HOCHSCHULE FURTWANGEN UNIVERSITY HFU

Master Thesis

Mobility concepts and the impact of changing circumstances: a strategic approach to innovation and market dynamics regarding mobility as a service

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Abstract

Population growth, urbanization and climate change are regarded as the megatrends of today's society. This goes hand in hand with a high consumption of resources and pollution. Indeed, these megatrends are mutually reinforcing. A significant part of this is due to mobility in daily life. Technological change such as digitalization, creates innovative concepts to improve mobility and to deal with these changing circumstances. A comprehensive concept in this respect is mobility as a service. This thesis focuses on the identification of the mobility ecosystem and thus on the various stakeholders. First of all, it deals with the definition of mobility as a service in order to identify the ecosystem in particular in the second step. Mobility is classified and analyzed by working on the basis of secondary literature and a quantitative as well as qualitative methodology in expert interviews. This allows conclusions about the relationships, prerequisites and obstacles within the ecosystem and stakeholders.

The results of the thesis suggest that collaboration within the ecosystem is a prerequisite for the implementation of mobility as a service. Furthermore, that mobility as a service should ensure adaptability, since local infrastructures differ between Germany, USA and China, but also within these countries. This adaptation process is iterative. The obstacles are interoperability and the willingness to cooperate. Moreover, the results imply that mobility as a service will assert itself more quickly in urban areas due to factors such as the pressure to act and the availability of mobility services as well as the number of customers.

Keywords:

Mobility as a service, MaaS, mobility ecosystem, mobility concepts, urbanization, integration

Table of Contents

Acknowledgements I

Abstract II

Table of Contents III

II. List of Abbreviations V

III. List of Figures VI

IV. List of Tables VII

V. List of Appendices VIII

VI. List of Annexes IX

1 Introduction 1

1.1 Problem Definition 1

1.2 Research Objectives 2

1.3 Structure 4

2 Background 5

2.1 Terminology 5

2.1.1 Mobility and Transport 5

2.1.2 Mobility Concepts 6

2.1.3 Mobility as a Service 6

2.2 Literature Review 7

3 Mobility Classification 12

3.1 Mobility Concepts’ Framework 12

3.1.1 Mobility Concepts’ Ecosystem 12

3.1.2 Structuring Approach to Mobility Concepts 15

3.2 Mobility as a Service’s Framework 17

3.2.1 Mobility as a Service’s Ecosystem 17

3.2.2 Structuring Approach to Mobility as a Service 21

3.2.3 Mobility as a Service’s Objectives and Status Quo 24

4 Methodology 30
4.1 Quantitative Model 30
4.1.1 Modules 30
4.1.2 Data Collection 32
4.1.3 Criteria to Evaluate Indicators 32
4.2 Qualitative Method 34
4.2.1 Interview Structure and Procedure 34
4.2.2 Description of Experts 37
4.2.3 Qualitative Data Analysis 39
4.2.4 Quality of Data 41
5 Analysis Results and Discussion 42
5.1 Modules 42
5.1.1 Consumer 42
5.1.2 Urbanization 46
5.1.3 Infrastructure 52
5.1.4 Economy 56
5.1.5 Digitalization 67
5.1.6 Policy 72
5.2 Discussion of the Results 74
6 Conclusion 84
6.1 Summary 84
6.2 Limitations 86
6.3 Outlook 87
References 89
Appendix 119

II. List of Abbreviations

AG	Joint-stock company (Aktiengesellschaft)
CEO	Chief Executive Officer
CPI	Consumer Price Index
etc.	et cetera
GDP	Gross Domestic Product
GDPR	General Data Protection Regulation
GPS	Global Positioning System
ICT	Information and Communication Technologies
IT	Information Technology
MaaS	Mobility as a Service
MAASiFiE	Mobility as a Service for Linking Europe
PwC	Pricewaterhouse Coopers
U.S.	United States
USA	United States of America
USD	United States Dollars
VDV	Association of German Transport Corporations (Verband Deutscher Verkehrsunternehmen e. V.)

III. List of Figures

Figure 1: Structure of the Mobility Concept Ecosystem (own illustration, own further development, based on Schnieder/Gebhardt (2016), p. 3) 16

Figure 2: Overview of the MaaS Ecosystem (own illustration)... 23

IV. List of Tables

Table 1: Sectors and Stakeholders within the MaaS ecosystem 21

Table 2: MaaS Use Cases Framework (own modified structure, framework based on Kamargianni, M. et al. (2016), p. 3301)... 26

V. List of Appendices

Appendix 1: Overview Modules and Indicators of the quantitative model……………………………………………..…………………..…...………119

Appendix 2: Overview Modules and Interview Guide of the qualitative method…………….121

Appendix 3: General Data Protection Regulation…………………………………………....126

Appendix 4: Sent Interview Requests…………………………………………..………130

Appendix 5: Framework of qualitative data analysis – Consumer module…………………...134

Appendix 6: Quantitative Model: Licensed Drivers and Total Population……………..…….135

Appendix 7: Framework of qualitative data analysis – Urbanization module………………..136

Appendix 8: Quantitative Model: Urban Population…………………………………………137

Appendix 9: Quantitative Model: Urban Density…………………………………………....138

Appendix 10: Framework of qualitative data analysis – Infrastructure module……………...139

Appendix 11: Quantitative Model: Infrastructure Density…………………………………...140

Appendix 12: Quantitative Model: Personal Mileage and Public Transport………………....141

Appendix 13: Email communication with VDV……………………………………………..142

Appendix 14: Framework of qualitative data analysis – Economy module…………………..143

Appendix 15: Quantitative Model: Economic Figures and Correlation……………………...144

Appendix 16: Framework of qualitative data analysis – Digitalization module…………..….145

Appendix 17: Framework of qualitative data analysis – Policy module…………………...…146

Appendix 18: Experts' assessment of the success factors for MaaS……………….………147

Appendix 19: Quantitative Model: Index……………………………………………………148

VI. List of Annexes

Annex 1: Interview Transcriptions

Annex 2: Quantitative MaaS Model as an Excel File

Annex 3: General Data Protection Regulation Documents

1 Introduction

1.1 Problem Definition

The world's population is growing rapidly, reaching 7.8 billion people in 2020 and 8.5 billion by 2030.[1] In both developing and developed countries, population growth will lead to an increase in living standards in the long term, while rapid population growth will have negative short-term effects.[2] Between 2020 and 2030, about two billion people will enter the middle class with corresponding effects on higher consumption and mobility.[3] These changes in the global economy and a corresponding standard of living in emerging economies increase energy consumption and the extraction of raw materials.[4]

Another aspect is that the age structures of the population are changing. In developed countries the population is getting older, whereas in developing countries it is getting younger due to population growth.[5] Furthermore, the proportion of people living in cities and urban areas has increased from 751 million in 1950 to 4.2 billion in 2018.[6] Currently, more than half of the world's population live in urban areas and the trend continues to rise to an estimated 60 percent of the world's total population in 2030.[7] Accordingly, it is a matter of world population growth, demographic change and urbanization. Together with climate change and technological change such as digitalization, these circumstances form the megatrends of today.[8]

Mobility is a significant part of everyday life in a modern society.[9] The megatrends as changing circumstances, have an impact especially on mobility.[10] The private car is the predominant means of transport, both for the daily commute to work and leisure activities.[11] Consequently, current transport systems are based on private means of transport and the urban areas are filled with private cars on the roads, becoming increasingly dense, congestion and pollution.[12] Indeed, since these megatrends are mutually reinforcing, especially in terms of mobility, they pose a

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[1] Cf. United Nations (2019)
[2] Cf. Simon, J. L. (2019), p. 3
[3] Cf. Bouton, S. et al. (2015) and cf. Kamarudin, M. et al. (2018), p. 126
[4] Cf. Lorenz, U. et al. (2017), p. 31
[5] Cf. Cruz, M./Ahmed, A. (2018), p. 95
[6] Cf. United Nations (2018)
[7] Cf. World Bank (2019)
[8] Cf. Eckhardt, J. et al. (2018), p. 75
[9] Cf. Pereirinha, P. et al. (2018), p. 236
[10] Cf. Stopka, U. et al. (2018), p. 419
[11] Cf. Kent, J. et al. (2019), p. 210
[12] Cf. Bouton, S. et al. (2015)

global challenge for the future.[13]

According to the megatrends, more and more people in dense urban spaces have a need for mobility, with effects on resource consumption and consequences such as congestion and environmental pollution. The advancing technological development is a megatrend that helps the mobility sector to find new solutions that are more efficient and transparent.[14] Due to customer demand and the technological development, more providers are entering the mobility market and complementing the private and public transport supply network.[15] Due to these market dynamics, this leads to a variety of innovative mobility services such as car sharing and other vehicle sharing concepts, shuttle services and ride sharing as well as ride pooling opportunities, but also routing and ticketing as well as the bundling of all these services.[16]

Consequently, the mobility sector not only moves people and goods every day, it is also in motion itself. In order to keep up with the changing circumstances and the market dynamics as well as the multitude of innovative mobility concepts, an overarching concept is needed which allows the user to choose the most suitable mobility service for his needs and to reduce the complexity.[17] Hence, the subject of this work is mobility as a service (MaaS).

1.2 Research Objectives

The objective of this research is to contribute to existing studies to identify the relationship between the various sectors of the changing mobility, including new concepts, and to draw relevant conclusions for the status quo and further development in particular for MaaS. Indeed, there is currently no generally accepted definition of MaaS.[18] Therefore, the first research question (RQ1) is:

What is MaaS?

In current literature, which is described in detail in chapter 2.2, explorative and qualitative elaborations can be found with experts who are exclusively from Finland and Sweden and have a direct MaaS reference. The author of this elaboration follows the approach, based on the

[13] Cf. Kappenthuler, S./Seeger, S. (2019), p. 1
[14] Cf. Eckhardt, J. et al. (2018), p. 75
[15] Cf. Whittle, C. et al. (2019), p. 302
[16] Cf. Stopka, U. et al. (2018), p. 419
[17] Cf. Hilgert, T. et al. (2016), p. 58
[18] Cf. Lyons, G. et al. (2019), p. 22

conclusion of current literature, that the implementation of MaaS requires an entire ecosystem of different economic sectors. The second research question (RQ2) is therefore to identify these sectors and thus the actors of the ecosystem:

What does the MaaS ecosystem look like and which economic sectors are represented?

On this basis, the third research question (RQ3) arises, which focuses on the status quo and development possibilities with regard to MaaS:

What is the current market environment for MaaS and what are development opportunities?

The second and third research questions are supported by the derived hypotheses one and two (H1 and H2). Both hypotheses represent claims to promote the answer of the research questions. The first hypothesis is thematically related to RQ2 and RQ3, since it includes both the MaaS ecosystem and the current position and development opportunities.

H1: MaaS is only possible through the collaboration of various stakeholders from different economic sectors.

The second hypothesis refers to RQ3 and thus to a position comparison regarding MaaS of the countries in consideration.

H2: Germany, China and the USA are at different positions regarding the status quo of MaaS.

Previous qualitative studies analyzed the MaaS topic using hypothetical implementations of such a service and with user centricity. Moreover, there are currently hardly any quantitative studies in this research area (see chapter 2.2). The current analysis of this elaboration therefore comprises a strategic, target-oriented approach of qualitative methodology with expert interviews from different economic sectors structured in modules, as well as a quantitative approach in the adequate module structure so that comparability is given in order to conclude results and interdependencies. Moreover, secondary literature is also used in chapter five to analyze facts and to question and support the results of this elaboration.

It should be noted in advance that a description and in-depth research of the various business models of the MaaS actors are not the subject of this work. Likewise, the pricing of mobility services is not relevant. Furthermore, the aspects of sustainability and ownership of vehicles are of only marginal importance for the objective of this elaboration.

1.3 Structure

The remainder of this work is structured as follows: the next chapter explains the terminology of relevant terms as a basis for further elaboration. In addition, this chapter contains a comprehensive literature review, whereby the focus of previous research results and correlations to the findings made are drawn and are therefore indicative for further research approaches of this work. Chapter three provides a classification of the mobility concepts and the ecosystem of MaaS as well as the stakeholders within the ecosystem. Chapter four presents the methodology of the quantitative model and the qualitative approach in the form of expert interviews. The findings of the analysis are outlined in chapter five, including a discussion of the economic sector characteristics and interdependencies. The conclusion, limitations and outlook are contained in the last chapter.

Furthermore, it should be noted that due to the novelty of the MaaS theme, the scientific work already begins in the second chapter of finding the appropriate terminology. RQ1 therefore relates to the definition of MaaS and is elaborated in chapter two. This provides a clear and sound foundation for a holistic approach in the course of this work. The author's contribution is that chapter three classifies the mobility and its framework conditions of the ecosystem as well as its structure and stakeholders. This forms the basis for further processing and analysis through the quantitative observation of mobility and qualitative assessment of the associated economic sectors through expert interviews. Both methods are compiled by the author of this work in the discussion chapter five to answer the research questions and to verify the hypotheses. In this respect, blind spots are supplemented with secondary literature and own results are questioned in order to draw conclusions and interdependencies.

2 Background

2.1 Terminology

2.1.1 Mobility and Transport

This subchapter is dedicated to a solid foundation around the topic of mobility and all related aspects. This is important in order to gain an overview of such an extensive subject area and to draw conclusions in the further course of this elaboration.

Basically, this topic it is about the movement of people or goods and thus about a targeted change of location. In scientific literature, the terms “mobility” and “transport” are usually used synonymously.[19] Nevertheless, a clear definition is important for the further course of this work in order to obtain a complete picture of the topic complex and thus to conclude with new findings. Therefore, according to Becker et al. (1999), the terms are defined and differentiated as follows: *Mobility* is merely a completed change of location and thus logically the fulfilled need for a change of place.[20] *Transport* is the instrument to fulfil and implement this need for mobility, for example different means of transport and infrastructures.[21]

These definitions allow for the conclusion that mobility is about the need to move from one place to another and about the accessibility of means of transport.[22] In order to meet this need for mobility arises accordingly transport.[23] Conversely, this does not allow any statement to be made as to how much transport is necessary for the implementation of the need for mobility, since mobility cannot be equated with transport. Local and decentralized structures, for example in the city, increase the degree of mobility, which can be associated with more or less transport.[24] To what extent the degree of mobility also affects the corresponding transport opportunities to meet the need for mobility, is discussed in more detail in third chapter.

[19] Cf. Nakamura, F. (2014), p. 53
[20] Cf. Becker, U. et al. (1999), p. 71
[21] Cf. Lenz, B./Fraedrich, E. (2016), p. 173 and cf. Becker, U. et al. (1999), p. 71
[22] Cf. Nakamura, F. (2014), p. 57
[23] Cf. Zierer, M./Zierer, K. (2010), p. 25
[24] Cf. Randelhoff, M. (2017)

2.1.2 Mobility Concepts

First of all, the “mobility concepts” definition is of high importance here as well in order to create a uniform understanding of the further topic. The term "mobility concepts" consists of two components. *Mobility* was already defined in the previous subchapter. A *concept* is the design and planning of a project in which the project objective defines the means and ways to achieve the objective.[25] The derived understanding of the term *mobility concepts* is therefore the need to change the location, both spatially and temporally, and the associated definition and selection of the means for the objective of this change of location.[26] Which means of transport are determined and selected depends individually on the objective and thus the need of the change of location.

2.1.3 Mobility as a Service

In this subchapter, the described fundamentals of mobility and their concepts are brought together with regard to a resilient definition of MaaS. In fact, there is no generally valid definition in the scientific literature.[27] This is partly because it is still a new field of research, but also because there are currently many approaches and different perspectives.[28] It is indispensable for the further course of this elaboration to describe the term comprehensively and to define the characteristics as well as to delimit sub-areas.

In addition to mobility, the terminology of the *service* is of central importance. Several economic sectors are becoming increasingly service-oriented, with the use of corresponding products and services being at the forefront and not owning it.[29] Therefore, in a complex ecosystem of services related to people's mobility, provision is an essential component.[30] Consequently, both the provision of mobility concepts and systemically linked processes are defined as a service.[31] The associated processes include the provision of mobility data with real-time travel information, but also trip planning, ticketing and payment methods.[32] This allows to

[25] Cf. Diehlmann, J./Häcker, J. (2013), p. 143
[26] Cf. Gouthier, M.H.J./Nennstiel, C. (2018), p. 578
[27] Cf. Lyons, G. et al. (2019), p. 22
[28] Cf. Holmberg, P.-E. et al. (2016), p. 8 and cf. Giesecke, R. et al. (2016), p. 1f.
[29] Cf. Sklyar, A. et al. (2019)
[30] Cf. Longo, A. et al. (2019), p. 118
[31] Cf. Pflügler, C. et al. (2016), p. 201
[32] Cf. Surakka, T. et al. (2018), p. 56

draw the conclusion, that in this context mobility is provided to users as a service.

In a second step, the term *mobility as a service* will be defined as a whole to answer the first research question. Considering the scientific discourse, a deliberate delineation of the topic area and the clear naming of the core points are essential. This avoids that goals are described rather than concrete content in this new field of research. The Mobility as a Service for Linking Europe (MAASiFiE) project in 2016 and the European Commission (2017) emphasize the expected positive effects in their MaaS definitions.[33] As these are future impacts and goals such as enhanced sustainability, affordability and environmental friendliness, these features are not addressed in the definition used for this elaboration. Only the core points of the MaaS concept are named, also to ensure a clear demarcation and definition in the further scientific work on this topic. For this purpose, the author of this elaboration has analyzed the most frequently mentioned definitions in the scientific literature by Hietanen (2014), Kamargianni and Matyas (2017) and the MaaS Alliance (2019a) on similarities and core statements.[34] These are compared with own findings of the previous course, and finally summarized in the following definition:

The transport needs of the costumer are met by a single digital application, taking into account the availability and combination of various mobility concepts of the mobility ecosystem, as well as planning, booking, ticketing and a payment system.[35]

2.2 Literature Review

This subchapter deals with previous scientific publications as well as current developments and scientific discussions regarding the complex of topics of new mobility concepts, in particular MaaS. For an extensive literature search, various databases (Business Source Premier, Science Direct, SpringerLink and Google Scholar) and external information sources such as the publication servers of universities in Germany and abroad are examined. The changes in terminology and the investigation of the market environment will be examined in detail. Since MaaS is a relatively new topic in the scientific discussion, the literature review is comprehensively designed. This is necessary because a solid foundation and framework of

[33] Cf. Eckhardt, J. et al. (2018), p. 75
[34] Cf. Utriainen,R./Pöllänen, M. (2017), p. 141
[35] Cf. Hietanen, S. (2014), p. 2 and cf. Kamargianni, M./Matyas, M. (2017), p. 4 and cf. MaaS Alliance (2019a)

previous knowledge is needed to identify areas of further research in order to proceed with this scholarly elaboration.

In fact, a concept that enables a specific application for the integration of mobility and environmental information is already mentioned in an article in 1996 at the Institute for Information Management, University of St. Gallen. The authors Tschanz and Zimmermann (1996) describe an intelligent information assistant with user interface and the main goal of showing the advantages of public transport over private transport in order to raise awareness of environmental problems, particularly in the Lake of Constance region. As a fundamental limitation the broad cooperation of different public transport companies is mentioned. Furthermore, characteristics of the system such as personal preferences in the choice of means of transport, changes in the timetable or congestion as well as the booking itself are described.[36] Preston (2012) investigate the concept of an integrated transport system in which public transport and available information and ticketing are implemented. In general, the result of the study is that this process towards an integrated and seamless transport has to overcome hurdles.[37] This approach to integrated mobility is evaluated by Motta et al. (2013) in their research project "Integrated Mobility: A Research in Progress" as feasible in the future with regard to a cloud-based mobility assistant. Schade et al. (2014) refers this approach specifically to urban regions. Furthermore, it is stated that transport research has largely neglected the development of novel concepts for mobility and that there is a need to catch up there.[38] The described principle of the information assistant was first associated with the term "mobility as a service" by Heikkilä in 2014 in her thesis "Mobility as a Service - A Proposal for Action for the Public Administration, Case Helsinki" and got the first international attention in the same year at the 10th International Telecommunications Society European Conference in Helsinki.[39] By stating that the development of technologies has made several economic sectors more efficient and modern, but that passenger transport is not affected by this transformation, it must contribute to a functional and comfortable ecosystem for mobility services by better organizing the provision of public transport.[40] Hietanen (2014), one of the thesis advisors of Heikkilä's elaboration and later founder of the company "MaaS Global",[41] made the term "MaaS" known

[36] Cf. Tschanz, N./Zimmermann, H.-D. (1996), pp. 204-207
[37] Cf. Preston, J. (2012), pp. 23-25
[38] Cf. Schade, W. et al. (2014)
[39] Cf. Smith, G. et al. (2018a), p. 592
[40] Cf. Heikkilä, S. (2014), pp. 10-12
[41] Cf. MaaS Global (2019)

in the same year, especially in Finland.[42] He concretizes the concept from 1996 and described a model for mobility distribution that meets the user's respective mobility needs through a service provider.[43] This was a feasible approach in the field of mobility, and the concept also received more attention in scientific terms.[44] Utriainen and Pöllänen (2017) stated, that from a scientific point of view the concept of MaaS is still relatively unexplored as only a small number of scientific articles, studies and conference papers have been published. However it should be noted, that due to the growing popularity and initiative projects since 2014, articles and studies have been increasingly disseminated.[45] For this reason, the author of this work divides the further scientific review within this chapter into the following goal-oriented categories for a better cluster-based overview: conceptual framework, travel behavior changes and a summary part.

Conceptual framework

This paragraph regarding the conceptual framework covers scientific publications that focus in greater depth on the conceptual development of MaaS. Based on the mobility concept described by Hietanen (2014), of a seamless combination of different transport options and operation via an interface, Holmberg et al. (2016) also take on the multiple requirements and interplay of transport modes. In this context, the importance of various shared services, which concern car, bicycle and ride sourcing, and the implementation of them via smartphone applications in an on-demand environment complements public transport, is considered in the scientific discussion.[46] Ambrosino et al. (2016) and Giesecke et al. (2016) formulate the basic idea of the concept in the realization of personal mobility needs without owning a car or exclusively using public transport. This will be a combination of many transport components and also the implementation of booking and payment, as Kamargianni et al. (2016) and Hensher (2017) noted with regard to digitalization and its possibilities. Therefore, the entire scope of the MaaS ecosystem is of great importance. Kamargianni and Matyas (2017) describe the MaaS environment as consisting of different layers. The researchers highlight that a MaaS provider is the center of the business and is surrounded by transport providers and other extended companies. At the outer edge of this schema there are regulators as well as policy.[47]

[42] Cf. Smith, G. et al. (2018b), p. 36
[43] Cf. Hietanen, S. (2014), p. 2
[44] Cf. Karlsson, I.C. et al. (2016), p. 3266
[45] Cf. Utriainen,R./Pöllänen, M. (2017), p. 154
[46] Cf. Shaheen, S. et al. (2015), p. 5f.
[47] Cf. Laurell, A. (2017), p. 1f. and cf. Kamargianni, M./Matyas, M. (2017), p. 6f.

Travel behavior

In this context, travel behavior is defined as trip purpose, choice of means of transport and trip frequency when traveling.[48] The means of transport, e.g. car, public transport or bicycle, has an influence on the travel satisfaction of the traveller. This is the result of a study by de Vos (2018), which examined the choice of travel mode or means of transport according to preferences. Accordingly, the choice of the preferred means of transport has a direct influence on the satisfaction of the traveller. Furthermore, it should be emphasized that travellers with multimodal preferences are to be seen at the same level of satisfaction as travellers with a clear preference for means of transport.[49] The result corresponds with the experiences of Lyons et al. (2019), who emphasize the importance of an user perspective in the design of new mobility services and accordingly recognize a connection with a changing mobility behavior when considering the consumer choice of these services. The user's perspective is central here, since the comfortable provision of a mobility service with integrated travel planning and payment creates competition with the private car and could thus change mobility behavior.[50] Although the term "MaaS" was not used, Huwer (2004) published a paper in which the benefits of the combination of car sharing and public transport are examined in two German cities, Mannheim and Aachen. The result is that the adoption process is lengthy to change the mobility behavior, although the study shows clear benefits for all involved parties through the cooperation of these services.[51]

Literature Review Summary

It can be summarized that since 2014 the scientific consideration of the MaaS mobility concept has clearly gained momentum. There are many directions and characteristics of the conceptual framework and scientists emphasize that it is still a new concept and under development.[52] With regard to the second cluster identified in the literature review - the change in mobility behavior - it should be noted that many pilot projects are analyzed at a qualitative level.[53] Furthermore, the previous publications have in common the user-centric approach as well as the investigation of the effects of the use of new mobility services, the choice of means of transport and travel satisfaction for individual users.[54] In consequence, the preferred scope on the research of MaaS

[48] Cf. Haustein, S./Hunecke, M. (2013), p. 198
[49] Cf. de Vos, J. (2018), p. 271
[50] Cf. Lyons, G. et al. (2019), p. 34 and cf. Sohor, J. et al. (2016), p. 57
[51] Cf. Huwer, U. (2004), p. 86f.
[52] Cf. Mulley, C./Kronsell, A. (2018), p. 568f. and cf. Lyons, G. et al. (2019), p. 22
[53] Cf. Durand, A. et al. (2018), p. 8f.
[54] Cf. Kamargianni, M./Matyas, M. (2017), p. 12

is the relation between the end-user behavior and transportation services. Initiative projects on new mobility concepts can be found in many European cities and the MaaS concept is being researched worldwide.[55] For example, a hypothetical MaaS offer in London was investigated in order to draw conclusions about travel behavior.[56] Ho et al. (2017) also followed this approach with a hypothetical MaaS scenario in Sydney, with the conclusion that current public transport users are cautiously skeptical about a mobility service. As far as Germany is concerned, there is, to the author's knowledge, only one feasibility study with a direct reference to the MaaS concept with regard to North Rhine-Westphalia and electromobility.[57]

In summary, it can be said that Finland and Sweden are becoming an agglomeration center for MaaS initiatives as well as for the ongoing, further research into an institutional, technical and business perspective with various study projects.[58] During this in-depth literature review, the author of this work identified two universities as *hubs* due to the variety of their MaaS-related publications in scientific journals. These are the Chalmers University of Technology in Sweden and the Institute of Transport and Logistics Studies at the University of Sydney.

There is much academic literature on the mobility topic. However, there is only a small academic literature specifically related to MaaS, but which is growing as mentioned above.[59] In principle, it is pointed out that in the scientific discussion on the MaaS topic mainly think pieces as well as qualitative elaborations and only little quantitative work has been done.[60]

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[55] Cf. Smith, G. et al. (2019), p. 169f. and cf. Mulley, C. (2017), p. 248f.
[56] Cf. Kamargianni, M./Matyas, M. (2017), p. 12f.
[57] Cf. Schädel, M. (2018), p. 5
[58] Cf. Holmberg, P.-E. et al. (2016), p. 6
[59] Cf. Ho, C. et al. (2017), p. 25
[60] Cf. Wong, Y. et al. (2018), p. 15 and cf. Utriainen,R./Pöllänen, M. (2017), p. 145

3 Mobility Classification

3.1 Mobility Concepts' Framework

3.1.1 Mobility Concepts' Ecosystem

In subchapter 2.1.2 it is shown that a mobility concept can be designed in different ways and with different components. The following is therefore about the theoretical-conceptional framework and thus about the ecosystem around mobility concepts. In fact, the mobility concepts should be considered more differentiated on the basis of their aspects. A mobility concept can basically be understood as various, multi-layered characteristics, ranging from individual vehicle types to services such as sharing.[61] The changes or suppression of existing mobility concepts as well as the emergence of new concepts has always been linked to novel means of transport in recent decades.[62] Schade/Kühn (2012) note that new mobility concepts can emerge in different ways:

- Integration of innovative means of transport
- New forms of use
- Networking of different means of transport.

