Economic Essays on the Framework Conditions for the Deployment of Intelligent Transportation Systems (ITS)

Isabella Geis

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Zeppelin Universität, Friedrichshafen
Chair for Mobility, Trade and Logistics

Supervisor:
Prof. Dr. Wolfgang H. Schulz, Zeppelin Universität, Germany

Second supervisor:
Prof. Dr. Laurent Guihéry, Université de Cergy-Pontoise, France

Third supervisor:
Prof. Dr. Uwe Clausen, Technische Universität Dortmund, Germany

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Dedicated to Gabriele Geis and Manuel Fünfrocken
Acknowledgements

“Believe you can and you are halfway there.” Theodore Roosevelt

These words are the beginning of the last chapter of a long journey that all started with one question: What actually drives the future of mobility? The more I tried to find an answer, the more questions came up. The idea of a dissertation and my passion for transportation research was born. Although writing a dissertation is an individual decision, it is not a journey I went alone. Therefore, it is now the time to thank my supporters, temporary and constant companions, my advisors and mentors that helped to believe in me, but also my most fervent critics that made me questioning my approaches and results.

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<th>Description</th>
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<tr>
<td>A</td>
<td>Age</td>
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<tr>
<td>ANOVA</td>
<td>Analysis of Variance</td>
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<td>BCR</td>
<td>Benefit-Cost-Ratio</td>
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<td>C2X</td>
<td>Car-to-X</td>
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<tr>
<td>CBA</td>
<td>Cost-Benefit-Analysis</td>
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<tr>
<td>C-ITS</td>
<td>Cooperative Intelligent Transportation System</td>
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<tr>
<td>CZ</td>
<td>Czech Republic</td>
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<tr>
<td>DE</td>
<td>Germany</td>
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<tr>
<td>DG MOVE</td>
<td>General Direction of Mobility and Transport</td>
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<td>DS</td>
<td>Data Security</td>
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<tr>
<td>EC</td>
<td>European Commission</td>
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<td>ECTRI</td>
<td>European Conference of Transport Research Institutes</td>
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<tr>
<td>EoU</td>
<td>Ease of Use</td>
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<td>ERTICO</td>
<td>European Road Transport Telematics Implementation Coordination Organisation</td>
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<td>EU</td>
<td>European Union</td>
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<td>EUR</td>
<td>Euro</td>
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<td>F</td>
<td>France</td>
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<td>FEHRL</td>
<td>European National Highway Research Laboratories</td>
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<td>FHWA</td>
<td>Federal Highway Administration</td>
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<td>FP</td>
<td>Framework Programmes for Research and Technological Development</td>
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<td>G</td>
<td>Gender</td>
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<td>GBP</td>
<td>Great Britain Pound</td>
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<td>GDP</td>
<td>Gross Domestic Product</td>
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<td>GDPR</td>
<td>General Data Protection Regulation</td>
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<td>ICT</td>
<td>Information and Communication Technology</td>
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<td>ICU</td>
<td>Intensity of Car Use</td>
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<td>IMC</td>
<td>Intended Modal Change</td>
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<td>IT</td>
<td>Italy</td>
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<td>ITS</td>
<td>Intelligent Transportation Systems</td>
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<td>IU</td>
<td>Intention to Use</td>
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<td>MMITIS</td>
<td>Multimodal Information and Ticketing System</td>
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<td>MMTIS</td>
<td>Multimodal Travel Information Services</td>
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<tr>
<td>NAP</td>
<td>National Access Point</td>
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<tr>
<td>Acronym</td>
<td>Description</td>
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<td>OEM</td>
<td>Original Equipment Manufacturer</td>
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<td>PL</td>
<td>Poland</td>
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<tr>
<td>PU</td>
<td>Perceived Usefulness</td>
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<tr>
<td>R&amp;D</td>
<td>Research and Development</td>
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<td>RTTI</td>
<td>Real-Time Traffic Information</td>
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<tr>
<td>SD</td>
<td>Standard Deviation</td>
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<td>SDO</td>
<td>Standard Developing Organisations</td>
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<td>SRTI</td>
<td>Safety-Related Traffic Information</td>
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<td>SSTP</td>
<td>Safe and Secure Truck Parking</td>
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<td>TAM</td>
<td>Technology Acceptance Model</td>
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<td>TRB</td>
<td>Transportation Research Board</td>
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<tr>
<td>UK</td>
<td>United Kingdom</td>
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<td>US</td>
<td>United States of America</td>
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<td>US DOT</td>
<td>United States of America Department of Transportation</td>
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<tr>
<td>V2X</td>
<td>Vehicle-to-X</td>
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Abstract

Today, transportation is a central element of a society’s welfare in terms of economic, political and social success. It creates jobs, allows international cooperation between firms and countries, contributes to firms’ productivity, and enables social participation and interaction. It has become an essential intermediate. Consequently, changes in transportation affect many more sectors. Therefore, transportation of goods and persons has been growing immensely within the past decades. Against this background, intelligent transportation systems (ITS) gain importance in improving and changing transport. Technology can cover all modes (e.g. advanced driving systems, cooperative vehicle systems as vehicle-to-vehicle or vehicle-to-infrastructure communication, or mobile and multimodal information and ticketing systems). The deployment of ITS substantially changes our transportation system. These changes concern several elements and stakeholders of mobility, e.g. infrastructure, technology, users, providers, public institutions, or regulatory frameworks. Up to now, research on ITS strongly focused on technical aspects, i.e. technical development and feasibility. However, these aspects can only represent part of a comprehensive analysis of ITS. This dissertation gives systematic analysis of elements that in the end have a strong impact on the successful market introduction of ITS. It discusses different aspects of intelligent transportation systems providing a view on the framework conditions for intelligent transportation systems. This work, hereby, focuses on passenger transportation. It shows that the successful deployment of ITS requires multiple actors. Each of them can positively or negatively influence the success of ITS-deployment. This work specifically analyses the investment decisions of public authorities on the example of socio-economic cost-benefit analysis, the users’ willingness to accept a multimodal information and ticketing system and its impact on modal choice, and finally the municipalities’ role in providing mobility for specific user groups on the example of immigrants showing the potential and limitations of ITS. The work picks up research questions that have not been addressed before and contributes to a deeper understanding of the interplay of ITS as a technology and the society.
1 Introduction, Motivation and the Future of Transportation

1.1 Overview

The history of transportation is impressive. Since the beginning of human history, mobility has always been there. Moving forward meant to hunt, find nutrition and survive. When people started to settle and build houses around 10,000 years ago, mobility did not lose relevance. However, for many thousand years, mobility was limited to walking. Then, invention cycles became quicker. People invented options for transporting goods, such as ledges. They used animals, for instance, donkeys or horses, for transporting goods but also moving. The invention of the wheel revolutionised land transport as it opened new modes of transport, such as carriages. However, not only by land but also by sea, people moved forward. Shipping allowed discovering other continents. Only in 1817, the bicycle was invented and only few years later, in 1825 the first railway that was also used for person transport was inaugurated. In 1886, the first motorised car disrupted the market. These inventions made mobility possible, led to an increase in speed, fewer need for muscular strength and fitness and the possibility to cover long distances without horses. However, these inventions were not showered with enthusiasm but with scepticism and fear. Some doctors assumed that the enormous railway speed, still less than 30 km/h, had a negative impact on people’s health, such as brain diseases or pneumonia. Even Gottlieb Daimler is said to have underestimated the potential of cars stating that the worldwide demand for cars would not exceed one million due to an insufficient number of chauffeurs. He could not have been more wrong. Invention proceeded. In 1914, the first passenger aircraft left the ground. After water and land, the last medium of transport, air, was explored. Since then, transportation has underwent many innovations. Transportation gained efficiency, speed, and comfort and transport capacity.

Today, transportation is a central element of a society’s welfare in terms of economic, political and social success. It creates jobs, allows international cooperation between firms and countries, contributes to firms’ productivity, and enables social participation and interaction. It has become an essential intermediate. Consequently, changes in transportation affect many more sectors. Therefore, transportation of goods and persons has been growing immensely within the past decades. Both, passenger and freight transport have increased by 28% from 1995 to 2016 (transport volume measured in passenger or ton kilometres) (European Commission, 2018b). Innovation in transport keeps going – partially industry-driven, partially policy-driven. However, innovation in transport has become more urgent than ever. It is not only luxury on the way to more profit. It has become a necessity for the transport sector itself, a topic of competitiveness of economies and politics, and a question of liveability and social equality for society, cities and municipalities.
Transportation as it has developed, has reached its limits: Vehicles overwhelm the infrastructure. Roads but also railways approximate their capacity limits. This leads to traffic congestion, accidents, pollution, delays, and susceptibility to failure. Similarly, external factors request transport to change, such as climate change or limited access to fossil fuels. New infrastructure that expands today’s capacities and alternative propulsion are important decisions and investments to be made and will be important element towards a future, sustainable, and resilient transportation system. However, innovation in transportation goes far beyond these aspects. Digitalisation has become a further important element. So called intelligent transportation systems (ITS) gain importance in improving and changing transport. Cooperative and automated driving, intelligent traffic management, multimodal information systems, and real-time travel and traffic information are examples of intelligent transportation systems. The first years of the development of ITS were characterised by a technological perspective. The question of what was technologically thinkable and feasible and how it could be developed was in the focus of attention. By the beginning of this dissertation in 2014, however, the transport sector, but also research and politics started to realise that technological feasibility was no guarantee for a technology to succeed. A multi- or even interdisciplinary perspective became necessary. A new need for research emerged. Against this background, this dissertation was written. It discusses different aspects of intelligent transportation systems providing an interdisciplinary view on the framework conditions for intelligent transportation systems. This work, hereby, focuses on passenger transportation.

Section 1 is an introductory section. It aims at providing a general understanding for intelligent transportation systems and picking up the reader with recent results on ITS-development and helps the reader to locate the following article in the general ITS-research. This section detaches from the typical article format and content to embed the singular topics in a wider framework of research and research questions. With this section, I want to give the reader the chance to understand the function, importance and role of intelligent transportation systems in the context of our modern society and independent from the reader’s disciplinary background. This synopsis is, therefore, the frame for creating a book, which is the outcome of this dissertation, and still appreciating the contribution of each of the single articles to the current research.

As this is an economic dissertation on a technological topic, an introduction to technical aspects helps for the overall understanding. Section 1 starts with a categorisation of functionalities of intelligent transportation systems that show the variety of the technologies. Functional areas are created that cover the status of research and development of ITS. The chapter does not aim at a comprehensive overview of all applications and functions but helps to understand how ITS is composed. This understanding later helps to locate the analysed technologies and results of the article in the overall market. The next chapter shows the most relevant actors in ITS-deployment and their role in deploying ITS. This actor perspective spans the frame for the later articles as each of the articles
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represents the perspective of a selection of these actors. Due to the multiplicity, the articles do not cover all perspectives. In the next steps, the motivational background of this work is shown. Additionally, the structure and a short overview of the article results of the later sections are given. Implications for ITS-implementation are derived. It is also worth looking left and right. Thus, developments that recently influence transportation are highlighted. It is not all about digitalisation. Therefore, a chapter shows what is done to make our transportation not just intelligent but also sustainable, smart and efficient.

1.2 Understanding the Scope of Intelligent Transportation Systems (ITS) – A Categorisation

Intelligent Transportation Systems (ITS) by definition cover a broad range of technology. Generally speaking, ITS is defined as the integration of information and communication technology (ICT) into transportation (e.g. Dimitrakopoulos & Demestichas, 2010; European Commission, 2010; Faouzi, Leung, & Kurian, 2011). Erroneously, ITS is often associated with road transport applications. However, this is only on field of application. Nowadays, ITS is applied for maritime transport and inland navigation (sea), such as for vessel management, or for air transport, for instance for optimising flights. However, also land transport is much more diverse than just road. Many applications can be found that also cover rail or public transport. In addition, the interfaces between the transport modes are subject to ITS-applications. Prominent examples for ITS-applications are real-time traffic information provision, situation-oriented routing or intelligent traffic light management as well as real-time information for multimodal travellers. However, this variety and complexity makes it difficult to clearly define and operationalise the term ITS.

The European Commission (2018c) divides applications according mainly mode into six categories: cooperative, connected and automated mobility, road, rail, maritime and inland navigation, air, and multimodal journey planners. As cooperative, connected and automated mobility (also called Cooperative Intelligent Transportation Systems (C-ITS)), the European Commission describes technologies that enable road users, traffic managers and traffic management systems to transfer data and communicate in order to coordinate their actions. These technologies are expected to optimise drivers’ decisions and enable a smooth and efficient traffic situation. ITS-applications in the area road include traveller information (static, real-time, pre- and on-trip) that is communicated via navigation devices, smartphones or signs, for example. It also includes traffic management services, such as section control or dynamic construction site navigation. Importantly, traffic management also connects different road users, especially car and public transport. Further sub-categories of ITS in road transport are electronic pricing and payment, freight and logistics (e.g. tracking of trucks, fleet management), vehicle safety systems and ICT-infrastructure (e.g. satellite navigation systems or traffic monitoring systems). Rail-related ITS-applications equally cover passenger and freight
transport before, during and after the trip (e.g. safety systems, real-time information, reservation systems or payment processes). Maritime and inland navigation refers to fleet management and traffic management on the water. Air-related ITS-applications focus on control infrastructure and traffic management. With the last element, the multimodal journey planner, the European Commission takes a mode-connecting perspective. It refers to the provision of door-to-door traveller information promoting seamless travelling on intermodal transport chains (European Commission, 2018c).

A further taxonomy is the categorisation according six functional areas. In some parts, they overlap with the European Commission categories but also add further perspectives: advanced traffic management systems, advanced traveller information systems, advanced vehicle control systems, commercial vehicle operations, advanced public transportation systems, and advanced rural transportation systems (Adler & Blue, 1998; Figueiredo, Jesus, Machado, Ferreira, & Carvalho, 2001; Martínez-Torres, Díaz-Fernández, Toral, & Barrero, 2011; Sussman, 2005).

Furthermore, it is possible to classify according their strategic goal. Each ITS-application aims at least at one of the following goals: increase of transport efficiency, improvement of traffic safety, and reduction of transportation’s impact on environment as well as different value-added services that for instance provide comfort or reliability for travellers (Dimitrakopoulos & Demestichas, 2010; European Commission, 2010; Schlingensiepen, Nemtanu, Mehmoood, & McCluskey, 2016; U.S. Department of Transportation [U.S. DOT], 2016).

All of these categorisations have strengths and weaknesses. The categorisation of the European Commission is relatively generic and requires sub-categories and examples to actually define ITS. The second way of categorisation is significantly more specific as it tackles functionalities. However, this categorisation does not cover ITS as it has developed today. The categorisation has a strong focus on information provision. However, today, intelligent services go further. For bringing categorisation up to date to the state of the art at the year of finalisation of this dissertation, existing categorisations are combined and expanded in this dissertation by current state of research and development. Five functional areas are identified in the following paragraphs. For this categorisation, the mode of transport is subordinate. It only follows function and proves the multimodal applicability of ITS. In addition, the new categorisation considers that ITS nowadays goes beyond information provision and services are much more comprehensive, such as parking support or ticketing systems. In the following paragraph, five categories of modern ITS based on the current state of research and development are presented:
**Category 1:**
The category *intelligent traffic management systems* is applicable for all modes of transport: water, air, land. This category describes applications aiming at an improved traffic flow. Real-time data collection and provision have a central role as this allows situation-based traffic control, such as in case of congestion. Intelligent traffic management uses ICT to collect the necessary real-time data on the traffic situation and return it to the transport users. In road transport, different output mediums are possible, such as dynamic signs, light signal systems, mobile phones or navigation systems. Data collection can be conducted via mobile phone data, cameras, localisation devices, for example. Traffic management for all modes aims at improving efficiency and optimising infrastructure usage. It can include navigation and routing of vehicles as well as of travellers or passenger flows. It covers freight as well as passenger transport. Examples of applications are traffic light control (e.g. Salama, Ahmed, S., Saleh, Bahaa, K., & Eassa, Mohamad, M., 2010), congestion avoidance (e.g. Leontiadis et al., 2011), decision support systems for busy railways (e.g. Corman, D’Ariano, Pacciarelli, & Pranzo, 2012; Corman, D’Ariano, Pacciarelli, & Pranzo, 2014) or train schedule adaptions in case of incidents and delays (e.g. Corman et al., 2012, 2012).

**Category 2:**
*Intelligent multimodal systems* is the further development of the often-used category of advanced traveller information systems. Originally, this category described real-time information provision to travellers to make better-informed decisions. This information can be displayed in the car, at home or somewhere else. These systems are supposed to provide travellers (by car, public transport or any other mode) with information before and on the trip that helps them to optimise the modal choice or route choice. Many different services have developed, such as routing and navigation services based on traffic information, for instance routing recommendations by Google Maps that work with mobile phone data. Multimodal journey planners cover different modes and help travellers to make informed modal choices (e.g. Bifulco, Cantarella, Simonelli, & Velonà, 2016; Kramers, 2014; Watkins, Ferris, Borning, Rutherford, & Layton, 2011). However, the connection of modes through ITS have developed beyond information provision, such as usage-based ticketing (“pay mobility as you use”) (e.g. Blythe, 2004; Puhe, Edelmann, & Reichenbach, 2014) or situation-based and user-centred intermodal traveller navigation (Eisenkopf et al., 2014). Further applications are in the progress of development, such as integration of individual e-mobility and public transport (e.g. EcoFev, 2014, EcoFev, 2014). It is remarkable that with ITS-applications the limits between individual and public mobility blur. Applications that belong to this category are generally those that support multimodality among travellers. They support seamless travelling. Multimodality, however, is not only a topic for passenger transport. It can also cover freight. Possible applications are capacity information collection and provision for optimised loading (e.g. Abadi, Ioannou, & Dessouky, 2016), for example.
Category 3:
The category **cooperative intelligent transportation systems (C-ITS)** represents a central element of intelligent transportation systems functionalities. C-ITS expands the vehicles from autonomous stand-alone elements and integrates them in a joint communication-driven system. C-ITS is a further development of current driving assistance systems. Currently, many vehicles are equipped with vehicle control systems, such as collision warning, anti-lock braking systems or hill hold control. Additionally, intervening systems are increasingly deployed in vehicles such as active emergency braking systems or lane keeping systems. With these systems, the vehicle actively reacts to environmental changes. Typical fields of applications are in cars and trucks. It, however, also exists for rail vehicles. Intervening systems, or advanced vehicle control systems, as categorised by Sussman (2005), have a strong focus on improving transport safety. Nowadays, the technological development goes further. It also counts on data transfer and communication between transport users and transport infrastructure. By fostering communication between transport participants (e.g. vehicles, infrastructure elements, traffic management, persons) intelligent transportation systems are transformed towards a cooperative system (C-ITS). In contrast to radar or lidar-based systems, the transport users receive warnings or the vehicle can react before they enter the critical situation, such as emergency vehicle warnings (e.g. Geis & Steindl, 2017; Martinez, Toh, Cano, Calafate, & Manzoni, 2010), green light optimal speed advisory (GLOSA) (e.g. Stahlmann, Möller, Brauer, German, & Eckhoff, 2018), hazard warning or road works warning (e.g. Dolk et al., 2018), or cooperative manoeuvre planning (e.g. During & Lemmer, 2016). C-ITS, furthermore, is not road specific. Applications are also developed for rail. Although, C-ITS is a further development of current advanced vehicle control systems based on local technologies, radar, for instance, C-ITS is not a substitute but rather a complementary technology on the way to efficient, green and safe transport.

