be to actively steer the process of launching AV. If this is not the case, it is likely that the stakeholders will enforce their own interests disregarding the great comprehension of overall risks and potentials. An actively steered process can be initiated with the establishment and further support of cross-national and intersectoral working groups on AD, from which common frameworks, projects, compromises and cooperation can arise. “Innovation needs guardrails”, as Respondent P said. That is why stakeholders who react now to the prevailing uncertainties with actions and decisions can shape the picture of future mobility towards a sustainable outcome.