In recent scientific literature, correspondingly several different mobility concepts are described. However, a generally valid statement on the respective designations of the various concepts is not yet possible due to their novelty.[63] Nevertheless, definitions are of great importance for the further processing of the subject area. Therefore, the most frequently mentioned key terms are analyzed according to the current state of research. In order to provide an overview of this ecosystem of mobility concepts, the categories and their aspects are characterized in a first step. In a second step, a structuring approach for this ecosystem will be applied.

Basically, a distinction is made between three generic key terms: firstly, electrification and other new types of drives. Second, the automation of driving and third, shared mobility models.[64] All three can be counted among the first two points mentioned above for the emergence of new concepts. For this reason, the three key terms are now analyzed briefly and concisely.

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[61] Cf. Janasz, T. (2018), pp. 25-27
[62] Cf. Schade, W./Kühn, A. (2012), p. 17
[63] Cf. Mogge, K. (2018), p. 22
[64] Cf. Axsen, J./Sovacool, B. (2019), p. 3 and cf. Sprei, F. (2018), pp. 238-241

Electrification and new types of drive

In particular, the new drive concepts include all-electric vehicles, hybrid vehicles and hydrogen-powered vehicles.[65] This applies both to private vehicles and to all variants of public transport.[66] Worth mentioning aspects of electromobility are the public charging infrastructure, which is still to be expanded.[67] Nevertheless, a new dynamic has recently emerged for electric vehicles, both as a result of technological progress and developments, but also in the social context and environmental aspects.[68] At this point, no precise definition of the drive options is given, as they are not relevant to the course of this elaboration.

Connected and autonomous vehicles

This type of vehicle is also referred to as a driverless or self-driving vehicle because it can capture its surroundings and navigate without human intervention.[69] The basic idea of an autonomous and connected moving vehicle is to improve safety in traffic, to make better use of passenger time, but also to reduce the driver as a cost factor.[70] This mobility concept is promised to be able to decisively change daily life.[71] But there are still many hurdles to overcome with fundamental technical, legal and political issues, so there is uncertainty for the future.[72] Therefore, this mobility concept is not elaborated deeper at this point.

Shared Mobility

This paper adheres to the definition of “shared mobility” by Shaheen et al. (2015), who defines the key term including “various forms of carsharing, bikesharing, ridesharing (carpooling and vanpooling), and on-demand ride services.”[73]. With regard to the multitude of mobility sharing, two points deserve special mention. First, the type of vehicle with which sharing is operated. These are primarily in cities cars and bicycles.[74] As already mentioned, some of these vehicles are electrically assisted or fully electric.[75] The vehicle takeover and parking can be organized in a station-based model or in a free-floating model.[76] The free-floating model is the newer

[65] Cf. Weiss, M. et al. (2019), p. 1478 and cf. Wilberforce, T. et al. (2017), p. 25695
[66] Cf. Gabsalikhova, L. et al. (2018), p. 670 and cf. Glotz-Richter, M./Koch, H. (2016), p. 2614f.
[67] Cf. Gnann, T. et al. (2018), p. 326
[68] Cf. Mounce, R./Nelson, J.D. (2019), p. 21f.
[69] Cf. Sperling, D. et al. (2018), p. 77
[70] Cf. Fulton, L. et al. (2017), p. 1
[71] Cf. Cohen, S./Hopkins, D. (2019), p. 33 and cf. Lu, Z. et al. (2017), p. 118
[72] Cf. Sovacool, B./ Axsen, J. (2018), p. 741 and cf. Haboucha, C. et al. (2017), p. 38f.
[73] Shaheen, S. et al. (2015), p. 3
[74] Cf. Laporte, G. et al. (2018), p. 105f.
[75] Cf. Cairns, S. et al. (2017), p. 327
[76] Cf. Nijland, H./van Meerkerk, J. (2017), p. 84f. and cf. Axsen, J./Sovacool, B. (2019), p. 4

model of car sharing and offers the user greater flexibility, since the vehicle does not have to be returned where it was taken over.[77] The second point relates to ride sharing and on-demand services. Ride sharing and the term "ride hailing" generally refer to the same service.[78] Nevertheless, a differentiation is necessary. The difference between these is that ride sharing refers to a trip in which several people share a ride. Ride hailing, on the other hand, is the booking of a ride, regardless of whether this ride is shared or not shared.[79] The distinction avoids misleading statements or the use of terms in further scientific work. Concluding on the shared mobility concepts, both vehicle sharing and ride sharing have grown significantly in recent times.[80] This applies to the North American markets as well as to Europe and China.[81]

In this subchapter, it is premature to note that the mobility concept of shared mobility is central to the new concept development. It includes and combines characters from other concepts, such as electrification, as well as in principle for the eventual automation of driving.[82]

Two mobility concepts are to be emphasized in the end. One of the main supporting pillars of the mobility ecosystem is public transport with bus, train and subway lines, which must also be named as a mobility concept.[83] Nowadays, the private car is the prevailing means of transport in most countries and thus the predominant mobility concept.[84]

In summary, it becomes clear that the term “mobility concept” is widespread in scientific literature. Mobility concepts can be described as both vehicles and their different ways of use. In addition, local and long-distance public transport as well as the interaction of different individual concepts are also regarded as mobility concepts, just as the traffic planning of a city is a mobility concept.[85] After defining the term mobility concept, it was possible to show that the fulfilment of an individual's need for movement and travel over distances can be represented by available means of transport and types of use.

It can be shown that mobility concepts arise through the integration of new drive types, new forms of use and the network of different concepts.

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[77] Cf. Sprei, F. et al. (2019), p. 128
[78] Cf. Bischoff, J. et al. (2018), p. 816
[79] Cf. Fulton, L. et al. (2017), p. 12 and cf. Chen, P./Nie, Y. (2017), p. 445f.
[80] Cf. Vanderschuren, M./Baufeldt, J. (2018), p. 607 and cf. Paundra, J. et al. (2017), p. 121
[81] Cf. Mindur, L. et al. (2018), p. 11
[82] Cf. Mounce, R./Nelson, J.D. (2019), p. 23f. and cf. Weiss, J. et al. (2017), p. 50f.
[83] Cf. Chowdhury, S. et al. (2018), p. 75
[84] Cf. Eisenmann, C./Buehler, R. (2018), p. 171
[85] Cf. Zheng, H. et al. (2019), p. 224 and cf. Garcia-Aunon, P. et al. (2019), p. 273

In conclusion, the emergence of new mobility concepts and their networking consequently form the described key terms and thus the ecosystem of the mobility concepts.

3.1.2 Structuring Approach to Mobility Concepts

In order to bring a kind of structuring into the different mobility concepts, the author of this work distinguishes between three concept levels in the further course of this elaboration. This is a first central structuring approach to integrate and delimit the concepts described in the previous course. The first level of the mobility concepts is described as monomodal. A monomodal mobility concept is defined by the use of only one means of transport for a specific trip.[86]

The second level contains multimodal mobility concepts and in the third level are intermodal mobility concepts. Both concepts are united by the fact that they involve the use of different means of transport.[87] However, multimodality refers to the general use of different travel modes.[88] Intermodality, on the other hand, refers to the seamless combination of different modes of transport during a single trip.[89] This leads to the conclusion, that intermodality is associated with the complexity of possible system transitions, such as access or use, within the ecosystem of mobility concepts.[90] For this reason, the following figure links the mentioned modality levels with the shown ecosystem of the mobility concepts and adds the respective differentiation in access possibilities and the corresponding use.

Figure 1 therefore provides the structure of the mobility ecosystem. With this four-field matrix it becomes clear which means of transport and associated mobility concepts are to be differentiated via access and use. In addition, the levels monomodal as well as the levels multimodal and intermodal are clearly presented, although the different levels are explained briefly in the following.

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[86] Cf. Gebhardt, L. et al (2016), p. 1186 and cf. Gouthier, M.H.J./Nennstiel, C. (2018), p. 580
[87] Cf. Gouthier, M.H.J./Nennstiel, C. (2018), p. 580 and cf. Kagerbauer, M. et al. (2015), p. 331
[88] Cf. Schlüter, J./Weyer, J. (2019), p. 188f. and cf. Klinger, T. (2017), p. 223
[89] Cf. Krajzewicz, D. et al. (2018), p. 865
[90] Cf. Schnieder, L./Gebhardt, L. (2016), p. 2

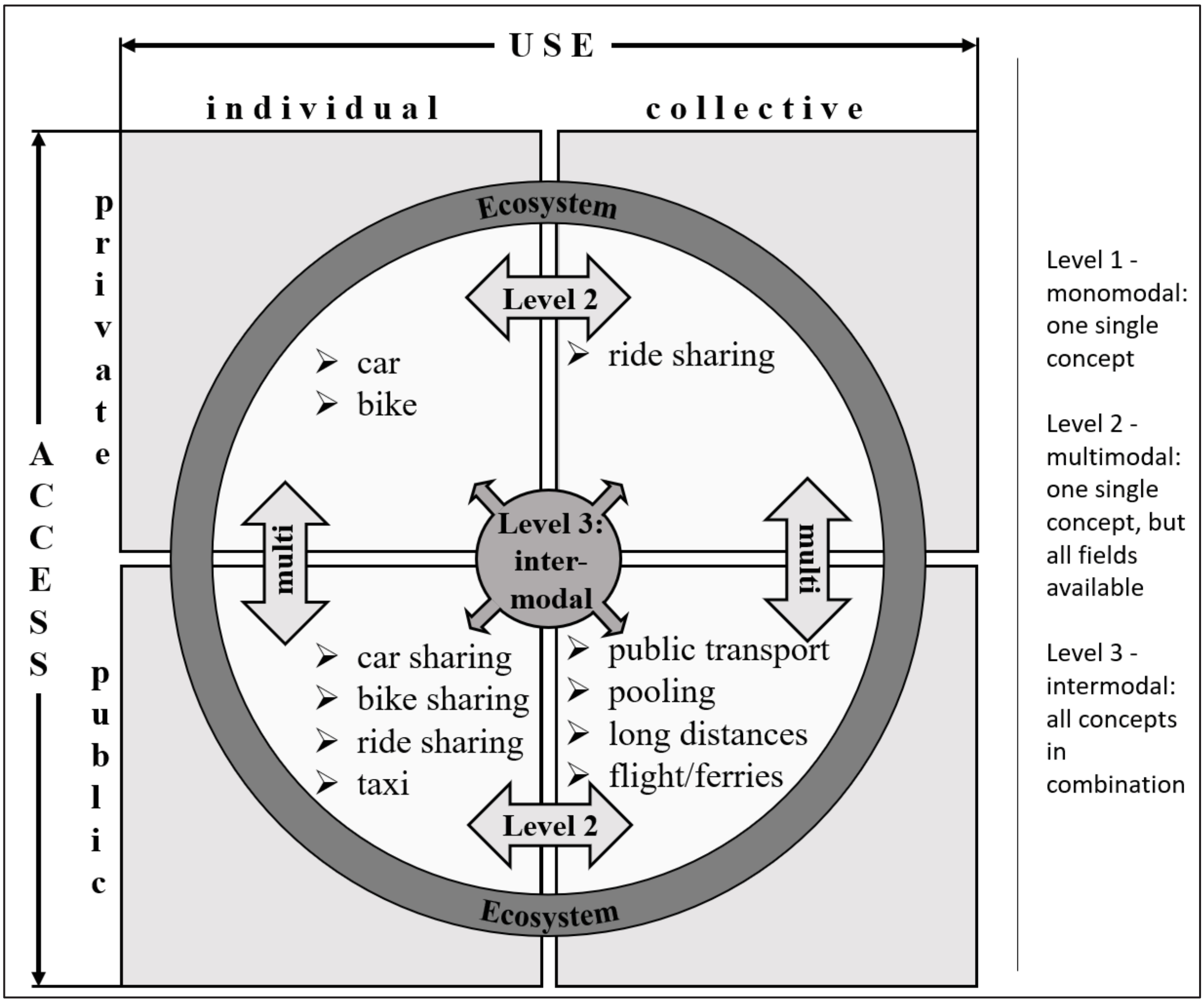

Figure 1: Structure of the Mobility Concept Ecosystem (own illustration, own further development, based on Schnieder/Gebhardt (2016), p. 3)

The first level represents the monomodal concepts, which means that the monomodal user can choose one single concept from only one field. The multimodal user from level two can also select only one concept per field and trip but can select from all four fields. The highest level and thus the intermodal concept has free choice on all four fields and all concepts, as these can be freely combined even during a single journey. This leads to the conclusion that the intermodal user is free to combine access and use and is therefore the most flexible.[91] This is why intermodal concepts are gaining in importance.[92] The system transitions between the four fields become blurred as a result. This is where the next subchapter starts.

[91] Cf. Oostendorp, R./Gebhardt, L. (2018), p. 72
[92] Cf. Gouthier, M.H.J./Nennstiel, C. (2018), p. 582

3.2 Mobility as a Service's Framework

3.2.1 Mobility as a Service's Ecosystem

By formulating the MaaS definition, the relevant sub-areas are clearly identified. This subchapter is dedicated to sufficiently describe the MaaS ecosystem. On the one hand, MaaS is a comprehensive service within an ecosystem that encompasses and combines all the levels and mobility concepts discussed in the previous subchapter. On the other hand, further services such as planning, ticketing and payment will be integrated into MaaS. Therefore, the MaaS ecosystem will be expanded in comparison to the described pure mobility concept ecosystem and has involved and united several different stakeholders and economic sectors.[93] Consequently, it is about answering RQ2.

For this purpose, the areas of the definition are broken down. First of all, it deals with the transport needs of the customer, which in the best-case scenario is presented as a practical and seamless door-to-door solution.[94] These corresponding transport solutions are provided via access and combination of multimodal and intermodal mobility concepts.[95] The planning of the travel chain already includes customer preferences as well as current traffic data and transport mode availability.[96] This information service is supplemented by booking, ticketing and payment.[97] In summary, all these services concerning the selection of transport modes, booking, ticket creation and payment processes are integrated into a single user application.[98] Consequently, the technical requirements are Information and Communication Technologies (ICT) to ensure the integration of these functionalities and connectivity.[99] Such a system network is also referred to as an intelligent transport system.[100] It creates space for a wide range of economic sectors and technologies to optimize travel solutions and expand variety, ultimately improving user benefits.[101]

The indicated, different economic areas and the technology of the MaaS ecosystem are now considered in a more highly granular way. Jittrapirom et al. (2017) formulate core

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[93] Cf. Jittrapirom, P. et al. (2018), p. 46
[94] Cf. Kamargianni, M. et al. (2016), p. 3294
[95] Cf. Hesselgren, M. et al. (2019), p. 1
[96] Cf. Atasoy, Bilge et al. (2015), p. 373f.
[97] Cf. Sohor, J. et al. (2017), p. 189f.
[98] Cf. Li, Y./Voege, T. (2017), p. 95
[99] Cf. Inturri, G. et al. (2019)
[100] Cf. Malygin, I. et al. (2018), p. 487 and cf. Javed, M. et al. (2019), p. 63
[101] Cf. Sumantran, V. et al. (2018) and cf. Jeekel, H. (2017), p. 4308f.

characteristics of MaaS. These include: the integration of transport modes, one platform and the use of digital technology.[102] Additional core points are also included in the list but are not relevant for the further course of this elaboration and therefore not considered in detail. Building on the above-mentioned core characteristics, these are analyzed fine-grained. Furthermore, the author of this work adds another characteristic. That is the data provision. In the next step, the characteristics of the MaaS business ecosystem are assigned to the respective economic sector. The sequence of the characteristics was chosen in such a way as to build on each other thematically.

Integration of Transport Modes

This core characteristic is the choice and combination of various means of transport, which is already known as multimodality and intermodality. That is why the economic aspect concerns transport operators such as public transport and long-distance transport, sharing services and on-demand services. In addition, the automotive industry is to be emphasized, as the original equipment manufacturers (OEMs) are responsible for the production of suitable transport vehicles and even create new business models in the area of servitization.[103] Therefore, transport operators and OEMs are the main suppliers in the MaaS ecosystem. Nevertheless, at this point infrastructure suppliers and thus national and local road authorities are also involved, as they are important as a basic prerequisite for transport.[104] Infrastructure quality is an important benchmark for the efficient flow of traffic and thus the use of transport modes.[105] In addition, the creation of a legal and regulatory framework for transport is an important aspect, both for infrastructure and transport modes.[106]

Data Provision

In fact, this characteristic also includes the transport operators that complement the MaaS ecosystem by adding real-time traffic information such as timetables and capacities, but also accessibility.[107] Furthermore, the passenger flows in the multimodal transport networks can be evaluated on the basis of mobile phone data in order to identify the means of transport used and the demand for main transport routes.[108] Additional possibilities for obtaining relevant data are

[102] Cf. Jittrapirom, P. et al. (2017), p. 16
[103] Cf. Eckhardt, J. et al. (2017), p. 29
[104] Cf. Gibbons, S. et al. (2019), p. 35
[105] Cf. Wessel, J. (2019), p. 42
[106] Cf. Behrends, S. (2017), p. 14
[107] Cf. Curtis, C. et al. (2019), p. 96
[108] Cf. Huang, H. et al (2019), p. 297 and cf. Bachir, D. et al. (2019), p. 254

traffic cameras and infrastructure sensors as well as vehicles with a global positioning system (GPS).[109] For example, weather data can also be of interest. All these data ultimately converge and are made available accordingly by the so-called data provider.[110] In the context of the MaaS ecosystem, interoperability means that the systems, infrastructures and devices within the ecosystem can communicate and understand information with one another.[111] Due to the large number of different sources, the data must be prepared accordingly so that interoperability can be guaranteed.[112] The requirement is a functioning interoperable information system, that the various transport systems and transport service providers can be integrated into the MaaS ecosystem.[113] The efficient information flows within the ecosystem are indispensable, as otherwise considerable problems arise in the use of mobility services.[114] As a result, it should be noted that various economic sectors are involved in data provision. In addition to transport operators, infrastructure providers, navigation systems and telecommunications companies are also important collectors of relevant data for and within the MaaS ecosystem.

Use of technologies

The previous point with interoperability can be directly connected in the technology-specific sector, since interoperability and the associated datasets, the integration of transport modes and other relevant services is referred to as ICT.[115] In addition, ICT includes applications such as an electronic payment system and the electronic ticket system, which are also integrated to enable seamless mobility.[116] These comprehensive ICT applications, which range from real-time user data to payment options, come with security and privacy concerns that must be addressed through a secure network architecture.[117] Furthermore, the ICT infrastructure is of great importance, as both a reliable mobile internet network is needed as well as cloud computing to quickly process the multitude of data.[118] Another important point is GPS, but also the distribution of mobile computers and smartphones.[119] In summary, ICT is the significant pillar in the execution, integration and connectivity of the underlying services in the MaaS

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[109] Cf. Respati, S. et al. (2018), p. 132
[110] Cf. Gellerman, H. et al. (2016), p. 2230
[111] Cf. Sousa, S. et al. (2017), pp. 320-323
[112] Cf. Ruiz-Alarcon-Quintero, C. (2016), p. 320f.
[113] Cf. Tibaut, A. et al. (2012), p. 788f. and cf. Borgogno, O./Colangelo, G. (2019)
[114] Cf. Gregor, D. et al. (2016), p. 108
[115] Cf. Harris, I. et al. (2015), p. 90f.
[116] Cf. Docherty, I. et al. (2018), p. 118
[117] Cf. Callegati, F. et al. (2018), p. 277
[118] Cf. Nowicka, K. (2016), p. 4077 and cf. Al Ridhawi, I. et al. (2018), p. 207
[119] Cf. Boutueil, V. (2019), p. 39 and cf. Chrétien, J. et al. (2019), p. 79

ecosystem.[120] From an economic point of view, the technology providers all around the ICT infrastructure deserve special mention here. In addition, telecommunications companies and navigation are once again an economic sector in connection with the MaaS characteristic regarding technology. It becomes clear that different technologies are necessary to enable MaaS.

One platform

This is the central point at which the three previous MaaS characteristics transport modes and infrastructure, data provision and technology use come together. As shown in the previous course, MaaS relies on operation by the end user on a single platform solution. Consequently, the user is provided on-demand access to all travel modes and other related services via the digital platform, for example as a mobile application on the smartphone or as a web page.[121] This is where the integration of all services takes place. Based on the mobility needs of the customer, the travel chain is planned, considering preferred means of transport and real-time traffic data, ticketing as well as payment.[122] This function is therefore called MaaS operator.[123]

In summary of these four core characteristics, it could be shown that there are several different actors within the MaaS ecosystem.[124] The MaaS core characteristics were used to identify various sectors of the economy. In order to subdivide the sectors into market participants in a further step, the aforementioned core characteristics are examined for technological requirements, integration and interaction of the actors. It became clear from the analysis above, which stakeholders in the relevant economic sectors have a MaaS relationship. In the following Table 1, the identified economic sectors in the MaaS ecosystem are presented in a clear overview. Moreover, the associated stakeholders are brief in their function and responsibilities described.

Sector	Stakeholder	Responsibilities
Automotive Industry	OEMs and Suppliers	Production and development of suitable transport vehicles
		Creation of new business models (e.g. servitization)

[120] Cf. Hasegawa, T. (2018), p. 40
[121] Cf. Ho, C. et al. (2018), p. 302
[122] Cf. Surakka, T. et al. (2018), p. 56
[123] Cf. Kamargianni, M./Matyas, M. (2017), p. 7
[124] Cf. Jittrapirom, P. et al. (2017), p. 16

Infrastructure	Cities and Municipalties	Urban planning and development strategies, local traffic planning
	Institutes	
	Road Authorities	Planning, monitoring and maintenance of the road and rail network
MaaS Intermediary	MaaS Operator	The transport needs of the costumer are met by a single digital application, taking into account multimodal and intermodal concepts of the mobility ecosystem, as well as planning, booking, ticketing and a payment system
Policy	Government and various Ministries	Legislation (traffic and transport)
		Incentives and disincentives
		Infrastructure financing
		Research funding
Technology and Mobile Service Provider	IT	Interoperability Integration of various services Mobile communication and internet
	ICT	
	Navigation	
	Telecommunication	
	Third Party Technology	
Transport Service Provider	Hailing Services	Provide passenger transport Data provision (timetables, capacities, real-time information, availability, booking information)
	Public Transport	
	Rental Services	
	Sharing Services	
	Taxi	

Table 1: Sectors and Stakeholders within the MaaS ecosystem

In conclusion, it can also be seen that in the MaaS ecosystem the boundaries between the given core characteristics become partly blurred with the participating economic sectors and already allow interaction. Furthermore, it became clear that ICT interoperability is a prerequisite for the integration of services like planning, booking, payment and ticketing. Finally, RQ2 is thus answered and forms a solid basis for further research.

3.2.2 Structuring Approach to Mobility as a Service

The sub-areas or the individual characteristics of the MaaS ecosystem are combined in the following to form an overall picture. Various interactions and the underlying communication will also be examined in more detail.

The starting point is the end-user, who has a need for mobility and therefore uses the online platform solution via the end-user interface. Here is the only point of contact between the MaaS operator and the end customer.[125] The need for mobility is correspondingly processed and passed on to the MaaS operator as an intermediary, thus forming the central and the mobility service layer.[126] This is where all information converges and is integrated. The MaaS operator can access all services from the ecosystem mobility concept described in chapter 3.1.1 in the sense of the third level of intermodal mobility. Accordingly, real-time data on timetables, changes, accessibilities and availabilities are communicated. Based on this, the MaaS operator calculates an individual travel chain according to the preferences of the end customer.[127] The end-user interface is used for further information exchange such as booking, routing, ticketing and payment between the MaaS operator and end-user.[128]

In order to clarify these complex processes and the underlying exchange of information, Figure 2 illustrates the composition and interaction within the MaaS ecosystem. The end-user is on the demand side with his mobility need. The MaaS operator is on the central stage as an intermediary. This is completed by the supply side with all available means of transport and concepts, for example public transport as well as private transport services.[129] The communication between the end-user and MaaS operator via the end-user interface should be emphasized. The exchange of information between the demand side and intermediary is symbolized in the clockwise direction in steps one, three, four and five in Figure 2.

[125] Cf. Sopjani, L. et al. (2019), p. 208
[126] Cf. Lyons, G. et al. (2019), p. 22
[127] Cf. Mulley, C./Kronsell, A. (2018), p. 568f.
[128] Cf. Lenz, B./Fraedrich, E. (2016), p. 179 and cf. Li, Y./Voege, T. (2017), p. 102
[129] Cf. Hesselgren, M. et al. (2019), p. 1

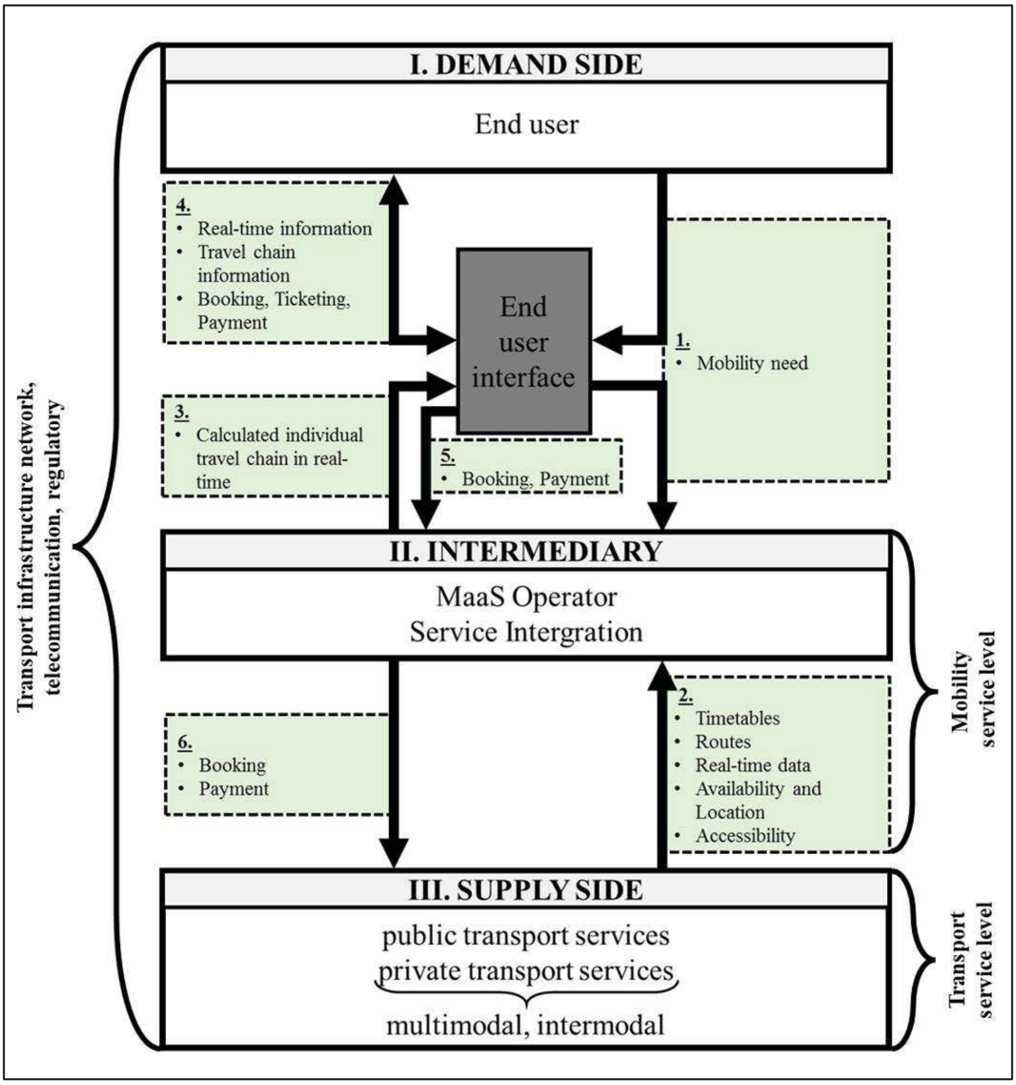

Figure 2: Overview of the MaaS Ecosystem (own illustration)

In summary, it can be said that the MaaS ecosystem basically consists of two sides and an intermediary in the center. On the one side there is the end-user as the demander, who is to be brought together with the other side and thus with the various different mobility services.[130] This function is assumed by the MaaS operator, which converges and integrates all transport services, additional services such as ticketing and payment as well as further information.[131] It has also turned out that several economic sectors are represented and interact with each other within this ecosystem.