Category 4:
**Automation** is a category that is closely linked to C-ITS. Research and technology development has shown that communication between vehicles and infrastructure is a necessary element for automated vehicles. Within the past decade, automation of vehicles on roads and rails has become a focus topic of public discussion. However, it is only possible if reliable data and message transfer between participants is possible. Therefore, development in this functional area is interlinked with the previous category. Nevertheless, automation is more than cooperative transport. It aims at partially or fully releasing vehicle drivers from their driving task and thus reducing accidents or transport inefficiencies due to human mistakes (e.g. Aeberhard et al., 2015; Körber, Gold, Lechner, & Bengler, 2016).
Introduction, Motivation and the Future of Transportation

Category 5: Disposition and fleet optimisation form a further category. Generally, optimising fleets and vehicle disposition is a traditional topic for fleet operators of all kinds of vehicles: cars, trucks, airplanes as well as trains or even ships. This is because an efficient deployment of vehicles can significantly reduce cost. Intelligent transportation systems have recently opened new potentials. The integration of information and communication technology in vehicles allows remote servicing or recognizing repair demand before it becomes visible to the driver. Reparation can therefore be planned. In this case, vehicle and fleet management or fleet disposition exchange data. Also vehicle routing and scheduling can be optimised based on real-time vehicle and traffic information which is specifically important in logistics, for instance (e.g. Bielli, Bielli, & Rossi, 2011; Hu, Chiu, Hsu, & Chang, 2015). Also in the context of police cars, this is an important function and is pursued. Here, ITS has shown the potential to improve police officers safety and reduce the cost of police cars under repair (Geis, 2017a; Geis & Steindl, 2017).

Table 1: Extended Classification of ITS-Functionalities

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<th>Efficiency</th>
<th>Safety</th>
<th>Environment</th>
<th>Comfort</th>
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<td>Traffic management</td>
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<td>Multimodal services</td>
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<tr>
<td>Vehicle control and C-ITS</td>
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<td>Automation</td>
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<td>Disposition/ Fleet optimisation</td>
<td>x</td>
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Source. Own work.

1.3 The Who is Who of ITS – An Actors Analysis of Politics, Groups and Organisations

Intelligent transportation systems’ deployment has become a complex undertaking: clearly, because the technological development is challenging, but also because it requires work and cooperation in many different fields. Research has shown that ITS can develop the maximum of positive effects when it is deployed on a large-scale, i.e. if vehicle-to-x-systems (V2X), for instance, are deployed in a significant proportion of vehicles, or if a multimodal information and ticketing system covers the majority of available mobility providers or if the respective systems are not restricted to small geographical areas but are available countrywide or even internationally. Especially with respect to the regular cross-border transport in Europe, the expected effects of a European deployment are considerable. Thousands and millions of trucks, cars, trains and travellers are daily mobile independent from their country of origin. The chaos would be immense if a truck starting in Germany and being driven to Italy spoke another “language” than the trucks in Austria and Italy, for example. Furthermore, the deployment of ITS (independent from the form of application) requires a number of organisations to cooperate. Connected cars, for example, require a stable and fast transfer of data.
Therefore, mobile network operators are requested to find solutions for providing a quick mobile network. Currently, the discussion on the provision of 5G drives the public debate. For multimodal information and ticketing systems, large-scale mobile networks are important as well – even if not with the same speed as for connected cars. However, in rural areas fast mobile internet is luxury. The provision of mobile internet per se is important and a challenge. Then, if the multimodal information and ticketing was provided internationally, a solution had to be found that mobile internet could be easily accessed in all countries. Regarding this topic, a significant change took place during the development of this work. At the beginning of the writing process of this dissertation, roaming costs impeded accessing mobile internet when being in another European country. Since June 2017, a new legislation of the European Union came into force that eliminated roaming cost.

These examples give an indication of the need for many different actors to be involved in the ITS-deployment. Each actor has different functions to fulfil. All together, they build a complex network of stakeholders and creators of ITS. Relevant actors are located on different levels: national, European/international or politics, industry, public and science. Each country and region is organised and driven differently. However, it is possible to divide actors in categories and explain their role and interest in ITS. Furthermore, all over the world, countries have specific institutions that drive ITS-deployment with different activities. The following sub-sections gives an indication for the most relevant categories of actors and their role for ITS-deployment. It is a generic overview but works with examples from two of the most relevant economies in ITS: the United States and the European Union. The overview helps the reader to get a sense for the multiplicity of strategic goals and interests but also the complexity of the interplay.

1.3.1 Governments, Ministries, Authorities and Supranational Equivalents

Governments all over the world have recognised the deployment of ITS as a declared goal for facing the challenges of modern transportation, such as impact on the environment, traffic inefficiency, accidents and congestion. Governments form transport policy and long-term strategies for countries. Based on these strategies, investment decisions of public authorities but also industry are made. Consequently, for ITS-deployment the role of governments is central as they are in the position to centralise activities and lead them towards the same direction. Governments are the beginning of activity harmonisation. The European Commission developed a number of action plans and directives that help to implement ITS on a European and Member State level. The European Commission has therefore defined six action areas: (1) optimal use of road, traffic and travel data, (2) continuity of traffic and freight management ITS services on European transport corridors and in conurbations, (3) road safety and security, (4) integration of the vehicle into the transport infrastructure, (5) data security and protection and liability issues, and (6) European ITS cooperation and coordination (European Commission, 2008). Each action is concretised with a set of actions. The action plan was later renewed and extended by further documents, such as with the “Roadmap to a
Single European Transport Area – Towards a Competitive and Resource Efficient Transport System” (European Commission, 2011) or the “Directive on the Framework for the Deployment of Intelligent Transport Systems in the Field of Road Transport and for Interfaces with Other Modes of Transport” (European Commission, 2010). Against this background, the EU Member States regularly report their actions on the deployment of ITS and the implementation of the listed action areas. Each of the European Union’s Member States additionally implements strategies on the deployment of ITS that on the one hand sharpen the countries profile and on the other hand foster the implementation of the European strategy. For most of the European countries a national ITS-strategy exists that is usually defined by the respective ministries based on the governments’ guidelines. The United States, for instance, regularly defines a five-year strategy plan for ITS-deployment. The current strategic plan (2015-2019) defines five strategic themes for ITS: (1) enable safer vehicles and roadways, (2) enhance mobility, (3) limit environmental impacts, (4) promote innovation, and (5) support transport system information sharing (U.S. DOT, 2014). With its strategic plan, the government gives a direction for research and development and the strategic priorities for research funding.

By giving direction for and supporting of research and development, governments help to define standards, and harmonise actions. They provide the necessary legislation on data protection or liability, for instance. Furthermore, governments highly push international collaboration for the implementation of ITS (European Commission, 2016).

Governments usually do not act by themselves but delegate strategies and actions to the respective ministries and sub-institutions. Based on the governments’ overall strategy, ministries provide more concrete strategies and plans to implement ITS-actions. Ministries implement research-funding programs or even engage institutions to conduct research and development. The United States Department of Transportation (U.S. DOT), for instance, is subdivided in operating administration institutions per transport mode. Among these, the Federal Highway Administration (FHWA) is highly active in fostering the deployment of ITS according the ministry’s and government’s goals. On a European level, General Direction for Research and Innovation (DG RTD) and for Mobility and Transport (DG Move) strongly drive the European Commission’s specifications. On national levels in Europe, similar organisations to the FHWA can be found that concretely implement the government’s strategies and develop measures and activities to bring together the adequate actors for implementation. In Europe, each country has such an institution, for example the Bundesanstalt für Straßenwesen (BASt)\(^1\) in Germany or the Institut français des sciences et technologies des transports.

\(^1\) In English: Federal Highway Research Institute.
de l’aménagement et des réseaux (IFSTTAR)\(^2\) in France. The European authorities cooperate on a European level under the European National Highway Research Laboratories (FEHRL). On this level of politics, measures that are more concrete can be found for international cooperation. Ministries and similar organisations have increasingly started to emphasise the necessity of international cooperation. They state that resources on research and development can be shared, knowledge be exchanged and above all, harmonisation of activities and standardisation of technical frameworks be fostered. Therefore, the 8\(^{th}\) Framework Programmes on Research and Technological Development (mostly known as Horizon 2020) was opened for third-party countries. For transportation, Horizon 2020 requested cooperation specifically for topics in which interoperability is necessary for a smooth transport system. The U.S. DOT, DG Move and the European Commission, therefore, increasingly implement twinning activities for transportation. Twinning projects are usually separately funded projects (one in the US and one in Europe – mostly a FP-project) that are coherent in scope, objectives and timeline. With these activities, synergies are created and activity harmonisation on the R&D-level is supported. The hope is that this can also support standardisation (Geis, 2018). Similar to the EU-level, activities can be found on national levels. National and supranational ministries or related organisations are usually responsible for research funding programmes and can thus directly influence the direction of research. In cooperation with the government, they bring forward the necessary legislation by bringing in expertise and consulting experts.

1.3.2 Non-Profit-ITS-Societies

Continent- and country-wise non-profit organisations on the deployment of ITS have developed in the past decades. On the continent level, these are: ITS America, ITS Europe (respectively ERTICO\(^3\)), ITS AsiaPacific and ITS Africa. Additionally, there are country associations such as ITS Japan, ITS Australia, ITS Germany, ITS China or ITS España. The network of these organisations is complex and sometimes non-transparent. They are all named similarly and on the first sight, have similar goals but it always must be clear that they are independent organisations without an umbrella organisation. They have in common that they are non-profit organisations targeting the deployment of ITS. Harmonisation of activities, standardisation efforts and lobbying are important activities among all organisations. They, therefore, claim to bring together the relevant ITS-stakeholders of the region they represent. ERTICO, ITS America and AsiaPacific have implemented the ITS World Congress which takes place annually (since 1994). The three institutions bring together around 13,000 representatives from research, politics and industry. ERTICO additionally organises the ITS

\(^2\) In English: French Institute of Science and Technology for Transport, Spatial Planning, Development and Networks.

\(^3\) European Road Transport Telematics Implementation Coordination Organisation-Intelligent Transport Systems & Services Europe.
European Congress every two years. All of the organisations publish white papers and further documents and bring them into politics as statements and consultation documents. The organisations want to support a more efficient, safer and environmental-friendly transport system. With their activities, they create platforms of exchange and cooperation of stakeholder. They thus help to create an attractive environment for ITS-implementation.

1.3.3 Standard Developing Organisations (SDO)
A large-scale deployment of ITS significantly depends on the interoperability of the applied systems. Interoperability is strongly driven by the systems’ ability to communicate with each other. Communication between vehicles of different manufactures and roadside infrastructure must be able in any case. Therefore, standard developing organisations (SDOs) increasingly have a function in ITS that becomes decisive for success. In Europe, the most important European standardisation organisations for ITS are the European Telecommunications Standards Institute (ETSI) and the European Committee for Standardization (CEN). Both organisations define standards in technical groups and work together with further international organisations (Festag, 2014). Standardisation of ITS covers all kinds of applications in road, rail, maritime or air transport. On an international level, the Institute of Electrical and Electronics Engineers (IEEE) and the International Organization for Standardization (ISO) are important for ITS. It is important to know that the standards suggested by ETSI and similar organisations are not directly binding. Only legal requirements or the industry’s decisions to work with the SDO’s specification transform it to a large-scale applied standard. There are several organisations and actors that drive standardisation efforts, such as ERTICO, further ITS-Societies or interest groups of the transport sector (e.g. the Car2Car-Communication Consortium (C2C-CC) (Car2Car-Communication Consortium, 2018)).

1.3.4 Transportation Stakeholder Groups and Lobbying
Generally, lobbying and interest groups play an important role for politics. Only in the EU, 11,327 organisations are registered for lobbying. The EU does currently not provide sector-based statistics on lobbying. However, a number of transport related companies can be found already at the beginning of the list, such as IDIADA Automotive Technology, S.A. with a budget of € 2.8 million, Volkswagen AG with € 2.7 million and the Verband der Automobilindustrie\(^4\) (VDA) with € 2.5 million (Integrity Watch, 2017). In the US, the top lobbyist in the transport sector currently is United Parcel Services (UPS) with lobby expenses of $ 2.5 million. Among the transport industries, air transport leads the list of the top spenders with $ 69 million, followed by the automotive industry with $ 52 million (OpenSecrets, 2018). Lobbying in the US and the EU works differently. However, in both cases it must be acknowledged that interest representation is an important topic. Therefore, actors

\(^4\) In English: Automotive Industry Association.
send their lobbyists to the relevant capitals in order to represent their interests. Companies, hereby, often represent themselves. Additionally, interest groups as a merger of many companies exert influence. For ITS, the list of groups is long. Some of them have already been named, such as the ITS-societies. There are also industry-specific groups, such as the European Automobile Manufacturers Association (ACEA), the Union des Industries Ferroviaires Européennes (UNIFE) or International Air Transport Association (IATA). Depending on the industry they represent, they have different activities. Nevertheless, transport interest groups all have in mind to support efficiency and optimisation in their industry. ITS is therefore an important topic. Nevertheless, the most active interest groups in ITS currently come from the automotive industry. They have the most visible statements to foster ITS. Generally, their role is to harmonise industry actions, foster exchange and bring forward implementation. They influence legislations with written statements, for instance, that make their opinion and suggestions visible. In Europe, a noteworthy stakeholder group specifically for C-ITS is the Amsterdam Group that works on the harmonisation of C-ITS activities of road operators and infrastructure providers. They are an influential group as they connect transport operators, SDOs and suppliers with the goal to implement C-ITS. C-Roads is also to be named as a platform that integrates eight EU-Member States and the respective road operators. In technical groups, they work on the harmonisation of activities and bring out pilot activities (C-Roads, 2018).

1.3.5 Technical Testing Organisations

Next, it may not be forgotten that systems and vehicles coming into the market have to pass strict tests and assessments before they are permitted for usage in transport. They are tested for reliability and safety, for instance. Technical testing organisations therefore increasingly develop methods to test new ITS-applications not just before they are deployed on the market but also to verify and certify them when they are already in use (see for instance vehicles that have to undergo regular roadworthiness tests). The testing procedure, however, varies already between the European countries and variance is added when comparing further countries. Only within the country of the United States, there are diverse regulations for vehicle testing that differs between the states. Nevertheless, these organisations worldwide are involved in the deployment of ITS as they bring in the expertise to certify and assess the impact on transport or traffic safety. For each system or vehicle, testing, assessment and certification must be developed. In Germany, these organisations are, for instance, the TÜV-Group (Technical Supervision Association) or DEKRA. On an international level, the International Motor Vehicle Inspection Committee (CITA) is noteworthy. However, testing organisations, such as the TÜV-Group are also internationally relevant. Generally, they ensure the functioning, safety and worthiness of the respective systems and vehicles. This in turn means for all R&D-conducting organisations to stay in close contact with these organisations.
1.3.6 Mobility Data Platforms and Related Organisations
Deploying intelligent transportation systems requires connecting and interlinking vehicles, infrastructure, and travellers or drivers. A reliable and secure access to data is therefore central for deploying ITS. Several technological solutions have developed around the topic of data exchange. They all face similar challenges: data must follow certain standards and interfaces must be accessible for the involved actors. To support the European-wide deployment of ITS, the European Commission has recommended its Member States to implement so-called National Access Points (NAPs) (European Commission, 2018d) referring to the DIRECTIVE 2010/40/EU which requests improved access to transport data (European Commission, 2010). The EC does not oblige the Member States to implement NAPs in a specific way. It must only be an access to national transport data with facilitated access, exchange options and possibilities to reuse these data. It can, for example be a database, a data warehouse, a storage or any other solution as long as it provides one single interface to national transport data. Four types of data must be available: multimodal travel information services (MMTIS), real-time traffic information (RTTI), safety-related traffic information (SRTI), and safe and secure truck parking data (SSTP). For all these types of data, the EC recommends a NAP. For SSTP-data, an additional EU-access point is requested. In European countries, these NAPs are not yet fully developed. Austria and Germany are the only two countries that have implemented NAPs that cover all types of data and have the EU-access point for SSTP.5 These NAPs are usually operated by a public authority or a private company on behalf of a ministry or public authority. In Germany, the NAP is operated by the Federal Highway Research Institute, for instance, and is called Mobilitätsdatenmarktplatz (MDM)6. Further initiatives on technological solutions for mobility data platforms are developed. These platforms play such a central role in the context of ITS that it is worth or even necessary to list them as an actor. Platforms bundle many data sources behind one interface and thus actually enable large-scale deployment. Although these platforms do mostly not offer ITS-applications themselves, their service is the basis for ITS. Still, ITS-applications can derive data from different sources and integrate different interfaces. Central access points facilitate applications in a way that they are multiplicator and accelerator for ITS-deployment. However, platforms can only be as good and helpful as the integrated data. A comprehensive analysis of mobility data and data platforms is, however, a topic of the extent of another dissertation.

1.3.7 Science Organisations
Research and development in ITS is strongly driven and conducted by industry. ITS has become a competitiveness factor for companies. Nevertheless, the topic is far too complex to work without

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5 The current status of NAP-implementation can be found on the website of the European Commission on National Access Points under: European Commission (2018d).
6 In English: Mobility Data Marketplace.
external help. Additionally, research-funding bodies, such as governments have notified the need for open systems and innovation and therefore put a lot of effort and money in research institutes and universities. Apart from the concrete work, numerous excellent researchers do worldwide, research also gathers in groups and science organisations that in turn closely work with legislation and strategy-giving institutions. With this channel, research can make sure that their results are noticed by politics, industry, and the other way around. The European Conference of Transportation Research Institutes (ECTRI), for instance, is the mouthpiece for 28 European transport research institutes that brings together multimodal competences on transport in general and supporting the EU-transport policy, thus also working on ITS. The Transport Research Board of the US National Academy of Science (TRB) is another example of a science organisation and aims at promoting innovation in transport. It, therefore, closely works with the government and its ministries and similar to ECTRI aims at supporting transport policy. Both organisations also support cooperation between research and industry and additionally foster international cooperation (Geis, 2018).

1.3.8 Original Equipment Manufacturers (OEMs) and Mobility Providers

Then, besides all the framework-giving institutions (legally, technically, or organisationally) there are those actors that actually implement ITS for the customer. These are original equipment manufacturers (OEMs) or mobility providers, such as public transport providers, airlines, bus operators, bike-sharers, car-sharers and many more. This category is highly diverse (as diverse as mobility offers). However, all of them work on ITS, even though with different applications and foci. These institutions are drivers of research and development as well as implementers. Due to the immense self-interest of opening new markets, remaining or building competitiveness, increasing efficiency and strategic advantages of their specific mobility offer in times of changing needs and conditions, these actors are highly active. Two direction can be identified: (1) mode-specific ITS-applications working on safety, efficiency and or environmental impact, and (2) multimodal applications working for increased traveller comfort, improved planning and synchronisation of different modes (or providers), facilitated access to modes, for instance. Due to their heavy self-interest and self-motivation they mobilise immense financial and personal resources for technically developing ITS, cooperating with the necessary actors, developing business models and attractive offers for users. It is striking that the borders between OEM and mobility provider are blurring. OEMs consider providing mobility additionally to or instead of vehicles only.

1.3.9 Mobile Network Operators and Further Suppliers

Mobility providers and OEMs, however, cannot work on their own. They can develop and provide part of the technology. Nevertheless, they are dependent on suppliers. One central supplier are mobile network operators as they actually provide the basis for some ITS-technologies, the communication network. For C-ITS or automated driving, it is the medium of data transmission with a minimum of time lags; for multimodal information services it is the medium that mobility providers can transmit
real-time information on the traffic and transport situation and that the final users can receive this information. Reliable and comprehensive mobile networks are the core for many ITS-applications of any nature. Suppliers can also be hardware suppliers for roadside stations, sensors, chips and all the technology that is not build by OEMs. It is striking that these suppliers for ITS also come from the typical automotive supplier that previously built motors, gears or any other part of vehicles but as well from new players that up to now had nothing to do with transport or mobility, such as Google or start-ups. This category of actors provides important services or technologies that have a complementary function to the actual mobility provision. They usually have business relations and cooperation with mobility providers and OEMs and jointly develop ITS. Additionally, a complex system between providers, suppliers and further actors develops. However, often, suppliers lack a profitable business case for component provision. For these cases, models are still to be developed (CONVERGE, 2013).