[130] Cf. Wen, J. et al. (2019), p. 346
[131] Cf. Mulley, C. et al. (2018), p. 583

3.2.3 Mobility as a Service's Objectives and Status Quo

Now that the definition and a description of the sub-areas in the MaaS ecosystem have been created, it is primarily a matter of summarizing the expectations and goals of the MaaS mobility concept. Once this framework has also been set, a further step is taken to ensure the actual implementation of the concept and thus the status quo. Of particular significance is the country comparison between Germany, USA and China.

In chapter 2.2 on the previous scientific literature it could be shown that the focus is mainly on the behavior of the end-user and the conceptual development. Based on the findings of this literature and combined with own insights around the MaaS ecosystem, goals and expectations are formulated and divided into a social perspective and a consumer perspective. The technological perspective has been sufficiently described in the previous chapters 3.2.1 and 3.2.2.

From a social perspective, the objective of new mobility concepts and MaaS in particular is to make the entire transport system more efficient. There should be hardly any private vehicles on the roads and further development, especially in the direction of vehicle sharing, ride sharing and more use of public transport, in order to counteract emissions and congestion.[132] A further goal is that more new technologies such as electromobility should be introduced through new mobility concepts.[133] This should make the transport system as a whole more sustainable.[134] In a long-term perspective, this should also maintain and increase the attractiveness of the city as a place to live.[135] It can be concluded that the social perspective and the listed points are closely related to the megatrends of today.

From a user perspective, the aim is to make the use of MaaS simple, flexible and reliable.[136] By having extensive access to appropriate means of transport, users could be prepared to refrain from owning a vehicle.[137] The simple usability applies on the one hand to the end-user interface, but also to the transparency of offers and pricing.[138] This therefore includes trip planning as

[132] Cf. Inturri, G. et al. (2019)
[133] Cf. Whittle, C. et al. (2019), p. 302
[134] Cf. Polydoropoulou, A. et al. (2018)
[135] Cf. cf. Sohor, J. et al. (2017), p. 191
[136] Cf. Cole, M. (2018), p. 5f.
[137] Cf. Namazu, M./Dowlatabadi, H. (2018), p. 38
[138] Cf. Smith, G. et al. (2018a), p. 592

well as other services such as ticketing and payment.[139] Another objective is data security.[140] In short, the end-user expects a intermodal service, with continuous information on the journey as well as single payment, and all this combined via a single application.[141]

These requirements, expectations and objectives are in line with the elaborated definition of MaaS and thus also a continuation of the answer regarding RQ1. A framework is now derived from the technological, social and user perspectives. It should be noted that great importance is attached to both the integration of services and transport modes. Therefore, these are important aspects of the framework. The “integration type” comprises the planning of a trip, the booking, the ticketing and the payment. Another important aspect for the framework is the actual implementation on the market. This can be in a city, region, nationwide or in several countries. In summary, three layers are of high importance for the evaluation using the framework: the number of different transport modes and the intermodality associated with them. Furthermore, the integration of user-friendly services for the usability within a single interface. The last important layer of the framework is the actual area in which the MaaS providers operate to the present state.

In the search for current MaaS deployments, the worldwide platform of the MaaS Alliance (2019b) was used as a basis and expanded by own literature research as well as research on the “iTunes App Store” and “Google Play Store”. The chapter on the literature review (see chapter 2.2) has already revealed a large number of pilot projects and MaaS deployments in Finland and Sweden. As indicated, only services in Germany, USA and China are included in the analysis. The mobility services are selected according to the framework aspects and were only included if they met the criteria in principle. As it is not expedient at this point, a detailed description of the cases is not provided. Only the aspects of the identified cases are described superficially according to the framework layers. The list corresponds to the status as of April 2019, and may not be complete, as pilot projects, beta versions and deployments can change quickly. The framework and an overview of the use cases described below, can be found in Table 2.

[139] Cf. Hilgert, T. et al. (2016), p. 58f.
[140] Cf. Callegati, F. et al. (2018), p. 277
[141] Cf. Karjalainen, P. (2018), p. 9

First Layer		Second Layer	Third Layer				
Name	**Area**	**Transport Modes**	**Integration***				**Additional Information**
			1	2	3	4	
Heyride	Denver, USA	bike sharing, car sharing, hailing services, public transport	x	x		x	Betalaunch in April 2019
ioki	Hamburg, Germany	on demand shuttles, public transport, ride sharing	x	x	x	x	
MBTA On-Demand Paratransit	Boston, USA	hailing services, public transport	x	x	x	x	Pilot Program 2019
Moovel	Different cities in Germany and USA	bike sharing, car sharing, car rental, public transport, ride hailing, ride pooling, taxi	x	x	x	x	Integration type and Transport Modes non-uniform and depending on city
Moovit	Different cities in Germany, USA and China	bike sharing, car sharing, ferries, hailing services, public transport	x	x	x	x	Integration type and Transport Modes non-uniform and depending on city
MVG more	Munich, Germany	bike sharing, car sharing, public transport	x	x	x	x	Forwarding to the provider regarding booking, ticketing and payment (car sharing)
Qixxit	Germany	bike sharing, car sharing, car rental, flights, public transport, taxi	x				Forwarding to the provider regarding booking, ticketing and payment
Switch MaaS	USA	bike sharing, car sharing, hailing services, public transport, taxi	x	x	x	x	No further information about cities or partners
Switchh	Hamburg, Germany	bike sharing, car sharing, public transport	x	x	x	x	
Transitapp	Different cities in Germany and USA	bike sharing, car sharing, hailing services, public transport	x	x			Integration type and Transport Modes non-uniform and depending on city
Üstra	Hannover, Germany	car sharing, public transport, taxi	x	x	x	x	
VIA goMobile	San Antonio and Portland, USA	public transport, ride hailing, vanpool service	x	x	x	x	Powered by Moovel North America

*1: Planning, 2: Booking, 3: Ticketing, 4: Payment

Table 2: MaaS Use Cases Framework (own modified structure, framework based on Kamargianni, M. et al. (2016), p. 3301)[142]

A total of twelve MaaS providers are identified. First of all, the area in which the identified cases operate is of importance. Four of these operate exclusively in the USA and a further five operate exclusively in Germany. A total of two providers focus on the German and American MaaS markets. Only one MaaS provider is active in China in addition to Germany and the USA. Moreover, in this case the offer is limited exclusively to local public transport and thus by definition is not a MaaS provider.[143] This suggests that public transport data is open to the platforms, but the Chinese public transport authorities have not yet actively participated in commercial MaaS offerings.[144] In the USA, on the other hand, MaaS projects and deployments are actively promoted by some transport authorities, for example in the greater San Antonio area through the VIA Metropolitan Transit authority.[145] In Germany, one example is the Munich Transport Corporation, which is actively promoting the development as a provider of its own

[142] Cf. Heyride (2019), cf. ioki (2019), cf. MBTA (2019), cf. Moovel (2019), cf. Moovit (2019a), cf. Munich Transport Corporation (2019), cf. Qixxit (2019), cf. Switch (2019), cf. Switchh (2019), cf. Transitapp (2019), cf. Üstra (2019) and cf. VIA goMobile (2019)
[143] Cf. Moovit (2019b)
[144] Cf. Streeting, M. et al. (2018), p. 8
[145] Cf. Pulido, L. (2017)

MaaS platform “MVG more”.[146] Based on the situation regarding China in comparison to Germany and the USA, it can be concluded that the support of local public transport authorities is a positive influence or a prerequisite for the deployment of MaaS.[147] Another aspect is the local operation radius. It can be stated that seven out of twelve cases are focused on a single city and the surrounding area. In the case of two providers, the actual action area is not clearly defined. Only three providers operate in several metropolitan regions and are also active in more than one country. Rural areas are not represented in the MaaS providers’ business areas. As a result, the focus is clearly on large cities right down to their outlying districts. The strong concentration on metropolitan regions is therefore conspicuous in the valuation. This applies to all identified cases in the USA, Germany and China.

In the second layer, the availability of different traffic modes is examined in more detail. In fact, among the twelve MaaS providers, public transport was the only constant means of local transport, while the remaining means of transport varied considerably from provider to provider. But also, from city to city, even with the same MaaS provider. Consequently, regional differences in the selection of transport modes must be clearly emphasized. In addition to public transport, sharing concepts for cars and bicycles are also strongly represented. In fact, this mode of transport has been steadily increasing in recent years, in all three countries considered.[148] Although it has already turned out that there is no MaaS provider by definition in China, it is still worth taking a look at the MaaS ecosystem. This is not covered by the framework but is still relevant for the development prospects of the potential MaaS market. The Chinese car sharing economy has estimated annual growth rates of about 45 percent until 2025.[149] The same applies to the ride hailing industry, which has been officially legalized in China since 2016.[150] This segment is also strong in the USA, whereas Germany has high regulatory requirements.[151] In contrast, the Chinese government is explicitly promoting the sharing economy with regard to transport.[152] In order to get back to the framework, it should be noted that the identified MaaS providers all focus on cooperations with the largest respective service providers with regard to car sharing and ride hailing.[153] In the ride hailing segment, these are Uber and Lyft for the USA

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[146] Cf. Munich Transport Corporation (2019)
[147] Cf. Audouin, M./Finger, M. (2018), p. 24
[148] Cf. Ferrero, F. et al. (2018), p. 501
[149] Cf. Karlberg, J. (2017) and cf. Jiang, H./Zhang, X. (2019), p. 145f.
[150] Cf. Li, J./Hou, L. (2019), p. 251
[151] Cf. Dobush, G. (2018)
[152] Cf. Karlberg, J. (2017)
[153] Cf. Aarhaug, J./Olsen, S. (2018), p. 574

and Didi Chuxing for China.[154] Furthermore the different transport modes are partly completed by taxi and pooling services. The bottom line is that there are certainly differences in the number of transport modes among the MaaS providers considered. However, public transport is involved in all of them and is therefore regarded as an important pillar. Another transport mode that is often represented is the sharing concept. Furthermore, there are regional differences in the scope of services provided by the MaaS Intermediary with regard to the choice of means of transport. In principle, all identified cases offer a multimodal service.

The last layer, with regard to the framework, is the integration type. Nine out of twelve cases have full integration from planning with real-time data to payment. Nevertheless, there are differences in totals as well as within some cases. Although the MaaS provider basically has the full amount of integrated functions, they are not available in some cities and regions. In some cases, the user is forwarded directly from the MaaS application to the respective application of the transport provider for further services such as booking and payment. The forwarding therefore clearly contradicts the definition of a MaaS Intermediary regarding the use via a single interface. This aspect correlates with the implementation of the local mobility services mentioned above. Nevertheless, this process is evenly distributed between the cases and occurs both for providers focusing on a single city and for providers with multiple regions.

All in all, one conclusion is that there are currently three different options on MaaS providers. On the one hand, there is a local public transport association that provides a corresponding application, as in the case of the Munich Transport Corporation. The second option is to become a large, specialized provider that is developing a MaaS-oriented business model and testing and implementing it in metropolitan regions in different countries.[155] These are the identified cases Moovel, Transitapp and Moovit. The third and last option is a local transport operation that relies on the know-how and service implementation competence of an established provider, such as VIA goMobile in cooperation with Moovel. This implies that there are varying business models currently being developed by both public and private mobility operators and in cooperation.[156]

Another conclusion is that in the cases considered there are differences in the number of transport modes available. In this layer of the framework it is striking that it depends on the

[154] Cf. Alemi, F. et al. (2019), p. 233 and cf. Dong, Y. et al. (2018), p. 1f.
[155] Cf. Li, Y./Voege, T. (2017), p. 97
[156] Cf. Cole, M. (2018), p. 21

interaction of various different local transport and service providers. If this interaction is not ensured, it also has an influence on other layers of the framework. Of course, the integration of the services has to be mentioned here, and this from two points of view at the same time. The first is the implementation of transport services and the second is the import of real-time data and schedules. This is the central point for the coordination of the MaaS Intermediary and finally of an intermodal combination.

In summary, MaaS deployments in Germany, the USA and China are found in a comprehensive search. The identified cases are evaluated using a three-layer framework. The result is that the integration and interaction of the various stakeholders is currently a hurdle. These findings largely support earlier reported outcomes by Kamargianni et al. (2016) and Sohor et al. (2017), who investigated various pilot projects in the Netherlands, Germany and Sweden. There are also regional differences and correlations in various aspects of the framework layers. In addition, it could be shown that there are major differences in the legal requirements between the countries considered, which can influence the future MaaS implementation and the ecosystem.[157] Moreover, it has emerged that public transport and ICT infrastructure are important pillars for the service integration.[158] Furthermore, there is currently a concentration on a few metropolitan regions and no area-wide MaaS use yet possible. In some metropolitan regions, Moovel and Moovit are largely able to provide the services. However, none of the identified deployments can be used according to the MaaS definition.

[157] Cf. Docherty, I. et al. (2018), p. 117
[158] Cf. Hasegawa, T. (2018), p. 40

4 Methodology

4.1 Quantitative Model

4.1.1 Modules

The literature review chapter 2.2 shows that scientific quantitative work on MaaS is limited. In fact, only hypothetical MaaS scenarios are examined with a strong reference to user expectations and thus always a user-centered approach. In this context, the quantitative investigation of mobility behavior should also be mentioned.[159] The author of this work therefore pursues the approach of examining the overall concept of mobility in order to identify and to take a closer look on the basics of the mobility ecosystem. The basis for this approach are the findings made in chapter three on the theoretical and conceptual structure of the mobility topic and in particular MaaS. The different areas of the ecosystem will be expanded with relevant aspects influencing the topic and future development. These so-called modules are provided with corresponding data.

In summary, it is fundamentally about people with mobility needs and the related distances. In order to correlate these two aspects and to draw conclusions, the modules are equipped with various indicators. To sum up, the quantitative approach comprises two objectives. Firstly, it is important to gain an impression of the various influences of the overall concept of mobility and to underpin it with quantitative data accordingly. The previous quantitative research on MaaS focused exclusively on an exact user-centered problem. The quantitative examination of the ecosystem and relevant factors can therefore provide a solid basis for further scientific research in a broader perspective. In addition, this quantitative basis serves as a tool to classify the many mobility sector forecasts, made by international business consultancies, concerning plausibility and reliability. Secondly, on this quantitative basis, a comparison can be made between Germany, the USA and China. Consequently, conclusions can be drawn as to which points of the MaaS ecosystem the countries have similarities or differences. Furthermore, it allows a conclusion on future requirements.

On the basis of the previous course of this elaboration, the modules for a quantitative model are now derived, so that a comprehensive consideration is possible. Thus, there is always a direct

[159] Cf. Utriainen,R./Pöllänen, M. (2018), p. 15

relation to the mobility topic and therefore a high meaningfulness. The investigation of the MaaS ecosystem shows that all affected economic sectors are connected in a certain way. Furthermore, it was found that there is a demand side that is user-centered.

The demand side is represented by the "Consumer" module and focuses on the population and demographic change. This module contains indicators based on the total population of the countries and the age structure. Further indicators show the total number of driving licenses and this also over time, based on the age structure of the population. “Urbanization" is derived as a further module with regard to the demand side, as this is directly related to mobility and future traffic. In the “Urbanization” module, the indicator of population density is calculated. Furthermore, a reference is made to cities with more than 300,000 inhabitants, as these are metropolitan regions and are meaningful for further MaaS development.[160] In addition, the growth rates of the cities and rural areas are regarded as further indicators.

When considering the MaaS ecosystem, it was also possible to identify a supply side that encompasses the several different mobility services. This certainly includes the entire transport infrastructure. Therefore, the module "Infrastructure" is derived. It is a comprehensive module with numerous indicators on the highway and rail network, as well as passenger kilometers and vehicle inventory. Furthermore, this module includes public transport with its various aspects. Further indicators are calculated on the basis of the mentioned infrastructure data.

The module "Economy" can be assigned to both the demand side and the supply side. The same applies to the "Digitalization" module. In the case of the “Economy” module, indicators relating to the gross domestic product (GDP) and the consumer price index (CPI) are used as a basis for calculating income levels and the mobility costs per household. Further indicators are car sales and mobility service revenues. With regard to the module "Digitalization", indicators correspond to the integration of ICT and IT infrastructures. In addition, indicators for online mobility services are included in order to be able to make statements about the users per year and ultimately draw conclusions about the overall population and age structure of the users.

The modules enable a comprehensive analysis with constant reference to mobility and the MaaS ecosystem. An overview of the modules and related indicators can be found in the Appendix 1.

[160] Cf. Peng, J. et al. (2017), p. 707

4.1.2 Data Collection

Extensive research requires data from various sources. Especially considering the variety of different indicators and modules, the data collection is correspondingly extensive. For the "Consumer" and "Urbanization" modules, the databases of the “United Nations” and the “World Bank” are used. Statistical development reports are used for the "Infrastructure" module. These reports are from the “German Federal Ministry of Transport and Digital Infrastructure”, the “U.S. Department of Transportation” and the “Ministry of Transport China”. The reports are supplemented by the “National Bureau of Statistics China”, the “American Public Transport Association” (APTA), and the “International Organization of Motor Vehicle Manufacturers” (OICA). For the "Economy" and "Digitalization" modules, the databases of the “Organization for Economic Co-operation and Development” (OECD) and the “Federal Statistical Office of Germany” are also included. The quantitative model is also provided as an Excel file, where the exact data sources are marked with the access date (Annex 2).

During the processing of the data, attention is paid to topicality. Furthermore, when considering the three countries with regard to comparability, importance is attached to the data reference from the same source. In some cases, this is not possible due to a lack of sources, which is why the comparability is taken into account when referring to different national statistical reports. Particular importance is attached here to ensuring that the influence aspects are examined. A further characteristic for ensuring comparability is the corresponding conversion from miles to kilometers and the currency to United States Dollars (USD) with corresponding exchange rates at the appropriate times. The data used is checked for plausibility by querying further sources.

4.1.3 Criteria to Evaluate Indicators

The quantitative model structure is based on Costa et al. (2017), who have analyzed various approaches to the creation of a mobility index for cities and public transport in scientific literature. It is about the process of defining indicators and quantifying them with data. They come to the conclusion that the most reliable way to create a mobility index is using themes and related indicators.[161] This basic scheme is adopted by the author of this work and adapted

[161] Cf. Costa, P. et al. (2017), p. 3651f.

according to the modules and indicators.

The evaluation of the various modules is carried out at indicator level. As mentioned above, the quantitative model has two objectives. First, to get an impression of the hard facts of each country. This is supplemented by corresponding statistical values over time in order to draw conclusions about the development. Furthermore, correlations are derived from the annual values and the respective changes. This gives an impression, based on comprehensible data, of how the overall picture of mobility in the country is presented.

The second objective of the quantitative model is to create an indexed comparison between the countries Germany, USA and China. For this purpose, the indicator level is scaled from zero to 100 points. This normalization makes the data comparable and thus the countries can be compared comprehensibly at the indicator level.[162] Furthermore, there is no weighting, as this leads to distortions in the aggregation at the indicator level and finally at the module level.[163] The purpose of this consideration, however, is that hard facts are compared with each other on a direct level. It should be emphasized that comparability with regard to the mobility position is in the foreground. Therefore, indicators without a relative reference or unclear positive or negative evaluation are not included. These factors would allow predictions about the future market size, which is not the subject of this model. The data used therefore refer to relative comparability with regard to per capita and density, based on total population, age structure distribution and total country area. However, another important aspect of the model is the comparability of the indicators. Hence, there may be several index categories within the modules to increase validity. Therefore, the data on indicator level are homogenized by normalization and in the next step, also on indicator level, aggregated exclusively within the module due to data equality, reliability and increased meaningfulness.[164] There is no agglomeration of different modules.

In summary, a total of 1.656 individual values are included in the quantitative model using 59 different indicators (see Annex 2). It should be noted, that for the comparison of the countries only suitable values with regard to significance and comparability are taken into account and that these are marked accordingly as index relevant. The evaluation of the modules proceeded in four stages. First, the modules are analyzed by the author for relevant, suitable indicators and

[162] Cf. Nardo, M. et al. (2008), p. 157
[163] Cf. Gan, X. et al. (2017), p. 492
[164] Cf. Santeramo, F. (2016), p. 4

provided with data accordingly. In the second stage, calculations are carried out to determine per capita data and density data. This allows conclusions to be drawn both in the hard fact level of the respective indicator and in the presentation of explicit comparisons. Thirdly, the data is indexed exclusively at indicator level. In the fourth and final stage, the index at the indicator level allows insights and is aggregated at the module level.

4.2 Qualitative Method

4.2.1 Interview Structure and Procedure

The objective of the interviews is to obtain diverse perspectives and assessments from experts who are involved in the MaaS ecosystem. The qualitative analysis is carried out to understand and draw conclusions about the mobility market, influences and interdependencies. This enables a holistic perspective on the status quo, but also links to current obstacles to development and a view into the future of the mobility market. The basis for gaining knowledge is the diversity of relevant economic sectors, which will be described in more detail in the next subchapter. In the following, the basic structure of the interview is outlined, before the design of the individual modules is discussed in more detail. This subchapter will conclude with a description of an interview procedure.

Structure

With regard to new research topics, the semi-structured interview method is suitable for examining the perceptions and opinions of the experts of a topic complex, since it focuses on the topics that are important for the participant and expresses different perceptions.[165] The following prerequisites, formulated by Kallio et al. (2016) in their systematic methodological review for qualitative semi-structured interviews, meet the technical conditions and objectives of this elaboration. The interview is divided into two separate parts, whereby the boundaries between the parts are blurred. The first part consists of predominantly open questions and is supplemented by a standardized part relating to potential barriers and success factors and therefore has a semi-structured character.[166] This is intended to underscore the explorative

[165] Cf. Cridland, E. et al. (2015), p. 3f.
[166] Cf. Bryman, A. (2012), p. 212

approach of this qualitative research. The second part of the interview builds on it, whereby the transition is fluently designed as mentioned and varies depending on the flow of the conversation. In this part of the semi-structured interview, the thematic focus is placed on the respective organizational context of the expert.[167] This covers the main topics as well as follow-up questions in order to discuss a wide range of topics and at the same time go into depth on meaningful aspects.[168] To conclude, the conceptual operationalization of the interview, starting from the research questions and the hypotheses, leads to the analysis dimensions and thus the modules described below.[169]

Modules

The interviews are also divided into modules due to the high number of interview partners and their different thematic sectors. This ensures a certain structure in the interviews. However, depending on the expert's thematic knowledge, an in-depth analysis can be made in individual modules, whereas other modules are less dealt with. The modules are designed according to the previously presented quantitative model. Thus, on the one hand, the corresponding subject areas are adequately covered, and on the other hand, a suitable basis for connections and knowledge acquisition is given. Important aspects can be linked, and interdependencies identified and described. Therefore, the qualitative acquisition of information is given by the semi-structured interview.[170] The questions therefore relate to the modules "Consumer", "Urbanization", "Infrastructure", "Economy" and "Digitalization". In addition, the interview is extended to include the module "Policy", as this cannot be depicted quantitatively, but is of high qualitative relevance for the further scientific and economic development of mobility. The chronology of the modules is subject to a sequence that is thematically coordinated. Indeed, the modules build on each other and ultimately result in an overall picture of mobility. An overview of the modules and a corresponding questionnaire can be found in Appendix 2.

Interview Procedure

In advance of each interview, the participants were provided background information regarding the research objective and the researcher by email. Furthermore, they received a document on the General Data Protection Regulation (GDPR) and the reference to the audio recording (see

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[167] Cf. Saunders, M. et al. (2012), p. 320f.
[168] Cf. Kallio, H. et al. (2016), p. 2960
[169] Cf. Kaiser, R. (2014), p. 57
[170] Cf. Bryman, A. (2012), p. 12

Appendix 3). Further information regarding the interview procedure and the planned timeframe as well as the reference to the voluntary nature of the interview was also provided.

All interviews are conducted as telephone interviews and in German language. During the interview only a few notes were made to mark thematic connection points and transitions. This enabled a high concentration on the interviewee.[171] After a brief personal introduction and short presentation to the thesis topic, attention was again drawn to the document on the GDPR. Furthermore, the participant was asked for his consent to the audio recording of the conversation. Afterwards, there was time to answer open questions from the participants before the interview started.

The interview starts with four questions, which are the basic understanding and definition of the topics mobility, mobility concepts, automotive keytrends and in particular the concept of MaaS. This ensures that the interviewee and the interviewer begin to enter the subject area with the same understanding. After these basic questions, the interview will be continued according to the module structure. For each module, a succinct phrase is formulated with the objective of the module. With this information at the beginning of the module, the interviewer informs the interviewee which thematic aspects are being dealt with. The sequence of modules was: Consumer, Urbanization, Infrastructure, Economy, Digitalization and Policy.

As mentioned, the modules constitute the analytical dimensions of the conceptual operationalization of the interview. Through the associated set of questions within the modules, the instrumental operationalization leads to the module-thematic, comprehensive interview questions.[172] After the last module was finished, the interviewer asked the final question whether the interviewee had any comments, a topic or aspect that would be interesting to discuss.

The interviews varied in duration and were linked to the time availability of the experts. The duration varied in a range between 40 minutes to 112 minutes. On average, the interviews were 70 minutes long. In order to close the circle on the scientific requirements of the semi-structured interview, a pre-test was started with reference to Kallio et al. (2016) to confirm and optimize the interview structure, the modules and the procedure for the coverage and relevance of the research objectives.

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[171] Cf. Saunders, M. et al. (2012), p. 480f.
[172] Cf. Kaiser, R. (2014), p. 57f.

4.2.2 Description of Experts

As indicated in the previous chapters, the author of this elaboration pursues the qualitative approach of a broad scientific focus on market participants or stakeholders in the MaaS ecosystem. In chapter 3.2.1 on the MaaS ecosystem, the relevant economic sectors and stakeholders are identified. The necessary condition is to subdivide the sectors and stakeholders into MaaS-relevant companies, institutions and associations. This will create a list of potential interview partners. For this purpose, a comprehensive research was carried out with the German Bundesanzeiger (Official Federal Gazette) as well as company registers and comprehensive internet research. The focus was on Germany, USA and China. In addition, appropriate companies and institutions were approached directly at trade fairs on new mobility concepts and symposiums.

A total of 118 interview requests were sent. The communication to the contact persons was made by email and telephone. If the author of this work considered the interview with an appropriate actor to be of topical importance and no feedback was received on the request, repeated requests were sent at different times. Since many multinational companies are represented, a division into Germany, the USA and China is proving difficult. In most cases, all locations of the companies were contacted in Germany, China and the United States. Therefore, the headquarters of the company is included as the main factor for this consideration. This is evident from the corporate form. A clear statement on the interview request country distribution is therefore not meaningful. Besides, two other MaaS Intermediaries were contacted from Finland. In addition, other companies and associations were contacted that are not included in the MaaS ecosystem but still offer important aspects and perspectives. These are listed under "Additional". This includes for example, industry associations, automobile clubs and business consultancies with a focus on the automotive industry. An overview of all contacted actors (companies, institutes, municipalities, cities, etc.) can be found in Appendix 4. However, this list only includes the names of the companies and institutions contacted. For privacy reasons, the names of the contact persons are not apparent.

Overall, the feedback was positive. However, the request was rejected in 62 cases. The justifications for the refusals were for reasons of capacity or generally regarding an equal treatment principle. On 42 interview requests was no feedback. An interview was arranged but did not take place. Altogether 13 interviews took place with 14 participants. The following is an overview of the interviewees and their professional and business background as well as the sector classification. It was important that the interviewees interact directly or indirectly with MaaS and in the ecosystem. A detailed description of the companies, institutes, cities and associations is omitted.

Automotive Industry

Initially, the pre-test interview was approved by a leading premium car manufacturer and provider of premium financial and mobility services for their employee of the brand portfolio strategy. Some time after the interview, the author was requested to anonymize the company and employee data accordingly, as the data release protocol could not be submitted later. The second interview in this sector was conducted with Mr. Heyder from the e.Go Mobile AG, who deals with platform-based services in research, as well as with the testing of urban mobility on demand in conjunction with autonomous driving.

Infrastructure

An interview took place with Mr. Vogel, Project Leader from the Center for Sustainable Urban Mobility of the State of Hesse. Another interview was conducted with Mr. Sygusch, Head of City Development, of the city of Wolfsburg. Indeed, there are connections in this sector with regard to infrastructural development, so that there is a fundamental interaction with the sector "Policy".

MaaS Intermediary

An interview took place in this sector. Interview partner was Mrs. Sagmeister, Partner Manager Multimodal Mobility at Munich Transport Corporation. The company is thus the operator of the MaaS platform "MVG more". This interview could also be classified in the sector of "Transport Service Providers". However, it is classified in this sector because of its relation to the MaaS platform.

Technology and Mobile Service Provider

Three interviews were conducted in this sector. Mr. Bitzl, Business Development Manager in the area of Innovative Mobility Solutions, represents Siemens Mobility GmbH. Furthermore, there was an interview with Mrs. Reiser, Senior Business Development Manager, and with Mrs. Schneider, Senior Public Relations and Marketing Manager, both at Telefónica Germany NEXT GmbH. Another interview was conducted with Mr. Zölzer, CEO of 25ways GmbH, a platform provider for operational mobility and consulting.

Transport Service Provider

In this sector, the interview with Mr. Heyn should be mentioned. Mr. Heyn is Head of Digital Project Management at Stadtwerke Konstanz GmbH. The company group of Stadtwerke Konstanz GmbH is a transport operator and an energy and telecommunications provider.[173] This is why there are links in this case at sector level to "Technology and Mobile Service Providers". Another transport operator to be included in this sector is the already above-mentioned Munich Transport Corporation.

Additional

This is where companies and associations are classified that are not directly represented in the MaaS ecosystem. Four interview partners are counted under this aspect. First, the interview with Zegemo - Center for Business Mobility and respective Institute Director Professor Vogt. Furthermore, Mrs. Richter was available for an interview on behalf of the Federal Association of German Industry e.V. (Bundesverband der Deutschen Industrie e.V.). Mrs. Richter is Deputy Head of Department - Mobility and Logistics. In total, two company consultancies were also prepared to hold an interview. Berylls Strategy Advisors AG was represented by Mr. Heid as principal. The interview partner of the Roland Berger GmbH was Mr. Riederle in his role as Senior Project Manager of the Automotive Competence Center.

As mentioned above, it is important to note that the roles of the actors can overlap significantly. This is illustrated by the “Policy” and “Infrastructure” sectors. This is also the case in the sectors “Transport Service Provider” and “MaaS Intermediary”. In summary, it is evident that the interviews provide a comprehensive and thematically complete view of all sectors in the MaaS ecosystem. In addition, further perspectives on the overall picture of mobility concepts are possible through additional related sectors such as business consulting with several intersections within the mobility sector.

4.2.3 Qualitative Data Analysis

The 13 interviews are analyzed in a partly iterative process analogous to the framework approach of Daftary and Craig (2018), which is adapted by the author of this elaboration to the

[173] Cf. Stadtwerke Konstanz (2019)

interview structure in modules. It should be noted that the analysis of the interviews was carried exclusively by the author. The analysis process is divided into several stages and begins with the transcription. This stage of the process allows the researcher to familiarize with the content and to take notes.[174] The audio recordings are transcribed verbatim. Exceptions are merely parts of the conversation that have no connection with the interview, and specific German speech disfluencies ("ähm", "ah", "hmm" and "oh"). These exceptions are removed. One text passage had to be blocked afterwards on request of the interviewee, because it contained confidential internal information. This text passage is marked accordingly in the transcription.

During the transcription of the 13 interviews, over 260 pages of text were created. The transcriptions are submitted separately in electronic form (see Annex 1).

In the next stage, the text material is concentrated and carefully read that important passages can be recognized and marked accordingly. The identified key themes were coded and summarized separately for further processing.[175] The various interviews are compared at the module level with regard to the identified codes. In the iterative review, the codes are then merged to groups, adjusted or deleted.[176] In addition, the codes are also checked for other modules in this process stage, which is repeated three times. This comparison promotes the potential to generate and propose plausible themes and approaches for further processing and research.[177] If the codes and the corresponding key themes are sufficiently segmented, a framework is put together in the last stage of the process.[178]

The analysis was performed manually by the author and supported by the use of the qualitative data analysis and research software ATLAS ti, due to the scope of the interview material. In the coding process 65 different codes were identified, which are segmented by the iterative review on a total of 15 key themes and 32 key topics across all modules.

In the analysis chapter five, only the experts' surnames are mentioned in the continuous text in the case of references. Direct quotations are translated from German into English.

Special mention is made here of the inclusion of the different perspectives of the interview participants and thus sectors of the MaaS ecosystem, as well as the division into the modules.

[174] Cf. Jamieson, S. (2016), p. 8
[175] Cf. Gale, N. et al. (2013), p. 4
[176] Cf. Daftary, A./Craig, G. (2018), p. 361
[177] Cf. Vaismoradi, M. et al. (2016), p. 105
[178] Cf. Neale, J. (2016), p. 1098f.

The analysis on key themes of perspectives and expectations led to identified similarities and differences, which were interpreted and embedded in the framework.[179] The key themes as well as their thematic reference can be found in Appendices.

4.2.4 Quality of Data

The objective of the qualitative method in the form of expert interviews is to gain a broad focus on the various sectors of the market participants within the MaaS ecosystem. Due to the subdivision and design into modules, further topics can be concentrated in depth according to the experts' background. The successful expert acquisition in all identified sectors of the ecosystem creates a valid basis for the interpretation of the data. Indeed, at least two perspectives per sector were considered in order to reduce subjectivity. This worked except for the "MaaS Intermediary" sector, where there was only one representative perspective. Of course, it should nevertheless be mentioned that a potential for bias cannot be ruled out since only a few market participants of the respective sectors could be interviewed.

Although the author of this elaboration constantly reviewed the assumptions made in an active and reflective manner, the author in particular is not an experienced qualitative researcher. Consequently, a certain influence on the data or on the questions posed cannot be excluded, as no other researchers were involved in this process either.[180] To conclude, subjective influences in a semi-structured interview cannot be eliminated completely either by the interviewer or by the interviewee.[181]

[179] Cf. Srivastava, A./Thomson, S. (2009), p. 76 and cf. Jamieson, S. (2016), p. 11
[180] Cf. Daftary, A./Craig, G. (2018), p. 365
[181] Cf. Göttfert, E. (2015), p. 27f.

5 Analysis Results and Discussion

5.1 Modules

5.1.1 Consumer

The coding process shows that the views of the experts can be divided into a total of three key themes. Therefore, the evaluation in the module "Consumer" is separated accordingly and begins with the consumer attitude to mobility. The second key theme is about the requirements that consumers place on a MaaS platform. This enumeration is completed by the current consumer perception. These three identified key themes are each subdivided into codes or focus topics. The framework of the qualitative data analysis for the module "Consumer" can be found in Appendix 5.

Attitude

First, it is about the attitude of the consumers towards mobility. All interview participants are convinced that there is a change. Nevertheless, this should be considered differentiated. It is striking that this is often mentioned in connection with the car as a status symbol. For example, the interview partners Zölzer, Sagmeister and Reiser point out that the importance of owning a car has decreased, especially for young people. Secondary literature contains studies that deal with this topic. However, by conducting representative statistical surveys, researchers come to different conclusions. When looking at the Chinese and American car perception, the result is that it remains a strong status symbol, even among young people.[182] With regard to the German personal car perception, it can be stated that young people define their status more by education and holiday trips than by car.[183] This is therefore a very mixed picture in the comparison of countries. Nevertheless, this is reflected in the age of driving licenses' acquisition. In this respect, it can also be seen that the driving licenses in China are not yet comparable on a population basis, as in Germany or the United States (see Appendix 6; Annex 2). Indeed, for both countries is the rate of young adults with driving licenses significantly lower than in previous generations.[184] Vogt and Heid also introduces this point. Likewise, the two experts agree that values and attitudes towards ecology are changing in combination with mobility.

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[182] Cf. Pojani, E. et al. (2018), p. 210, cf. Moody, J./Zhao, J. (2019), p. 334 and cf. Zhao, Z./Zhao, J. (2018), p. 13
[183] Cf. Strathmann, T. (2019), p. 25
[184] Cf. Thigpen, C./Handy, S. (2018), p. 24

Heid goes on to point out that the change in consumer attitudes towards mobility is being driven by age and generation. As well as the living conditions, which are even more dynamic at a young age and where mobility depends on the phase of life. Basically, this is an often-mentioned point in the interviews and is therefore a focus topic under the key theme “Attitude”. Riederle points out that younger people have a different preference for mobility than older people. This statement is supported by an article by Konrad and Wittowsky (2018), in which a change of travel behavior was noted at 14 to 24 year olds, as they appreciated the simple availability of travel information for the feasibility of their spontaneous activities. For young people, the use of different travel modes is an interesting topic with regard to mobility and the efficient use of travel time.[185] This article also supports Heid's statement that young people are characterized by the availability of information and thus represent dynamic living conditions and no dependency on the car. Harvey et al. (2019) recognize the similarity that, especially for older people, the simple technical availability of travel information means greater mobility and independence. Nevertheless, the life phase is also to be considered here.[186] This has an influence on the choice of means of mobility and overall mobility, especially during parenthood.[187] Another aspect regarding age and the different ways in which mobility is considered is that it is no longer ownership, but rather usability that comes to the fore. Vogt clearly emphasizes this, referring moreover to the importance of access, to one's own car or even to means of transport. For younger people, mobility is therefore more connected with usability and less with property. Ecological reasons were not mentioned in the expert interviews as a reason and, in the opinion of Zölzer, rather fell into the background. Looking at the age structure and especially the age median in Germany, USA and China, a non-uniform picture can be seen. If the age median is close to each other in the USA and China at around 37 years, the median age in Germany is higher at 45.9 years (see Annex 2).[188]

The first interim conclusion is that the experts share the same views regarding a change in the attitude of mobility in Germany. Mobility is therefore increasingly perceived as a flexible use of different modes of transport, especially by younger people. It could be shown that in this regard, there is an international not coherent picture for the car as a status symbol. Nonetheless, it becomes clear that a less car-intensive lifestyle is emerging in young adults in both the U.S.

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[185] Cf. Konrad, K./Wittowsky, D. (2018), p. 16f.
[186] Cf. Zölzer, H. (2019), Annex 1 and cf. Heid, C. (2019), Annex 1
[187] Cf. Hopkins, D. (2016), p. 161
[188] Cf. United Nations (2019)

and Germany.[189] The reason for this is the availability of information about alternative transport options. Moreover, there are fewer ecological reasons that lead to this generational difference, but economic factors related to the car in conjunction with the knowledge of alternatives and their usability.[190] Studies that have investigated daily travel behavior show that the choice of means of transport and routes is strongly influenced by routines and automaticity.[191] This allows the conclusion to be drawn on the psychological aspect that a regular activity in the sense of using mobility services could lead to a change in travel behavior. Nevertheless, Kroesen et al. (2017) found out in their study that a change in people's attitude towards mobility does not automatically lead to a change in behavior.

It has been found that the points mentioned in the focus topic on the demographic perspective are directly related to the second identified focus topic. This is about the urban and rural perspective. The link is that young urban adults do not rely on a car and tend to use public transport and other mobility concepts, whereas young people in rural areas do not have these alternatives available in that form.[192] The experts Vogt, Richter and Bitzl refer to this important distinction in the general attitude towards mobility. In a study on attitudes towards mobility and vehicle ownership in Sichuan, China, the researchers Ao et al. (2019) found that due to the economic and infrastructural development of the country, vehicle ownership, especially in rural areas, has increased twelvefold over the last 16 years. Nevertheless, it can be concluded that China is at a different point of private mobility and attitude towards mobility than Germany and USA.[193] To conclude, regional differences thus influence the availability of mobility concepts and, consequently, the changed attitude towards mobility.

Consumer requirements

The second key theme is about the consumer requirements for a MaaS platform. As could be shown in the previous course of this elaboration, previous scientific literature focused on the future hypothetical users of a MaaS platform. Therefore, the core statements on the focus topics demand, interfaces and user-friendliness gained in the expert interviews are briefly and succinctly presented.

Heyder and Reiser formulate a need-based mobility as the core, so that mobility meets the need

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[189] Cf. Blumenberg, E. et al. (2016), p. 53
[190] Cf. Klein, N./Smart, M. (2017), p. 20f.
[191] Cf. Scheiner, J. (2017), p. 388f.
[192] Cf. Melia, S. et al. (2018), p. 445
[193] Cf. Ao, Y. et al. (2019), p. 24 and cf. Ma, Y. et al. (2019), p. 389

and thus be demand-oriented. Furthermore, mobility should be available through the use of a single platform. Bitzl describes the expectations of the consumer and thus the requirement that not a multitude of applications are needed to get from one city to the next. The only interface to the consumer is therefore the smartphone and in a single application or platform as a technical interface, the mobility services are aggregated.[194] Heyder, as an expert for platform-based services, further points out that by bundling in one application, the consumer expects seamless intermodal transport and the connection of the means of transport. The consumer-friendliness of such a platform results, on the one hand, in a comprehensive combination and aggregation of mobility services, as well as ease of use via one application.[195] In summary, the experts' answers are the characteristics and thus consumer requirements, which is a paraphrase of the formulated definition of MaaS.

Consumer perception

The focus is on the perception of the consumers for the possibility of whether and how multimodal services and intermodal services can currently be used. Based on the sample of experts, the German area and the status quo are of particular importance. As the manager of a leading German automobile manufacturer explains in the interview, it is currently possible to plan an individual journey yourself via various providers and platforms. However, there is currently no platform as a total ecosystem that allows this. Riederle also states that situational planning of the travel chain is only possible via the use of various platforms and thus raises the question of a cost-benefit effect. Another aspect Sagmeister points out is that when using the "MVG more" platform, this ultimately does not represent the actual mobility provider, and thus the clear line must remain recognizable for the consumer. This point is also supported by the manager of the German car manufacturer at the example of charging stations. The interaction of various charging station operators and partners should remain in the background and the final consumer's orientation is decisive. Sygusch notes that although there are pilot projects, they were only there for collecting experience data. Translating them into an economically viable solution is the challenge. Therefore, it should be summarized that MaaS is currently not possible by definition as a consumer. However, multi-modal mobility can be combined through various platform mobility concepts through consumer effort.

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[194] Cf. Heid, C. (2019), Annex 1
[195] Cf. Heyder, M. (2019), Annex 1

Module Summary

By analyzing the three key themes of the module "Consumer", it can be concluded that the attitude towards mobility is dependent on age, and on the other hand, it is related to the regional differences. It should be emphasized that especially young adults in metropolitan areas have a clear opening towards new mobility concepts and its combination. It can also be concluded that these two aspects show interdependencies with the respective phase of life. Furthermore, it could be shown that this attitude to mobility is similar in the USA and Germany, whereas China is at another point of development.[196] In principle, it should be noted that the consumers requirements for a MaaS platform correspond to the MaaS definition. However, with regard to Germany, there is currently no cross-regional service possible. In the interviews, the success factors for MaaS can be seen in the user-friendliness and comfort of the travel chain, which is based on an ecosystem that is as comprehensive as possible. Finally, from a consumer's perspective, "[…] the need to get from A to B is consistently high […]"[197].

5.1.2 Urbanization

In this module, a total of two key themes were worked out. The first relates to "Mobility in the city" and focuses on the causes and problems of urban traffic as well as urban traffic management and corresponding approaches for MaaS. The second key theme deals with "Mobility in the peripheral and rural areas" and the core issues of chances and risks and the associated opportunities for MaaS. Appendix 7 shows the framework for the qualitative data analysis for the module "Urbanization", with the exact structure and description of the focus topics.

Mobility in the city

According to the current figures of the World Bank, about 77% of the population in Germany lives in urban regions. In the USA, 82% of the population lives in cities. China has had a high urbanization rate of over two percent yearly since 2010, which according to World Bank projections will slowly weaken by 2025. However, about 58% of the Chinese population

[196] Cf. Le Vine, S. et al. (2018), p. 129
[197] Riederle, S. (2019), Annex 1

currently live in urban areas (Appendix 8; Annex 2).[198] Another comparison, based on the quantitative model, is to look at the metropolitan areas with more than 300,000 inhabitants. Whereas Germany has only 22 of these regions, there are 144 in the U.S. and 424 in China.[199] Of course, these are only hard figures, but they increase their significance in relation to the total area of the country. This gives a different picture, so that Germany is ahead of China and then the USA and has therefore the highest density of these urban agglomerations (see Appendix 9; Annex 2). Since the quantitative model puts the people with a need for mobility in relation to the distances, it is possible to make a valid conclusion about the influences and characteristics of total mobility. This is especially true for cities. The reasons for increasing urbanization are not dealt with in detail as this is evidenced by the quantitative analysis. However, the experts Bitzl and Riederle point out that the cities are particularly attractive through employers and cultural offerings. Commuter traffic is the main reason for traffic in the city, but also the flow of goods and daily life. Zölzer observes for the daily commuter traffic that "[…] the distances to work become longer. So if the rents increase then you have to go further and further to find an apartment for the right personal budget."[200]. In a study, the researchers Zhao and Hu (2019) found out that city traffic congestion regularly occurs on working days and also on weekends and holidays, but with persistent congestion peaks. Accordingly, there are different congestion patterns in a city, which are due to different mobility needs. On weekdays, it is above all the commuter traffic that leads to a high traffic volume, especially near the economic centers. On weekends there are leisure activities and shopping errands that lead to increased traffic and therefore to congestion.[201] For the most part, this traffic is based on individual journeys by car, and as a result, in peak-hours at the bottlenecks of the urban traffic infrastructure, there is an interruption of the traffic flow and ultimately congestion.[202] In addition, the compactness of a large city is an important factor that slows down traffic and thus the mobility needs of people.[203] This aspect is also emphasized by Vogel. Heyder sums up that urban traffic is shaped by individual traffic and that growing cities not only increase the number of inhabitants, but also increase the volume of traffic.

Since the reasons for high traffic in cities are set out, it is about the consequences of traffic. Riederle points out that due to the traffic volume at rush hours in the city, the efficiency suffers

[198] Cf. World Bank (2019)
[199] Cf. United Nations (2019)
[200] Zölzer, H. (2019), Annex 1
[201] Cf. Zhao, P./Hu, H. (2019), p. 164
[202] Cf. Nguyen-Phuoc, D. et al. (2018), p. 1 and cf. Hale, D. et al. (2016), p. 483
[203] Cf. Li, Y. et al. (2019), p. 100

both in terms of time and resource consumption. Another problem is complemented by Sagmeister regarding the city residents. "[…] they have a car and have the opportunity to drive by car, but do not use it for fear of not getting a parking space anymore."[204]. This leads to the conclusion that, due to the large number of vehicles in cities, there is also a lack of parking space. This increases the problem, as the search for a parking space in turn leads to more traffic volume.[205] The following problems of urban traffic are mentioned by the expert sample: high traffic volume and congestion subsequently lead to environmental pollution in the form of air pollution and noise pollution as well as parking shortages. The direct effects of these problems on human health are controversial and not yet sufficiently profoundly explored by the various influences.[206] Therefore, in the further course of this elaboration, only the influence of the identified traffic problems with the quality of life is referred to. The quality of life in both Chinese and European cities has been scientifically substantiated, with the result that a high traffic volume can have a negative impact on the quality of life of the residents.[207] From this it can be concluded that there are problems with traffic in the city and this has several effects. Therefore, the crucial question is how these problems can potentially be solved. Because Sygusch considers that "[…] individual mobility, as it is basically lived today, […] can no longer be the solution for the density we have."[208].

In the next focus topic "Urban Traffic Management" solution approaches will be addressed and discussed. First, it is necessary to define traffic within the city in more detail. As the previous subchapter on the consumer shows, there are a lot of possible transport modes in the city. Zölzer argues that there is "[…] a mobility backbone. For example, for some this is the car, for others it is the bicycle and for a third party it is public transport."[209]. It can be deduced that mobility is limited to one main means of transport and is supplemented by other means of transport. Sygusch also affirms this approach, so that a city should orient itself to the concept of mobility backbone and supplementary offers. "With regard to mobility solutions, there is no magic recipe that can be had for all cities."[210]. The conclusion regarding this quote is the differences in the mobility infrastructure of the cities. If there is neither a subway nor a tram available as public transport in the city, road-bound solutions such as buses are in demand. In this regard, Heyn

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[204] Sagmeister, C. (2019), Annex 1
[205] Cf. Hampshire, R./Shoup, D. (2018), p. 184
[206] Cf. Khan, J. et al. (2018), p. 661, cf. Lercher, P. (2018), p. 443 and cf. Steinberga, I. et al. (2019), p. 385
[207] Cf. Olsen, J. et al. (2019), p. 263 and cf. Wey, W.-M. (2019), p. 275f.
[208] Sygusch, R. (2019), Annex 1
[209] Zölzer, H. (2019), Annex 1
[210] Sygusch, R. (2019), Annex 1

states that there is often not enough space in the city to set up another bus lane. In China, a mobility concept is already being integrated into the planning, as the cities there are growing rapidly, which would not be easily possible in a core city in Germany.[211] Vogel supplements, that it is important for city planning to use the space and the areas accordingly, for streets or public spaces. Moreover, efficient use of fewer transport providers is another aspect of urban space utilization.[212] Another aspect is the difference in the number of inhabitants and thus the size of the metropolises in China and Germany in comparison.[213] Berlin, Germany's largest city, is home to about four percent of Germany's total population. In comparison, only 1.5% of China's total population lives in Shanghai, China's largest city, with Shanghai's population is more than four times as high as Berlin (see Appendix 9). Tian and Wu (2015) studied urbanization patterns based on a comparison of the USA and China. They came to the conclusion that the process of urbanization must take into account the traffic routes and corridors as well as the most frequently used means of transport. China and the United States are currently different in this respect, as the private car is widespread in the United States and not yet in China.[214] The use of various means of transport in European metropolises is investigated by Woods and Masthoff (2017). They report that commuters and city dwellers are open to multimodality and like to use it, if possible.[215]

The author of this work concludes that each city individually develops a mobility idea based on the existing mobility infrastructure and implements it with mobility concepts, because "[…] cities have to take mobility into their own hands. And that there are different mobility cultures in every city."[216]. In the case of Munich this is Sagmeister from the Munich Transport Corporation and states that "[…] it is our task to massively expand the entire range of mobility services. In any form, and at the same time to get people away from the car."[217]. In this context, Heid notes that the cities have a responsibility to steer the process. There is a real chance that there will be less traffic on the road through new mobility services such as intelligent pooling rides and related sharing services. This increases the capacity utilization of the vehicles.[218] However, there is also a risk that consumers will switch within the traffic modes and that traffic

[211] Cf. Heyn, M. (2019), Annex 1
[212] Cf. Vogel, J. (2019), Annex 1
[213] Cf. Richter, P. (2019), Annex 1
[214] Cf. Tian, G./Wu, J. (2015), p. 29
[215] Cf. Woods, R./Masthoff, J. (2017), p. 219f.
[216] Zölzer, H. (2019), Annex 1
[217] Sagmeister, C. (2019), Annex 1
[218] Cf. Heyder, M. (2019), Annex 1

will only shift. For example, that exactly the consumers of a pooled travel service are acquired from public transport.[219] In a study, Schaller (2018) examined the traffic behavior of new shared services in American cities. The result of the study is that it distracts users of public transport. The key point is that there has only been a shift in traffic, as users continue to use a combination of car, public and other modes of transport, and more traffic on the roads at the end.[220] From this, it can be deduced that the actual goal is to provide complementary offers as support in addition to the mobility backbone. On the one hand, public transport could be relieved, but it could also be supplemented in the city.[221] Cities should therefore ensure that new mobility services lead to less traffic on the roads and not to a displacement competition.[222]

This is where the MaaS approach comes in. By analyzing urbanization and the reasons for traffic and resulting problems, as well as urban traffic management, the following aspects could be clearly highlighted: growing cities present urban infrastructure with challenges. New mobility concepts create opportunities for improvement, but also risks of aggravation or relocation of traffic. Furthermore, every city is different and there is no one fits all solution for urban mobility. In summary, there should be an overarching traffic management system to manage traffic with a mobility backbone of the city as well of the individual user, and complementary transport services.

It is therefore a question not of creating an additional type of transport as an offer of mobility, but of regulating people's need for mobility.[223] Sagmeister says about the role as an urban transport service provider and operator of the platform “MVG more”: "[…] we already see ourselves as a regulator, try to pull the whole new mobility service on our side and say, […], we have some experience, we can help you. But of course, to advise in a certain way, and thus to direct the whole thing."[224]. The issues outlined, the author of this work conclude that MaaS also has a regulatory task, especially in the urban area. By integrating the various information of different transport providers as well as real-time traffic volumes, the MaaS Intermediary is able to recognize the traffic bottlenecks and to optimally support the users in satisfying their mobility needs. Therefore, this could avoid congestion by proposing redirection strategies and suggesting suitable transport modes whereas city traffic would become more fluid.[225] This

[219] Cf. Heid, C. (2019), Annex 1
[220] Cf. Schaller, B. (2018), p. 27
[221] Cf. Sygusch, R. (2019), Annex 1
[222] Cf. Heid, C. (2019), Annex 1
[223] Cf. Heyder, M. (2019), Annex 1
[224] Sagmeister, C. (2019), Annex 1
[225] Cf. El-Sayed, H./Thandavarayan, G. (2018), p. 3672

requires on the one hand a critical mass of customers within the respective city to make use of MaaS, and on the other hand a corresponding range of services must be available so that urban traffic can be managed in this way.[226]

Mobility in the peripheral and rural areas

As in the previous subchapter, the regional difference is emphasized with regard to urbanization. Public transport and other mobility services are well developed in metropolitan areas, whereas rural regions have poorer connections.[227] In rural areas the distances are longer, which is why bike sharing services, for example, are not possible.[228] Due to lower demand, these connections via public transport are loss-making and are in fact declining. Nevertheless, in terms of urbanization, Vogt argues that a well-developed public infrastructure of peripheral and rural areas could slow down further urbanization. According to the public transport supply principle, these connections must be guaranteed.[229] Sygusch suggests that MaaS and corresponding pooling services should be used here to ensure connections in the sense of supplementary services to public transport. By linking rural regions to economically stronger metropolitan areas, it would be possible to strengthen the overall.[230] In principle, the rural population should not be excluded and access to mobility should be unrestricted.[231] Furthermore, rural areas in particular have great potential to satisfy their mobility needs more efficiently through intelligent integration into a MaaS system.[232]

Module Summary

Conclusively, the circumstances of urbanization and influences on mobility could be shown. In addition, interdependencies within the city and transport modes became apparent, as well as the approach MaaS takes for a growing city and urban traffic management. In the expert interviews, it turned out to be particularly important that new mobility concepts are necessary to maintain the quality of life in cities. Furthermore, the experts are of the opinion that new mobility concepts will establish more quickly in metropolitan areas. The connection of rural areas to cities is regarded as protracted and difficult.