1.3.10 Municipalities and Cities – The Applicants
After having comprehensively discussed actors on the provision side, implementers have to be taken into account as well. Within the past years, municipalities and cities have increasingly developed a need for more efficient transport systems. ITS herein is a glimmer of hope for distributing public transport and individual transport more efficiently and thus relieve urban transport systems. Municipalities increasingly implement ITS in cooperation with providers and suppliers. Düsseldorf in Germany, for instance, develops a test field for automated driving. London, England, strengthens public transport with multimodal traveller information and easy ticketing. The Rhine-Main region, Germany, currently tests demand-based ticketing based on a digital tap-in-tap-out system. The prioritisation of public transport, intelligent traffic management or situation-based traffic light controls are further important fields of application. However, this requires costly investment in infrastructure and internal structures. Municipalities have a need to apply ITS but underlies the restrictions of public institutions, such as little financial resources, certain decision-cycles, and many stakeholders to involve. This is why municipalities and cities are an important implementer but also an actor that can influence harmonisation efforts. Due to their role, they also have a policy component and can thus influence strategies at least for their regions. They usually do not conduct research themselves but are often involved in research projects and thus contribute significantly.

1.3.11 The Users
Finally, there are the users themselves – the people that want or have to be mobile by car, public transport, train, bus, airplane, or any other mode. This category is different from the other categories as they are not an institution or organisation. Nevertheless, they are the users and their acceptance finally decides about failure and success. This means even if all the necessary steps beforehand were taken successfully (e.g. technical development, legal framework, large-scale deployment, attractive business models), the users can let ITS fail. They can make it fail because of scepticism towards the
application, because of misuse or wrong usage or because they simply do not see the advantage of doing things differently and integrating ITS in their behaviour. Consequently, previously listed actors must consider the users’ perspective. It is said that users are changing – that they have new mobility needs. In short, it must be admitted that users today are extremely diverse in age, cultural background, socialisation, residential environment, income, or mobility preferences. This group does not have an active function for the deployment of ITS but is the final success barrier.

1.3.12 Overview of Institutions and Functions

The above listed actors all together strongly influence the deployment of ITS – all with different interests and scopes of actions. However, as the following summary shows, they all have a function and entitlement in the deployment. It must be clear that there are national difference. Still, these categories summarise the most relevant actors. When reading the table, it must be kept in mind that some of the actors drive a certain function and actively conduct it. Others rather support this function. These actors can also be found in the later articles of this dissertation as actors to be considered.

Table 2: Actors of ITS-Deployment Based on the Previous Descriptions

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<th>Actor</th>
<th>Function</th>
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Source: Own work.
1.4 Motivation – Bringing together Perspectives

This dissertation is threefold motivated: (1) by the need for interdisciplinary research, (2) the complexity of ITS-deployment due to the multiplicity of involved actors and (3) challenges of modern transportation.

1.4.1 The Need for Interdisciplinarity

First of all, research on intelligent transportation systems was long an engineering territory where other disciplines, such as psychology, social science or economics, only had a minor role. Industry (OEMs as well as suppliers) worked on innovations and inventions to integrate information and communication technology in the transportation system. Many European but also international research projects worked on modifications and further developments. There was enough to do before it was possible even to think of letting respective technologies enter the market. This approach was indirectly supported by research funding institutions, The European Commission with its Framework Programmes for Research and Technological Development since 1984, for instance, long mainly addressed technological questions and supported technological developments. There was enough to do and enough technological challenges to be taken. However, after many years of technological invention and refinement the question appeared: How can we bring the technologies into the market? What would the effects on society be? Would there be users? How can applications be financed? It was realised that technological perfection alone is not enough. It must consider the user. As a consequence, user-centred designs and the interaction of users with ITS gained importance. Furthermore, ITS-application can mostly not be implemented by one actor. It requires infrastructure, software, hardware, transport providers (e.g. OEMs, public transport, etc.) and the public. All these actors have to work together – they have to cooperate. Lacks of standards were one issue, but also rules for cooperation. Therefore, research projects partially started to incorporate and emphasise further disciplines: The EU-project DRIVE C2X, for instance, contained an analysis of potential business models for ITS-applications and included an economic analysis of costs and benefits as well as interactions with further mobility trends, such as mobility as a service and the joint impact on mobility behaviour. Similar developments can be found in many other relevant ITS-projects, for instance: In CONVERGE the so-called institutional role model was developed. It is a system for distributing economic responsibilities and benefits among the participating partners (CONVERGE, 2013). In simTD a comprehensive socio-economic analysis of ITS-deployment was conducted (Schulz, Joisten, & Mainka, 2013). The project All Ways Travelling is a detailed analysis of the economic, legal and technical aspects of an ITS-application (Eisenkopf et al., 2014).

However, not only the implementing and research-conducting actors underwent a change in perception. In addition, research-funding institutions increasingly emphasise the need for interdisciplinarity: With Horizon 2020, the European Commission set up its 8th Framework
Programme for Research and Technological Development (lasting from 2014 to 2020) with the largest transnational research-funding budget (€ 70 billion). This research programme wrote history in terms of budget but also with a new focus for research in a programme dedicated to technology development: The EC put significant focus on ‘social science and humanities’. Thus, it acknowledged the interplay of technology, society and markets for the success and sustainability of the European economy. It stated that societal challenges, such as climate change or an economy’s competitiveness had to be solved by a cross-disciplinary approach. Research projects funded in this programme mostly have to take into account minimum market deployment aspects, often business models, economic evaluation and/or stakeholder analyses but also impact on society or behaviour (depending on the topic). For transportation projects, the EC emphasises the need for socio-economic analyses and studies with prognoses on future transport developments. This has been path breaking for research and technology development in all sectors. This dissertation takes up this new demand for interdisciplinary research. It examines intelligent transportation systems from an economic perspective including different facets: socio-economic, behavioural economics and political economics and public organisation. This work adapts economic methodologies to the needs and specifications of intelligent transportation research, on the one hand, and sheds light to different economic aspects of ITS including theory from related disciplines, such as social science, psychology and research on public institutions, on the other hand. The dissertation, thus, sets a profound basis for further interdisciplinary research and generates interdisciplinary results at the same time.

1.4.2 Different Actors, Different Interests – The Need for Cooperation, the Need for Discussion

The second motivation for this dissertation arises from the multiplicity of actors that are and have to be involved in ITS-deployment. Chapter 1.3 has shown that the number of stakeholders and relevant actors in ITS-deployment is huge. There are so many interests to be considered and so many roles to be fulfilled. Chapter 1.3 pointed out interest groups and institutional categories of actors. If the concrete implementation and deployment is analysed, from these categories of actors sub-categories have to be derived: For a multimodal information and ticketing service (as explained in chapter 3): platform provider, mobile network providers, mobility providers (of different modes and regions), maybe map service and traffic data providers are required, for instance. For the deployment of C-ITS other actors become important: Mobile network providers receive a central role. Then there are OEMs that build and equip vehicles. Suppliers that provide additional hardware for vehicles but also equip infrastructure. Road authorities or cities have to be considered that finally operate the system and at least have to do the investment. Each of these actors have own interests, such as profit maximisation, strengthening competitiveness, improving traffic quality and efficiency, savings of public financial resources and providing mobility, for instance. Interests can be congruent but also contradictory. A traditional approach for analysing diverging interests is the stakeholder analysis that
reveals roles, relationships and influence on a certain project. From the number of involved actors and division of labour, the need for cooperation between various stakeholders arises. Specifically, cooperation between different providers is necessary that can be competitors. Additionally, business case or interest strengthening arguments (such as improving the competitive position) for each of the involved actors is necessary. The relatively new theory of the institutional role model develops a role and profit distribution mechanism that makes ITS-deployment to an attractive activity for all involved players instead of following a “the winner takes it all”-approach (Schulz, Wieker, & Arnegger, 2019). This model picks up the complexity of diverging interests, especially for specific ITS-applications. For substantiated statements on the framework conditions for ITS-deployment it is, therefore, important to adopt the perspectives of different actors or on a more aggregated level: categories of actors. Looking through the eyes of different actors helps to understand their motives. This, in turn, allows deriving strategies and measures in the process of ITS-deployment that incorporate these motives and overcome potential resulting barriers from these motives. This dissertation picks three perspectives: (1) the government, ministries and related institutions, (2) the users, and (3) municipalities and local authorities. For each of them, recommendations and strategies are developed to incorporate their needs and motives in ITS-deployment better.

1.4.3 Transportation Today – The Need for Action

After all this academic motivations and reasons for writing this dissertation, there is one last motivation that is even more striving than everything else: Transportation as it is today faces challenges. Especially conurbations nowadays are stuck in traffic and traveller masses (equally by car and public transport). In 2017, 1.5 million kilometres congestion appeared only on German highways (ADAC, 2018). According the TomTom Traffic Index, 41% of the most congested cities are in the United States. 43 out of 189 cities in the TomTom Traffic Index are European cities. In Germany, the most congested cities are Cologne (average increase in travel time 34%), Hamburg (33%), Munich (30%), Berlin (29%), Frankfurt/Main (28%) and the Ruhr-region west (23%) and east (21%) – increasing tendency (TomTom, 2018). These congestions on roads worldwide lead to efficiency losses, immense emissions and time losses as well as restrictions in quality of life. The European Commission estimated that the annually congestion in Europe costs the EU around 1% of the GDP (European Commission, 2018a). With a GDP of 15,373 billion EUR in 2017 (Eurostat, 2018) this corresponds to 153 billion EUR per year of economic losses only due to congestion. Some studies have shown that a large-scale deployment of ITS, i.e. a broad market introduction, can have noteworthy positive effects on congestion – given that it is an application for road transport or traffic management (Ferreira et al., 2018; Goliás, Yannis, & Antoniou, 2002; van Driel & van Arem, 2010;
Victor, Rothoff, Coelingh, Ödblom, & Burgdorf, (2017). However, it is not just congestion that occupies local and road authorities worldwide. It is also the number of accidents that take place every day all around the world. Only in Germany, almost 400,000 people were injured in traffic accidents in 2017 from which more than 3,000 died (Statistisches Bundesamt, 2018). In the EU-28, 25,000 people died in traffic accidents in 2016. The numbers all over Europe have been declining within the past 10 years and still there are so many fatalities (European Commission, 2018b). Many ITS-applications focus exactly on these applications and aim at increasing traffic safety by supporting the driver during the demanding driving activity.

Not to be forgotten are the impacts of today’s transportation on the environment: First, its impact comes from transport’s dependency on fossil fuels. The transport sector contributes with around 25% to the total greenhouse gas emissions that are said to cause climate change (European Commission, 2018b). Especially in 2017 and 2018, nitrogen oxides determined the public discussion and political strategy. They are especially produced by diesel motors. They can cause health problems for people in areas of high pollution. Besides new forms of propulsion technology, an increase in traffic efficiency and people rather travelling by public transport than by car have become important measures not just in Germany. Therefore, cities, traffic manager and public transport are desperately searching for solutions and strategies that help them to relieve their region from the negative impact of traffic. Making public transport quicker, more reliable and easier to access are approaches (Landeshauptstadt Düsseldorf, 2018). The solutions are still to be found or to be implemented. It requires knowledge, strategies and recommendations for cities to help them through the jungle of ITS-applications to optimise the transport system on a multimodal level. These are not the only reasons why there is a need for action and why the deployment of ITS is worth to be fostered. However, these are the most important ones. Additionally, today’s travellers make change increasingly easier as they change in habit and attitude. Several studies have shown that mobility behaviour changes and there is more openness for multimodal mobility behaviour and new forms of mobility, such as sharing or on-demand mobility (Kortum, Schönduwe, Stolte, & Bock, 2016; Nijland & van Meerkerk, 2017; Schaefer, Schmidt, & Knese, 2014). Furthermore, there are more and more people equipped with digital media, such as smartphones, and have a general acceptance for information and communication technology (Strenzke, Geis, & Schulz, 2016). Therefore, if there are generations of travellers willing to be different why not combining the need for action because of negative impacts of transportation with trends that can make change easier. This dissertation strives to make a contribution to smarter transport in the future by showing the potential of ITS but also critically discussing deployment issues from different perspectives and giving recommendations and strategies.
1.5 Thesis Structure and Insights in the Framework Conditions for ITS-Deployment

The previous section has highlighted the need for research not just on technological challenges and achievements of ITS but also and specifically for analysing economic efforts and framework conditions of ITS-deployment. This dissertation therefore picks up economic questions. The thesis includes three research articles on economic questions. The chapters 2, 3 and 4 each contain one of these research articles. Each article is dedicated to a set of research questions and different aspects of the deployment of intelligent transportation. At the beginning of each article, a short background is provided that covers information on the status of the article at the time of the finalisation of the thesis, the authors and if existent further necessary information.

1.5.1 Public Investments – Measuring Costs and Benefits

The first out of the three articles, “Future Role of Cost-Benefit Analysis in Intelligent Transport System-Research”, takes a government and governmental authority perspective. It covers the following research questions: How can the socio-economic cost and benefits of deploying ITS comprehensively be evaluated? How must this evaluation differ from a business profitability analysis? How can cost-benefit-analysis extend current evaluation methods and what are its limitations? How can socio-economic benefits and influence on transportation be evaluated in terms of money, such as comfort gains, efficiency and impact on traffic safety or environment? The article is based on a case analysis. It compares the different approaches of socio-economic evaluation, shows the development along European ITS-research projects, derives limitations, and needs for methodological further development. An in-depth analysis of evaluation results is given for two ITS-projects: simTD and All Ways Travelling. Whereas simTD is a project with automotive application, All Ways Travelling focuses on the deployment of ITS as a multimodal technology. Referring to table 1, simTD developed functions of traffic management and C-ITS, All Ways travelling covered multimodal services.

Background

With the beginning of this thesis in 2014, the European Commission released its new Framework Programme on Research and Technology (Horizon 2020). The EC provided € 70 billion for research projects from which € 6 billion is dedicated to smart and green transport (Geis, 2018). The Commission made clear that innovation is necessary and that it is willing to give support. Nevertheless, it is not done with the research project. If the results of research are to be implemented, even more investments become necessary. Depending on the ITS-application, public investments are necessary, for example for equipping infrastructure with respective communication elements. Especially for traffic management applications for example in urban areas, large investments are expected. Typically, investment decisions are made with an easy calculation: if benefits exceed cost, it is a rentable investment. However, an analysis must be more differentiated. ITS aims at a societal
impact (e.g. reducing accidents or congestion, improving air quality). This is also what has to be considered when making the investment decision in ITS. This was also acknowledged by the European Commission, which is why the EC recommended for projects of the smart, green and integrated transport programme to include socio-economic analyses that bring out the total cost and benefits of a certain technology. With this recommendation, socio-economic analyses gained new attention and above all importance. The idea of assessing socio-economic costs and benefits of an investment itself was not new. There is a long history of methodological developments. However, up to then many different methods of measuring societal effects varied and were hardly comparable.

**Results**

This is why Wolfgang H. Schulz and I decided to shed light onto this topic and elaborate the current situation of socio-economic impact assessment in ITS-research and from this derive needs for action for a valid socio-economic assessment. Our analysis points out that a socio-economic impact assessment does not substitute business case analysis or business-individual investment decisions. We show that for a long time socio-economic impacts were discussed but only sporadically measured. Based on a case study of historic ITS-projects (going back to the 1990), we revealed that there have been several attempts to include socio-economic costs and benefits. However, assessments often lacked a solid database or an adaption of the methodology (of impact assessment) to the needs of the technology (ITS). Consequently, we decided to create a profound methodological basis for the reader and deeply introduced a quantitative and systematic approach of impact assessment: the socio-economic cost-benefit analysis (CBA). We explained the calculation of the so-called CBA-ratio that is the central indicator of this methodology as it reveals on one sight how costs and benefits are related. With a literature review, we revealed that this approach has proven its validity for a number of technologies and large-scale investments, such as IT-investments or medical expansion investments but also in transport related investment decisions, a congestion charging system, for instance. The literature review showed that the CBA is generally assessed as objective and comprehensive. We thus decided narrowing our focus and deeply analysing approaches of CBA in ITS-research. The deeper analysis of two projects exposed that it is strictly necessary to work with scenarios in the CBA to satisfy the fact that it is uncertain how future develops. On the cost-side, the projects accounted investment costs for infrastructure or vehicle equipment, for instance. On the benefit-side effects on traffic safety\(^8\), congestion\(^9\) or reduction of emissions were first quantified and then monetarized with equivalents in Euros. Sometimes, the listed effects were only indirect effects (because of modal change, for instance). The results of the projects both showed that benefits noteworthy increase with the deployment rate. It is also striking that although higher deployment

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\(^8\) Measured in changes in injured persons or fatalities.

\(^9\) Measured in time losses that lead to productivity losses.
rates also lead to higher absolute cost, the probability that benefits exceed cost increases with the rising deployment rate. As deployment rates, however, are highly speculative the projects worked with worst, medium and best case scenarios. We also discussed the challenges and difficulties of CBA and showed that results have to be carefully interpreted as they underlie several restrictions: (1) calculations can only be as good as the input data; (2) different projects meet different assumptions that have to be known when making interpretations; (3) moderating or mediating effects are often not considered; and (4) the CBA is up to now a non-standardised approach, not even for ITS-projects.

**Implications beyond the Article**

The European Commission and further institutions have continuously emphasised the need for impact assessment. Within the past years, a number of transport political projects have come up that were evaluated with CBA as investors (private and public) want to have at least an idea of the impacts of their decision. From this paper, twofold-recommendations for ITS-deployment can be derived. The first type is of methodological nature: As CBA gains importance in political decision-making, a standardisation should be brought forward. Institutions have already started, for instance by providing monetary values. The second type of recommendation is ITS-driven: CBAs emphasise the impact of the deployment rate. They all show positive effects and even more they show that a breakeven point is necessary to make benefits exceed cost. Consequently, if the need for action is urgent (such as for congestion in many urban areas), deployment rates have to be fostered. Governments and public authorities can do this by funding research, investing in the respective infrastructure equipment and fostering industry collaboration. Furthermore, governments must urgently define the framework conditions they can or have to set to make ITS work. A current and prominent example is the introduction of 5G, which is discussed as the necessary condition for highly automated driving. In a nutshell: If the societal benefits are relevant enough, governments and executing institutions need to act to at least make sure that it is not the political or legal frame that impedes deployment.

1.5.2 Does ITS Make a Difference? Measuring the Effects on Mobility Behaviour

The second article “Incentivizing Modal Change—Exploring the Effect of Multimodal Information and Ticketing Systems for Medium and Long Distances in Europe” brings in a psychological and behavioural economic point of view showing the user perspective. It focused on the research questions: Is a multimodal information and ticketing system able to reduce uncertainty and information overload for multimodal travellers? How do the effects differ between frequent and infrequent travellers? Is such a system able to disrupt mobility habits and make travellers rethink their modal choice? How does it influence modal choice of heavy car drivers? The article as one of the first gives indication of the effects of a multimodal ITS-service in advance of the actual deployment of the system. Therefore, a scenario approach was chosen for the methodology that
helped survey respondents to imagine a situation in which their trips are supported by multimodal services.

**Background**
Mobility behaviour is a popular topic in research. It is marked by the fact that it is highly habituated and socialised and therefore difficult to change. These characteristics combined with the fact that the most favourite mode of transport is the car, has led to immense problems on streets worldwide. Thus, researchers, politicians, transport planners and many more have been desperately seeking for possibilities to make people rethink their modal choice. Providing travellers with information, routing and facilitated ticketing is one of the ITS-solutions. The European Commission has set the implementation of a multimodal information and ticketing system as a strategic goal but also other governments and institutions. Now, in the year 2018, the topic has not lost importance. It is still as relevant as in 2014/2015 when the article was developed, as there is a strong need for changes in the modal split towards more environmental-friendly and less space-consuming modes. Urban areas and highways are still congested with traffic. Furthermore in Europe, but specifically strong in Germany, metropolitan regions cannot fulfil official standards for emissions. Since 2017, Germany therefore discusses green zones in city centres to which diesel vehicles have not access. Additionally, multimodal information and ticketing systems are developed and stepwise implemented on local levels for triggering a modal change and reducing car use. However, as emphasised in the previous article: Benefits of ITS-solutions increase with the deployment rate. The European Union therefore has the goal of implementing a European-wide system. This goal also gave the starting point for the second article, which uses data collected in a European project on a multimodal information and ticketing system focusing on medium and long distances. However, in the project data were mainly used descriptively. No inductive analysis was conducted. Furthermore, up to then research put little attention to the question whether providing such a system, which requires relatively high efforts in coordination and organisation, would actually make a difference.