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[226] Cf. Bitzl, D. (2019), Annex 1
[227] Cf. Manager of a leading German automobile manufacturer (2019), Annex 1
[228] Cf. Sagmeister, C. (2019), Annex 1
[229] Cf. Heyn, M. (2019), Annex 1
[230] Cf. Riederle, S. (2019), Annex 1
[231] Cf. Richter, P. (2019), Annex 1
[232] Cf. Eckhardt, J. et al. (2018), p. 82

5.1.3 Infrastructure

This module is aimed at the status quo and requirements placed on the infrastructure and its expansion. Furthermore, the building blocks for networked and integrated mobility concepts such as MaaS will be identified and discussed in more detail. The coding process highlighted the focus topics of transport infrastructure, public transport and the digital infrastructure (see Appendix 10 for the Framework of qualitative data analysis).

Status Quo and Requirements

The first focus topic relates to the transport infrastructure. First and foremost, transport infrastructure includes physical infrastructure such as roads, railways and waterways. These are the basic requirements for mobility at all.[233] All basic mobility concepts are based on this physical infrastructure. Thus, it is a necessary building block, since all the concepts of the mobility ecosystem from chapter 3.1.1 depend on it. It can therefore be concluded that the transport infrastructure is a multi-user facility in terms of scale economy, both for the mobility, the economy as a whole and the flow of goods.[234] For this reason, transport infrastructure is also an integral part of the economy and thus of the country.[235] The transport infrastructure is provided by the municipality if it can be used to derive added value for the population.[236] This is often done in cycles and with lengthy planning processes, so that the actual implementation of transport infrastructure projects contrasts with the rapid development of population density.[237] At this point, a derivation can be made with regard to the already discussed urbanization and the identified problems of urban traffic.

Interesting aspects are also provided by the quantitative model. Here, the transport infrastructure is set in proportion to the total area of the respective countries. From this the density of the roads and rail infrastructure can be deduced. The road density of overland traffic in Germany is 64 kilometers per 100 square kilometers. The USA is slightly higher at 68 kilometers per 100 square kilometers. With a road density of about 50 kilometers per 100 square kilometers, China is currently at the bottom of the league, but since the end of the 1990s the Chinese road network has been able to grow significantly.[238] As for the rail network, Germany has the densest rail

[233] Cf. Richter, P. (2019), Annex 1
[234] Cf. Ferrari, C. et al. (2019), p. 5
[235] Cf. Skorobogatova, O./Kuzmina-Merlino, I. (2017), p. 319
[236] Cf. Sygusch, R. (2019), Annex 1 and cf. Kyriacou, A. et al. (2019), p. 93
[237] Cf. Bitzl, D. (2019), Annex 1
[238] Cf. Feng, Q./Wu, G. (2018), p. 97

network in comparison. In fact, it is five times higher than the rail network of the U.S., which lies ahead of China (see Appendix 11). In summary, Germany and the USA have a good road transport infrastructure network and China has invested heavily in recent years.[239] Vogel confirms that the German infrastructure is at a good level in general, but that it has suffered in recent years as a result of cost-cutting measures.

The next focus topic is public transport. The basis for public transport is the described transport infrastructure. Nevertheless, public transport is considered an independent infrastructure and is therefore handled separately.[240] As was shown in the previous subchapter, public transport varies from city to city. The difference is in the available public transport options as well as other alternatives such as carsharing and taxis.[241] Nevertheless, the perception of the public transport offer is an essential factor. The attractiveness of public transport as an offer has many approaches, for example a high frequency, an attractive price model or good main traffic routes.[242] Many experts mention the German Federal Law on Passenger Transportation (Personenbeförderungsgesetz) in the interviews. This is the legal basis for German local and regional road transport and regulates the carriage of passengers by road vehicles with regard to the necessary authorization issued by the authorities.[243] The road vehicles concerned are bus services, light rail vehicles, taxi services, car and driver hire.[244] However, rail transport is regulated in a separate law in Germany.[245] The German Federal Law on Passenger Transportation has regulations on the stops where people may be picked up and set down.[246] This has corresponding effects on the flexibility of public transport as well as ride sharing and ride hailing.[247] By contrast, the legal regulation of passenger traffic, especially with regard to ride hailing, is much more open in the USA and China.[248] The quantitative model shows that demand for public transport is highest in Germany, ahead of China and, ultimately, in the USA, based on the number of passengers in relation to the population. From this it can be concluded that public transport in Germany is attractive. On the other hand, individual car travel is highest in the U.S. (see Appendix 12; Annex 2). Vogel states in this regard that in the "[…] USA, in

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[239] Cf. Li, Z. et al. (2017), p. 116
[240] Cf. Bernal, L. (2016), p. 499
[241] Cf. Riederle, S. (2019), Annex 1
[242] Cf. Heyn, M. (2019), Annex 1 and cf. Vogt, R. (2019), Annex 1
[243] Cf. Karl, A. (2018), p. 320
[244] Cf. German Federal Law on Passenger Transportation (2019), §§ 1-4
[245] Cf. Karl, A. (2018), p. 320
[246] Cf. Müller, A.-K. (2018), p. 124f.
[247] Cf. Bitzl, D. (2019), Annex 1
[248] Cf. Standing, C. et al. (2018), p. 226 and cf. Sun, Q. et al. (2019), p. 2

most cities public transport is quasi placebo."[249]. The conclusion on this focus topic is that there are differences in public transport between the countries to be compared. Certainly, one aspect that will be examined in more detail is the legal framework. Nevertheless, it should be noted that public transport is used to varying degrees in Germany and the USA.

In the coding process of the interviews, another area was identified as a focus topic, namely the digital infrastructure. As a prerequisite, the mobile internet network is mentioned, without which a digital implementation of all services and infrastructure components would not be possible.[250] Especially on the main traffic axes a reliable internet connection is indispensable.[251] In conclusion, a reliable internet network is the central component for networking the various market participants. This ensures communication and fast data exchange within the ecosystem. Therefore, the interfaces within the system are of great importance and are equally a success factor.[252] It concludes, that a uniform digital standard and the free availability of data by and for the individual service providers as well as public transport service providers are of great importance. However, such a uniform standard for real-time traffic information in Germany is currently not available.[253] In fact, there is a project of the Association of German Transport Corporations (Verband Deutscher Verkehrsunternehmen e. V., VDV) on such a standard, to which the experts Schneider, Zölzer and Sagmeister referred.

The digital infrastructure in conjunction with an intelligent transport system produces a high amount of data that could be evaluated accordingly.[254] Based on the generated big data, optimizations for the existing infrastructure as well as the public transport could be derived. As a result, the infrastructures are more efficient and more profitable.[255] In a study, Chen et al. (2018) examined the spatial distribution of the inhabitants within the city using the smartphone movement patterns in Shenzhen, China. Accordingly, the accessibility to means of transport could be substantially improved.[256] Such approaches are also available in Germany from Telefónica Germany NEXT GmbH, which provide recommendations for the various infrastructure providers based on the anonymized mobile movement flows.[257] For the operators

[249] Vogel, J. (2019), Annex 1
[250] Cf. Bitzl, D. (2019), Annex 1
[251] Cf. Richter, P. (2019), Annex 1
[252] Cf. Vogt, R. (2019), Annex 1
[253] Cf. Richter, P. (2019), Annex 1
[254] Cf. Ghofrani, F. et al. (2018), p. 226
[255] Cf. Zhu, L. et al. (2019), p. 383
[256] Cf. Chen, B. et al. (2018), p. 1115
[257] Cf. Schneider, C. (2019), Annex 1

of public transport, these data are also interesting in terms of rush hours and main traffic routes.[258] But also for taxi and ride hailing services, as a corresponding routing low empty trips and therefore ensures an efficient operation.[259] In addition, the digital infrastructure also includes communication between vehicles and road infrastructure.[260] This is also where the point of autonomous driving, which is often mentioned in the interviews, comes in. Autonomous driving will not be further explored at this point in the elaboration. However, in this context the experts Zölzer, Schneider and Riederle argue with the expansion of the mobile broadband of the fifth generation (5G), which represents an important building block for both real-time data exchange and vehicle communication.

Module Summary

In total, three focus topics were identified in the module "Infrastructure" and examined accordingly. In scientific literature, there are hardly any indications of the interdependencies between infrastructure and MaaS. Considering the results of the quantitative model, the interviews and the inclusion of extended secondary literature, the following conclusions can be drawn for the dependence between MaaS and infrastructure. Transport systems are primarily dependent on the physical infrastructure consisting of roads, rails, waterways and aviation. These are the prerequisites for the implementation of all the mobility concepts. This includes public transport as part of the necessary infrastructure for the MaaS ecosystem. As a further prerequisite, especially for MaaS, the digital infrastructure could be identified. Providing a reliable and fast mobile network is an important building block. In addition, data complexity and data provision as well as data supply across a consistent standard are essential. The interfaces are also required for networked booking systems and corresponding roaming of service providers among each other.[261] The conclusion is that roaming defines the central and internal billing of the MaaS Intermediary so that the consumer has only one platform and one bill, despite the use of multimodal services and infrastructures. Therefore, this corresponds to an interoperability of the different systems and service providers. Consequently, the interoperability could be identified as a major success factor in the implementation of a MaaS platform. With regard to the traffic real-time data, the author of this work has therefore contacted the relevant office of the VDV in order to obtain the current status of the project. In

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[258] Cf. Heyn, M. (2019), Annex 1
[259] Cf. Zölzer, H. (2019), Annex 1
[260] Cf. Bitzl, D. (2019), Annex 1
[261] Cf. Vogt, R. (2019), Annex 1

fact, in the course of 2019, a pilot project will be launched with a uniform target architecture, tariff modules and real-time data. Furthermore, a large number of transport associations are involved in the further process (see Appendix 13). Therefore, it can be summarized that MaaS requires the physical infrastructure with public transport as well as the digital infrastructure. Through the intelligent networking of these infrastructures and corresponding mobility services, traffic management can be facilitated. In conclusion, Heid is convinced: "There are many varieties of mobility services and I do not believe that the wheel will be reinvented in the next few years […]."[262]. The outcome to be drawn from this is that MaaS has to adapt to the situation and the corresponding existing infrastructure and, through the intelligent and need-based combination of mobility concepts, complements the overall picture of transport.

5.1.4 Economy

The aim of this module is to define the position of the mobility market and further development options and directions in more detail. Indeed, four key themes are identified. These relate to the OEMs, new market entries into the mobility ecosystem, collaborations within the mobility ecosystem and multipliers. Depending on the key theme, the focus is on the challenges, value creation and strategies (see Appendix 14).

OEMs

The first step is to determine the current position of the OEMs on the market. The automotive industry is undergoing a radical change, with significant technological shifts affecting both drive technology and smart applications.[263] In fact, there are many topics that the automotive industry will change. The generic terms of this change - electrification, connected and autonomous vehicles and shared mobility - have already been highlighted in chapter 3.1.1 on the ecosystem mobility concept. This technology-driven change, coupled with sustainability policies and changing consumer preferences regarding ownership, will revolutionize the business models of OEMs.[264] “Because the business model for them will change from owning to renting, or to sharing however, so I believe that the big car manufacturers, […] will always concentrate on such sharing models and put a focus on them, or maybe cooperate because they

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[262] Heid, C. (2019), Annex 1
[263] Cf. Xu, J./Liu, X. (2018)
[264] Cf. Gao, P. et al. (2016), p. 3

see it as a future field."[265] Ultimately, the OEM and supplier industry, previously pure automotive manufacturers, will adapt to an expanded definition towards mobility. Based on these challenges, it can be concluded that the industry of OEMs is actually in a strategic transformation towards becoming a fully-fledged mobility provider.

This development can also be identified by the investment sizes and technology areas in 2018. The highest growth in investment volume can be seen in the concepts of sharing services, whereby the overall main areas of investment are the above-mentioned generic terms of change.[266] The investment cases confirm the results of the study by Kuhnert and Weber (2019) on innovation pressure in the individual areas of the mobility industry. This is particularly relevant for this elaboration, since mobility services have proven to be an important future factor for the mobility industry.[267]

An important aspect in this development is the transition from a hardware-driven automobile manufacturer and the now increasing importance of software in the vehicles. The use of sensors and the corresponding electronic and software components in vehicles is increasing and thus gaining more and more importance, also for the differentiation of vehicles.[268] In connection with the above mentioned strategic transformation to a mobility provider and the emerging software-centric automotive world, it can be concluded that effective methods are needed by OEMs to optimize their organization accordingly. For the development and procurement of software, the focus must be on the requirements and strategic orientation for the future. Therefore, it can be assumed that the OEMs' expenses will increase with regard to the greater software intensity in the vehicle and the services around the vehicle.[269]

Nonetheless, car sales are particularly important to an OEM. The quantitative model shows that car sales in 2017 were the highest in relation to the population in Germany. However, it is clearly evident that China is the largest market for new car sales in the consideration of pure sales figures. In addition, future potentials can be derived from the cars per household specification, with Germany having the highest saturation in the market, ahead of the U.S. and China (see Appendix 15; Annex 2). However, for the year 2018 it should be noted that the sales figures for China's car sales market have been declining for the first time in two decades and

[265] Heyn, M. (2019), Annex 1
[266] Cf. Holland-Letz, D. et al. (2019)
[267] Cf. Kuhnert, F./Weber, H. (2019), p. 26
[268] Cf. Burkacky, O. et al. (2018)
[269] Cf. Apostu, S. et al. (2019)

the outlook for 2019 has turned out to be restrained.[270] This is linked to the end of the tax exemption policy for private cars in China, the economic slowdown and that car ownership in some Chinese cities has reached saturation.[271] This corresponds due to the fact that several Chinese cities have introduced a license plate auction or lottery to break the fast growth of cars on urban roads.[272] Another reason is the improved public transport and the increase in ride sharing services.[273] This raises the question of how new mobility concepts affect OEMs, especially with regard to vehicle sales. In fact, it is about the increase or decrease of vehicle sales by vehicle fleets of mobility service providers. Two scenarios could be deduced for OEMs as manufacturers, regardless of whether the OEM decides to become a mobility service provider or not. Either fewer vehicles are sold, as the utilization of vehicles increases and less are needed to meet the mobility needs. Or, in fact, more vehicles are being sold as the market for mobility service providers is growing and even public transport users are taking advantage of it (see urbanization chapter 5.1.2). Both scenarios are conceivable, which is why there are various studies by renowned consulting companies, like McKinsey & Company (2016) and Pricewaterhouse Coopers (PwC; 2018). They are forecasting further growth by 2025 in car sales in the United States, Europe and especially in China, despite an expected increase in sharing services, and only in a slightly weaker form than in previous years.[274] The Lazard and Roland Berger Automotive Teams refer in their study explicitly to car sales with new mobility services and expect new mobility services to account for around 10% of total car sales in Europe and the USA by 2025, and up to 35% of total new car sales in China.[275] In fact, these are just forecasts on a variety of individual indicators. Although these forecasts appear plausible on the pure data basis of the quantitative model, at this point it should be emphasized that the studies are assumptions regarding a paradigm shift of the OEMs and their strategic transformation.[276] Therefore Heid summarizes for the OEMs: "[…] it is completely unclear whether mobility service is now a real opportunity or a threat."[277]. On the current point it can only be concluded and noted that the question of car sales is primarily about the efficiency of transport performance and thus empty runs, vehicle wear and customer acceptance.

[270] Cf. Sun, Y./Goh, B. (2019)
[271] Cf. Hancock, T. (2019)
[272] Cf. Yang, X. et al. (2017), p. 62
[273] Cf. Hancock, T. (2019)
[274] Cf. McKinsey & Company (2016), p. 7 and cf. PwC (2018), p. 18 and cf. Kempf, S./Heid, B. (2018), p. 6
[275] Cf. Berret, M. et al. (2017), p. 22
[276] Cf. Cornet, A. et al. (2019), p. 19
[277] Heid, C. (2019), Annex 1

Indeed, the automotive industry of OEMs needs to be viewed in a more differentiated way regarding a mobility service provider scenario, as there are volume manufacturers and premium manufacturers. Zölzer considers the premium manufacturers to be well positioned, as the high utilization of the vehicle means that the additional costs for premium vehicles do not fall into the equation. However, the segment of cheaper vehicles would presumably be under increased pressure to act as a result of mobility services.[278] Accordingly, consumers would be willing to use a mobility service when it comes to pure functionality of the transport service and to forego owning their own small car in return.[279]

To counteract this, the OEMs are starting to expand their value creation options and to center customer mobility.[280] That is why they have started to position themselves as goods and services providers.[281] This can be observed at the OEMs Daimler AG and BMW Group with their car sharing services "DriveNow" and "car2go", which were bundled in March 2019 in the joint venture "ShareNow".[282] This joint venture is already active in China, the USA and Germany.[283] Furthermore, the already introduced mobility platform "Moovel", which also belongs to Daimler AG, has to be considered.[284] The cooperation between Daimler AG and BMW Group is discussed in more detail in the following key theme "Collaborations". Another example is provided by Volkswagen AG with the ride sharing project "Moia" in the cities of Hamburg and Hanover.[285] Therefore, it should be noted that OEMs are adding additional services to their business activities with respect to product-service offerings and usage-based value creation.

So far, the current situation of the OEMs and the challenges around electrification, connected and autonomous vehicles and the shared services could be identified and described. The OEMs have matured experience and processes in the production of vehicles. However, coping with these new challenges is not to be underestimated. In addition, consumers expect mobility to become part of their digital ecosystem.[286] This requires a strategic cultural change at the OEMs.[287] Subsequently, this affects the process and organizational structure in an internal company analysis. As a result, it is about the development of digital services and the

[278] Cf. Heid, C. (2019), Annex 1
[279] Cf. Paundra, J. et al. (2017), p. 122f.
[280] Cf. Grieger, M./Ludwig, A. (2018), p. 1f.
[281] Cf. Bosler, M. et al. (2017), p. 1006
[282] Cf. car2go (2019)
[283] Cf. Daimler (2019a)
[284] Cf. Daimler (2019b)
[285] Cf. Moia (2019)
[286] Cf. Hensher, D. (2017), p. 93 and cf. Mulley, C. et al. (2018), p. 583
[287] Cf. Manager of a leading German automobile manufacturer (2019), Annex 1

transformation to a mobility service provider, which certainly has a corresponding impact on the business model of the OEM. In conclusion, the OEM becomes a software company through this step.[288]

In an external company analysis, further challenges can be identified. These relate to the aftersales business, the dealer and service station network of the OEM.[289] In the servitization described above, the classic dealer network is no longer required, and the OEM has completely new contact points with the customer as well as marketing concepts and sales channels.[290] Overall, the added value of the OEM shifts significantly. The manufacturing depth is lower in electric drive trains compared to internal combustion engines and electric vehicles are also cheaper in terms of maintenance intensity.[291] For the other generic terms and challenges such as connected and autonomous vehicles and shared services, the software contributes to the OEM as a significant value-adding part of the car.[292]

In addition, services are all around the vehicle conceivable, especially for the autonomous driving these kinds of services are concrete. In today's driving services, most of the added value is provided by the driver through vehicle financing, driving and other services such as cleaning and refueling.[293] The loss of the cost-intensive driver in autonomous driving increases the attractiveness for the operator through a higher margin and at the same time falling price levels. In their analysis, Bösch et al. (2018) examined the cost structure of an autonomous vehicle service. They came to the conclusion that by including the necessary services around the vehicle, for example by the OEM with its urban service station network, the price differential with driver-operated services is low. Hence, despite autonomous vehicle technologies, there will continue to be competition from other modes of transport.[294]

In a first brief summary in this module, the OEMs faces a variety of challenges. These could be identified in the analysis and further processed. The conclusion is therefore that OEMs are increasingly focusing on software because of the challenges they face and are adjusting their business model accordingly, thereby characterizing the future of the automotive industry. This results in a constellation that has already been observed in the telecommunications industry: in

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[288] Cf. Manager of a leading German automobile manufacturer (2019), Annex 1
[289] Cf. Heid, C. (2019), Annex 1
[290] Cf. Zölzer, H. (2019), Annex 1
[291] Cf. Manager of a leading German automobile manufacturer (2019), Annex 1
[292] Cf. Morgan Stanley (2015)
[293] Cf. Heid, C. (2019), Annex 1
[294] Cf. Bösch, P. et al. (2018), p. 86

terms of value creation, the manufacturer steps into the background and the service provider into the foreground.[295] It can therefore be concluded that different business models could exist in the value chain of the OEMs in accordance with the implementation of the strategic transformation. On the one hand, a fully-fledged mobility provider with a high proportion of software, and on the other hand a business model for an exclusive car manufacturer, who develops and manufactures appropriate vehicles for the various mobility providers.

New Market Player

Since the mobility market represents large potential, it is attractive for new market entries.[296] In fact, it is difficult to quantify the mobility market in size or volume. Another difficulty is the definition of what the mobility market entails, such as annual revenues of OEMs, transport services and what kind of services are included, as well as public transport. There is a lack of necessary information. Hence, no reliable information could be found in the research. However, it can be assumed that this is an attractive market on the basis of the figures in the quantitative model regarding expenditure on transport. This is supported by significant investments in various areas related to mobility, which open up new business areas and therefore seem to be attractive to previously non-mobility-related companies with a strong software relationship.[297]

This leads to the new market entries. In contrast to OEMs, new automobile manufacturers are more dynamic and are growing into the market environment. Heyder explains that new manufacturers like e.Go Mobile AG identify themselves as mobility service providers right from the start and recognize and implement the products in line with market requirements. This change of direction is therefore more difficult for an established OEM.[298] In conclusion and in connection with the outcome regarding OEMs, a new market participant as a manufacturer has been designed with a high level of software competence from the outset. The challenge is therefore not only to get the hardware in the sense of automotive engineering, but also the software competence into the companies. The future goal for an automotive company is a mix of different competencies in hardware and software.[299]

Furthermore, a new market segment and thus a new travel mode has been developed, which is

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[295] Cf. Bernhart, W. et al. (2016), p. 12
[296] Cf. Bitzl, D. (2019), Annex 1
[297] Cf. Möller, T. et al. (2018)
[298] Cf. Heyder, M. (2019), Annex 1
[299] Cf. Heyder, M. (2019), Annex 1

becoming increasingly popular in the cities of North America, China and worldwide.[300] The new transport mode is ride hailing, and new online companies have entered the mobility market. Uber, Didi Chuxing and Lyft are the most popular companies worldwide in 2018 based on market values.[301] Because this mode of travel is considered new and unresearched, the impact on other transport modes has been examined on the basis of a study by Young and Farber (2019). The result of the study is that there is considerable influence within the market segment through ride hailing services. In particular, the taxi business is impacted by a decline in rides, but other modes of transport, such as public transport, are also experiencing a decline in passenger numbers.[302] The results of the study are supported by the findings of the "Urbanization" module.

There are also market entries by non-mobility companies. Google has been using its subsidiary Waymo since 2009 for the research and development of self-driving cars.[303] In general, however, it should be noted that many tech-companies have been involved in the new mobility concepts from the start, both in the U.S. and in China.[304] Therefore, it is a question of differentiation, which goal and which strategy the tech-companies pursue in the mobility market.[305] With regard to Waymo, Zölzer defines the business model of a type of operating system for self-driving vehicles and thus the possibility of a profitable business as well as further approaches to data collection and advertising. Accordingly, new business models are conceivable for the automotive industry as well as for the mobility market as a whole. This is also of crucial importance in relation to the software competence around the vehicles and the discussed conversion for OEMs. The core business of tech-companies is software-focused, with OEMs increasingly under pressure in their core businesses, with implications for further investment.[306]

Reiner and Nienhaus (2018) analyzed the patent applications for the years 2012 to 2016 in the mobility sector and compared the automotive players with non-automotive players from the tech-industry. First of all, it is not surprising that tech-companies mainly focus on software and OEMs on hardware issues and only minor software issues. However, it is striking that the high level of research activity in the mobility sector of the tech-companies Google, Apple, Microsoft,

[300] Cf. Sui, Y. et al. (2019), p. 495
[301] Cf. UBS (2018)
[302] Cf. Young, M./Farber, S. (2019), p. 383
[303] Cf. Teoh, E./Kidd, D. (2017), p. 57
[304] Cf. Riederle, S. (2019), Annex 1
[305] Cf. Heid, C. (2019), Annex 1
[306] Cf. Heid, C. (2019), Annex 1

Amazon and Uber points to great interest and the attractiveness of the market.[307] Nevertheless, Reiner and Nienhaus (2018) note that tech-companies are investing primarily in service-oriented and customer interaction segments in the mobility sector. The corresponding conclusion is that tech-companies are pursuing the strategy of creating user-centric interfaces to the customer. Consequently, this would be a point of differentiation in mobility services. In this area of digital interaction with the customer and customer relations, classic OEMs have so far had no concepts or experience.[308] Finally, customer access will prove important in the development of mobility service providers.

In principle, it is also possible to enter the mobility market for any utility company. An energy supplier could expand the business area by offering electric car sharing vehicles and a large charging infrastructure.[309] Since electric mobility is considered to be a future market in Germany, Otto et al. (2018) examined German energy suppliers for their commitment in the mobility sector. They found out that the energy suppliers are actively investing in the development of a charging infrastructure and are thus working on security of supply. Beyond that, however, no consistent business model of the energy suppliers for the German mobility market is discernible.[310]

Another option for entering the market is to expand the business activity of an existing company in the mobility market. As with the car sharing services of Daimler AG and BMW Group previously mentioned, the Munich Transport Corporation would also have to be listed here with the "MVG more" mobility platform. As a result, the corporation is expanding its business activities and bundling carsharing service providers in its platform. It is not possible for a market participant to offer all the services themselves, so it is necessary to cooperate with the competitors.[311] Hence, in the coding process the “Collaborations” was recognized as another key theme.

Collaborations

The first focus topic in this key theme relates to cooperation between OEMs. The challenges described for OEMs mean that automobile manufacturers are facing a strategic structural and organizational change. This transformation into a software focused company or mobility service

[307] Cf. Reiner, J./Nienhaus, A. (2018), p. 23
[308] Cf. Zölzer, H. (2019), Annex 1
[309] Cf. Zölzer, H. (2019), Annex 1
[310] Cf. Otto, H. et al. (2018), p. 23f.
[311] Cf. Sagmeister, C. (2019), Annex 1

provider is changing the business model and sales channels and requires a new way of working. Consequently, a new way of collaborative development and the formation of alliances with existing competitors is required.[312] The BMW Group, Daimler AG, Ford Motor Company and the Volkswagen Group have joined forces in a joint venture called “Ionity” to set up a European network for charging infrastructure for electric vehicles.[313] In order to achieve an important goal more quickly and comprehensively, they are working together accordingly. "And it's remarkable that they have finally realized that they can still do anything together."[314]. Furthermore, in the key theme about the OEMs, the joint venture “ShareNow” between the car sharing services of BMW Group and Daimler AG was addressed. In fact, it involves the merger of all business areas in the mobility services division of Daimler AG and the BMW Group. This results in a total of five joint ventures, each of which belongs equally to the groups.[315] The joint ventures relate to multimodality, charging, ride hailing, parking and the aforementioned sharing services.[316] In this case too, the aim is to meet the challenges of the current market environment and form strategic partnerships in order to master the technological and economic requirements. Dieter Zetsche, CEO of Daimler AG, said in his statement: "We're stronger together. That's why we are now combining our respective mobility services, ranging from driving to parking, charging, and sharing."[317]. This leads to the conclusion that the merger of their mobility services forms a stable financial basis and provides a comprehensive range of mobility services for the individual mobility needs of customers and thus good conditions for establishing themselves in the mobility market.

An important factor here is that the competitors rely on corresponding interfaces both in the design of the vehicle systems of hardware and software and in communication within the alliances. "Without open interfaces, we will not move forward.”[318]. Certainly, here is a link to the importance of interoperability for the ecosystem as a whole. This can also be transferred to collaboration. Hence, it is a central key issue that a company needs to open up internally and externally in order to provide appropriate data to its own employees, cooperation partners and competitors.[319] Such an open innovation platform poses corresponding organizational hurdles

[312] Cf. Manager of a leading German automobile manufacturer (2019), Annex 1
[313] Cf. Ionity (2019)
[314] Vogt, R. (2019), Annex 1
[315] Cf. BMW Group (2019)
[316] Cf. Daimler (2019c)
[317] Zetsche, D. (2019)
[318] Bitzl, D. (2019), Annex 1
[319] Cf. Manager of a leading German automobile manufacturer (2019), Annex 1

and boundaries, since knowledge from external sources outside of one's own value chain is internalized and one's own knowledge is externalized as well. In a study, Wilhelm and Dolfsma (2017) examined the cooperation of German automotive manufacturers in an initiative open innovation platform. They came to the conclusion that although the car manufacturers have experience in the field of innovation through their cooperation with suppliers, it is difficult to assess and integrate sources from outside.[320] Therefore, it can be concluded that OEMs need to develop routines among themselves to overcome the obstacles and to recognize and seize the knowledge and data outside their own value chain as opportunities. This is a success factor, because one's own resource-based view can be dynamically built up by influences from outside and new ideas emerge.[321]

Another focus topic is the collaboration of OEMs and tech-companies. In an analysis of the investment volume in the mobility sector for the year 2018, Holland-Letz et al. (2019) found out that automobile manufacturers traditionally invest mainly in their internal technology development. By contrast, non-automotive tech-companies are investing heavily in external technology companies.[322] As has been shown so far, other competences are required for the challenges of OEMs than those of classic automotive engineering.[323] From this, the author concludes that OEMs are dealing with an increasing software intensity and as a result will have to split their development budget between hardware and significantly increasing software requirements in the future. It should therefore be clearly stated that since the hardware competence is no longer sufficient to overcome the challenges, the software is required to be supplemented.[324] That is why collaboration between OEMs and tech-companies is required. It is also about the learning curve, because it is much easier to learn and adapt skills through cooperation.[325] In the research for this elaboration, the pressure of innovation in the field of autonomous driving was particularly evident. For this reason, various cooperations have been established in this area between tech-companies and automobile manufacturers, for example between Waymo and Fiat Chrysler Automobiles or Uber and Volvo Cars.[326] Since tech-companies lack the necessary hardware expertise and automobile manufacturers lack software expertise, the two players complement each other in the development of complex requirements

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[320] Cf. Wilhelm, M./Dolfsma, W. (2017), p. 231f.
[321] Cf. Manager of a leading German automobile manufacturer (2019), Annex 1
[322] Cf. Holland-Letz, D. et al. (2019)
[323] Cf. Riederle, S. (2019), Annex 1
[324] Cf. Manager of a leading German automobile manufacturer (2019), Annex 1
[325] Cf. Riederle, S. (2019), Annex 1
[326] Cf. Ritz, J. (2018), p. 135

in the mobility sector.[327] In addition, Microsoft also works with the BMW Group on cloud services.[328] Also of interest are software companies with expertise in ticketing and cashless payment, especially for a mobility service provider.[329] The decisive factors will be the long-term goal of the cooperation partners of software companies and OEMs and their expectations. As between automotive manufacturers and suppliers, an ecosystem will evolve through competition and complexity. At present, no logical constellation can be identified, especially for mobility service providers.[330]

Sagmeister adds another perspective regarding collaborations by responding to Google's request for current departure times by the Munich Transport Corporation. In principle, it would be hypothetical for Google to establish a commission business model via routing and ticket brokerage. Therefore, the current departure times are not given to Google by the transport operators to protect their own market.[331] Nevertheless, collaborations are important and indispensable, as it is not possible for a mobility service platform like the "MVG more" to offer every transport mode or mobility service through a transport company like the Munich Transport Corporation. “No one can represent everything at the end. So they can't operate it themselves either. There is simply too much for that. And that's why these cooperations are definitely indispensable, but for every competitor of ours.”[332].

As far as the key theme of collaborations is concerned, it can be summarized that the focus is on meeting the challenges of the mobility sector: electrification, connected and autonomous vehicles and shared mobility (see chapter 3.1.1). It is shown to what extent collaborations are suitable for the respective partners and which motives are decisive. Furthermore, the situation between the partners is assessed and advantages as well as obstacles are described. OEMs to each other create a stronger financial basis as well as know-how and market penetration. In a collaboration between OEMs and tech-companies, the focus is on complementing hardware and software expertise.

Multiplier

This key theme deals with the implementation of mobility services and the business models of

[327] Cf. Manager of a leading German automobile manufacturer (2019), Annex 1
[328] Cf. Manager of a leading German automobile manufacturer (2019), Annex 1
[329] Cf. Bitzl, D. (2019), Annex 1
[330] Cf. Heid, C. (2019), Annex 1
[331] Cf. Sagmeister, C. (2019), Annex 1
[332] Sagmeister, C. (2019), Annex 1

a mobility service provider via a multiplier. A multiplier could be a company with a large fleet of company cars. Therefore, addressing these sales channels is a key factor in the first phase of market penetration for mobility services.[333] "Because companies are great multipliers in which a few people decide about a lot of mobility."[334]. A conceivable concept would therefore be a kind of mobility budget instead of a company car, with which the employee of the company can use all available mobility services accordingly for his mobility needs.[335] However, especially in urban areas and city dwellers or commuters, such an approach would make sense through multiplier, but also depends on the nature of the mobility needs of employees and business.[336]

Module Summary

To sum up, the challenges for the overall mobility ecosystem are identified in this module. To this end, the influences on automobile manufacturers are examined in more detail and effects on their value-added chain are derived. It was possible to conclude that the OEMs are in a strategic and digital transformation to become mobility service providers and that this will have a corresponding impact on the business model. In addition, new market participants are identified and their motives for entering the mobility market are examined. In a further step, the relationships between the various players in the market are analyzed and collaborations derived on the basis of the market environment and future challenges. Ultimately, for automotive manufacturers to achieve this turning point in the mobility sector, they must enter into partnerships and alliances to concentrate their research and development resources and ensure customer access. This applies both to collaboration with other automotive manufacturers and non-automotive companies such as tech-companies. Finally, the majority of experts consider collaborations in the mobility sector to be necessary in order to meet the emerging challenges in the future.

5.1.5 Digitalization

Digitalization is a very broad term. It is therefore important to make the necessary distinctions and to communicate the focus of this module accordingly. Digital transformation and

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[333] Cf. Riederle, S. (2019), Annex 1
[334] Vogt, R. (2019), Annex 1
[335] Cf. Sagmeister, C. (2019), Annex 1
[336] Cf. Heid, C. (2019), Annex 1

digitalization are equated semantically, whereby a digital transformation is to be defined much more far-reachingly.[337] From a business context, digital transformation refers to a profound transformation of the business model, the organizational processes and the capabilities made possible by the application of digital technologies. Digitalization, on the other hand, refers only to the use of digital technology to create, improve or adapt processes.[338] The digital transformation can therefore be assigned to the module "Economy" and was sufficiently discussed from a business context. The module "Digitalization" deals with the use of digital technology in an exclusive relation to the mobility sector. For this reason, sub-areas of digitalization such as "Industry 4.0" are not addressed either. The aim of this module is to analyze the development possibilities of digital applications with regard to mobility.

In the coding process of the interviews, the independent answers given by the experts have resulted in an image that identifies three key themes. In the area of digitalization, the experts dealt with the topic of autonomous driving. Another important point that was dealt with is the handling of digital data. The last key theme is ICT and the associated interoperability of systems (see Appendix 16).

Autonomous Driving

The topic of autonomous driving was affected in some modules. Under the module "Digitalization" it is now discussed in more detail. It should be noted in advance that autonomous driving in road traffic is being tested and there is no serious estimate of when it is possible outside of test drives and pilot projects.[339] Therefore, it is still somewhat hypothetical and is not treated in depth. Nonetheless, the topic is mentioned by the experts as it could trigger a complete change in the mobility sector.[340]

In order to establish the connection between autonomous driving and digitalization, autonomous driving is described briefly and concisely. It is deliberately a superficial description, since an in-depth consideration would exceed the scope of this work and would not be appropriate in this respect. Autonomous driving is based on the environment of the vehicle and visual information sources are derived digitally via various sensors, cameras and radar.[341] The corresponding data is internally processed by intelligent algorithms and artificial

[337] Cf. Bloomberg, J. (2018)
[338] Cf. Ng, H. et al. (2018), p. 1269
[339] Cf. Heyder, M. (2019), Annex 1
[340] Cf. Heyn, M. (2019), Annex 1
[341] Cf. Wang, J. et al. (2018), p. 1

intelligence. This enables the vehicle to independently make decisions and steer, brake or accelerate according to the environment and destination in a kind of vehicle's self-awareness.[342] Since none of the surveyed experts has a direct technical connection to autonomous driving, only the influence and applicability of this digital technology will be explained in the following.

So far, contact points within this elaboration have been that autonomous driving is considered one of the key challenges of the industry and that the loss of the driver increases the attractiveness of pooled or autonomous taxis. Sygusch is therefore assuming effects on public transport and Vogel is of the opinion that autonomous transport in the city is not a solution, as more traffic is induced by its attractiveness. However, public transport such as the subway, tram and bus lines could also be operated autonomously with the same savings potential.[343] Nevertheless, autonomous driving has a strong reference to mobility services and accordingly to MaaS. Because it can be concluded that the individual mobility needs of the customer are simply solved by monomodal travel with an autonomous vehicle and that even the last mile problem of public transport would be solved. This would mean less traffic on the roads and a step towards a fully shared economy.[344] Heyder also sees a strong influence of autonomous driving on MaaS. Individual solutions to satisfy the customer's mobility needs can be provided efficiently and affordably.[345]

Heid recognizes fundamental differences between Germany, the USA and China in an assessment of the viewpoints regarding the implementation of autonomous driving. "The whole western world and China are mentally at completely different points."[346]. In the USA and Germany, for example, attempts are being made to integrate the associated digital technology into the vehicle, whereas in China the infrastructure is being equipped with the corresponding technology and communication is being maintained with the vehicles.[347]

Data Handling

With regard to data protection, different approaches can also be identified among the countries to be compared. Riederle considers Germany in this comparison behind, since the data protection in comparison to the U.S. and China in Germany has the highest priority and also

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[342] Cf. Traub, M. et al. (2018), p. 2
[343] Cf. Heyn, M. (2019), Annex 1
[344] Cf. Sagmeister, C. (2019), Annex 1
[345] Cf. Heyder, M. (2019), Annex 1
[346] Heid, C. (2019), Annex 1
[347] Cf. Heid, C. (2019), Annex 1

seems to be anchored in society. In Germany, it is about the data sovereignty and thus about the possibility of the customer to control the data generated by him.[348] In the U.S., data security is less stringent as in Germany, where data protection is rewarded above all by customers and is responsible for a certain amount of trust.[349] However, it is important to note that data is collected to evaluate it accordingly. The data of relevance differ from automobile manufacturer to mobility provider or public transport operator. In the case of public transport, for example, the capacity utilization of the means of transport is relevant for improving frequency rates, whereas for the car manufacturer the main speed range of the engine is important.[350]

From the data collected, a more efficient mobility could be designed, as traffic could be managed as needed.[351] At this point, a connection to the module "Infrastructure" is recognizable. However, data evaluation appears to be important for transport operators to be able to plan efficiently and estimate demand.[352] Hence, the data can be used to gain a competitive advantage in terms of operational efficiency. Nonetheless, data protection regulations make it difficult for companies in the mobility sector to collect and analyze data, which means extra work and, in some cases, an obstacle.[353]

ICT and Interoperability

In the course of this elaboration it has already become clear that the interoperability of the various services within the mobility ecosystem is of essential importance (see chapter 3.2.2). This is supported by the statements of the experts in the interviews. Two focus topics are identified in the coding process. The first one refers to the general platform in different forms. The second focus topic relates to the overall ecosystem. In both focus areas, ICT and interoperability are equally highly important.

The "Consumer" module highlighted that the only link between the MaaS Intermediary and the consumer is the end user interface. It is therefore crucial that the consumer does not have to use different applications to satisfy his individual mobility needs for an appropriate travel chain.[354] Accordingly, a superordinate and overarching system is needed, which includes the different cities and regions as well as the corresponding local traffic modes and can adequately cover

[348] Cf. Schneider, C. (2019), Annex 1
[349] Cf. Sagmeister, C. (2019), Annex 1
[350] Cf. Manager of a leading German automobile manufacturer (2019), Annex 1
[351] Cf. Reiser, S. (2019), Annex 1
[352] Cf. Zölzer, H. (2019), Annex 1
[353] Cf. Sagmeister, C. (2019), Annex 1
[354] Cf. Heyder, M. (2019), Annex 1

them. The various local transport service providers can thus be integrated via this white-label solution and could also be used supra-regionally for the consumer. A platform as a white-label solution therefore offers various advantages. For the consumer it offers access to the traffic modes and integrated routing, booking and payment. The local transport companies are integrated on one platform and thus gain access to customers and usage data of their routes, depending on data protection regulations. For a municipality or city, a white-label solution enables more efficient transport by using public transport.[355] In order to implement such a white-label solution as a platform, the integration of the various services is crucial. This underlines the importance for ICT and interoperability. A white label solution should include a single sign-on, ticket solutions and an integrated payment process. This is only possible through the appropriate interfaces and interoperability, so that external services can also be integrated into the platform.[356] Another important component is the provision of real-time traffic information and public transport departure times, which must also be integrated into the platform.[357] In order to create the connection to the "Infrastructure" module, the VDV is endeavoring to achieve this integration of real-time data throughout Germany with various participants from the public transport sector in a pilot project.

In fact, not only the interfaces and the integrability of the services are decisive for the implementation of a white-label solution. In addition, another important factor is the willingness of the various regional and local transport operators as well as supra-regional providers to cooperate. The transport associations and individual transport operators describe a lack of interest in integration on such platforms.[358] At this point there is a link to the module “Economy”. As a result, this has an impact on the ecosystem through the non-integration of individual transport operators and thus a regional deterioration in mobility provision.

In a test run in various cities, Makino et al. (2018) implemented an intelligent traffic management system based on MaaS and consequently on the ICT integration of the various local transport services. They point out that there is a need in the metropolises to carry out this intelligent integration and recommend the implementation of international technical standards and a uniform digital architecture in the future. Finally, these mobile services have the potential to promote the ecosystem MaaS and the development of better urban mobility by overcoming

[355] Cf. Barbeau, J./Fretheim, D. (2018), p. 4
[356] Cf. Bitzl, D. (2019), Annex 1
[357] Cf. Richter, P. (2019), Annex 1
[358] Cf. Heyn, M. (2019), Annex 1

the barriers in the integration of services.[359]

Module Summary

To sum up this module and its findings, it is important to note that the expert sample attach great potential to autonomous driving, which could have a lasting impact on the mobility of the future. Especially with regard to MaaS, the potential consequences are far-reaching. Furthermore, the use of data is another discussed aspect. The conclusion can be drawn that overly stringent data protection laws and regulations result in a disadvantage on the development and use of digital services. Data is the raw material for the efficient optimization of mobility services.[360] Digitalization is therefore an important component of future mobility concepts.[361] Ultimately, the module and the lessons learned show once again that ICT and the interoperability of the services are essential for the implementation of a MaaS platform.

5.1.6 Policy

This module is discussed with a view to identifying the legal requirements and opportunities for political influence that can be exerted on the further development of the mobility sector. It should be noted beforehand that, due to the sample of experts, in this module German policy is at the center of attention. In the coding process, it emerged that the experts' statements refer to political expectations. That is why “Expectations” are the key theme. This key theme is subdivided into two different focus themes, one relating to funding and the other to the legal framework (see Appendix 17).

Expectations

In Germany, policy is moving towards municipalities and cities through funding programs.[362] However, it is important to note that there is a distinction between federal politics and politics at the state level. As far as mobility is concerned, federal politics has only limited powers of implementation in municipalities and cities. This is more likely to be addressed directly to cities

[359] Cf. Makino, H. et al. (2018), p. 59
[360] Cf. Schneider, C. (2019), Annex 1
[361] Cf. Richter, P. (2019), Annex 1
[362] Cf. Sygusch, R. (2019), Annex 1

and municipalities at the state level.[363] The aim of such funding programs is to strengthen and improve social mobility, infrastructure and sustainability issues.[364] However, in an expanded perspective, this will only be effective if a key objective is formulated accordingly. For this reason, the resources provided are usually earmarked for specific purposes, such as the creation of infrastructure between the city and rural regions. An important aspect is therefore that the funding is targeted at the needs of the municipalities and also transparent in the application for resources.[365] The experts Richter and Zölzer address field experiments and experimental clauses that would, for example, allow cities to try out new mobility concepts and ideas. The policy should be open enough for new offers and ideas to emerge, even in a looser legal framework for approval.[366]

By means of regulations and laws, politics can decisively influence the progress in terms of mobility.[367] Ambiguities or vacancies in the legal framework as well as the formulation of conditions result in various effects on the willingness and speed of companies to develop within the mobility ecosystem.[368] Using the example of autonomous driving, Heyder states that the exceptional approval process for test drives is linked to external expert opinions and that overall more transparency is necessary on the part of policymakers in this respect. This regulatory and legal dimension still requires time in Germany, especially for autonomous driving.[369] This leads to the conclusion that at this point there is no clear plannability for companies active in the field of autonomous driving and that there is no clear legal framework yet. The reason for this is that there are ethical questions and liability issues to be clarified.[370]

Another point regarding the legal framework with direct reference to MaaS and mobility concepts is the German Federal Law on Passenger Transportation, which is listed by some experts. This issue is controversially discussed, as public transport operators and the taxi industry do not threaten their business model and therefore new mobility services such as ride hailing are not taken into account by not adapting the law.[371] Consequently, interests are in conflict with each other, hampering multimodal combinations of transport services and thus

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363 Cf. Richter, P. (2019), Annex 1
364 Cf. Vogt, R. (2019), Annex 1 and cf. Federal Ministry of Transport and Digital Infrastructure (2019)
365 Cf. Richter, P. (2019), Annex 1
366 Cf. Zölzer, H. (2019), Annex 1
367 Cf. Sagmeister, C. (2019), Annex 1 and cf. Bitzl, D. (2019), Annex 1
368 Cf. Manager of a leading German automobile manufacturer (2019), Annex 1
369 Cf. Riederle, S. (2019), Annex 1
370 Cf. Heid, C. (2019), Annex 1
371 Cf. Richter, P. (2019), Annex 1

MaaS.

As shown in the previous module, data protection in Germany is important. The GDPR, which applies throughout Europe, ensures uniformity for the collection and handling of personal data.[372]

A further aspect of the legal framework is the difference, as mentioned, between the federal and state levels. For legislation and legislative adjustments regarding mobility and mobility services, it is important that the legal framework exists across state boundaries and that not every state has its own legal basis for MaaS.[373]

Module Summary

To conclude for the "Policy" module it should be noted that a clear political objective can be recognized as a premise. By creating appropriate framework conditions, legal certainty and plannability can be reaffirmed. This is particularly important for the economy and companies in the mobility ecosystem. Furthermore, it could be shown that in this module too, there are links to various other sub-areas of the ecosystem in the form of "Urbanization" and "Infrastructure" modules.

5.2 Discussion of the Results

The research objectives set at the beginning of this elaboration formed a solid foundation for the further scientific consideration of the mobility ecosystem. The definition of MaaS and the identification of the associated economic sectors enabled the derivation of the modules. Thus, the first two research questions are answered by sufficiently defining MaaS and describing the different areas of the ecosystem. This was an important step to advance further research and to map the corresponding formation of the MaaS ecosystem.

In the previous subchapters, the modules are analyzed in detail with regard to the identified key themes and considered in connection with the ecosystem. Based on this, the modules are further processed. By means of these results, the various economic sectors in the ecosystem are examined for correlations and counteractions and conclusions are drawn. Hence, the aim is to

[372] Cf. Schneider, C. (2019), Annex 1
[373] Cf. Sygusch, R. (2019), Annex 1

take a closer look at the hypothesis presented at the beginning of this work and finally to adequately verify it by means of the inferences and to answer the third research question. For this reason, the following elaboration is based on the overall concept of the MaaS ecosystem and thus on a general level.

The design and structure of the interviews is based on a specific sequence of modules. In the postprocessing of the interviews and in the examination of the findings, various interdependencies between the modules and module areas could be identified. First of all, the "Consumer" module shows that the relationship of young people to mobility changes and is related to their phase of life. Likewise, another factor is the availability of information and the knowledge of alternatives besides owning a car. The outcome is that especially young people who live in a city have a different relationship to mobility than young people in rural areas, due to the more comprehensive mobility offers in the city. Consequently, the next module, "Urbanization", is confronted with the question of traffic problems and traffic management. The thematic link to urban infrastructure can be derived from this and in the following module "Infrastructure", the prerequisites for MaaS and the entire mobility ecosystem are presented. Through the physical and digital infrastructure, the modules "Economy", "Digitalization" and finally "Policy" are also linked and relate to each other. Especially the module "Economy" combines central approaches of the collaboration of different economic and municipal stakeholders of the MaaS ecosystem, whereby interactions to the modules “Urbanization”, “Infrastructure”, “Digitalization” and “Policy” clearly emerge. Furthermore, the modules “Infrastructure” and in particular the digital infrastructure are consistent with the module “Digitalization”. Therefore, the first conclusion that can be drawn from a cross-section through the module structure is that a differentiation of the modules is not possible. There are logical overlaps across the module structure, and these are thematically indistinguishable. However, the modules correctly represent the various stakeholders within the ecosystem. Therefore, it is important to emphasize that due to this insight the interdependencies shape the MaaS ecosystem.

With respect to previous scientific publications regarding MaaS, the user is at the center of consideration. In this elaboration, it could be emphasized that it is about fulfilling the need for mobility and thereby causing transport. Furthermore, based on the first research objective and thus the MaaS definition, the expectations of the users on MaaS and the success factors user-friendliness and the inclusion of various transport modes for the travel chain could be emphasized as crucial. The MaaS Intermediary is intended to offer the user mobility tailored to his needs, whereby the MaaS provider makes optimized decisions for the user at the mobility service level, taking into account all available influencing factors such as infrastructure, current traffic situation and available means of transport and personal preferences. This is supported by the experts' assessment of the success factors for MaaS (see Appendix 18).

In the processing of the “Consumer”, “Urbanization” and “Infrastructure” modules, it became apparent that there are regional differences in the type and scope of mobility services. It was found that there are more transport modes available in urban areas than in rural areas. This schema could also be transferred to China and the USA. In fact, there are also regional differences there, but it is noticeable that public transport use is not particularly pronounced in the United States. With the accessibility of the urban transport modes and the availability of information on digital infrastructures such as the mobile internet and platforms, the relationship to mobility and thus the perception of young city dwellers in particular is also changing. Consequently, there is a fundamental regional difference for future MaaS concepts.

This leads to the conclusion that MaaS can be implemented and established faster in urban areas than in rural areas. A further outcome is that regional infrastructures and the availability of public transport as well as the available means of transport differ. As a result, it is important to note that MaaS and mobility service providers must adapt to the local situation and given infrastructures and not the other way around. Therefore, a general implementation of a single MaaS concept will not be effective, as regional differences are crucial and the concept has to adapt accordingly. Another fundamental approach that became clear in the course of this work is the inclusion of the mobility backbone in the further MaaS consideration. This is particularly important with regard to the adaptation to existing infrastructure, including public transport, as well as local conditions, but also a question of the pricing of a MaaS concept. At this point, the subdivision into the mobility backbone and supplementary mobility services is necessary.

Urban transport is in a separate consideration due to reasons and resulting problems of traffic. It was found that commuters, other high traffic volumes and limited space for road infrastructure and public transport, create congestion and other burdens for city dwellers. The increasing urbanization of the city has become an aggravating aspect. In order to maintain the quality of life, urban traffic management is an essential aspect to define. It has been found that the implementation of an overarching MaaS concept with the inclusion of available mobility services and other traffic information can be a building block for the improvement of urban traffic management. Another conclusion in this regard is that such an optimization of a large number of individual systems in the city will reduce congestions and increase the use of public transport, which is in combination a resource-friendly and time-saving way of maintaining and even improving the quality of life in the city. This is also a bridge to consumers, as this point is particularly important for young people in terms of active lifestyles and environmental aspects, as has been investigated.

The infrastructure is one of the main pillars of the MaaS ecosystem. First, all mobility concepts discussed in this paper require the physical infrastructure as a basis. Therefore, politics as well as municipalities and cities and federal states are involved. Furthermore, public transport, which is also linked to the aforementioned connection points, forms an essential part of the MaaS ecosystem with the operating companies in the background. Furthermore, the digital infrastructure is the central communication system within the ecosystem. At multiple points of this elaboration, the digital infrastructure in the form of ICT was of central importance for the operation of various concepts. It should be clearly emphasized that integration into the platform is not possible without the interoperability of the various systems. Therefore, appropriate interfaces and standards must be created. Otherwise, key cornerstones that define MaaS cannot be implemented. These include real-time traffic information, but also the integration of mobility service providers, their fleets and services such as ticketing and the payment process. In conclusion, the relevant interfaces, interoperability of the systems and adequate mobile internet technology are decisive success factors for the integration of the extensive services within the MaaS ecosystem.

At this point regarding ICT and interoperability an interdependence with the module "Digitalization" is also recognizable. Consequently, digitalization is linked to all other modules and corresponding economic sectors of the ecosystem. Data is collected and processed within the system and the use of the services. Furthermore, it has turned out that data can contribute to the optimization of the systems, which benefits the city and the traffic management system in particular. Certainly, in a mobility ecosystem the data is more essential for further development and optimization of the ecosystem. However, some protection is needed with the processing of the data. Nevertheless, the analysis has shown that overly stringent requirements with regard to data processing can hamper new services and improvements. Another aspect is autonomous driving, which is given importance in terms of changing everyday mobility and is one of the challenges of the mobility industry.

In the research process, a total of four challenge areas of the mobility industry could be identified. These challenges relate not only to the OEMs, but also to the entire MaaS ecosystem. The challenges include electrification, connected and autonomous vehicles and shared mobility. When analyzing the current market position and the impact of these challenges for OEMs, it can be seen that OEMs have developed mature processes in the manufacture of vehicles and thus on the hardware side. But the challenges require a growing share of software development, both for the vehicles themselves and in the market environment, especially with regard to customer requirements. The development budgets of OEMs and suppliers are therefore increasingly split between hardware and software. The automotive industry is undergoing both strategic and digital transformation. As a result of this transformation process, the value-added chain is increasingly shifting into a digital area and the direct distribution of mobility services. This leads to a corresponding change in the business models. It can be concluded, that the strategy is followed by the structure and organization and that new ways of working and customer contact points are created within OEMs. The market environment is therefore changing and requires speed and flexibility to respond. Hence, to realize the potential of this transformation, agile management and new ways are necessary, especially in connection with the increasing focus of software issues and related investment requirements. This is evident from the formation of the joint ventures between Daimler AG and the BMW Group with regard to their mobility services.

In terms of the OEM's business model, in addition to the change to a mobility provider, the research has also revealed a concentration as a vehicle manufacturer for corresponding mobility service providers. In the interdependence with the increasing urbanization and fleet concepts within the cities, the focus is on an appropriate vehicle concept geared to the needs of city traffic and optimized operating costs. A new manufacturer entering the market has advantages in terms of the business model and the structures that agilely grow and align with these dynamic market requirements.