**Results**
We, Wolfgang H. Schulz and I, therefore decided to ask exactly this question. Based on a dataset from six European countries, we evaluated first whether travellers were willing to accept such a system and second how it would change their modal choice. We therefore reviewed the theoretical background and found relevant indicators that a multimodal information and ticketing system could have an effect. The literature review revealed that modal choice is driven by comfort. People who prefer car do this because they perceive multi- and intermodal travelling as complicated and because they often feel uncertain. Studies showed that heavy car drivers often feel so uncertain that they even prefer the car when it is obviously more expensive or takes longer. A multimodal information and ticketing system hooks in at exactly this point. By providing the traveller with pre- and on-trip information it offers support when planning a trip or in case of unexpected disturbances or individual
changes. An integrated ticketing system could help especially the unexperienced traveller or those who are not familiar with the region and the local fare system finding the right ticket. Even more: It books the right ticket for the intermodal journey. So far the theory. Our results showed that travellers have a significant willingness to accept and use the system (measured based on an extended Technology Acceptance Model). Nevertheless, we found a difference between light and heavy car users. The more multimodal a traveller’s behaviour already was the higher was the intention to use the system. The striking result however was that heavy car users revealed a high willingness to rethink their modal choice and switch to other modes of transport. The challenge lies in making them use the system. Concisely, this means that a multimodal information and ticketing system is an effective incentive to rethink car use. It, however, requires an incentive that makes them use the system.

**Implications beyond the Article**
There are several implications for the deployment of ITS. First of all: Only because ITS is there and works, it is not necessarily used. Providers of such a multimodal information and ticketing system or any other ITS-application therefore have to rethink the barriers users might have. In the case of a multimodal information and ticketing system, one important factor is that people do not have the need to consider another mode than the car. However, also scepticism towards new technologies can lower acceptance. Digitalisation is not positive in everyone’s eyes. Fear of privacy loss or being substituted by a technology (even if this is not a relevant fear for the respective system), or the fear of loss of self-determination are important factors. All these fears and many more generate user barriers that can significantly disturb a system’s success. These fears (in different manifestation) can meet any ITS-application. Automated driving is, for instance, another important technological development with a huge potential to relieve our transport system from accidents or congestion. However, the slogan “Freude am Fahren”¹⁰ of the BMW Group already expresses one of the core issues. People like to drive although this is sometimes hard to imagine when being stuck in a traffic jam. However, when implementing ITS-solutions it must always be clear that it is for the people and the potential users. Therefore, when designing the systems and when bringing them into the market, this scepticism and fear has to be taken seriously and has to be addressed. Nevertheless, it must also be admitted that younger generations show less signs of scepticism. Therefore, industry, research and politics must address generations differently and help them with different approaches adapting ITS-applications. In a number of decades, it might be the most normal thing to travel intermodally with a multimodal information and ticketing system and take the automated car when it is actually the optimal choice.

¹⁰ In English: The pleasure of driving.
1.5.3 Providing Mobility – How to Face the Challenges as Local Authority

The third article “Foreign Countries, Foreign Customs: An Analysis of Short-Distance Mobility of New Immigrants in the Rhine-Main Region in Germany” leaves the digital world behind and goes back to the roots – to what mobility actually is: a physical act of moving between different locations. The article integrates user and municipality perspective and addresses a topic that became urgent during the years of writing this thesis. It is a topic that was not foreseeable in its importance by the beginning of the dissertation. However, the societal situation changed and so this dissertation addressed the topic as well to make sure this work is not a theoretical work independent from current developments but meets the needs of society. The article addresses the topic of everyday mobility of new immigrants (specifically asylum seekers) in Germany. With the sudden increase of asylum seekers all over Europe especially in 2015 and 2016, public institutions and politics suddenly were confronted with the question of how to integrate a large number of people in our society quickly and efficiently. Mobility plays a central role as it allows social participation, education and work. Many different measures were developed among which digitalisation played an important role. Among others, this article asks the following questions: What does mobility behaviour of recently arrived immigrants look like? How does their mobility behaviour differ and how do they find orientation and are mobile? What can transport politics, municipalities and transport planners do to facilitate mobility for this group of people? What digital but also analogous measures work given strongly restricted resources of public institutions? How can digital applications (e.g. smartphone apps) help? Can they actually help? This article seems to be a bit off-topic. It, however, tackles the most relevant question: Against the background of all our optimisation efforts and digitalisation strategies for transport: How can the physical process of mobility be shaped and is digitalisation in the end rather a nice to have?

**Background**

Since 2014, the immigrant situation changed because all over the world trouble spots developed. People from Africa and the Middle East increasingly were forced to leave their countries because of war, extreme poverty and starvation. Europe became an important destination. This changed a lot in Europe. Whereas politicians on high levels argued on how to handle thousands of new immigrants on one spot, whether to close European borders or not, and which role religious differences make for our society, on a very concrete level integration had to take place – without time to wait for political decisions. Cities and municipalities were confronted with the question how to integrate thousands of people and how to satisfy their basic needs. Housing had to be supplied, educational systems up-scaled and a way to be found to let them participate in our social system without unbalancing it. These were challenges to be faced independently from any political view. The more people came, the more transport planning became a challenge. In discussions, mobility providers reported their difficulties in providing mobility to these new immigrants. They reported from new immigrants having trouble with ticketing systems of public transport and from wild, traffic destabilising cycling
behaviour. Due to the novelty of the topic, there were no studies that could either confirm or disprove whether this were single events or a general problem. Independently from these anecdotes, it however became obvious that municipalities and public transport providers needed support. This is how the idea for this last article emerged. Data for this article were generated in a research project in the Rhine-Main region with the aims (1) to provide a first empirical basis for short-distance mobility behaviour of this new immigrant group and (2) to develop recommendations for public authorities on how to improve mobility provision for new immigrants. This article thus keeps mobility real by showing the potential but also the clear limitations of ITS for solving some of our challenges in transportation planning.

**Results**

With this article as my single-authorship, I decided to take a new and situation-adapted way. As research may not only be generating theoretical results but also taking up urgent problems and challenges of society, I wrote this article. The article is based on a mixed-methods-approach in order to capture the different actors’ views. Focus groups were conducted with experts and representatives of municipalities, local authorities, transport planners and organisations involved in the work with immigrants. An additional short-survey was sent to municipalities in the region to validate the focus group results. Furthermore, the immigrants’ perspective was incorporated with a survey among immigrants. The development of this survey was challenging, as the target group mainly did not speak German or English fluently. Therefore, a survey was developed based on easy German and English with repeating sentence structures and pictures. After several pre-tests, the survey was ready for the field. For the survey, a face-to-face interviews were conducted to help in case of non- or misunderstandings. This also enabled us surveying illiterates. The analysis generated a number of path-breaking results and insights on a user group, research did not know anything at all about. The results showed that language and different mobility cultures impede that they can directly and intuitively be mobile. They often feel overloaded with information and unable to prioritise. It was shown that men are more confident in using public transport than women. Furthermore, differences between urban and suburban areas were identified. The further they live outside, the more they walk and the less they use public transport. This is because local mobility offers, such as busses, do not connect the destinations they need. They stated that paper-based information was the most important source for learning mobility. Only asking other immigrants or counsellors is equivalently important. Although many of them own a mobile phone and can use internet at their accommodation, they did not use it for information on public transport. Also on the organisational side, the results show that paper-based information for immigrants is the main channel. The results also highlighted that there indeed exists a number of measures to support short-distance mobility of immigrants, such as bicycle courses, information material and access to bicycles. Furthermore, it was shown that implementing organisations often work isolated. They cooperate little with other municipalities and only partially
with other organisations which leads to enormous inefficiencies in the organisation of mobility offers.

**Implications beyond the Article**
The article reveals that mobility remains a very analogous problem where digitalisation can only partially help. However, a central finding of the article was that although municipalities provide information on mobility opportunities, immigrants are often unaware of their opportunities that can be ascribed to the information overload they are exposed. Both sides, supply and demand, are overstrained with the language barriers and different mobility cultures. However, municipalities lack financial resources to provide more individualised information. This is where ITS can now start to help even though on a more basic level: smartphone apps for immigrants in their native language or with signs and podcasts or the possibility to let the content read out loud are one element. A reduced multimodal information and ticketing system as smartphone application can bring support and relieve municipalities. Furthermore, ITS-applications for passenger navigation does not only help immigrants but also other foreigners or even the local population. A dynamic signage routing at railway or bus stations can help to reduce uncertainty or the fear to take the wrong bus. As some immigrants also stated that when taking the bus they sometimes lose orientation and do not know when to get off the bus, smartphone applications can help that show them where on the route they currently are. Many more applications are thinkable. Research and public authorities are only at the beginning of the solution development. ITS provides potential that can improve the situation for all.

1.6 It’s NOT All about Digitalisation: A Future-Oriented Transportation System

Now that we are at the end of the introductory chapter and on the transition point to the articles, this is the time to widen the horizon, discuss intelligent transportation systems as one of many elements of a future-oriented transportation system and show open questions. The following articles – each from another perspective – show the potential of ITS. The articles, however, also reveal limitations. Without doubt, ITS is an important element in transportation systems development. It has the potential to improve efficiency (of traffic and travellers), to increase safety of transport and certainty about complex travel chains, to reduce the environmental impact by optimising traffic flows and routing, reducing congestion, or supporting people to reduce their car use. However, the deployment of ITS is at least equally challenging as its technological development. Even more: Technological development and economic aspects are strongly interlinked such that if either of them fails, the deployment of the system risks failing. The dissertation shows that there is still need for action on technological and economic side:

Interoperability and standardisation of ITS-applications of different modes and providers is still an issue. Communication standards and data formats have to be unified. Here, the current state is very diverse depending on the company and the ITS-application. Then, specifically important for C-ITS,
dynamic traffic management (on road and rail) requires quick communication channels which is why the 5G-expansion is an important step. However, current discussions in Germany show that this is not easy. It requires large investments. As this investments, however, are thought to be beneficiary for society as a whole, this brings back the topic of socio-economic cost-benefit analysis and governmental needs for action. Technologically, there is still a lot to develop in terms of accuracy of situation recognition, indoor- and outdoor localisation, data aggregation, data security, artificial intelligence and many more topics. Each application, hereby, has its own specifications and needs for action. The articles show that often cooperation and role distribution is not clear: Who is responsible for which component and how are the total profits distributed? Business cases are still to be developed. Especially in case of multimodal applications, it is mostly unclear how to earn money. Travellers, nowadays, mostly are not willing to pay for such systems because they are used to information provision for free. Therefore, business models have to be developed that allow an efficient business case. Business-to-business-models are equally important as business-to-customer-models. If the charging of travellers is not possible, models such as data-driven models (e.g. provide your data, get the service for free) or advertisement or provision-based models are thinkable. It was shown that the deployment rate significantly influences the benefit of ITS. However, many framework conditions are still to be solved. Data protection is one of the most striking topics because wherever technology is intelligent, data play a role. It has to be analysed whether personalised data are also part of the technology. Data protection is, furthermore, an important topic for users. If they trust the system, their acceptance increases. All these topics are still to be solved, although many conditions have improved during the time of the dissertation: Europe pushed data protection forward and published the General Data Protection Regulation (GDPR), which has to be implemented since May 2018. In 2017, roaming fees for cellular communication were eliminated in Europe. More and more pilot sites and tests of ITS are also open for the public: In Bad Birnbach and Wiesbaden, Germany, for instance, autonomous mini-busses can be tested by the public. In Amsterdam, dynamic traffic management and intelligent combination of travellers in the same mode (ride pooling) is possible, for example. The C-ITS-corridor from Rotterdam over Frankfurt/Main to Vienna demonstrates people the multiplicity of C-ITS-solutions. These is only a small number of examples. There are many more all over Europe and the world. These pilots serve for technological further development but also for bringing people into contact with new technologies. The secure and save environment is created that helps to overcome social scepticism and improve acceptance.

However, we must be clear that with all its meaning and importance ITS is just one element of a future-oriented transport. There is, for instance, no getting around expanding and modernising infrastructure. Rail and road have reached their limits especially in peak hours. Furthermore, infrastructure require modernisation to improve resilience. Alternative propulsion technologies gain attention. Batteries and hydrogen fuel cells are important developments on our way to emission
reduction. It does not matter how efficient transportation is and how many driving optimisation functions are integrated in the vehicles. As long as they emit carbon dioxide or nitrogen oxides and further greenhouse gases, vehicles damage our environment. Almost all OEMs have therefore an electric model in their assortment. Especially for large and heavy vehicles, industry and cities do research on the application of hydrogen. New forms of mobility are also noteworthy, such as all kinds of sharing a vehicle (e.g. cars, bikes, rides). Not to forget: New concepts of vehicles. Besides some cars becoming larger, so-called micro-mobiles are developed. They are electric vehicles that are neither car, nor motorbike nor bicycle but something in between (e.g. segways or hoverboards). They are specifically adequate for short-distances. On the long-distance, concepts such as high-speed trains and the Hyperloop, shape discussions on the future of transport. Each of these developments deserves an own dissertation. However, they also form the framework for ITS. Many of these developments benefit from increasing digitalisation and ITS: the shared car that can be opened with a smartphone, booking a ride via app, optimising fleet management of e-fleets and also optimising the usage of an electric car, for example by giving weather- and situation-adapted driving and routing recommendations for a maximum range. This, however, means that the deployment of ITS depends on further developments as well and other developments in turn depend on ITS.

This dissertation aims at giving an indication on the framework conditions for ITS-deployment. It provides important knowledge and findings from different actors’ perspectives and can thus contribute to making our future transportation system better.
2 Future Role of Cost-Benefit Analysis in Intelligent Transport System-Research

2.1 Abstract and Details of the Article

This paper is a postprint of a paper submitted to and accepted for publication in IET Intelligent Transport Systems and is subject to Institution of Engineering and Technology Copyright. The copy of record is available at IET Digital Library.


2.1.1 Abstract

For a successful implementation of intelligent transport systems (ITS), technological progresses and innovations are undisputable important. Nevertheless, economic viability may not be forgotten as a prerequisite. Considerable investments for stakeholders (such as public or industry) are needed to equip vehicles, install the necessary infrastructure or to set up traffic management centers. This study enhances the technological perspective on ITS-projects by picking up the topic of economics. In this study, viable business models are acknowledged as a central success factor for the implementation of ITS. The focus, however, lies on the often neglected socio-economic perspective which includes societal costs and benefits. These impacts can be determined with a cost–benefit analysis (CBA). On the basis of a systematic case study, this study provides a profound understanding for the methodology of the CBA and the importance for public-decision making. By means of ITS-projects of the European Framework Programs, the automotive ITS-project simTD and the multimodal-related project All Ways Travelling, the significance of CBA-results for ITS-projects is shown. At the same time, the method is critically assessed by showing a number of limitations that can strongly determine the validity of the results, and therefore require a methodological adaption to the needs of ITS-projects.

2.1.2 Details of the Article

This article is a co-authorship with Wolfgang H. Schulz (Schulz, Wolfgang, H. & Geis, 2015).

The article was written in American English.

A working version of the article was presented at the 10th ITS European Congress in Helsinki, Finland in June 2014.

In August 2014 it was handed in for review at the IET Intelligent Transport Systems, which is an IEEE-journal. The journal publishes work on applications of ITS and infrastructures. The article was accepted in August 2015.
Since 2015, the article is published in the IET Intelligent Transport Systems, Volume 9, Issue 3, pages 626-632.

Keywords: Cost-benefit analysis, impact assessment, intelligent transport systems.

2.2 Introduction

Investment decisions are driven by the central criterion whether the investment is expected to have a significant positive return within in a certain timeframe. In consequence, an assessment of the costs and benefits is necessary in order to detect whether benefits exceed costs. This is the question of the economic viability of a project. The heavier the investments are expected to be, the more relevant the question of economic viability becomes. Intelligent transport systems (ITS) increasingly gain importance for modern transport systems as they are supposed to have positive efficiency effects (such as traffic flow, emission or time saving effects) and safety effects. Nevertheless, investments in the equipment of vehicles, adaption/instalment of respective infrastructure, application of databases etc., make it necessary to validly and reliably assess these investments. The basis has to consist of trustworthy assumptions (Payton, 1988).

A commercial profitability analysis already provides valuable information on the viability of a project; however, only from a business economic perspective. To draw a full picture of the costs and benefits of a specific ITS-technology, a much more comprehensive analysis is necessary. Against this background, research has developed a number of approaches that enable an assessment of the expected costs and benefits for the society and the economy, for example, multi-criteria analysis, cost-effectiveness analysis or cost–benefit analysis (CBA). It is thus pointed out the importance of socio-economic impact assessment in ITS-projects. Nevertheless, this does not imply that respective methods find the necessary application in projects that require a profound and extensive investment decision.

This paper therefore discusses this gap between the claim to theoretically consolidate large-scale financial investments and the daily business of applied research in which the socio-economic assessment up to now plays a minor role. The aim of the discussion thereby is twofold. On the one hand, we discuss the relevance of the results of CBAs for ITS-projects. On the other hand, we point out the challenges methodological research faces in order to produce meaningful results. We therefore conduct a combined literature review and case study analysis. This approach allows determining the discrepancy between theoretically based necessity and applied research decision-making policies. It must be noted that this paper has a theoretical focus. It analyses existing CBAs, identifies general weaknesses and proposes countermeasures. Thus, the following proceeding has been chosen.
By giving a short insight into the methodological approach, advantages and benefits of the application of a CBA are pointed out. In a next step, we show the stepwise evolution of CBA along the European Framework Programs. In this chapter, it becomes clear that applied science mostly does not yet apply CBA as comprehensively as it would be possible. Nevertheless, a number of important and ground-breaking ITS-project used a CBA. Afterwards, two recent ITS-projects are presented: simTD which has an automotive focus and All Ways Travelling (AWT) with a multimodal focus. On the basis of these two projects, essential findings of the CBA in ITS-research are pointed out. These chapters reveal a general methodological and result pattern of CBAs. In a last chapter, limitations from the existing projects are identified. The chapter shows that CBA has still a long way to go although it is an already well-proven methodology. An outlook on the future role of CBA states challenges, research still has to solve in order to provide a method with an increased reliability.

2.3 Theoretical Foundation of the CBA

The method of the CBA is based on the theory of welfare economics and additionally includes elements of capital investment budgeting. Welfare economics basically seeks for the solution which brings the highest societal utility (Loomes, 2006; Sugden, 2005).

To systematically assess the surplus of a new ITS-measure, the CBA has the following steps:

1. Definition of cases (e.g. with or without a certain ITS-technology).
2. Identification of relevant parameters (e.g. traffic, environment).
3. Quantification of the physical effects.
4. Transformation of the effects of step 3 into monetary values.
5. Calculation of the benefit-cost ratio (BCR).

The central index CBAs is the BCR as shown in equation (1):

$$\text{BCR} = \frac{\sum_{t=0}^{T-1} B_t (1 + i)^{-t}}{\sum_{t=0}^{T-1} C_t (1 + i)^{-t}}$$

Equation 1: Central Index of Cost-Benefit Analyses

with BCR as the benefit–cost ratio, t as the examination time period, B_t as the benefits per year t, C_t as the costs per year t and i as the interest rate.

This measure includes discounted costs and benefits. Costs and benefits can be found on micro- and macro-economic level. The result is an objective economic-based indicator for the cost-effectiveness of projects.

The assessment of the BCR follows some rules:

For measures which cost more than they offer benefits:
1. $0 < BCR < 1$: ‘poor’ BCR, inefficient project.

And for measures which make society better off:

2. $1 \leq BCR < 3$: ‘acceptable’ BCR, social benefits exceed the costs.
3. $BCR \geq 3$: ‘excellent’ BCR, priority for market deployment.

By applying such an indicator for decision-making in ITS-projects, it can be ensured that decisions are taken under objective criteria instead of being solely interest driven. This can become especially important in industries that are driven by lobbying and strong individual interests (Sassone & Schaffer, 1978).

2.4 Added Value of CBA in ITS-Research

Socio-economic impact analysis for ITSs has a tradition that goes back to the 1980s (PIARC, 2000), however the applicable methods vary in complexity and regarding the relevant data included. In its conceptual 6-step impact assessment guidelines, the European Commission gives credit to the necessity of comprehensively assessing the external impacts of public decisions. For the concrete impact analysis, the European Commission suggest the identification of economic, social and environmental impacts that shall be qualified and quantified and expressed in monetary terms (Adelle, Hertin, & Jordan, 2006). Against this background among the number of assessment methods (such as, cost-effectiveness analysis or multi-criteria analysis), the CBA plays a special role.

The CBA is a systematic and well-proven technique of economic evaluation. It is a process of comprehensively contrasting benefits and costs associated with the introduction or implementation of a project. The results allow an assessment of the desirability of a project. It, therefore, provides a helpful component for decision making, for example, in the public sector (Boardman, Greenberg, Vining, & Weimer, 1996; Priemus, Flyvbjerg, & van Wee, 2008; Robinson, 1993).

A number of publications undertaking a socio-economic impact assessment with a CBA can be found in several fields, as for instance for medical investments (Poulos et al., 2011; Robinson, 1993) or IT-investments (Kondo, Javadi, Malecot, Cappello, & Anderson, 2009). All of them have in common that the analysed projects rely on large-scale investments and societal benefits are expected independently from a business economic point of view.

Moreover in ITS-research, we increasingly find evidence for the application of socio-economic impact assessments. Eliasson (2009), for example, analysed the impact of the Stockholm congestion charging system. The calculations showed that the system is worth its investment as the socio-economic benefit exceeds investment as well as operational costs.

Furthermore, Juan, Wu, and McDonald (2003) applied two methods of socio-economic impact assessment for advanced convoy driving on motorways: CBA and multi-criteria analysis. The authors
state that CBA is especially effective where costs and benefits can exactly be measured, whereas the later rather expresses discretionary impacts.

Gordon (2013) in turn discusses the applicability of CBAs to ITS-projects and points out its relevance for ITS-projects in Australian capital cities. Another publication by Carsten and Tate (2005) calculate the accident savings resulting from an intelligent speed adaption by applying a CBA. The authors’ central finding is an excellent BCR with benefits exceeding the implementation and operational costs by 15 times.

The review has shown that the CBA has provided helpful findings for several kinds of projects of different fields. They all have in common that large public investments were to be expected such that a careful assessment of the project efficiency was undisputable. By having created a comprehensive picture of the expected costs and benefit, an objective decision background for public-decision making was provided.

This objectivity and comprehensiveness provide an important advantage in contrast to other methods, such as the multi-criteria analysis or the cost-effectiveness analysis. Whereas the multi-criteria analysis includes weighting schemes according to the importance for the individual decision maker, the CBA is free of such schemes.

Furthermore, the cost-effectiveness analysis indeed provides a comprehensive analysis of the cost side but does not include socio-economic benefits. The inclusion of direct/internal as well as indirect/external costs and benefits within a CBA provides a full assessment of all effects that occur. From this, an efficient use of financial means can be derived.

Nevertheless, as every assessment method, CBA requires a variety of quantititative information on the cost and benefit sides. However, even if complete information is not available for single cost or benefit components, the CBA can still be conducted and given a range for costs or benefits such that it still can serve as a decision support.

The CBA shall therefore not be seen as an exclusive alternative to the previously named multi-criteria or cost-effectiveness analysis. It rather provides an objective knowledge base for further financial analyses, such cost-effectiveness analyses, break-even analyses, multi-criteria analyses or business case analyses for ITS-projects (Newman-Askins, Ferreira, & Bunker, 2003). The CBA does not solely allow a business individual perspective but includes general economic costs and benefits.

2.5 Evaluation of CBA-Methods in European Applied ITS-Research

The above described characteristics make specifically the CBA as a helpful tool for the assessment of the impacts of large-scale projects. Within the European Framework Program, an evolution of the CBA can be observed on national and international/European level. The European Commission funds
projects within the Framework Programs. Already in the Fourth Framework Program evidence for the application of CBAs can be found. The project CHAUFFEUR I and later in the 5th Framework Program the following project CHAUFFEUR II investigated the application of ITS in freight transport. Both projects were based on several economic evaluation methods including a CBA that assessed the electronic linkage of trucks. On the basis of the CBA, the break-even for system users was calculated (CHAUFFEUR II, 2003). The RESPONSE II project as part of the 5th Framework Program was dedicated to the introduction of intelligent vehicle systems into the market. It focused on the trade-off of a high economic cost-effectiveness and the risk of entering a new market (RESPONSE II, 2004). In the 6th Framework Program, the SEiSS project further developed the methodological framework and, furthermore, included the stakeholder analysis (SEiSS, 2006). In addition, the eIMPACT project, funded by the 6th Framework Program played a central role concerning the evolution of CBA-methods. It focused on the socio-economic effects of intelligent vehicle safety systems (eIMPACT, 2008). In the 7th Framework Research Program PRE-DRIVE C2X and DRIVE C2X as consecutive programmes further developed the CBA (DRIVE C2X, 2013; PRE-DRIVE C2X, 2010). PRE-DRIVE C2X based its CBA on the tools and data generated in previous projects, such as CHAUFFEUR I and II.

Table 3: Evolution of Socio-Economic Analysis within the Framework Programmes

<table>
<thead>
<tr>
<th>Project Name</th>
<th>Funding Period</th>
<th>Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHAUFFEUR I</td>
<td>4th FP, 1996-1998</td>
<td>▪ Economic cost-benefit analysis of the electronic linkage of trucks</td>
</tr>
<tr>
<td></td>
<td></td>
<td>▪ Analysis of transport-related effects</td>
</tr>
<tr>
<td></td>
<td></td>
<td>▪ Logistical effects</td>
</tr>
<tr>
<td></td>
<td></td>
<td>▪ Break-even analysis with regard to system users</td>
</tr>
<tr>
<td>CHAUFFEUR II</td>
<td>5th FP, 2000-2003</td>
<td>Identification of enablers and disablers regarding the market entrance of vehicle technology taking into account possible trade-offs between high economically efficiency and the introduction of new technology into the market</td>
</tr>
<tr>
<td>RESPONSE II</td>
<td>5th FP, 2002-2004</td>
<td>▪ Analysis of the current state of research concerning intelligent vehicle systems</td>
</tr>
<tr>
<td></td>
<td></td>
<td>▪ Development of a further-reaching methodological framework</td>
</tr>
<tr>
<td></td>
<td></td>
<td>▪ Enhancement of the CBA to the stakeholder analyses</td>
</tr>
<tr>
<td>SEiSS</td>
<td>6th FP, 2004-2005</td>
<td>▪ Application test of the SEiSS methodology</td>
</tr>
<tr>
<td></td>
<td></td>
<td>▪ Economic cost-benefit analysis</td>
</tr>
<tr>
<td></td>
<td></td>
<td>▪ Stakeholder analyses for users, automotive industry, insurances, state (employment effects, fiscal effects, income distribution)</td>
</tr>
<tr>
<td>eIMPACT</td>
<td>6th FP, 2006-2008</td>
<td>▪ Cooperative vehicle systems</td>
</tr>
<tr>
<td>PRE-DRIVE C2X</td>
<td>7th FP, 2008-2010</td>
<td>▪ Preparation of field tests</td>
</tr>
</tbody>
</table>
2.6 Empirical Findings of CBAs in ITS-Research: A Case Analysis

The following subchapters present the results of two recent ITS-projects on a national and a European level. The case studies help to illustrate general patterns and approaches of a CBA. On the basis of these patterns, the authors then critically assess the recent approach of CBA. simTD focuses on ITS as a linkage between cars and automobile-external components. It was conducted in Germany. AWT has recently been finalised and analyses the impact of ITS in form of a multi-modal information and ticketing system (MMITS) on travelling in Europe.

2.6.1 simTD: Findings from Automotive Travelling

simTD is a large-scale field operational test focusing on C2X-communication. The project was conducted in Frankfurt (Germany) and the surrounding area, trying to put into practice findings from previous C2X-projects. The basic assumption based on previous projects was that the implementation of C2X-technology has a positive effect on road safety. simTD was finished in 2013.

The CBA was applied to fully capture the socio-economic benefits of such an increase in safety. In a second part, the CBA quantified the extent of increased transport efficiency. It resulted that over...
In the years an increasing socio-economic benefit can be assessed for each safety system. These effects resulted from avoided accidents with severe damages or personal injuries, a reduction in the severity of accidents with personal injuries and avoided other accidents with damages. A detailed calculation of the road safety effects can be found in the simTD-report (Schulz et al., 2013).

A similar picture resulted for transport efficiency gains that show an increasing benefit over the years. Here, the effects of three ITS-technologies were calculated: dynamic navigation, traffic lights and traffic light assistance.

![Figure 2: Benefit of simTD due to an Improved Transport Efficiency in Million EUR](source)

Source: Own graph based on data from Schulz et al. (2013).

After having calculated the investment and operational costs for vehicle-related systems, traffic lights and infrastructural equipment, the BCR was calculated as illustrated in the following figure. In the simTD-project, the CBA enabled an economic evaluation of the effects of road safety and transport efficiency at the same time. It resulted that the BCR strongly improved over time up to an excellent BCR.
2.6.2 AWT: Findings for Multimodal Travelling

The AWT project analysed the development and implementation of a journey planning and ticketing system (Eisenkopf et al., 2014). The CBA gave insights into possible resource savings by the application of a MMITS. In the project, four areas were identified that can be influenced by the implementation of such an MMITS: safety impacts, modal choice, environmental impacts and cost effects. However, the project focused on the environmental impacts. A basic assumption for the CBA-calculations is that the implementation of this special ITS-technology can cause a modal shift that leads to a decrease of car usage. Therefore the BCR was estimated in a five-step process:

1. The available passenger kilometres travelled by car were split into inter- and intra-zonal passenger kilometres.
2. On the basis of the occupancy rate, passenger kilometres were transformed into vehicle kilometres.
3. The vehicle kilometres were again split in inter- and intra-zonal kilometres and into kilometres travelled by diesel cars and petrol cars.
4. The reduction potential (based on the assumption of a modal shift) was calculated on the basis of the travel choice pillar.
5. In the last step, the emission reduction because of a modal shift is calculated from which monetary benefits for society were derived.

The table below briefly summarises the calculated results assuming two different approximations for the travellers’ modal choice: a linear transformation (no saturation effect with regard to the willingness to change the mode) and a convex transformation (existence of a saturation effect). The dichotomous choice primarily states the travellers’ preferences and change in preferences. It is based
on the item ‘Could you envisage changing from the mode of transport used to date to one of the following?’ (asked before and after the introduction to the MMITS). Furthermore, each transformation contained an estimation that assumes that travellers overestimated their willingness to change from the car to another transport mode. It becomes clear that the application of ITS can lead to significant emission savings in any scenario. The lower part of the table contrasts the range of costs that are possible to still obtain a positive BCR. This CBA used a cost range instead of definite costs as the latter were not available at the point of analysis. The general conclusion was: the more positive the benefits (i.e. the emission savings in monetary units) or the lower the costs are, the better the ratio can be assessed. Therefore three normative grades of BCR were introduced: poor, acceptable and excellent. The calculation of the emission savings is based on the assumption that an MMITS determines a reduction in vehicle kilometres. However, indirect effects, for example, on traffic flow or accidents, could not be reliably calculated. Thus, on the benefit side only emission savings were included. For the estimation of the affordable costs, the AWT-authors used the upper limit per BCR-grade: poor BCR: 0.9; acceptable BCR: 2.9; and the lower limit for the excellent BCR: 3.1. For this paper, the authors added respective opposite limit in order to provide a range for affordable costs. By giving a range of costs, incomplete information regarding the development and implementation costs of an MMITS can be compensated.

Table 4: MMITS-Effects under Different Assumptions and Related MMITS-Costs per Year for Different BCR-Grades

<table>
<thead>
<tr>
<th>MMITS-effects</th>
<th>Dichotomous choice option of respondents from 1 to 5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Linear transformation</td>
</tr>
<tr>
<td></td>
<td>With risk of overest.</td>
</tr>
<tr>
<td>Emission savings</td>
<td>2834 million Euro</td>
</tr>
</tbody>
</table>

Affordable costs allowing for different BCR-grades

<table>
<thead>
<tr>
<th>BCR Grades</th>
<th>[Poor BCR (0; 1)]</th>
<th>[Acceptable BCR (1; 3)]</th>
<th>[Excellent BCR (3; ∞)]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>[∞; 2835] million Euro</td>
<td>[∞; 946] million Euro</td>
<td>[∞; 630] million Euro</td>
</tr>
<tr>
<td></td>
<td>[∞; 652] million Euro</td>
<td>[∞; 224] million Euro</td>
<td>[∞; 774] million Euro</td>
</tr>
</tbody>
</table>

Source: Extracted from Eisenkopf et al. (2014) and slightly modified.

2.7 Critical Assessment and Implications for ITS-Research

In this section, the method of CBA is subject to a critical assessment whether and if yes under which conditions the CBA is a suitable method for the socio-economic assessment. We discuss the methodological limitations and derive an outlook for the future development of the CBA in ITS-research.
Although the CBA is a well-developed and acknowledged evaluation method, a critical assessment shows some remaining weaknesses that can be categorised into data-related limitations, underlying assumption-related limitations, unconsidered variables and effects and the absence of standardisation. On the one hand, these limitations are necessary to know in order to interpret the results correctly and with the necessary attention. On the other hand, solutions are demonstrated that can help to improve reliability of the results, for example, by improving accuracy of the input data and the calculation method.

2.7.1 Data-Related Limitations

First of all, it must be stated that the quality of the outcome strongly depends on the quantity of input. A number of projects—including the above used cases—have shown that CBA is often faced with incomplete information. The incompleteness can cover the benefit as well as the cost-side.

The reasons for not having sufficient information on the benefits can differ from project to project. A reason can be that potential benefits are not yet anticipated in an early stage of the project, that is, before the field tests. However, as the data generation often takes place via field test, a later catch up is often impossible. This limitation can easily be solved by an early and careful analysis of the possible impact channels (e.g. traffic safety effects, such as number/severity of accidents; non-safety-related effects, for instance environmental effects). An earlier participation of interdisciplinary expertise (e.g. economist, psychology and behavioural studies) may be helpful at this stage of the project. On the cost-side, incomplete information is often a result of an unwillingness or sometimes disability to give estimation on the emerging costs. Original equipment manufacturer (OEMs) tend to be reluctant to share their data on the costs because they fear to lose a competitive advantage.

However, incomplete data strongly limit the explanatory power and validity of the CBA. The AWT project has resulted to be an example for incomplete information on the cost-side. In this project, an ex-post solution had to be found which is why cost-ranges for several BCR-grades have been provided.

Nevertheless, further projects will no longer be able to obtain around reliable and comprehensive data. A detailed interdisciplinary pre-analysis of the potential impact channels will be essential as well as concrete cost-calculations. Only if the incompleteness of information can be overcome, the CBA can fully develop its potential and give a differentiated picture of the expected socio-economic costs and benefits.

Additionally, cost-unit rates require an actualisation adapted to potential changes in values. The European Proposal on a Directive for the charging of heavy goods vehicles (European Commission, 2003, European Commission, 2003), for example, contains possible cost-unit rates. However, the
directive is from 2003, the values even older. It is questionable whether a simple updating based on inflation rates would have the same effect as a completely new calculation.

2.7.2 Underlying Assumption-Related Limitations

Another category of limitations is enrooted in the assumptions the CBA is based on. First, the CBA gives an assessment of the socio-economic costs and benefits. Therefore on the first sight individual preferences and attitudes towards a certain ITS-technology are not relevant. However, all projects have shown that the BCR strongly improves with an increase of the market penetration (e.g. because of network effects (Liu & Tate, 2004)). The market penetration in turn is subject to individuals’ decision (if no obligation for market introduction exists). Therefore a reliable CBA needs a realistic simulation and estimation of the market penetration. Assumptions made for the market penetration, directly affect the CBA. Therefore it is essential to not only traditionally rely on rational decision-making but also on the inclusion of attitudes.

Currently, the implicit assumption that the emergence and introduction of a new ITS-technology directly leads to a buying decision dominates CBAs (Guria, Leung, Jones-Lee, & Loomes, 2005). This is however a critical assumption that can immensely disturb the reliability and validity of the results. Bounded rationality has to be considered (Kahneman & Sugden, 2005; Sugden, 2005).

Furthermore, the CBA is based on the implicit assumption that system costs equal marginal costs, resulting from the price-cost margin. The price-cost margin (Lerner-Index) targets an industry’s market power, that is, its ability to price above marginal cost. Therefore the Lerner-Index is a popular measure for the industry performance. The index ranges between a low market power of 0 (perfect competition) and a maximum market power of 1 (monopoly). As an index of 0 is the basic assumption for all CBAs, the consecutive assumption for the ITS sector is that it is a market of perfect competition. That is, C2X-technology system costs equal marginal costs. Reality, however, shows that this is an invalid assumption as the automotive market is characterised by market power. It is, therefore, a prime example for a concentrated market. In consequence, it is a market where there is indeed some competition but no perfect one. Therefore future CBAs are bound to estimating a more realistic and trustworthy cost-function to better evaluate the socio-economic effects of ITS-projects.

Additionally, although the CBA has already proven to generate success-related results, its importance remains underestimated by OEM that host publicly financed ITS-projects. Economists are often not included in steering committees and there is a general scepticism towards the economists’ ability to assess human life or the effects of climate change in monetary units. This leads to relatively low budgets for the economic assessment of ITS-projects.
2.7.3 Unconsidered Effects and Variables

Up to now, CBA in ITS-research has focused on benefits related to transport efficiency, emission savings, safety increases etc. We however find some further aspects that could substantially improve the results of CBAs.

Socio-economic effects have always been measured from a macro-perspective, that is, which benefits do result for society for instance by lifesaving. The rational of decision utility has been applied. In other words: the outcome of the observable aggregate choice is calculated (decision utility). However, it is not taken into account the effects that result for the user himself in terms of comfort or quality effects or the experienced utility (Kahneman & Sugden, 2005). The application of ITS for cars and other modes also aims at making travelling/driving more comfortable, for example, by dynamic navigation. Thus, a central effect to be included is whether and if yes, how much better/more comfortable/safer etc. do ITS-users feel while travelling or driving in contrast to a situation without the technology. If these impacts are not included, an underestimation of direct benefits can occur which might in turn cause an underestimation of indirect cost effects.

In turn, the phenomenon of induced traffic effects has to be considered more strongly. Assuming that ITS in cars makes driving safer and more comfortable. Kulmala, Rämä, and Sihvola (2008) provide a categorisation of nine impact channels of ITS on safety: (i) direct in-car modification, (ii) direct influence by roadside systems, (iii) indirect modification of user behaviour, (iv) indirect modification of non-user behaviour, (v) modification of interaction between users and non-users, (vi) modification of road user exposure, (vii) modification of modal choice, (viii) modification of route choice and (ix) modification of accident consequences. An increase in safety and comfort might reduce the barrier of car usage (e.g. unsafe under certain weather conditions, unreliable because of traffic jam). The consequence might be that the traffic volume increases which would again reduce benefits of emission savings.

Finally, macroeconomic variables, especially economic growth have to be included into the CBA. CBAs are usually based on the ceteris paribus assumption regarding macroeconomic variables. The complexity of the impact of macroeconomic variables is illustrated on the following example. The cost-unit rate for fatalities is calculated basically on the basis of the actual GDP. However, the real GDP changes (not as a result of price changes but because of real growth). This real growth, however, is currently not included in prospective CBA calculations.

2.7.4 Absence of Standardisation

Nevertheless, CBAs do not only bring knowledge gain within a project. In addition, the comparison of CBAs of several projects can be beneficial. The comparison of socio-economic impacts of different technologies allows, for example, a prioritisation and ordering of which technology brings the highest benefits. This is especially important against the background of new mobility concepts
and connected mobility in order to relieve infrastructure on the one hand and to improve efficiency on the other hand. It can easily be compared which technology aims the best at a certain goal, such as safety increase or emission reduction.