In the course of this work, it has become clear that tech-companies are investing in the mobility market. In addition, an important aspect of this consideration is the types of mobility-related applications these companies invest in. These are primarily customer-oriented and therefore potentially important for further developments in the MaaS market. This is particularly significant because the research has highlighted the importance of collaboration between OEMs and tech-companies. The collaboration combines the core competences of the respective partners, thus complementing hardware and software expertise. Nevertheless, it can be stated that the long-term objectives of this kind of collaboration do not yet permit sufficient conclusions to be drawn on a logical market constellation.

According to the expert sample, a clear policy objective is important for the further development of the mobility sector. This includes establishing a binding framework to provide legal certainty. From this it can be deduced that the overall responsibility for the framework conditions for the creation of a networked transport system is necessary, involving both public and private companies. This would create the foundations for a MaaS platform. Another aspect is legal and regulatory control. This also applies from a regional and city perspective to try out new concepts and actually implement them. Consequently, this is also associated with hurdles, as could be shown by the distinction between the federal level and state level in Germany. It can therefore be concluded that uniformity in the regulatory framework is a factor in implementing MaaS. In order to summarize the expectations of the policy, the clear political objective with regard to mobility as well as the establishment of a binding legal and regulatory framework for public and private mobility companies to create a networked system must be emphasized as premises.

The country analysis revealed similarities and differences both in the expert interviews and in the quantitative model. First of all, the differences in area and population size are to be emphasized, as these are important factors with regard to mobility needs and travel distance. Both factors have effects on population density and thus on mobility via infrastructure development, public transport and private transport, which are elaborated in the quantitative model. Another factor is the age structure. In contrast to China and the USA, Germany already has a population that is in median ten years older. The elaboration shows that the age of the population and thus consumers of mobility have an impact on the use of new mobility concepts, especially in cities. Urbanization has also proved to be a factor for mobility, which is increasing in all three countries and has the highest growth rates in China. It has been shown that the pressure to act to improve mobility has increased, especially in cities. This has an impact on infrastructure and public transport. Hence, China has the highest investments in infrastructure projects and public transport in the last 20 years and is moving along the economic upswing. Of note in this development is the near-perfect correlation between China's GDP growth and passenger car sales growth (see Appendix 15; Annex 2). Nevertheless, it is clear from the quantitative model and the qualitative elaboration that China has not yet caught up with Germany and the USA and is regarded as a developing country. This is evident from the infrastructure data, public transport, mileage per inhabitant and GDP per capita. A further aspect is the vehicle inventory and procurement of the countries and thus the saturation of the markets, whereby Germany is ahead of the USA and China is experiencing strong growth. At this point, the legal aspect is also taken into consideration, as Chinese cities are already subject to licensing restrictions. In Germany, it was also possible to work out legal framework conditions such as the Federal Law on Passenger Transportation, which concerns the ride hailing mobility service. This mobility service is successful in the U.S. and China. Furthermore, legal differences can also be observed within the countries, for example in Germany at state level and in the USA in the states using the example of autonomous driving. In general, the country analysis has also shown that there are regional differences within the countries and that the countries cannot be regarded as a complete unit. This is based on the conclusion that the economic strength of conurbations and related industries has a significant influence on the development of the local infrastructure and thus on the mobility of the population.

These outcomes are supported by the index results of the quantitative model (see Appendix 19; Annex 2). These show that Germany represents the best prerequisites in infrastructure, both in physical infrastructure and in the expansion of public transport and private car ownership. In this module, the USA and infrastructure catch-up China follow in order. The correlation between growing economic strength and mobility can be clearly seen in China's economic module (see Appendix 15; Annex 2). The USA, on the other hand, is strong in the modules “Digitalization” and “Consumer” as far as the index is concerned.

On the basis of the discussion, the conclusions drawn and the interdependencies found, it is feasible to work on the third research question and associated hypotheses posed at the beginning of this elaboration. The question of the current market environment for MaaS and development opportunities is supported by two accompanying hypotheses. The discussion of the results shows that various factors influence the current position and development potential of MaaS. The module structure is particularly helpful in this respect, as the identified economic sectors are considered separately and in combination with correlations. This allows the current market environment to be described. In this approach, increasing urbanization and changes in attitudes, especially among young people, create dynamic access to mobility. This is supported by the aspects of driving license age and the use of alternatives of owning a car and thus mobility services. Another important aspect to be mentioned here is the expansion and improvement of public transport. The changing circumstances in the city and the associated problems of urbanization are also to be emphasized. A further aspect that could be worked out is digitalization and servitization, which is about simple use and information acquisition via electronic applications on the smartphone. It has been shown that these circumstances have an impact on OEMs and the automotive industry, which are therefore undergoing both strategic and digital transformation. A direct consequence of this transformation is the emergence of collaborations. Thus, it was possible to show that OEMs bundle their resources to ensure the financial basis in the digital market, reduce risks and provide a broad product portfolio of mobility services and market access. However, it should be noted that collaboration with non-automotive partners, especially from the software sector and thus tech-companies, is regarded as a prerequisite for meeting the overarching challenges of autonomous and connected vehicles, shared mobility and autonomous and electric driving. This reflects new market entries into the mobility market, both by companies from outside the mobility industry and by mobility service providers, but also the expansion of the business areas of existing companies in the mobility market. So far, the current market environment of the relevant actors is described in the MaaS ecosystem.

The description of the current market environment as well as the processing in the module structure has shown and leads to the conclusion that a multitude of different collaborations are necessary for the implementation of MaaS and therefore form the prerequisite. This is an essential point for the verification of the first hypothesis that MaaS is only possible through the collaboration of various stakeholders from different economic sectors. It has been shown that all sectors are interconnected, starting with mobility consumers, through urbanization and emerging problems, and the influence of and through infrastructure and the economy. Therefore, interdependencies are emerging between the different stakeholders to implement MaaS. The infrastructure and public transport with direct connections to municipalities, city administrations and urban planners as well as politics play a major role. Furthermore, the creation of a mobility service offering by operators of public and private transport services as well as the changing business models of OEMs and suppliers, but also the influence of tech-companies, is of great importance. An identified main pillar in the implementation of the collaboration is interoperability and related ICT and IT environment. A prerequisite is the flow of information between the stakeholders and corresponding interfaces for the implementation of services such as real-time data and booking as well as payment services. This interaction of different stakeholders and the finding of a balance in the mobility services market must be clearly emphasized in order to ultimately implement MaaS according to its definition. To conclude, the first hypothesis applies.

The second hypothesis refers to the comparison between the USA, Germany and China and the associated assumption that these countries are in different positions with regard to the MaaS status quo. Despite China's economic growth and the associated expansion of its infrastructure, as well as its rapidly growing cities, the country is lagging behind the USA and Germany in terms of the range of mobility and is still considered as an emerging market. However, it is unclear whether this is a disadvantage for China in relation to new mobility concepts, as this assessment is not the subject of this paper. Important aspects with regard to mobility are certainly the population and the distances covered. Based on the quantitative model, these aspects are supported by population density and various data on mileage and means of transport. The index observation of the quantitative model shows an uneven picture. The differences between the countries vary depending on the module (see Appendix 19; Annex 2). Germany has the highest index values in terms of the significant aspects identified with regard to mobility and thus to infrastructure and digitalization, ahead of the USA and China. Based on the index and thus with respect to the current MaaS position, Germany has good prerequisites. However, with regard to the total population, country area and the economic and infrastructural development of the last few years, a differentiated view is to be emphasized. Furthermore, other relevant factors for the MaaS status quo include the political framework as well as the use of public transport and other mobility services. In principle, the aspects described in this paragraph and in the module analysis allow the conclusion to be drawn that Germany, the USA and China differ in their positions with regard to the status quo of MaaS. The second hypothesis is therefore confirmed. Nevertheless, it should be noted that each country has differences within. A conclusion on the country as a whole is therefore only possible to a limited extent.

At this point, the second part of the third research question is linked to the development possibilities of MaaS. In the course of the elaboration, it was shown with regard to mobility that there are regional differences between the countries, but also within the countries in consideration. This turned out to be a decisive factor, as aspects such as infrastructure and mobility services play a role here and are also linked to the economic strength of the region. Due to the problems in cities, the pressure to act is highest there in order to maintain the quality of life. However, the availability of mobility services in the city is also higher compared to rural regions and thus the prerequisite for the implementation of MaaS is given. It should also be emphasized that the connection of MaaS to a traffic management system can optimize the inner-city traffic flow. In conclusion, it can be assumed that MaaS will become more widespread in urban areas than in rural regions. This is a clue and link to the second hypothesis, as it has been shown that in China there are 424 metropolitan regions compared to 144 in the USA and only 22 in Germany. However, this also presupposes that MaaS is adaptable. It could be clearly shown that MaaS has to adapt to the different regions, the local infrastructure and mobility service providers. This allows a mobility backbone to be formed and in sum also requires the willingness of the various potential stakeholders in the ecosystem to be integrated into the MaaS platform. Here again, basic interoperability is the main pillar.

In summary, the term MaaS could be defined and the stakeholders of the ecosystem identified. On this basis, the analysis of the potential stakeholders and the market environment could be carried out. First of all, it should be noted that the sectors are interconnected and build on each other, with ICT and interoperability being the most important pillars and prerequisites. In addition, the diverse collaboration of stakeholders is of decisive importance for the implementation of MaaS according to the definition. It has turned out that MaaS consists of an integrated network of stakeholders from different sectors and is therefore co-created in the implementation. This leads to the conclusion that MaaS intelligently combines different mobility concepts and technologies in order to offer consumers intermodality individually tailored to their needs. Furthermore, the identified regional differences show that MaaS adapts to the regional circumstances and that this process can be described as iterative until the MaaS ecosystem and the corresponding number of users unfolds its potential and the region-wide approach is adopted.

6 Conclusion

6.1 Summary

The subject of this thesis is the processing of the new research topic within the mobility sector and refers to the MaaS concept. Therefore, the scope is quite broad. However, this broad consideration is necessary in order to investigate MaaS on a conceptual level in a holistic way.

Therefore, a strategic approach with the combination of a quantitative model and qualitative methodology is in the foreground. In contrast to previous scientific literature, participants of the MaaS ecosystem are identified and integrated into the qualitative methodology. This results in conclusions and connections within this ecosystem. Furthermore, the strategic approach is supported by a quantitative analysis of the mobility sector.

In order to build the bridge to the introduction, first the changing circumstances are considered. It is noted that today's challenges are the megatrends of population growth, urbanization, climate change, and technological change. In addition, it has been shown that these trends are mutually dependent, supportive and reinforcing. This has a particular impact on people's mobility and thus on both their daily lives and quality of life. These trends are therefore exerting pressure on infrastructure, consumers, the economy and, ultimately, policy and city administrations to combat road congestion, resource consumption and pollution. Hence, in a further step of this elaboration it is concluded that new mobility concepts are needed to counteract these trends. Therefore, mobility concepts are examined in more detail and, using a framework, subdivided into monomodal, multimodal and intermodal concepts, as well as differentiated into vehicle type and type of use. In order to ensure user-friendly operation in this dynamic market with innovative mobility concepts, with the integration of the available mobility services and the intermodal combination, this ultimately corresponds to the overarching MaaS concept. Consequently, innovative mobility concepts and in particular MaaS, are investigated with a strategic approach under the influence of changing circumstances and market dynamics.

The lack of a generally accepted definition of MaaS illustrates the obstacle to the effective progress of MaaS, as the key objectives and various stakeholders of the ecosystem are not clearly identified and therefore no exchange takes place. Hence, it is important that this emphasis of the MaaS key characteristics is clearly highlighted in this elaboration. As a result, it should be noted that a comprehensive ecosystem with different sectors and stakeholders could be identified on the basis of the definition of MaaS and its classification. The MaaS Intermediary is of central importance, as this is where integration of all services takes place. The associated sectors and corresponding stakeholders are the automotive industry, infrastructure, technology and mobile service providers, transport service providers and policy. It has been shown that the sectors are interconnected in terms of MaaS and that various interdependencies arise. ICT, the digital infrastructure as well as the necessary interfaces and interoperability have emerged as the prerequisites for the integration of the various services and information on the MaaS platform.

Furthermore, insights are gained on the current market environment and development opportunities. It should be emphasized that the collaboration of the various stakeholders is of great importance for the implementation of mobility services. Indeed, in addition to new market entries, there is also the merger of corporate divisions to provide a solid financial base, market access and development resources to meet the challenges of the mobility industry. Therefore, the conclusion is that the trends and challenges as well as the increasing amount of software will change the business model of the OEMs. Moreover, tech-companies are entering the mobility market and investing in the application and user access of mobility services. In addition, the OEMs engage in tech-company collaborations to enable the necessary development and complementarity of software and hardware expertise. Finally, for the complex of collaborations in the mobility market, it is clear from the point of view of the MaaS Intermediary that collaboration and exchange are necessary to provide users with a comprehensive range of mobility services. As a result, stakeholder engagement and synergies are crucial, as is the long-term goal pursued by stakeholders.

The comparison of the status quo on the basis of Germany, China and the United States has shown that these are indeed in different positions. It has turned out that the reasons are manifold. In principle, the decisive factors are the population density, the distances to be covered, the expansion and existing infrastructure, as well as public transport and political and regulatory differences. Above all, a clear political objective and the establishment of a binding regulatory framework are listed as factors for the further development of MaaS.

It turned out that a white label solution is a way to integrate the different stakeholders and services of the MaaS ecosystem and to provide the user an intermodal offer as well as routing, booking and payment. The transport providers are thus simply connected to the network and can access data such as capacity utilization and route optimization, and the user has a comprehensive, supra-regional mobility service offering and additional services combined in one single application.

A MaaS platform also gives cities the opportunity to gain insights into mobility patterns and thus collect data for planning purposes and manage the city's mobility network. This leads to an improvement of the traffic management system in the city and therefore to less traffic on the roads, congestion and pollution. Furthermore, another possibility is to relieve public transport by integrating mobility concepts such as ride sharing, as a supplement to underutilized and unprofitable bus routes. Another aspect that needs to be considered is the redistribution or acquisition of passengers through the implementation of MaaS and the availability of other mobility services in addition to public transport. Furthermore, it can generally be concluded that MaaS will spread faster in cities than in rural areas due to the multitude of available transport options and thus the formation of a mobility backbone for the respective users of the platform.

Another finding of this elaboration is that MaaS must develop a certain adaptability, as each city and region has different infrastructures, public transport and mobility service providers. At this point, interoperability and standard interfaces must be emphasized so that the services can be integrated. It should therefore be noted that MaaS adapts to the existing situation in each region. In conclusion, this process is iterative.

Above all, it can be concluded that MaaS can make a lasting contribution to the further development of individual mobility and at the same time counteract the described challenges and megatrends of today, especially in urban areas.

6.2 Limitations

With regard to the holistic approach required to comprehensively address MaaS, it is obvious that this thesis has several limitations. First, the selection of the interview partners should be mentioned, as these represent a part of the MaaS ecosystem but do not represent the entire ecosystem. Therefore, other stakeholders or experts in other positions can provide further insights or represent other perspectives. In addition, it should be stressed that only experts from Germany could be acquired. Therefore, an in-depth analysis and more detailed statements on the USA and China are only possible to a limited extent.

Another limitation is the snapshot of the current state of development of MaaS. As MaaS's status is constantly evolving and the business environment is changing, the answers and views of the experts may change in the future. Furthermore, another limiting factor is the conduct of the interview itself and the subjective influences of both the interviewer and the interviewee. Likewise, bias is to be mentioned here. It is also important to note that all interviews were conducted by telephone and therefore aspects such as facial expressions and gestures could not be included in the data evaluation.

Furthermore, due to the processing of data from different national sources, the quantitative model constitutes a limitation with regard to the actuality and comparability of the data.

6.3 Outlook

It has been shown that MaaS adapts to the local infrastructure situation and transport providers in order to meet people's mobility needs. This creates the basis for the further development of mobility services. One starting point for this expansion is the white label solution, which involves the various stakeholders as well as integrating city administrations directly. Further research is needed in this area, particularly as various approaches will be implemented during 2019. Chapter 3.2.3 shows that there is currently no MaaS operator in Germany, USA and China that offers MaaS by definition. This is due to the fact that only a few regions are covered, and the integration of services is not complete or only with forwarding. These are issues that need to be addressed in order to meet MaaS by definition and the social as well as technical requirements and user perspective. As an important aspect, the stakeholders' willingness to integrate into an appropriate platform has emerged. One approach for further research areas is therefore to identify which obstacles the integration poses for stakeholders and what benefits or disadvantages would be possible.

One conclusion is that the business model of OEMs will continue to change, and that the entire mobility sector is in transformation. Further research is needed to transfer the impact of autonomous and connected driving as well as shared services. Another interesting question for the future is the extent to which mobility services such as ride sharing through a MaaS platform cause an increase or decrease in user numbers in public transport.

Another area of research that has resulted in the processing of the MaaS complex is the business model design. Above all, which characteristics are conceivable and economically feasible for a MaaS Intermediary, OEM, public transport company or city administration. Another point in this connection is the pricing of MaaS.

A further aspect of MaaS is certainly, in addition to carrying people and thus fulfilling their need for mobility, the carrying of goods. This transferred position should be taken into account in further scientific research.

Furthermore, the outlook for the implementation of MaaS is directed towards urban areas, since the population density for a large number of users and therefore attractiveness is guaranteed for mobility service providers. In addition, the pressure to act is highest in urban areas in order to improve the traffic management system and therefore to pursue approaches such as MaaS.

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Appendix

Appendix 1: Overview of modules and indicators of the quantitative model

It should be noted that some indicators are only for the overall picture, but not relevant for index formation.

Modules	**Indicators**
Consumer	Age Structure and Change
	Driver Age/Total Driver
	Driver Licenses by Age
	Median Age and Change
	Total Driver Licenses
	Total Driver/Total Population
	Total number of households
	Total Population and Change
Urbanization	Density of Urban Areas >300k inhabitants/100 sq km
	Forecast Average Annual Rate of Change of the Rural Population
	Forecast Average Annual Rate of Change of the Urban Population
	Forecast Rural Population
	Forecast Urban Population
	Number of Urban Areas >300k residents
	Percentage of the Total Population Residing in each Urban Agglomeration >300k residents
	Rural Annual Growth and Median
	Rural Population/Total Population
	Total Rural Population
	Total Urban Population
	Urban Annual Growth and Median
	Urban Population/Total Population
Infrastructure	Cars per household
	Highway - Passenger kilometers
	Highway - Passenger traffic (persons)
	Highway Density/100 sq km
	Motorization Rate (Passenger Cars/Population)
	Passenger cars in use and Change
	Passenger Rail km/population
	Passenger Road km/population
	Population Density and Change
	Public Transport: Passenger-kilometers
	Public Transport: Road & Subways, Train Rides
	Rail Network Density/100 sq km
	Railroad - Passenger kilometers
	Railroad - Passenger traffic (persons)
	Road km per day and person

	Total Length of Highways
	Total Length of Rail Network
	Train km per day and person
Economy	Consumer Price Index
	Correlation GDP Growth Rate and Passenger Car Sales Growth Rate
	Final consumption expenditure
	GDP and Change
	GDP per Capita and Change
	Gross National Income
	Household Disposable Income (Annual growth)
	Net Saving Rate in Household Disposable Income
	Online Mobility Services Growth Rate
	Online Mobility Services Revenue and Growth Rate
	Passenger Car Sales and Change
	Passenger Car Sales per 1k inhabitants and Change
	Per Capita Personel Expenditure: Transportation
	Real GDP (Annual growth)
Digitalization	Connectivity (further information in Annex 2)
	ICT Structure (further information in Annex 2)
	Knowledge (further information in Annex 2)
	Online Mobility Services User
	Online Mobility Services User/Total Population
	Regulation Aspects (further information in Annex 2)

Appendix 2: Overview Modules and Interview Guide of the qualitative method

Start questions: Basic understanding of mobility

Please describe what "mobility" means to you.

When we talk about mobility concepts - what are you thinking about?

In your opinion, what are the "automotive keytrends"?

How do you define the concept "mobility as a service"?

Note: The module structure is designed to deepen the interview according to the professional background of the expert. For this reason, this interview guideline and question catalogue will vary in its depth and intensity depending on the expert. As a result, this questionnaire is incomplete, since the interview can be carried out freeform to define new approaches and perspectives more closely and to deepen them with the expert. In addition, the interviewer explicitly asks details about the technical projects of the respective company and brings them into connection with the module contents.

Consumer

Module Objective: Mobility approach and perception change.

- Is the consumer's attitude to mobility changing?

- What are the reasons?

- Which requirements should be covered by interfaces in MaaS systems?

- What are the decisive success factors with regard to the user experience of a MaaS platform?

- Is it currently possible as a user to find the individually optimal travel chain according to the situation?

- How important is the environmental aspect in new solutions?

- Are new mobility solutions attractive to the public?

Regarding user experience: How do you rate the following success factors from 1-5 (poor to excellent):

User-friendliness; Travel comfort

Urbanization

Module Objective: Reasons and consequences of increasing urbanization.

- What are the demands of increasing urbanization for new mobility concepts?

- Reasons for increasing urbanization?

- What are the problems caused by the increase in urban areas?

- What role does the aspect of environmental friendliness and quality of life play?

- How are rural areas evaluated in terms of coverage of mobility services?

- What does MaaS mean for a city and its transport companies regarding a development management?

- Public transport has a service obligation: are new mobility services a supplement, relief or suppression?

How would you rate the following statements from 1-5 (not applicable to absolute applicable):

In order to maintain the quality of life in cities and to guarantee mobility, new mobility concepts are needed. New mobility concepts will become established more quickly in urban areas. Coverage of rural areas with MaaS is problematic.

Infrastructure

Module Objective: Requirements for the infrastructure and its expansion.

- How do you assess the status quo with regard to the road network, public transport, taxi and car traffic?

- Comparison to USA and China?

- What are the necessary prerequisites for MaaS?

- In order to fulfil these prerequisites, will a large number of market participants have to cooperate?

- What do you think are the most important building blocks of new, networked mobility concepts and their integration? Foreseeable problems?

- What role does public transport play in the development of new mobility concepts?

- Multimodal combination: The user has only one contract with a service provider. How do you see the development of a roaming process of service providers (cities, countries, several providers) so that the user only has to conclude one contract?

How do you rate the following success factors from 1-5 (poor to excellent):

Interoperability; 5G Networks; Multimodal Combination

Economy

Module Objective: Current position and further development of the market.

- What is your assessment of the starting position of the German automotive industry, further development and competitive advantages?

- Connection of German manufacturers on foreign markets, in particular the USA and China?

- The starting position of local companies?

- MaaS business models can be designed differently. In your professional opinion - which objective is decisive with regard to the business model?

- Will the dimensions of the market participants differ according to brand type?

- Which type of market participants, i.e. OEMs, intermediaries, fleet operators, currently have the best starting position?

- How will the market change as a result of the interaction between modes of transport and mobility services? In what time frame?

- How will the automotive industry react to the new challenges of future mobility?

- How will the sales and profits of automobile manufacturers and suppliers change?

- Which success factors are decisive?

- How can automobile manufacturers find the balance between traditional business and new technology and service?

- Are alliances between industry-related and non-industrial partners useful in order to provide innovative services faster?

- What is your assessment of new market participants?

- New cars are mostly business vehicles. For MaaS providers an opportunity to use companies as multipliers?

How do you rate the following factors from 1-5 (bad to excellent):

German starting position with regard to MaaS; Investments in research and development; Collaborations

Digitalization

Module Objective: Development opportunities through digital applications regarding mobility.

- German position in comparison to the USA and China?

- Influence of autonomous driving on MaaS? Realistic time horizon?

- How do you see the digital fundamentals and framework conditions in Germany with regard to mobility and MaaS?

- How do you assess the importance of data protection?

- Comparison of the legal framework in the USA, Germany and China?

- What about the connection between hardware and software?

- How important do you consider a customer-centric service platform to be? Problems and functions?

- To what extent do cloud services play a role in mobility?

- How do you assess the need or use of user data for motion patterns to optimize networks and calibrate supply and demand?

How do you rate the following success factors from 1-5 (poor to excellent):

Connectivity; Autonomous driving; Compatibility

Policy

Module Objective: Legal requirements and influence.

- What is specifically expected of the government regarding infrastructure, funding and legal framework?

- How can policy influence progress through regulation?

- How is the political influence or legal framework, taxes and duties, and traffic data assessed with regard to the speed of transformation in the mobility sector?

- What are regulatory trends regarding autonomous and electric driving?

- Which clear goals and strategies should be defined?

- Your recommendations on regulatory frameworks?

How do you rate the following factors from 1-5 (unimportant to absolute important):

Clear policy objective; Promotion of a technology/service

Final Question

Do you have any further comments or a topic you would like to talk about?

Appendix 3: General Data Protection Regulation

Einwilligungserklärung zur Erhebung und Verarbeitung personenbezogener Daten für Forschungszwecke

A. Gegenstand des Forschungsprojekts und Grundlage der Einwilligungserklärung

1. Forschungsprojekt:

Masterthesis: „Mobility concepts and the impact of changing circumstances: a strategic approach to innovation and market dynamics regarding mobility as a service"

2. Beschreibung des Forschungsprojekts:

Quantitativer und qualitativer Ansatz zur Untersuchung des Status quo sowie zukünftige Potenziale von Mobilität, insbesondere am Beispiel von mobility as a service.

3. Durchführende Institution:

Studierender: Tobias Rapp, Hochschule Furtwangen University

4. Projektleitung:

Tobias Rapp

5. Interviewer:

Tobias Rapp

6. Interviewdatum:

-

7. Art der personenbezogenen Daten des Betroffenen (der interviewten Person) / besondere Kategorien personenbezogener Daten:

- Name: -
- Beruf/Funktion: -
- Unternehmen/Institution: -
- Tonaufnahmen des Interviews

B. Einwilligungserklärung und Information über die Erhebung personenbezogener Daten

1. Einwilligungserklärung

Hiermit willige ich ein, dass die im Rahmen des unter A. beschriebenen Forschungsprojekts erhobenen personenbezogenen Daten meiner Person, in Form von Originalaufnahmen des Interviews / der Interviews und deren Transkripte an

• Tobias Rapp

für die Erstellung einer Masterthesis gemäß Ziff. 2 verarbeitet werden dürfen. Sofern ich besondere Kategorien von personenbezogenen Daten angebe bzw. angegeben habe, sind diese von der Einwilligungserklärung umfasst.

Ihre Einwilligung ist freiwillig. Sie können die Einwilligung ablehnen, ohne dass Ihnen dadurch irgendwelche Nachteile entstehen.

Ihre Einwilligung können Sie jederzeit gegenüber Tobias Rapp widerrufen, mit der Folge, dass die Verarbeitung Ihrer personenbezogenen Daten, nach Maßgabe Ihrer Widerrufserklärung, durch diesen für die Zukunft unzulässig wird. Dies berührt die Rechtmäßigkeit der aufgrund der Einwilligung bis zum Widerruf erfolgten Verarbeitung jedoch nicht.

Relevante Definitionen der verwendeten datenschutzrechtlichen Begriffe sind in der Anlage Begriffsbestimmungen enthalten.

2. Zweck der Datenverarbeitung / Ziel des Projekts

Erstellung einer Masterthesis.

3. Kontaktdaten der Datenschutzbeauftragten

Tobias Rapp

Rathausstr. 3, 72401 Haigerloch

Telefonnummer: 07474/9183743

4. Rechtsgrundlage

Tobias Rapp verarbeitet die von Ihnen erhobenen personenbezogene Daten auf Basis Ihrer Einwilligung gemäß Art. 6 Abs. 1 S. 1 lit. a) DSGVO. Sofern besondere Kategorien personenbezogener Daten betroffen sind, verarbeitet Tobias Rapp die von Ihnen erhobenen personenbezogenen Daten auf Basis Ihrer Einwilligung gemäß Art. 9 Abs. 2 lit. a) DSGVO.