This however requires a comparability of the results. Nonetheless, when comprehensively comparing the results and approaches of different CBAs, we clearly note a limited comparability of the results. Reasons can be that projects did not cover all effects such that they did not measure the same ones. Another very significant problem is the usage of different cost-unit rates, for example, to measure the value of a saved life.

Therefore, a standardisation in the CBAs is a worthwhile goal. The European Commission has already started a number of efforts (Radaelli & Meuwese, 2010), for example, by implementing the impact assessment guidelines that at least provide a standardised procedure for European projects (European Commission, 2009). They however do not provide a standard for the effects that shall be considered (a consideration might be beneficial even if the result is that there is no benefit) or the cost-unit rates that should be applied. Additionally, cost-unit rates require an actualisation adapted to potential changes in values. The European project HEATCO (HEATCO, 2006) provides guidelines for a harmonisation of CBAs in transport. It provides a rough framework, which can be used for a clear standardisation of the methodological approach.

2.8 Conclusion and Recommendations

Although ITS-projects progressively apply socio-economic assessment methods, it is a new research field. The analysis of ITS has special requirements as it is a new technology that on the one hand comes along with immense costs but is expected to substantial change mobility, mobility behaviour and thus to influence human life. This can have effects on trade, logistics, infrastructure and especially unforeseeable changes of labour division will be nudged. Furthermore, societal and individual behaviour and attitudes will be affected in unpredictable ways.

In our paper, we have shown that the CBA already is a beneficial method that allows an objective assessment of new ITS-technology which supports public-decision makers. Nevertheless, the critical assessment of the methodological approach has shown that the CBA still requires enhancements and corrections that strongly improve the reliability and validity of the results. These results are based on a comprehensive case study. We therefore chose a systematic four-step approach: we showed the added value of CBA with a review of the literature on CBA. It became clear that this kind of socio-economic assessment gained importance in research, especially for large-scale projects in several fields of public interest. In a next step, we showed the evolution of the CBA in ITS-projects of the European Framework Programs. In this chapter, it was shown that the socio-economic assessment of ITS increasingly gains importance in the European research and thus for European public-decision making on ITS. We then analysed the automotive-focused project simTD and the multimodal-driven
project AWT. With these projects, we showed the current state of the results for ITS-assessment. On the basis of the case study, we derived four categories of limitations, which help to recognise the scope but also the barriers when interpreting the results of recent CBAs. On the basis of these limitations, we derived leverages for a methodological enhancement.

With our paper, we recommend an enhancement of the theoretical basis for CBAs. To resolve systematically the discussed limitations, we give the following three recommendations: (1) this paper provides insights into the on-going practical use of CBA in the field of ITS. However, these insights cannot represent the full-picture of undertaken socio-economic assessment for ITS. In consequence, we recommend to conduct a transparency-creating review that sums up the status quo of the existing CBAs in ITS. (2) We pointed out the importance of standardisation. On the basis of step (1), we then recommend that a flagship project introduces a standardisation, for example, by calculating cost-unit rates for Europe that can be used for all transport modes and by finding the optimal joint level for the basic assumptions. (3) In a last step, we recommend that these standardisation efforts are bindingly reported, for example, by updating the existing impact assessment guidelines. These guidelines at its current stage provide a standardisation for the process how to conduct an impact assessment. It however should also include the details elaborated in step 2. As stated in the introduction, it is a theoretical paper, which provides a starting point for a further elaboration. Consequently, it is the beginning of an improvement process to be challenged by interdisciplinary approaches. Such a methodological enhancement is a laborious project. Nevertheless, it might be worthwhile as it contributes to a well-considered public-decision making and resource allocation.
3 Incentivizing Modal Change – Exploring the Effect of Multimodal Information and Ticketing Systems for Medium and Long Distances in Europe

3.1 Abstract and Details of the Article


3.1.1 Abstract

The past decade has been characterized by a substantial increase in transport volume. Particularly, road networks have reached their limits. Increasing emissions, congestion, and accidents have signaled a need for action. Besides technological innovations and behavioral change due to regulations, incentivizing voluntary modal change is increasingly becoming important for European policy makers. The deployment of a multimodal information and ticketing system (MMITS) is considered an appropriate incentive to facilitate intermodal trips by reducing transaction costs and uncertainty (the system provides pre- and on-trip information and a booking option for one ticket for the whole intermodal trip). This paper analyzes travelers’ willingness to accept such a system and the impact of intention to use a MMITS on travelers’ modal choice, especially for medium and long distances. Based on a sample from six European countries, multiple regression analyses reveal a high acceptance for the MMITS but a low impact on the intended behavioral change. Remarkably, for heavy car users, a reverse relationship is identified. The results give an empirical proof that a MMITS has an impact on travelers with weak habits. The results provide an empirical basis for the political decision whether to promote the deployment of a MMITS.

3.1.2 Details of the Article

This article is a co-authorship with Wolfgang H. Schulz (Geis & Schulz, 2016).

The article was written and published in American English.

The data used in this article were collected as part of the project “All Ways Travelling – To develop and validate a European passenger transport information and booking system across transport modes”, which was funded by the European Commission (Contract No.: MOVE/C2/SER/2012 489/SI2.646722) and finalised in 2014. The project consortium was scientifically led by Zeppelin Universität, Friedrichshafen and managed by Amadeus. The consortium, furthermore, consisted of Thales, BeNeRail International, UNIFE, and IATA.
A working version of the article was presented at the 95th Annual Meeting of the Transportation Research Board in Washington D.C., United Stated of America, in January 2016.

The German Academic Exchange Service (dt.: Deutscher Akademischer Austauschdienst, DAAD) promotes the participation of doctoral candidates and young scientists at international scientific conferences. Important requirement is that the presented work presents original scientific and recent results.

Since 2016, the article is published in Transportation Research Record: Journal of the Transportation Research Board, Volume 2565, pages 1-7.

3.2 Introduction

The past decade has been characterized by a substantial rise in transport volume. Except for sea transport and buses/coaches, all transport modes show significant increases in their volumes (European Commission, 2014). However, transport infrastructures cannot develop at the same pace. Particularly, road networks are reaching their limits as car use is increasing (Frei & Gan, 2015). Congestion and accidents have become a severe problem. Additionally, the transport sector accounted for 25% of the total CO2 emissions in 2012, from which road transport contributed 72% in the EU-28 (European Commission, 2014). Consequently, the transport network is stressed by a variety of challenges. In order to build and maintain an efficient transport network, European transport policy considers several measures. Three main strategies can be identified: (1) technological developments for making existing transport modes more efficient or safer, such as a new propulsion technology; (2) behavioral changes through regulation or economic incentives that address the price mechanism, such as taxes; and (3) behavioral changes triggered by intelligent transportation systems (ITS), which have become a keyword when optimizing transport networks (Sussman, 2005). Triggering behavioral changes, however, is challenging as human reactions (direction and strength) can hardly be predicted. Yet still, technological enhancements are not enough to improve transport. It is therefore not a new question of how people can be triggered to desist from a certain behavior, or in this case, how travelers can be made to move from excessive car use to intermodal transport chains.

Research has shown that modal choice is a highly habitualized behavior (Eriksson, Garvill, & Nordlund, 2008; Verplanken, Walker, Davis, & Jurasek, 2008), not just for repetitive trips, but for any trip in which travelers feel sufficiently confident about their options (Verplanken, Aarts, van Knippenberg, & van Knippenberg, 1994).

Additionally, the car is a comfortable decision as door-to-door mobility is guaranteed without having to think of schedules or the last mile (Eriksson et al., 2008). Luggage can be easily transported. Navigation systems explain real time how to reach a particular destination. Additional intelligent
vehicle systems make cars safer and the driving process more comfortable as the car takes over a number of functions and responsibilities (such as lane keeping or speed control).

Thus, the challenge is to provide an intermodal transport chain that is able to compete with the comfort of a unimodal car-based transport chain and to disrupt travelers’ habits. Therefore, European politics attempts to improve the seamlessness of intermodal transport chains; that is, modes are connected in a way that door-to-door multimodal mobility is enabled without discomfort for travelers. Hence, the European Commission considers the development and implementation of a multimodal information and ticketing system (MMITS) on a Pan-European level to facilitate intermodal trips (information seeking, decision making, booking, traveling). The system provides integrated real-time travel information, including availability, optimal routes, or price information, and makes the use of several modes also over long distances even easier by providing a single ticket. In consequence, the system is not only an information system but includes the booking and ticketing process as well. Therefore, the system is not restricted to urban areas and covers medium and long distances within Europe (European Commission, 2010).

Research increasingly considers the impact of MMITSs on transport chains and travel behavior. Frei & Gan, 2015 have shown in a study of commuters in Shanghai that smartphone-delivered information can have significant effects on modal choice varying according socioeconomic variables., Kenyon and Lyons (2003), however, have revealed different results from English travelers. Respondents were exposed to information, such as cost and time, as well as comfort factors on a journey they were familiar with. The authors concluded that travelers do not rethink their modal choice and stay with their habitualized decision even if additional information is provided. Only for information on comfort (such as facilities on board) were indications for behavioral changes found. These results confirm an earlier study on a student sample by Aarts, Verplanken, and van Knippenberg (1997), which showed that the more habitualized the modal choice was, the less elaborate the travelers’ information use was. Complementary to the mentioned papers, Wang, Khattak, and Fan (2009) have presented a study of American households. They showed how information access could alter the probability of a change in modal choice. They argued that information accessed through the Internet had the strongest effect on modal choice.

Whereas, information provision is rather a passive travel companion (such as Google Maps), the European Commission’s MMITS provides an active component of intermodal trips by offering a booking possibility of a single ticket for the whole intermodal trip. Taking away the complexity of having to cope with several booking systems, terms, and conditions, or the uncertainty of local ticket machines, is supposed to increase the comfort of intermodal transport chains. However, little is known about the impact of ticketing systems on modal choice. Jakubauskas (2006) discussed ticketing solutions for urban public transport and concluded that contactless smart cards and e-
ticketing are the most promising developments. The author pointed out that an easy payment is crucial for seamless intermodal transport. A study by Mallat, Rossi, Tuunainen, and Öörni (2008) analyzed the acceptance of the mobile ticketing services in public transport. Based on the technology acceptance model, the authors showed that prior experience with similar systems and social influence strongly influenced the intention to use such a system. Impact on modal choice was not tested. A case study by Sauter-Servaes and Nash (2009) provides a system for the combination of information and ticketing on the example of Night and Fly (a combination of night train trip and flight). This example aimed at the shift from airplanes to railway on long distances. They argued that a system with accurate and reliable information motivates travelers to substitute flights or parts of a flight with train. This study considers modal shift on long distances. This represents a new research focus. Until today, only little is known about travel behavior on medium and long distances and even less about reactions to the deployment of ITS.

In contrast to many urban trips, medium- and long-distance trips are often associated with less routine and familiarity, which creates a complex and uncertain situation for travelers (Jin & Horowitz, 2008). It is therefore worth taking a closer look at medium and long distances and how ITS can influence modal choice on these trips. In this paper, the authors examine the effect of a MMITIS on travel behavior for medium and long distances. It must be clear that a MMITIS does not yet exist. It is thus an analysis of a technology that is not accessible. Still, it is worth examining the impact of this hypothetical system to find out whether it could bring the expected change on travel behavior, which is crucial for the European Commission to promote the deployment of a MMITIS.

The paper is based on data collected from the project All Ways Travelling (Eisenkopf et al., 2014) funded by the European Commission. The project provided a comprehensive market study on the implementation of MMITIS in the European market. Whereas the project focused on the legal, technical, and economic framework conditions of the deployment of a MMITIS, this paper enhances the descriptive analysis of the project through an in-depth analysis of the effect of the MMITIS on modal choice for medium and long distances.

Against this background, this paper aims to contribute to the understanding of the impact of a comprehensive MMITIS (covering information and ticketing) on medium and long distances. A process model in a modified analogy to Davis (1993) is constructed and frames users’ attitude toward a MMITIS and its impact on behavioral change. Specifically, the authors test behavioral and cognitive factors to determine users’ intention to use a MMITIS and in the next step to evaluate whether the use of a MMITIS is strong enough to trigger a change in modal choice. The remainder of the paper is structured as follows: After a theory-driven derivation of the conceptual framework, the methodology and data analysis are presented. Then, the results are described. In the last section, a discussion of the results gives practical recommendations.
3.3 Conceptual Framework and Hypotheses

In this chapter, the authors develop a conceptual framework that examines the impact process of a MMITS on the users’ modal choice (Figure 1). Following the behavioral model on technology acceptance (TAM) by Davis (1993), the authors assume that users first have to respond to the system provision itself, that is, intend an application within their travel process before it can affect behavior. Davis (1993) argued that a system would cause a cognitive response (evaluation of the system use), which in turn would lead to an affective response (intention to use). A behavioral response is expected only if intention to use exists. Cognitive response is operationalized with the items of perceived usefulness and ease of use. Affective response corresponds with the intention to use in the TAM (Davis, 1989). Intention to use is then tested for its influence on the actual behavior. In this paper, this multistep process model is adapted to the MMITS and addresses the question of the influence of a MMITS on users’ intended behavioral change.

The core element of the process is the TAM, which was developed for assessing the users’ willingness to accept or reject information systems (Davis, 1989). Later research has shown the transferability and validity of this model for a variety of other technological systems. All studies have proven perceived usefulness (PU: defined as the degree to which the user’s performance is improved by the respective system) and ease of use (EoU: defined as the degree to which the use of a system is free of effort) as relevant predictors for intention to use (IU). Furthermore, it is assumed that the easier the use of the system is perceived, the better is the perceived usefulness. The following hypotheses are proposed:

H1a: Perceived usefulness of a MMITS positively influences the intention to use a MMITS.

H1b: Perceived ease of use of a MMITS positively influences the intention to use a MMITS.

H1c: Perceived ease of use of a MMITS is partially mediated through perceived usefulness of a MMITS.

These elements of the traditional TAM are enhanced by the predictor data security (DS). Data security and privacy concerns increasingly affect users of the Internet and services that require the provision of personal data (Bélanger & Crossler, 2011; Malhotra, Kim, & Agarwal, 2004). The use of a MMITS requires the provision of personal data (e.g., for payment) and accurate travel data. As a consequence, users’ concerns about their digital footprint are expected to negatively influence their intention to use. The following hypothesis is suggested:

H2: Data security (DS) concerns of travelers regarding the MMITS negatively influence the MMITS.
Previous research has shown that not only cognitive variables have an effect on intention to use. Thus, the model is enhanced by the intensity of car use (ICU). (Aarts et al., 1997) have argued that a strong habit leads to less susceptibility to alternative modes. A high intensity of car use is associated with a strong preference for the car or a habitualized car use (Eriksson et al., 2008; Verplanken et al., 2008). Therefore, the hypothesis is as follows:

H3: The intensity of car use negatively influences the intention to use a MMITS.

Finally, the set of predictors is enhanced by the variable age. Up to now, age was not much included in the TAM (Chung, Park, Wang, Fulk, & McLaughlin, 2010), although a number of previous studies have discussed the relevance of age to technology acceptance (e.g. Morris & Venkatesh, 2000; Porter & Donthu, 2006). The following hypothesis is suggested:

H4: The age (A) of the traveler negatively influences the intention to use a MMITS.

Additionally, gender is discussed as research mostly assumes that gender affects technology usage. The gender difference argument is based on the assumption that women are less confident in and less experienced with technology. However, Gefen and Straub (1997) have shown that although attitude toward technology differs according gender, there is no gender difference in usage. It can be assumed that the nonexistence of this effect is even strengthened over time as smartphones have become an essential part of everyday life independently from gender.

H5: The intention to use a MMITS does not differ with gender.

H1–H4 express the assumed relationships with intention to use a MMITS. Collected data can furthermore be used to test hypotheses on the intended behavioral change. In this model, only the intended modal change can be tested as the MMITS is a hypothetical technology. The central idea of the MMITS is that it is able to reduce complexity and uncertainty for intermodal travelers. The MMITS facilitates modal choice among a set of alternatives and provides the traveler with all relevant information before and during the trip. Additionally, it reorganizes the booking process as it combines all modes within one booking process and ticket. Therefore, the following hypothesis is suggested:

H6: The intention to use a MMITS positively influences the intended modal change (IMC).

Intensity of car use is tested for its relevance to intended modal change. Research has shown that travelers with strong car habits are more likely to switch to another mode when presented with a suitable stimulus (Eriksson et al., 2008; Ferrer & Ruiz, 2013). For this model on medium and long distances, the following is therefore proposed:

H7: The intensity of car use positively influences the intended modal change.
Moreover, the role of gender is examined. Research has shown that women are generally more willing to reduce car use in favor of a more environmentally friendly travel behavior (Matthies, Kuhn, & Klöckner, 2002; Polk, 2003). The hypothesis, thus, is as follows:

\[ H8: \text{Being a woman positively influences the intended modal change.} \]

Figure 4: Conceptual Framework for Testing Technology Acceptance and Intended Modal Change

Source: Own work.

3.4 Methodology

3.4.1 Survey and Measurement

Data were collected using a survey designed and conducted for the European project All Ways Travelling (Eisenkopf et al., 2014). The project provided a market analysis for developing and validating a multimodal journey planning and ticketing system on a Pan-European level. The project and the underlying study are based on a real-time trip companion that covers pre- and on-trip information, as well as the possibility to directly buy a ticket that covers the whole trip. The ticketing and booking possibility thus differentiates the MMITS from existing systems, such as Google Maps. In contrast to current booking portals in Europe, it is not limited to one European country or a small number of modes; rather, it covers all modes, including urban public transport.

The questionnaire was spread as an online survey. Data were collected between July and August 2013. Six European countries were preselected for the project. These countries were the Czech Republic (CZ), France (F), Germany (DE), Italy (IT), Poland (PL), and the United Kingdom (UK). This resulted in a sample of European citizens (n=695).
Three screening questions restricted the respondents to certain characteristics. First of all, the respondents had to be at least 18 years old. Additionally, all the participants had planned at least one trip over 100 kilometers (60 miles) within the past 12 months. The time limit made sure that they had relevant experience vivid in their mind. The distance limit was necessary to guarantee focus on medium- and long-distance trips as it was the subject of the study. Furthermore, commuting trips were excluded as they were marked with different features (such as high repetition). The questionnaires were available in the national language of each country.

The questionnaire contained questions about the status quo of planning and mobility behavior: modal split and estimated travel costs (in EUR or GBP), criteria of modal choice, willingness to change from main mode to another mode, and criteria for not choosing modes. Furthermore, the respondents’ planning and booking habits were asked. Then all the respondents were exposed to a description of the functions of the MMITS by describing an exemplary journey. The description helped illustrate the characteristics and features of a MMITS.

The respondents were asked to picture themselves in a travel situation that they plan to go through, from their home address to a random destination in Europe using an intermodal transport chain. The description reactivated several stations of a journey (from planning to booking and the trip itself, including a delay on the trip). The description provided all information and services users could obtain when using the system. In the planning phase, the user receives information on possible alternative transport chains covering intermodal and unimodal transport chains. It provides the user with a variety of information about alternatives, such as travel time, costs, and emissions. It allows booking the final transport chain with one booking process and receiving one ticket that is valid throughout the whole trip. During the trip, the system provides the user with necessary real-time information and allows a rebooking in case of delays that lead to missed connections.

The system description was followed by a set of questions: The respondents were asked to evaluate the described system according the items of perceived usefulness, perceived ease of use, and intention to use in analogy to the TAM (Davis, 1989). Additionally, the respondents were asked to rate the perceived security of personal data when interacting with the system. The question for willingness to change the mode was repeated under the condition of having access to a MMITS. Additionally, sociodemographic data were asked (e.g., gender, marital status, and job).

The items for perceived usefulness, ease of use, intention to use, and data security were rated on a seven-point Likert scale (from 1 = I disagree completely to 7 = I agree completely).

Perceived usefulness (PU) was operationalized with four items. A Cronbach’s alpha of 0.93 was met. The instrument for ease of use (EoU) consisted of four items with a Cronbach’s alpha of 0.88. Intention to use (IU) consisted of two items with a Cronbach’s alpha of 0.86. Thus, all TAM-related
constructs met the common threshold of 0.7 and were characterized by strong internal consistency (Nunnally, 1978). Data security (DS) was measured with one item: “I’m not sure my data would be safe.”

Additional relevant variables for the conceptual model were measured as follows: Intensity of car use (ICU) was measured using a metric scale. The respondents indicated the share of car use on the main routes in percentage. Age (A) was also measured using a metric scale. Gender (G) was a binary variable.

Intended modal change (IMC) (i.e., change in preferences) was measured as the difference of the after- and before-description question on willingness to change the mode. These questions are based on a rating of willingness to change to car, car sharing/rental car, airplane, train, and bus rated on a five-point Likert scale (from 1 = I can’t envisage it at all to 5 = I can envisage it well).

3.4.2 Data Analysis

The data set was first analyzed using ANOVA to identify group differences according nationality, which would make regressions for each nationality necessary.

Hierarchical regressions were performed with the intention to use a MMITS and its influence on willingness to change as endogenous variables. Strictly speaking, intention to use is an ordinal variable. However, it can be assumed that the underlying concept is metric, and the centric Likert scale is considered to be close to equidistant. The authors, therefore, followed the common research practice of applying regression (Chung et al., 2010; Venkatesh & Davis, 2000). Group differences were tested with a t-test.

For testing the role of perceived usefulness as mediator for ease of use, the approach by Baron and Kenney (1986) was applied. This approach is based on regressions that subsequently test the effect of ease of use on intention to use, ease of use on perceived usefulness, and perceived usefulness on intention to use. Finally, it was tested whether the effect of ease of use on intention to use is significantly reduced by including perceived usefulness into the regression. A beta of zero for ease of use would indicate a total mediation through perceived usefulness; a beta significantly smaller than without the mediator but still larger than zero indicates a partial mediator.
3.5 Results

3.5.1 Descriptive Statistics

In total, 695 respondents finished the survey with an almost equal share from six European countries: the Czech Republic (n=115), France (n=113), Germany (n=120), Italy (n=119), Poland (n=110), and the United Kingdom (n=118).

Among the participants, the share of males was 52.60% (n=361), and the share of females was 47.40% (n=325). The respondents’ average age was 45.54 years (SD=13; median=46; range=18–70). This is slightly higher than the European-wide median of 41.9 years (Eurostat, 2014). However, taking into account that the minimum age for the respondents was 18 years, the sample is rather younger than the average.

A total 98.10% (n=682) had planned at least one private trip during the past 12 months, whereas only 23.3% (n=162) had planned a business trip; 92.7% (n=644) had planned the trip themselves. The respondents’ average modal split has the following pattern: car=45.90% (SD=35.58; median=40), car sharing/rental car=3.20% (SD=9.36; median=0), train=18.37% (SD=25.14; median=10), airplane=20.57% (SD=26.63; median=10), bus=9.60% (SD=17.91; median=0), ferry=2.34% (SD=5.28; median=0). Of all the respondents, 12.7% indicated 100% car use, and only 2.3% indicated 100% train use. Other modes showed an even lower concentration in the extreme. The 75% quantile for car use already came with 80%, for airplane 30%, and for train 23.50%.

The ANOVA showed that there are no national differences for the intended modal change (p=0.125). Intention to use showed significant differences (p=0.003). However, only two groups showed significant differences (Germany–France and Italy–France). Therefore, the authors decided not to perform different regressions for each nationality.

3.5.2 Hypotheses Testing

The results of the regression analysis are presented in Table 1. As a first step, OLS regression was performed to test predictive variables for intention to use. The results of the regression showed that the isolated TAM already had a very good fit (F=1075; p=0.000; adj. R²=0.758). The constructs perceived usefulness and ease of use accounted for 75.8% of the variance of the intention to use a MMITIS. The beta values showed the highly significant influence of perceived usefulness (β=0.790; p<0.001) and perceived ease of use (β=0.181; p<0.001) of a MMITIS on the travelers’ intention to use such an application. Consequently, H1a and H1b are supported.

The mediation check for ease of use being partially mediated by perceived usefulness was positive. In the first step, it was shown that ease of use had a significant effect on perceived usefulness (β=0.772; p<0.001). Additionally, the check showed that perceived usefulness (β=0.865; p<0.001) and ease of use (β=0.732; p<0.001) had an independent effect on intention to use. As the independent
effect of ease of use ($\beta=0.732$) was significantly higher than the combined effect with perceived usefulness ($\beta=0.157$), all conditions for a mediation effect were found. Thus, H1c of a partial mediation of ease of use through perceived usefulness was confirmed.

The additional variables data security and intensity of car use both increased the adjusted $R^2$ of the model to 76.1%; that is, the explained variance increased a little. Nevertheless, the negative effect of data security and intensity of car use on the travelers’ intention to use a MMITS, as suggested in H2 and H3, was confirmed. Adding the age variable, however, did not affect the model. Furthermore, the effect was insignificant. Thus, H4 was not confirmed. Although a direct effect of age on intention to use was not seen, an additional regression of age on ease of use indicated an indirect effect of age on intention to use by negatively influencing ease of use.

For the test of group differences between male and female, the necessary condition of homogenous variances between the groups was not rejected. Thus, the t-test was valid. As expected, no significant difference for the use of a MMITS between male and female was found ($p=0.081$). H5 was confirmed.

For the second step in the impact process model (IPM), predictors for the intended behavioral change in modal choice were tested. Intention to use already accounted for 5.5% of the explained variance with a highly significant coefficient. The inclusion of intensity of car use contributed to an improvement of the adjusted $R^2$ to 7.9% with a very good fit ($F=30.419; p<0.001$). H6 and H7 were confirmed. The adjusted $R^2$ for the total model, including gender, accounted for 8%, which was negligibly higher than without gender. The $F$-value even decreased ($F=20.906; p<0.001$). Additionally, the gender effect missed the common significance levels. Consequently, data did not support H8.
Incentivizing Modal Change – Exploring the Effect of Multimodal Information and Ticketing Systems for Medium and Long Distances in Europe

Table 5: Regression Results: Technology Acceptance and Intended Modal Change

<table>
<thead>
<tr>
<th>Process step 1: Intention to Use</th>
<th>beta</th>
<th>adj. R²</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perceived Usefulness</td>
<td>0.790**</td>
<td>0.758</td>
<td>1075.512***</td>
</tr>
<tr>
<td>Ease of Use</td>
<td>0.181**</td>
<td>0.760</td>
<td>724.367***</td>
</tr>
<tr>
<td>Perceived Usefulness</td>
<td>0.792**</td>
<td>0.760</td>
<td>1075.512***</td>
</tr>
<tr>
<td>Ease of Use</td>
<td>0.182**</td>
<td>0.760</td>
<td>724.367***</td>
</tr>
<tr>
<td>Data Security</td>
<td>-0.041*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Perceived Usefulness</td>
<td>0.784**</td>
<td>0.761</td>
<td>547.355***</td>
</tr>
<tr>
<td>Ease of Use</td>
<td>0.187**</td>
<td>0.761</td>
<td>437.784***</td>
</tr>
<tr>
<td>Data Security</td>
<td>-0.042*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intensity of Car Use</td>
<td>-0.002*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Perceived usefulness</td>
<td>0.785**</td>
<td>0.761</td>
<td>437.784***</td>
</tr>
<tr>
<td>Ease of use</td>
<td>0.187**</td>
<td>0.761</td>
<td>437.784***</td>
</tr>
<tr>
<td>Data security</td>
<td>-0.042*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intensity of Car Use</td>
<td>-0.002*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
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<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Process step 2: Intended Modal Change</th>
<th>beta</th>
<th>adj. R²</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intention to Use</td>
<td>0.132***</td>
<td>0.055</td>
<td>40.794***</td>
</tr>
<tr>
<td>Intention to Use</td>
<td>0.145***</td>
<td>0.079</td>
<td>30.419***</td>
</tr>
<tr>
<td>Intensity of Car Use</td>
<td>0.004***</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intention to Use</td>
<td>0.147***</td>
<td>0.080</td>
<td>20.906***</td>
</tr>
<tr>
<td>Intensity of Car use</td>
<td>0.004***</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td>0.086</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* p<0.05
** p<0.01
*** p<0.001

Source: Own work.

3.6 Discussion

The objective of this study was to expand the theory of technology acceptance of intelligent transportation systems. Applying a modified Technology Acceptance Model by Davis (1993), the authors investigated the impact process of a hypothetical multimodal information and ticketing system—as suggested by the European Commission—on the intended modal change. The results of this study provide a theoretical model for the understanding of the role of ITS as an incentive for modal change and empirical results that allow a critical discussion.

The results confirmed previous research that the traditional TAM are reliable and valid predictors for intention to use. Data security and intensity of car use played a minor role compared with the traditional predictors. The strong dominance of perceived usefulness may be a result of logical decision making. If travelers do not perceive sufficient usefulness of applying the system, it does not matter how easy to use was the system or whether data were safe. There would simply be no need to change the current searching and booking behavior. A negative perceived usefulness would even
strengthen this argument. Perceived usefulness, therefore, is a necessary condition for intention to use. As hypothesized, ease of use not only had a direct effect on travelers’ intention to use but was also mediated by perceived usefulness. This fact reinforces the central role of perceived usefulness for the prediction of intention to use. It, however, also opens the discussion for further influencing the factors of perceived usefulness as the construct might be more complex as assumed in the current research.

As predicted, the results show that privacy concerns negatively affect travelers’ intention to use a MMITS. However, the effect was surprisingly low. This may be explained by the fact that respondents might not have fully understood the multiplicity of the provision of private data necessary for this system. A more detailed analysis distinguishing between trip-related data (e.g., routes, modal preferences), personal data (e.g., address, gender, age), and payment data (e.g., credit card) could lead to more precise results. Furthermore, it is possible that the low effect of data security results from a certain habituation and deadening to the provision of personal data, for example, because of an excessive social media use. However, it would be interesting to test whether the influence changes with scandals of misuse of private data. Here, a longitudinal study could give important insights.

Intensity of car use showed the expected negative sign and thus confirmed results from previous research, which emphasized the resistance of car users to additional information (Eriksson et al., 2008). The explanation may be that heavy car users assume that they already know their alternatives and perceive the car as the most comfortable or practical one, which makes the use of such a system obsolete. At first sight, this may imply that the MMITS does not fulfill its objective as it is designed for reducing road transport. However, the effect on light and medium car users may not be underestimated when assessing the potential of a MMITS, for instance, with a cost-benefit analysis.

In contrast to what was predicted in the conceptual model, age did not have a direct effect on intention to use. However, an indirect effect via ease of use was found. The results indicated that the older the respondent was, the lower the perceived ease of use of the MMITS was. An explanation may be rooted in the description of the system as being smartphone based, which is more strongly spread among younger users. Consequently, the negative impact on perceived ease of use may be the result of missing familiarity with the technology itself and similar applications.

In summary, the process step of accepting a MMITS is explained very well by the designed partial model. The traditional TAM, as provided by Davis (1989), is a very good starting point for prediction. However, the discussion of this process step has shown that an extension helps improve the complex concept of the acceptance of a MMITS.
The next step in the impact process model (IPM) presented empirical results for the behavioral impact of a MMITS on the intended modal change and provided a first indicator for the effect of the deployment of a MMITS. As predicted, intention to use had a positive effect on the intended behavioral change. This result shows that travelers’ exposure to potential alternatives and a reduction of transaction costs and complexity during the searching, booking, and traveling process can have a positive effect on travelers’ modal choice.

The study revealed that adding intensity of car use as a second indicator improved the explanatory power of the model, and this variable now has a positive impact. Whereas in the first step heavy car users showed a lower acceptance of a MMITS, they had a higher susceptibility to intended behavioral change when using the system anyway. These contradicting results can also be found in previous research (Eriksson et al., 2008; Ferrer & Ruiz, 2013). However, research has never integrated both aspects within one model and has shown either one or the other. The IPM, however, allows a reflection of this controversy within one model. This means that the potential for also triggering heavy car users for modal change is not as low as assumed due to an isolated look at the role of car use for the acceptance of the technology. For research, this opens discussions for incentives that would increase heavy car users’ acceptance of such a system.

However, the study has certain limitations: Although data were collected from six European countries and fulfill the statistical requirements for statistically significant results, a limitation is that conclusion for the European population cannot easily be drawn. A broader study is necessary, which would then also allow national comparison to reliably identify differences.

Likewise, the authors did not split the sample into subsamples according nationalities as these subsamples showed only little significant group differences and the groups would have been close to the limit of reliability (n≈100). Furthermore, an analysis according nationalities would require a detailed analysis of cultural, structural, and geographical differences in order to make substantial conclusions. Based on the underlying data, this could not be performed in this paper. An analysis with an explicit focus on national differences may lead to more pronounced effects with regard to the intention to use the MMITS as it might be able to better cover availabilities. This study, however, should also take into account social norms and attitudes toward mobility. Geographical differences might not be as important for medium and long distances as they are relevant for short distances, where bike plays an important role. However, what should be better captured is the individual availability of different modes.

Additionally, data were collected online, which already generates a certain bias in the data set as it must be assumed that participants of an online survey are more comfortable with the Internet and related technology.
Furthermore, the adjusted $R^2$ is remarkably higher for process step 1 than for 2. However, whereas process step 1 aims to explain what makes travelers use a MMITS, process 2 mainly focuses on the impact size of a MMITS on the intended modal change. A more sophisticated analysis might take into account further explanatory variables or triggers for modal change.

Moreover, it has to be noted that this study measures intended behavior, not actual behavior, because the MMITS does not exist. Further research could reduce the impact of this limitation by providing simulations to respondents where they can actually test the features of the system. A discrete choice modelling could allow a more detailed analysis of the respondents’ choice.

Finally, the study provides a general analysis of the MMITS. Further research might consider analyzing the single features of the system (information before and during the trip, booking, and ticketing). This would also generate important insights for the design of the system. Nevertheless, researchers should be aware that the summed effects of the components are not necessarily equal to the effect of the whole system.

3.7 Conclusion

The aim of this study was to construct and empirically test the link between travelers’ exposure to a MMITS and an intended behavioral change due to the system especially on medium and long distances. The empirical findings of this model confirm the predictive power of the TAM and present a novel view on the impact process of MMITS on travelers’ behavior by integrating acceptance and behavior within one model. The authors give empirical evidence on what is implicitly known but has never been proven to be true: The acceptance for the use of a MMITS is high. Nevertheless, it is rather used by those who already have a stronger multimodal travel behavior. It can be assumed that for multimodal travelers, it is a welcome and comfortable relief. Heavy car users, in turn, only rarely consider the use of a MMITS. Hence, further and stronger incentives are needed to disrupt habits. Nevertheless, a MMITS is still able to reduce the complexity of modal choice and multimodality and can therefore still improve travel experience for a large number of travelers. These results, thus, form an empirical basis for the political decision-making process to support a MMITS as, for the European Commission, it is crucial to foster multimodality.

These study findings also have practical implications. Regarding the design, the following recommendations are pointed out: As the ease of use was shown to be a hidden champion in the model with a direct effect on intention to use and also have an indirect effect on perceived usefulness, a user-friendly interface is essential for the success of the system. It is recommended to enable an easy and intuitive handling of the system and not to overstrain the user with information. The type of information provided may vary between users and according their preferences. The impact of age on perceived ease of use shows that a technically advanced MMITS does not necessarily reach all
travelers. A technological solution that allows a comfortable and barrier-free access to the system independently from the degree of experience with new technology and applications is needed.

Although data security issues may not have been perceived as central among the respondents of this study, its importance may not be underestimated as misuse of personal data may lead to a loss of trust in the system, which is hardly reversible. It is thus recommended that political and technological standards guarantee data security.

Still, it must be clear that the deployment of a MMITS depends not only on the user but also on a number of other aspects that require a detailed analysis, such as profitability, business models, public or private provision, legislation, or technological developments. Only if the MMITS is attractive on customer and provider side is a successful deployment that has the potential to alter mobility behavior possible.
4 Foreign Countries, Foreign Customs: An Analysis of Short-Distance Mobility of New Immigrants in the Rhine-Main Region in Germany

4.1 Abstract and Details of the Article

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4.1.1 Abstract

Mobility is an important driver of social integration. Against this background, the years since 2014 challenged cities and municipalities in Europe when a large number of immigrating refugees came to Europe and had to be integrated into society. Federal, regional, and local politics had to find strategies to overcome these difficulties without detailed understanding of the needs. Research has shown that mobility behaviour of recently settled immigrants significantly differs from locals because of language barriers or different mobility cultures, for example. However, little is known about the details of difference and how supportive measures actually affect their mobility behaviour. Using the example of asylum applicants from the Middle East and Africa in the metropolitan region of Frankfurt Rhine-Main in Germany, this paper analyses mobility for immigrants from the demand and supply sides. It brings together mobility demand and local and political efforts to satisfy this demand. Data were collected in focus groups, a survey among relevant public organisations, and a survey among immigrants. Results show that there is a need for action, as current measures, such as information on public transport or bicycle courses for immigrants, are not as effective as expected. Concurrently, data reveal that public administration and voluntary organisations have reached their limits and cannot intensify mobility measures for immigrants. Based on these findings, recommendations for public administration, voluntary workers, transport planners, and policy makers are derived that help to improve the situation of immigrant mobility.

4.1.2 Details of the Article

This article is my single authorship.11

11 I would like to thank Wolfgang H. Schulz, Uwe Clausen and Manuel Fünfrocken for their helpful comments and discussion mobility behavior, transport planning and political intervention measures.
The article is written in British English. A working version of the article was presented at the 6th German Conference for Mobility Management in Kassel, Germany in November 2017.

The article has been submitted for review in October 2018 in European Transport Research Review and has received the status “under review” November 2018.

Keywords: mobility behaviour, transport planning, mobility provision.

4.2 Introduction and Background

Mobility is an important component of social participation and integration. It allows access to employment, education, and social networks — in total, to modern life and societal opportunities (Boisjoly & Yengoh, 2017; Jeekel & Martens, C. J. C. M., 2017; Li & Zhao, 2017). Digitalisation, herein, can have a substituting effect: Internet and mobile devices allow home office solutions for a number of jobs. Education can increasingly take place with online courses and seminars. Emails, smartphones, sophisticated video conference systems, and messenger services have become essential elements of communication. They enable contact bridging long distances with little or no time lag. Still, digitalisation does not succeed in reducing the need for mobility. It remains with its central position in people’s everyday life. Moreover, constant growth in the annual passenger transport volume can be recorded. Herein, the car is by far the most important means of transport in industrialised countries (European Commission, 2017). At the same time, mobility is a learned and highly habitualised behaviour (Diana & Mokhtarian, 2009; Eriksson et al., 2008; Geis & Schulz, 2016). It strongly depends on social and cultural context. Differences even start with little aspects such as different ticketing systems, different rules for using public transport, differences in the importance of several means of transport (e.g. car, bike, public transport), or simple language barriers. This fact builds barriers for mobility usage when being in a foreign mobility system. As a consequence, it is a challenge for all involved groups (mobility users and mobility providers) to find their way in a foreign mobility system or to provide a mobility system that is understandable and usable for all.

Against this background, the years since 2014 challenged many cities and municipalities in Europe, when a large number of immigrating refugees came to Europe. The political situation in countries of the Middle East but also on the African continent drove many people towards Europe. Countries, administrations, and cities suddenly were confronted with questions of integration on a very large scale. Quite suddenly, public administrations had to handle additional demand for public services. Housing and education were not prepared for this rapid rise in demand. Among these challenges, mobility seems to be a subtopic. Yet besides overcoming language barriers, mobility is a central aspect of integration, as it allows immigrants to participate in integration and language courses, to find employment, and, above all, to expand their social network outside of their direct surrounding. As refugees were often accommodated in groups with other refugees, the risk of isolation and little
enclaves exists. Research, however, has shown that especially immigrants living in isolated areas tend to be less mobile and have fewer networks outside their direct environment (Li & Zhao, 2017; Schwanen et al., 2015). This, in turn, causes higher risks of unemployment and social exclusion (Boisjoly & Yengoh, 2017). This already shows that mobility has a highly social component that has to be considered when planning mobility. It is thus essential to ensure that mobility systems are accessible and understandable for immigrants, even when they have only been staying shortly in the country. However, mobility provision is costly and resource-consuming, and additional offers are therefore not only a question of good will. Nevertheless, in Germany and other countries, a list of short-term measures to enable mobility for new immigrants has been set up.