5. Empfänger oder Kategorien von Empfängern / Drittstaatenübermittlung

An folgende Empfänger oder Kategorien von Empfängern werden Ihre personenbezogenen Daten durch Tobias Rapp übermittelt oder können übermittelt werden:

• Hochschule Furtwangen University

6. Dauer, für die die personenbezogenen Daten gespeichert werden / Kriterien für die Festlegung der Dauer

Die Tonaufnahmen werden nach Abschluss, Abgabe und Benotung der Masterthesis gelöscht.

7. Ihre Rechte

Im Rahmen der gesetzlichen Vorgaben haben Sie gegenüber Tobias Rapp grundsätzlich Anspruch auf:

• Bestätigung, ob Sie betreffende personenbezogenen Daten durch Tobias Rapp verarbeitet werden,

• Auskunft über diese Daten und die Umstände der Verarbeitung,

• Berichtigung, soweit diese Daten unrichtig sind,

• Löschung, soweit für die Verarbeitung keine Rechtfertigung und keine Pflicht zur Aufbewahrung (mehr) besteht,

• Einschränkung der Verarbeitung in besonderen gesetzlich bestimmten Fällen und

• Übermittlung Ihrer personenbezogenen Daten – soweit Sie diese bereitgestellt haben – an Sie oder einen Dritten in einem strukturierten, gängigen und maschinenlesbaren Format.

Darüber hinaus haben Sie das Recht, Ihre Einwilligung jederzeit gegenüber Tobias Rapp zu widerrufen, mit der Folge, dass die Verarbeitung Ihrer personenbezogenen Daten, nach Maßgabe Ihrer Widerrufserklärung, durch diesen für die Zukunft unzulässig wird. Dies berührt die Rechtmäßigkeit der aufgrund der Einwilligung bis zum Widerruf erfolgten Verarbeitung jedoch nicht.

8. Keine automatisierte Entscheidungsfindung (inklusive Profiling)

Eine Verarbeitung Ihrer personenbezogenen Daten zum Zweck einer automatisierten Entscheidungsfindung (einschließlich Profiling) gemäß Art. 22 Abs. 1 und Abs. 4 DSGVO findet nicht statt.

____

Vorname, Nachname in Druckschrift

____________________ _________________________

Ort und Datum Unterschrift

Anlage: Begriffsbestimmung

• „Personenbezogene Daten" sind gemäß Art. 4 Nr. 1 DSGVO alle Informationen, die sich auf eine identifizierte oder identifizierbare natürliche Person (im Folgenden „betroffene Person") beziehen. Als identifizierbar wird eine natürliche Person angesehen, die direkt oder indirekt, insbesondere mittels Zuordnung zu einer Kennung wie einem Namen, zu einer Kennnummer, zu Standortdaten, zu einer Online-Kennung oder zu einem oder mehreren besonderen Merkmalen identifiziert werden kann, die Ausdruck der physischen, physiologischen, genetischen, psychischen, wirtschaftlichen, kulturellen oder sozialen Identität dieser natürlichen Person sind. Das kann z.B. die Angabe sein, wo eine Person versichert ist, wohnt oder wie viel Geld er oder sie verdient. Auf die Nennung des Namens kommt es dabei nicht an. Es genügt, dass man herausfinden kann, um welche Person es sich handelt.

• „Verarbeitung" ist gemäß Art. 4 Nr. 2 DSGVO jeder mit oder ohne Hilfe automatisierter Verfahren ausgeführten Vorgang oder jede solche Vorgangsreihe im Zusammenhang mit personenbezogenen Daten wie das Erheben, das Erfassen, die Organisation, das Ordnen, die Speicherung, die Anpassung oder Veränderung, das Auslesen, das Abfragen, die Verwendung, die Offenlegung durch Übermittlung, Verbreitung oder eine andere Form der Bereitstellung, den Abgleich oder die Verknüpfung, die Einschränkung, das Löschen oder die Vernichtung.

Appendix 4: Sent Interview Requests

Multiple naming possible, as several sectors can be assigned

Sector	Requested
Automotive Industry	Association of the German Automotive Industry (Verband der deutschen Automobilindustrie e.V.)
	Audi AG
	BMW Group
	BYD Auto Company
	Byton
	Continental AG
	Daimler AG
	e.Go Mobile AG
	Fiat Chrysler Automobiles
	Ford Motor Company
	Geely Auto Group
	General Motors Company
	Mercedes-Benz Research and Development North America, Inc.
	NIO
	Robert Bosch GmbH
	Schaeffler AG
	Tesla, Inc.
	Volkswagen AG
	ZF Friedrichshafen AG
Infrastructure	Beijing - Department of Transportation
	Centre for Sustainable Urban Mobility of the State of Hesse (Fachzentrum nachhaltige urbane Mobilität des Landes Hessen)
	Changshu - Department of Transportation
	City of Hamburg
	City of Los Angeles - Department of Transportation
	City of Wolfsburg
	City of Zurich
	e-mobil BW GmbH (State Agency for New Mobility Solutions and Automotive in Baden-Württemberg)
	Federal Ministry of Transport and Digital Infrastructure (Germany)
	Hong Kong - Department of Transportation
	Kunshan - Department of Transportation
	Ministry of Transport Baden-Württemberg
	Ministry of Transport of China
	Nanjing - Department of Transportation
	New York City - Department of Transportation
	Shanghai Department of Transportation
	Thuringian Innovation Centre Mobility (Thüringer Innovationszentrum Mobilität)
	U.S. Department of Transportation

	Urban Mobility — SrV 2018 (German System of Representative Traffic Surveys)
	Washington D.C. - Department of Transportation
MaaS Intermediary	HeyRide Inc.
	ioki GmbH
	Kyyti Group
	MaaS Alliance
	MBTA On-Demand Paratransit
	Moovel GmbH
	Moovel North America
	Moovit Inc.
	MVG more (Munich Transport Corporation)
	Qixxit (QT Mobilitätsservice GmbH)
	Switch MaaS (Switch USA)
	Switchh (Hamburger Hochbahn AG)
	Transit (Transitapp)
	Üstra Mobility Shop (Greater Hanover Transport Association, Hannoversche Verkehrsbetriebe AG)
	VIA goMobile (VIA Metropolitan Transit)
	Whim (MaaS Global Oy)
Policy	Federal Ministry of Economic Affairs and Energy (Germany)
	Federal Ministry of Transport and Digital Infrastructure (Germany)
	Ministry of Transport of Baden-Württemberg
	Ministry of Transport of China
	U.S. Department of Transportation
Technology and Mobile Service Provider	25ways GmbH - rethink mobility
	Alphabet Inc.
	Apple Inc.
	AZOWO GmbH
	Baidu, Inc.
	Bitkom - Federal Association for Information Technology (Bundesverband Informationswirtschaft)
	Bosch Service Solutions GmbH
	Bytemark, Inc.
	DemandTrans Solutions Inc.
	Deutsche Telekom AG
	EnBW Energie Baden-Württemberg AG
	eos.uptrade GmbH
	Google Ireland Limited (for Android operating system)
	Google LLC
	HaCon Ingenieursgesellschaft mbH - A Siemens Company
	HERE Technologies
	IBM Corporation
	Innogy SE
	IONITY GmbH

	Mobimeo GmbH
	OpenData-Portal ÖPNV (Project by Verkehrsverbund Rhein-Ruhr AöR)
	RWE AG
	Siemens Mobility GmbH
	Telefónica Deutschland Holding AG
	Telefónica Germany Next GmbH
	TomTom N.V.
	Vodafone Group
	Waymo LLC
Transport Service Provider	American Public Transportation Association
	Association of German Transport Companies (Verband Deutscher Verkehrsunternehmen e.V.)
	Berliner Verkehrsbetriebe (AöR)
	car2go Deutschland GmbH
	Cluno GmbH
	Deutsche Bahn AG
	Didi Chuxing Technology Co.
	DriveNow GmbH & Co. KG
	Europcar Mobility Group S.A.
	Flinkster (Deutsche Bahn Connect GmbH)
	Flixmobility GmbH
	Hertz Corporation
	Lyft, Inc.
	Metropolis Taxi GmbH
	mobileeee GmbH
	MOIA GmbH
	Munich Transport Corporation (Münchner Verkehrsgesellschaft mbH)
	mytaxi (Moovel GmbH)
	Rhein-Main-Verkehrsverbund Servicegesellschaft mbH
	Sixt SE
	Stadtwerke Konstanz GmbH
	Transport and Tariff Association Stuttgart (Verkehrs- und Tarifverbund Stuttgart GmbH)
	Uber Technologies Inc.
Additional	AAA Auto Club South, Inc.
	Accenture Plc
	ADAC e.V.
	Berylls Strategy Advisors GmbH
	Deloitte Touche Tohmatsu Limited
	Federal Association of German Industry (Bundesverband der Deutschen Industrie e.V. - Mobilität und Logistik)
	ITS International
	mobility inside INFRA Dialog Deutschland GmbH
	Nahverkehrs:praxis (German journal for modern mobility)

	Network intelligent mobility (Netzwerk intelligente Mobilität e.V.)
	PwC Autofacts
	Roland Berger GmbH
	zegemo - Zentrum für geschäftliche Mobilität

Appendix 5: Framework of qualitative data analysis – Consumer module

Consumer	
Key Themes	**Focus Topics**
Attitude	Demography Perspective
	Rural and Urban Perspective
Requirements	Demand
	Interfaces
	User-friendliness
Perception	Intermodal use
	Cost Benefit Effect
	Pilot Projects

Appendix 6: Quantitative Model: Licensed Drivers and Total Population[374]

	Total Driver Lincenses (Car)	Change	Total Driver/Total Population
Germany			
2011	48.030.221		59,34%
2012	50.272.982	4,67%	62,01%
2013	52.337.407	4,11%	64,40%
2014	54.203.370	3,57%	66,52%
2015	56.067.298	3,44%	68,62%
2016	57.933.321	3,33%	70,72%
2017	59.783.743	3,19%	72,81%
2018	61.619.040	3,07%	74,88%
USA			
2011	211.875.000		68,12%
2012	211.815.000	-0,03%	67,60%
2013	212.160.000	0,16%	67,24%
2014	214.092.000	0,91%	67,38%
2015	218.084.000	1,86%	68,17%
2016	221.712.000	1,66%	68,82%
2017	221.994.424	0,13%	68,42%
2018	-	-	-
China			
2011	174.090.000		12,73%
2012	200.560.000	15,20%	14,58%
2013	219.000.000	9,19%	15,84%
2014	247.000.000	12,79%	17,77%
2015	280.000.000	13,36%	20,04%
2016	310.000.000	10,71%	22,09%
2017	342.000.000	10,32%	24,26%
2018	369.000.000	7,89%	26,08%

[374] Cf. German Federal Motor Transport Authority (2019), cf. U.S. Department of Transportation (2018) and cf. Ministry of Public Security China (2019)

Appendix 7: Framework of qualitative data analysis – Urbanization module

Urbanization	
Key Themes	**Focus Topics**
Mobility in the city	Reasons for Traffic
	Problems with Traffic
	Urban Traffic Management
	The Case of MaaS
Mobility in the periphal and rural areas	Chances and Risks
	The Case of MaaS

Appendix 8: Quantitative Model: Urban Population[375]

	Urban Population of Total Population	Total Urban Population	Urban Annual Growth	Median Annual Growth		Forecast Avg. Annual Change of Urban Pop.	Forecast Urban Population
Germany							
2011	77,16%	62.448.674	-1,60%	0,43%	2015 - 2020	0,27%	63.930.000
2012	77,17%	62.558.632	0,20%		2020 - 2025	0,13%	64.346.000
2013	77,18%	62.720.327	0,29%		2025 - 2030	0,16%	64.871.000
2014	77,19%	62.902.131	0,43%		2030 - 2035	0,18%	65.466.000
2015	77,20%	63.078.576	0,88%		2035 - 2040	0,19%	66.094.000
2016	77,22%	63.258.040	0,84%		2040 - 2045	0,15%	66.593.000
2017	77,26%	63.442.098	0,47%		2045 - 2050	0,07%	66.826.000
USA							
2011	80,94%	251.777.121	0,96%	0,97%	2015 - 2020	0,95%	273.975.000
2012	81,12%	254.174.219	0,97%		2020 - 2025	0,96%	287.421.000
2013	81,30%	256.528.426	0,93%		2025 - 2030	0,92%	301.001.000
2014	81,48%	258.886.973	0,98%		2030 - 2035	0,84%	313.969.000
2015	81,67%	261.289.214	0,99%		2035 - 2040	0,75%	325.949.000
2016	81,86%	263.742.992	0,97%		2040 - 2045	0,66%	336.914.000
2017	82,06%	266.244.566	0,95%		2045 - 2050	0,61%	347.346.000
China							
2011	50,51%	690.727.823	3,06%	2,83%	2015 - 2020	2,42%	875.076.000
2012	51,77%	711.871.762	2,94%		2020 - 2025	1,78%	956.554.000
2013	53,01%	733.060.053	2,88%		2025 - 2030	1,24%	1.017.847.000
2014	54,26%	754.259.785	2,83%		2030 - 2035	0,80%	1.059.619.000
2015	55,50%	775.351.095	2,77%		2035 - 2040	0,45%	1.083.464.000
2016	56,74%	796.289.760	2,74%		2040 - 2045	0,16%	1.092.037.000
2017	57,96%	816.956.053	2,69%		2045 - 2050	0,00%	1.091.948.000

[375] Cf. United Nations (2019) and cf. World Bank (2019)

Appendix 9: Quantitative Model: Urban Density[376]

	Number of urban areas >300k residents	Country total area (sq km)	Density of urban areas >300k inhabitants/100 sq km	Most populous cities (Top10)	City Population	Percentage of the Tot. Pop. Residing in Each Urban Aggl. with 300k
Germany						
	22	357.022	0,0062	Berlin	3.613.495	4,39%
				Hamburg	1.830.584	2,22%
				Munich	1.456.039	1,77%
				Cologne	1.080.394	1,31%
				Frankfurt am Main	746.878	0,91%
				Stuttgart	632.743	0,77%
				Düsseldorf	617.280	0,75%
				Dortmund	586.600	0,71%
				Essen	583.393	0,71%
				Leipzig	581.980	0,71%
USA						
	144	9.833.517	0,0015	New York City	8.622.698	2,64%
				Los Angeles	3.999.759	1,22%
				Chicago	2.716.450	0,83%
				Houston	2.312.717	0,71%
				Phoenix	1.626.078	0,50%
				Philadelphia	1.580.863	0,48%
				San Antonio	1.511.946	0,46%
				San Diego	1.419.516	0,43%
				Dallas	1.341.075	0,41%
				San Jose	1.035.317	0,32%
China						
	424	9.596.960	0,0044	Shanghai	20.930.000	1,48%
				Beijing	18.619.000	1,32%
				Guangzhou	12.086.000	0,85%
				Tianjin	12.080.000	0,85%
				Shenzhen	11.908.000	0,84%
				Wuhan	8.588.000	0,61%
				Chengdu	7.790.000	0,55%
				Chongqing	7.583.500	0,54%
				Dongguan	7.364.000	0,52%
				Foshan	7.086.000	0,50%

[376] Cf. United Nations (2019), cf. Central Intelligence Agency (2018), cf. German Federal Statistical Office (2019), cf. United States Census Bureau (2018) and cf. National Bureau of Statistics of China (2019)

Appendix 10: Framework of qualitative data analysis – Infrastructure module

Infrastructure	
Key Theme	**Focus Topics**
Status Quo and Requirements	Transport Infrastructure
	Public Transport
	Digital Infrastructure

Appendix 11: Quantitative Model: Infrastructure Density[377]

	Total length of Highways 2017 (in kilometers)	Density/100 sq km	Length of rail network 2015 (km)	Density/100 sq km
Germany				
	229.970	64,41	38.466	10,77
USA				
	6.734.236	68,48	202.322	2,06
China				
	4.773.500	49,74	127.000	1,32

[377] Cf. German Federal Ministry of Transport and Digital Infrastructure (2018), cf. U.S. Department of Transportation (2019), cf. U.S. Department of Transportation (2018), cf. Ministry of Transport of China (2018) and cf. National Railway Administration of China (2018)

Appendix 12: Quantitative Model: Personal Mileage and Public Transport[378]

	Highway - Passenger traffic (persons)	Highway - Passenger kilometers	Railroad - Passenger traffic (persons)	Railroad - Passenger kilometers	Passenger Road km/Population	Passenger Rail km/Population	Public Transport Rides/Population
Germany							
2013	57.318.000.000	921.420.000.000	2.613.472.000	89.615.000.000	11.338	1.103	148
2014	57.586.000.000	934.957.000.000	2.693.011.000	90.976.000.000	11.473	1.116	149
2015	58.297.000.000	945.729.000.000	2.707.450.000	91.709.000.000	11.574	1.122	149
2016	59.511.523.111	965.459.557.967	2.830.257.878	95.829.660.283	11.786	1.170	151
2017	-	-	-	-	-	-	-
USA							
2013	-	6.930.886.502.345	4.638.407.489.081	62.948.508.564	21.965	199	34
2014	-	7.035.579.585.198	4.633.149.162.261	63.228.048.247	22.144	199	34
2015	-	7.199.136.983.776	4.802.568.734.952	63.311.350.623	22.502	198	33
2016	-	7.371.962.607.799	4.900.781.989.089	63.743.145.289	22.882	198	-
2017	-	-	-	-	-	-	-
China							
2013	-	-	-	-	-	-	-
2014	17.362.700.000	1.099.630.000.000	2.304.600.000	1.124.190.000.000	791	809	61
2015	16.190.970.000	1.074.270.000.000	2.534.840.000	1.196.060.000.000	769	856	61
2016	15.427.590.000	1.022.870.000.000	2.814.050.000	1.257.930.000.000	729	896	60
2017	14.567.840.000	976.520.000.000	3.083.790.000	1.345.690.000.000	693	955	60

[378] Cf. German Federal Ministry of Transport and Digital Infrastructure (2019), cf. U.S. Department of Transportation (2019), cf. Ministry of Transport of China (2018), cf. American Public Transportation Association (2018) and cf. National Bureau of Statistics of China (2018)

Appendix 13: Email communication with VDV

AW: Anfrage über www.mobility-inside.de

Montag, März 11, 2019 10:18 CET

Ackermann, Dr. Till | VDV
ackermann@vdv.de

An

Tobias.Rapp

Sehr geehrter Herr Rapp,

vielen Dank für Ihr Interesse an Mobility inside.

Wir stehen in den Vorbereitungen zur Gründung der Mobility inside-Gesellschaften. Die Gremiendurchläufe zur Gründung bzw. zur Beteiligung an der Mobility inside Holding GmbH & Co. KG wurden aktuell bei BOGESTRA, DSW 21, RMV, AVG, RNV und SSB (Kommanditist) positiv abgeschlossen. Aktuell laufen die Beteiligungsprozesse bei MVG München, LVB Leipzig und in Stuttgart bzgl. der Komplementärrolle. Weitere Verkehrsunternehmen (z.B. DB AG) befinden sich in Gesprächen zur Beteiligung. Die Gesellschaftsgründung wird bis Juni 2019 angestrebt. Der LOI-Prozess hat bis Ende Januar weit über 100 Unterstützungserklärungen aus der Verkehrsbranche erbracht.

Parallel stehen wir in den Vorbereitungen eines Mobility inside Piloten zur VDV-Jahrestagung. Zur VDV-Jahrestagung in Mannheim im Juni 2019 soll ein Demonstrationspilot mit einigen Grundfunktionen gezeigt werden. Es ist vorgesehen für jeden Pilotpartner eine Mobilitäts-White-Label App anzubieten und einen Test mit „Friendly User“ (Plan: 300 je Partner) mit der Laufzeit bis Jahresende 2019 durchzuführen. Der Pilot wird durch Eigenentwicklungen von drei Initiatoren (DB, RMV und MVG) entwickelt. Im Piloten ist vorgesehen, dass bereits Aspekte der Zielarchitektur, die Verwendung der Tarifmodule (PKM) sowie eine Partnerschaft mit DELFI für die statischen Fahrplandaten sowie mit der DB AG für die Echtzeitdaten umgesetzt werden.

Mit freundlichen Grüßen

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Präsident: Ingo Wortmann · Hauptgeschäftsführer: Oliver Wolff
Vereinsregister AG Köln VR 4097 · USt.-IdNr. DE 814379852

Appendix 14: Framework of qualitative data analysis – Economy module

Economy	
Key Themes	**Focus Topics**
OEMs	Challenges
	Added Value
New Market Player	Challenges
Collaborations	OEM and OEM
	OEM and Tech Company
	Others
Multiplier	Strategy

Appendix 15: Quantitative Model: Economic Figures and Correlation[379]

	GDP per capita (USD)	Real GDP growth (Annual growth)	Passenger Car Sales	Passenger Car Sales per 1k inhabitants	Passenger Car Sales Change	Correlation GDP Growth and Passenger Car Sales Growth (2010-2015)
Germany						
2010	39.955	4,09%	2.916.259	36,05	-	0,12
2011	42.693	3,65%	3.173.634	39,21	8,77%	
2012	43.564	0,50%	3.082.504	38,02	-3,03%	
2013	45.232	0,48%	2.952.431	36,33	-4,45%	
2014	47.190	2,19%	3.036.773	37,27	2,57%	
2015	47.892	1,73%	3.206.042	39,24	5,29%	
2016	49.187	2,24%	3.351.607	40,92	4,28%	
2017	50.878	2,15%	3.442.100	41,92	2,45%	
USA						
2010	48.394	2,56%	5.635.432	18,26	-	-0,06
2011	49.800	1,55%	6.089.403	19,58	7,22%	
2012	51.521	2,25%	7.241.900	23,11	18,06%	
2013	53.016	1,84%	7.585.341	24,04	4,01%	
2014	54.935	2,45%	7.689.110	24,20	0,67%	
2015	56.701	2,88%	7.516.826	23,50	-2,92%	
2016	57.797	1,57%	6.872.729	21,33	-9,21%	
2017	59.774	2,22%	6.096.111	18,79	-11,92%	
China						
2010	9.311	10,60%	13.757.794	10,12	-	0,97
2011	10.360	9,50%	14.472.416	10,58	4,60%	
2012	11.323	7,90%	15.495.240	11,27	6,47%	
2013	12.338	7,80%	17.927.730	12,96	15,06%	
2014	13.405	7,30%	19.707.677	14,18	9,35%	
2015	14.413	6,90%	21.210.339	15,18	7,09%	
2016	15.478	6,70%	24.376.902	17,37	14,40%	
2017	-	6,80%	24.961.948	17,71	1,96%	

[379] Cf. OECD (2019) and cf. OICA (2018)

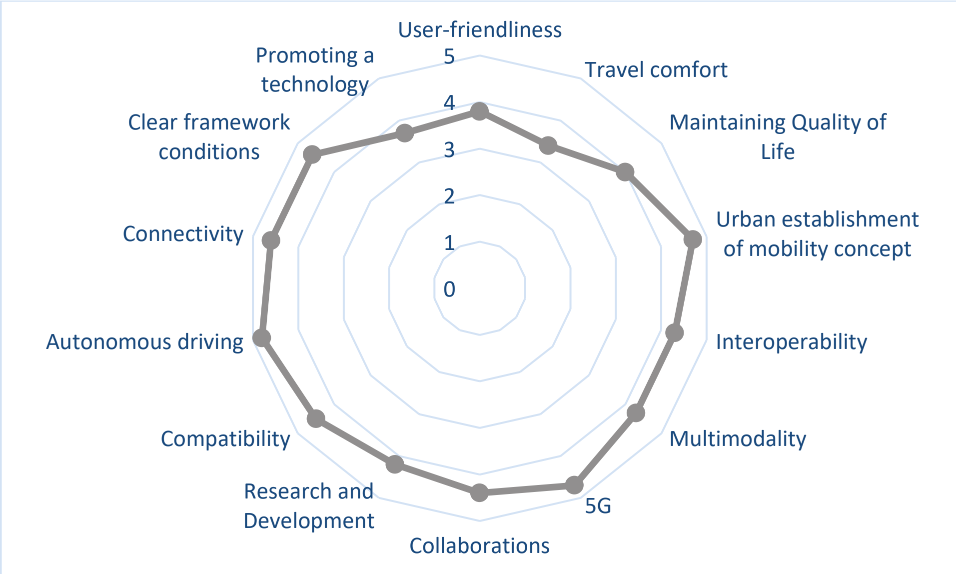
Appendix 16: Framework of qualitative data analysis – Digitalization module

Digitalization	
Key Themes	**Focus Topics**
Autonomous Driving	Influences
	Usage
Data Handling	Differences
	Challenges
ICT and Interoperability	Platforms
	Ecosystem

Appendix 17: Framework of qualitative data analysis – Policy module

Policy	
Key Theme	**Focus Topics**
Expectations	Funding
	Legal Framework

Appendix 18: Experts‘ assessment of the success factors for MaaS



1 to 5: poor to excellent

Appendix 19: Quantitative Model: Index

The objective of this index formation is to compare the country position in terms of mobility.
Since it is not about the determination of future market sizes but only about the determination of the mobility position, various factors are not relevant, even in the question of whether they are to be evaluated positively or negatively.
Nevertheless, these factors are listed in part in order to clarify the dimensions.
The most recent available values are used in index formation.
Attention is paid to the comparability of the indicators. Hence, there may be several index categories within the modules to increase the validity.

Modules	Indicator	Germany	USA	China	Indexrelevant
Consumer	Total Driver/Total Population	100,00	93,98	33,33	x
	Annual Population Growth Median	10,82	100,00	67,84	x
	Total Population	5,81	23,17	100,00	
	Total Number of Households	11,01	33,64	100,00	
	Consumer Index	**55,41**	**96,99**	**50,58**	
Urbanization	Urban population of total population	94,15	100,00	70,63	x
	Density of urban areas >300k inhabitants/100 sq km	100,00	23,76	71,70	x
	Median annual urban growth	15,19	34,17	100,00	x
	Number of urban areas >300k residents	5,19	33,96	100,00	
	Urbanization Index	**69,78**	**52,65**	**80,78**	
Infrastructure	Population Density (persons per sq km)	100,00	15,13	63,84	x
	Highway Density/100 sq km	94,06	100,00	72,63	x
	Rail Network Density/100 sq km	100,00	19,10	12,28	x
	Passenger Road km/population	51,51	100,00	3,19	x
	Passenger Rail km/population	100,00	16,91	76,61	x
	Motorization Rate (Passenger Cars/Population)	100,00	69,31	17,62	x
	Country total area (sq km)	3,63	100,00	97,59	
	Infrastructure Index 1 (Density Focus)	**98,02**	**44,74**	**49,58**	
	Infrastructure Index 2 (Population Focus)	**83,84**	**62,08**	**32,47**	
Economy	GDP per capita (USD)	85,12	100,00	26,78	x
	Passenger Car Sales per 1k inhabitants	100,00	44,82	42,25	x
	Passenger Car Sales	13,79	24,42	100,00	
	GDP (USD)	18,97	100,00	63,11	
	Economy Index	**92,56**	**72,41**	**34,51**	
Digitalization	Connectivity	100,00	87,53	38,04	x
	ICT structure	100,00	90,10	76,10	x
	Online Mobility Services - User/Total Population	86,03	100,00	89,55	x
	Digitalization Index	**95,34**	**92,54**	**67,90**	

Statutory Declaration

I hereby confirm this thesis with the title “Mobility concepts and the impact of changing circumstances: a strategic approach to innovation and market dynamics regarding mobility as a service” is my own work and contains no material that has been submitted previously, in whole or in part, to achieve an academic grading or is being published elsewhere. To the best of my knowledge all used sources, information and quotations are referenced as such.

Villingen-Schwenningen, 29th May 2019 ______________________________