The distribution of immigrants differs over Germany. The Rhine-Main region has become the fifth strongest region for immigrants. In 2015 alone, 75,000 refugees arrived in the metropolitan region (Hessische Landesregierung, 2017). Generally, the share of immigrants strongly differs between 7% in Vogelsberg, in the northern part of the region, to almost 35% in Offenbach, which is located in the heart of the metropolitan region. However, different groups of immigrants have to be differentiated: (1) people with immigrant background, which covers all people who have either immigrated themselves or have at least an immigrated parent, and (2) immigrants, which describes people who have immigrated themselves. For the second group, motivation can be very different, such as employment, political instability up to wars, poverty, social reasons, education, and many more. Among the group of immigrants, refugees and asylum-seeking people are a sub-group that has immigrated from necessity because of war or political or religious persecution, for example. This group of immigrants has a non-European background and has recently come from the Middle East or Africa. Little is known about these immigrants. Neither socio-demographic details nor facts about their mobility behaviour or mobility background are known. This is because before 2014 this group existed but did not stand out in terms of size. Many assumptions circulate about how this group of immigrants is mobile and uses the mobility system. What is clear is that there are immense language barriers orally and in writing and that this group is characterised by a high rate of illiteracy. Learning and integration therefore have special challenges to overcome.

As this group has received so little attention in research up to now but nowadays plays a significant part in German and European society, this study aims at providing a profound understanding of the mobility behaviour of recently settled immigrants. The results of this paper are based on a study conducted in the metropolitan region of Frankfurt Rhine-Main in the centre of Germany. The study focused on recently settled immigrants from the Middle East and the African continent, usually refugees and asylum-seeking people, and service providers that offer support to these people when trying to start life in the metropolitan region (e.g. municipalities, public transport providers, or voluntary workers). Therefore, in this paper, a twofold perspective is taken to answer the question of how short-distance mobility of recently settled immigrants can be supported: First, the paper sheds
light on the question of what marks short-distance mobility behaviour of immigrants from the Middle East and African countries in Frankfurt Rhine-Main. Second, the author analyses current mobility offers and challenges for public transport providers or municipalities in the integration of this immigrant group in our mobility system. The demand and supply sides are compared, and recommendations for policy makers, transport planners, and further groups are developed. Data were collected in focus groups, a survey among relevant public organisations, and a survey among immigrants. For reasons of readability, the term immigrant is used in this paper without further specification. However, it means only those who have recently settled in Germany (not more than two years) and are from the Middle East or the African continent.

The rest of the article is structured as follows. Section 2 presents a literature review to highlight the most relevant research contributions in this research field. Section 3 explains the underlying methodology as well as the challenges that have to be overcome for this research. The research-relevant characteristics of the target group are explained, and the study area is introduced. Section 4 shows the results of the data collection. The analysis is divided into supply and demand sides. Section 5 discusses the empirical results, highlights gaps between demand and supply, and formulates recommendations for the involved stakeholders on how to facilitate mobility and mobility provision. Herewith, the author addresses public administration, voluntary workers, and policy makers and points out organisational and planning aspects to be considered.

4.3 Literature Review

Determinants of travel behaviour are an important topic in research (Geis & Schulz, 2016). Research has shown that demographic factors, such as gender or age, have an effect on how people travel (Frändberg & Vilhelmson, 2011; Fu & Juan, 2017; Gefen & Straub, 1997; McGuckin & Murakami, 1999). Furthermore different mobility behaviours can be explained by different cultures and the geographical environment. Buehler (2011), for instance, argues that Germans have a higher probability to use public transport compared to Americans. Research shows an increasing interest in mobility behaviour of immigrants. Most studies on the mobility behaviour of immigrants have been conducted among immigrants in America. Blumenberg (2009), for example, argues that immigrant mobility behaviour significantly changes local mobility behaviour. The author suggests that the increasing number of immigrants changes the demographic structure of daily travellers and specifically increases the demand for mobility (Blumenberg, 2009). As other authors have already shown that demographic factors influence modal choice, these results indicate that transport policy has to be rethought if immigrants significantly change travellers’ characteristics.

Additionally, Tal and Handy (2010) conducted a more differentiated analysis of immigrants in America. They analysed the relation between mobility behaviour and immigrant status. Based on data of the National Household Transportation Survey, the influence of the place of birth and the
year of immigration to the United States was examined. The central result was that the year of arrival plays a role for immigrants who have recently settled in the US but loses importance the longer the immigrants have already been in the US. The place of birth had a rather diffuse effect. Some countries of origin had an influence, whereas others did not (Tal & Handy, 2010). An analysis by Hu (2017) showed similar results for Asian immigrants. It was pointed out that recently settled Asian immigrants have a significantly different mobility behaviour to Asian immigrants who have already been in the country for a while (Hu, 2017).

Other studies focus on a specific immigrant group. An article from 2016, for example, examined the mobility of Chinese immigrants in New York City. The article suggests that Chinese immigrants in Queens are relatively immobile because they experience a number of structural barriers, such as racial discrimination, language barriers, or economic restrictions. It was pointed out that accessibility to transport is not enough to solve these barriers or to prevent immigrants from social exclusion. It was emphasised that integration has to be a holistic approach that integrates transport policy, labour policy, and social integration measures (Yu, 2016). In general, research agrees that a lack of mobility leads to enclaves, social exclusion, and reduced job opportunities. A negative impact on the integration of the immigrants is predicted (Bose, 2014; Li & Zhao, 2017).

Besides analysing the mobility demand of immigrants, mobility provision for immigrants is a relevant topic. Interestingly, up to now, little research has focused on this topic. One article, however, identified strategies to address mobility needs of immigrants in California. Five approaches were developed: (1) improvement of transit in public transport, (2) safer and more accessible car travel, (3) improvements for pedestrians, (4) improvements for bicyclists, and (5) innovations in land use patterns for a better integration with transport (Handy et al., 2011).

Some studies have analysed the neighbourhood effects among immigrants. Research has found that immigrants have a higher probability to carpool if they live in immigrant neighbourhoods than non-immigrants in non-immigrant neighbourhoods (Blumenberg & Smart, 2014). Based on a geocoded dataset, Smart (Smart, 2015) found that immigrants in the US use carpooling, walking, bicycling, and transit significantly more than non-immigrants. The author pointed out that, especially for shopping, immigrants tend to use short-distance mobility by bicycle or foot. An article from 2014 also emphasised the importance of carpooling for immigrants. The authors stated that immigrants tend to be in strong ethnic-related networks, which increases their probability of finding carpooling partners (Blumenberg & Smart, 2014). Most of the research has been conducted in America, which is a strong immigrant nation. For Europe, there exists almost no research on immigrant mobility. The United Kingdom and the Netherlands, however, have received attention (Harms, 2007; Tsang & Rohr, 2011). Also for the city of Offenbach am Main in Germany, differences in mobility behaviour of immigrants have been analysed (Welsch, Conrad, & Wittowsky, 2018). It is striking that the
European studies mostly do not differentiate between people with immigrant background and recently settled immigrants. This is because Germany has a high share of people with immigrant background whose parents already immigrated to Germany (e.g. from Italy or Turkey). Their children were already mostly born in Germany. However, recently settled immigrants receive little attention and pose challenges for public administration. Yet, with the strong immigrant years of 2015 and 2016, this became an important and relevant research topic. This paper starts filling this research gap.

4.4 Methodology and Data Collection

4.4.1 The Target Group

The research of this paper focuses on immigrants with a refugee background. Labour immigrants, students, etc. are excluded from this research. This brings a number of challenges that have to be considered when designing the methodological approach. As the target group comes from many different countries, it is not in the scope and financial resources of this research to provide translation of questionnaires in all languages. The target group is non-native speaking in English and German. Moreover, it must be expected that the target group has only basic knowledge of English or German and can articulate itself with difficulty. Therefore, language barriers are expected. Furthermore, it must be presumed that a significant proportion of the potential respondents is illiterate, which means that even if German or English is understood, it cannot be guaranteed that a questionnaire can be read. Additionally, it must be assumed that relevant questions are not answered honestly, such as age or home country, as the respondents do not trust or understand the concept of anonymity and because they are afraid that an honest answer would cause them disadvantages regarding residence permission or financial support. Therefore, questions have to find balance between being sufficiently unspecific for triggering honest answers and specific enough for data analysis and interpretation. Finally, refugees interact in relatively closed groups because of language barriers or isolated housing, for example. This means that gatekeepers are needed to access suitable research participants.

4.4.2 The Study Area

As a study area for the research project, the metropolitan region of Frankfurt Rhine-Main was chosen. It covers an area of around 15,000 km² with around 5.7 million inhabitants. It consists of seven district-free towns and 18 districts. (Regionalverband FrankfurtRheinMain, 2018b). An overview of the region is given in figure 5. The region is located in the centre of Germany and extends over three federal states (Hesse, Rhineland-Palatinate, and Bavaria). The highest growth for inhabitants is in the cities of Frankfurt, Offenbach, and Darmstadt, whereas other regions are marked by declining inhabitant numbers. Frankfurt Rhine-Main has an average share of foreigners of 16%. The district of Vogelsberg is marked by the lowest proportion with around 6.5%, whereas Offenbach has the highest proportion of foreigners with around 34% (Regionalverband FrankfurtRheinMain, 2018a). In 2015,
applications for asylum reached a maximum in Germany and also in the metropolitan region. In Hesse alone, 75,000 people applied for asylum in 2015. Already in 2016, the number of applications decreased to 20,500 and fell by another half in 2017. Syria, Afghanistan, and Iraq were the most common countries of origin in 2015. In 2017, the relation changed slightly. Whereas only 600 asylum applications came from Turkey in 2015, 1,366 came in 2017, and Turkey became the second most common country of origin after Syria (Hessische Landesregierung, 2017).

Figure 5: The Study Area
Source: Own work designed with OpenStreetMap

Frankfurt Rhine-Main generates € 250 billion of GDP yearly. It is therefore a significant economic driver in Germany and one of the most important locations for employment. The area is characterised by its strong finance and investment industry as well as logistics. This also makes the area an important transportation hub for the whole of Europe, with attractive living conditions. However, this economic prosperity leads to a higher price level. Urban areas in particular are characterised by high housing prices. Frankfurt has become the second most expensive German city in terms of housing prices (after Munich). The cities of Mainz, Darmstadt, and Wiesbaden are also among the top 10 (Empirica, 2018). Yet, prices strongly differ per district in the metropolitan region. The more rural a region is, the lower the housing prices are. The local connection to the general transport infrastructure, such as rail connection and suburban railway, buses, or distance to the airport, strongly influences housing prices. Normally, the worse the local transport system is, the lower the housing price level is. As a consequence, it becomes more and more attractive to live in the outer areas, given that mobility does not depend on local public transport and people can be mobile by car. Therefore, a higher share of car ownership can be noticed for regions outside the urban areas.
These facts strongly challenge housing for refugees. On the one hand, in 2015 and 2016 municipalities quickly needed large housing areas. Space in urban areas is usually rare and, above all, expensive. On the other hand, accommodations in more rural areas often lack connections with public transport, and being mobile with one’s own car is no option for this group. This contraction makes this study site very interesting and perfect for analysis, as it clearly shows the dilemma in locally and geographically integrating these immigrants in a smart way. It is a question of not including this group and impeding the development of enclaves.

4.4.3 The Methodological Approaches

An explorative approach was chosen for this paper. Data were collected in the research project ‘Short-distance mobility of new immigrants as part of a successful integration strategy: A needs analysis for the Rhine-Main area’ (Geis, 2017b). The project aimed at an analysis and comparison of the mobility demand of new immigrants and the mobility supply from the perspective of cities, municipalities, and public transport providers.

This paper is based on three data collections. First, for the supply side perspective, three focus groups with each between 10 and 12 participants were conducted. Each focus group was dedicated to another topic. Participants in the focus group were representatives of municipalities; the local public transport, especially transport planners; and professional and voluntary integration workers. Participants had to have experience in the provision and planning of mobility, traffic education, or the integration of new immigrants. Participants were invited from the Rhine-Main area to make sure they were familiar with the local conditions and the specific challenges of the region. All focus groups were accompanied by a partially structured guideline. Focus group 1 took place in April 2017. It focused on current measures of supporting short-distance mobility. It covered measures, ratings of acceptance among the immigrants, and organisational aspects of planning mobility for new immigrants. The second focus group was conducted in May 2017 and covered implicit knowledge of the mobility culture, challenges, and barriers to the mobility demand. In August 2017, the third focus group was conducted. Solutions for municipalities and public transport providers were developed that help to provide demand-based and efficient mobility to new immigrants.

Second, the focus groups were complemented with a questionnaire for municipalities and public transport providers. Questions mainly covered the discussion in the focus groups to receive an additional and larger-scale picture. The questionnaire was sent to respective institutions of the region via email. Interested institutions filled out the document and sent it back via mail, email, or fax. The survey resulted in 41 respondents and consolidated hypotheses built in the focus group but also disagreed and allowed for new hypotheses.

Third, data on the demand side (i.e. the immigrants’ perspective) were collected with a paper-and-pencil survey among new immigrants (in English and German). As the questionnaire was designed
for people of different nationalities with little or no German skills, it was designed to be bilingual. Because of cost restriction, a translation in other languages was not possible. The target group of the survey was new immigrants with a non-European background. Labour immigrants, exchange students, and immigrants with an above-average professional level or education were not analysed in the study. The survey focused on refugees and immigrants with low educational background. Data collection was conducted from April 2017 to August 2017.

4.4.4 Survey Design

The survey among immigrants forms an essential part of the data collection. However, several difficulties had to be considered. The target group was diverse in education, language, and reading skills. Due to restricted financial resources, the survey was designed for people with at least basic German or English skills. The language was designed to be as basic as possible, and the questionnaire was accompanied with pictures and signs to facilitate understanding. A first draft of the questionnaire was pretested with representatives of the target group. The pre-test showed that the language had to be further simplified, and the process of filling out a questionnaire had to be explained first. Therefore, instructions for how to fill out a questionnaire were developed. The questionnaire contained questions on the modal split for daily mobility covering car, taxi, public transport, bike, and walking. For each mode, questions were asked on usage frequency, reasons for and against the usage of the mode, and trip purpose.

The respondent was led through the questionnaire mode by mode and always with the same questions per mode to facilitate understanding as far as possible. Furthermore, each block of questions was complemented with mode-specific questions, such as driving licence, car/bike ownership, and distance to the next public transport station. A final block of questions was dedicated to the knowledge of and experience with local mobility offers: subsidisation of public transport tickets, biking lessons, workshops for broken bicycles, information material on local mobility offers, and safety trainings for traffic. Finally, the respondents were asked how well they think mobility in their region fits their needs and how satisfied they are with their daily mobility. The questionnaire was closed with questions on socio-demographics, including gender, age, origin, and year of arrival in Germany. When asking for the country of origin, regions were asked for, such as Eastern Europe, Near East, Northern Africa, etc., as the pre-test showed that specific country origins are not or are incorrectly answered. In the case of age, a range was asked to reduce the risk of deliberately wrong answers. All questions were designed as closed questions. Furthermore, each respondent was accompanied by a trained interviewer who helped with problems of understanding or read out the questions. This was necessary, as most of the respondents had limited or no reading skills.

Participants in the survey were acquired in cooperation with local organisations and institutions that had the role of gatekeepers. The organisations allowed access to waiting rooms during the immigrant
consultation hours in social welfare offices, integration courses, or shared accommodations. In all cases, interviewers were on-site to be able to support participants when having language or reading barriers.

4.5 Results

4.5.1 Supporting Mobility for Recently Settled Immigrants

4.5.1.1 Focus Groups and Complementary Survey Sample

The analysis of supporting measures in the metropolitan region for the mobility of recently settled immigrants is based on the three focus groups and a follow-up survey among relevant institutions and districts. Focus group 1 (‘Current supporting measures’) consisted of 12 representatives from public transport, local transport planners, regional municipalities, regional stakeholders for mobility, and voluntary workers. For focus group 2 (‘Daily mobility of recently settled immigrants’), seven participants joined. The group consisted partially of similar and partially of new participants. Participants were again representatives of municipalities in the metropolitan region as well as of public transport providers. However, people with direct relation to the everyday life of immigrants had a stronger share of participation to provide direct experience and impressions. Immigrants and voluntary integration workers participated. Finally, for focus group 3 (‘Validation of potential strategies’), eight representatives from municipalities, public transport, and voluntary workers participated. Again, partially new and known participants were selected. The survey conducted between focus groups 2 and 3 served to more comprehensively evaluate the questions and topics of focus groups 1 and 2. Therefore, the topics were transferred to closed questions. Finally, 41 institutions, mainly municipalities, participated in the survey. Focus group participants were explicitly not invited to the survey. Seventy-six percent of the respondents were from municipalities in the metropolitan region. Twelve percent were public transport providers. Voluntary organisations participated with a share of ten percent. Additionally, an institution of public interest that was not further defined participated. Fifty-six percent of the respondents indicated to have supportive measures to improve mobility of immigrants. Public transport providers added that they usually apply the measures that are offered by the superior transport association, which is the Rhine/Main Regional Transport Association in the metropolitan region.

Table 6: Characteristics of the Survey among Institutions

<table>
<thead>
<tr>
<th>Type of institution</th>
<th>Number of survey participants (share in %)</th>
<th>Number of institutions with mobility offers for immigrants (share in %)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Municipality</td>
<td>31 (76%)</td>
<td>17 (55%)</td>
</tr>
<tr>
<td>Public transport provider</td>
<td>5 (12%)</td>
<td>3 (60%)</td>
</tr>
<tr>
<td>Voluntary organisation</td>
<td>4 (10%)</td>
<td>3 (75%)</td>
</tr>
<tr>
<td>Institution of public interest</td>
<td>1 (2%)</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>TOTAL</td>
<td>41 (100%)</td>
<td>23 (56%)</td>
</tr>
</tbody>
</table>
Source: Own sample.

4.5.1.2 Mobility Provision and Constraints

In a first step of the analysis, the current situation in mobility provision for new immigrants was analysed. The focus groups as well as the survey showed that mobility support for immigrants is an important topic that concerns a number of actors. This is why a multitude of institutions decided to implement supporting measures. The majority of the participating institutions admitted that supporting measures for the mobility of immigrants were mainly introduced in 2015 with the sudden increase of immigrants all over Germany. Discussions and the survey made clear that municipalities were often unprepared and had to find quick solutions. In general, it became clear that, due to time pressure, districts often did not work together or jointly address the topic. Therefore, many isolated programmes and measures can be identified. However, it is clear that there exist a number of similarities as well as variety and differences, although they all belong to the same metropolitan region.

The discussions and the survey revealed that information provision is the most frequent measure to support immigrants after their arrival. Two steps can be identified: (1) Information material is provided and handed out to immigrants. The superior transport association, the Rhine/Main Regional Transport Association, has designed a brochure in German and Arabic that contains general information on the local public transport system. It explains how and where to buy tickets, how to read the schedules, or which tickets exist. The brochure works with a combined written and picture language. This brochure was mentioned as the most important material, as municipal transport operators mostly distribute this and similar brochures provided by the association. Participating municipal transport operators stated that they did not develop specific material. Material is often distributed during counselling hours, in shared accommodations, or at other contact points. (2) Information events, for instance in first accommodations, were conducted. These events were used to inform large groups of recently arrived refugees and provide them with relevant material. Whereas the brochure-based information is mostly focused on public transport, additional events and counselling hours often have a more general character, according to the results. The events contain information on public transport usage as well as the local options for further mobility, such as bicycles.

Integration workers, however, criticised that immigrants receive a huge amount of information with their arrival and first registrations. They start with a lot of paper and brochures that contain information that is necessary for their first months in the region. These include information on social offers, administrative duties, integration courses, and much more. Information, herein, is only one out of many. The workers, therefore, admit that information often gets lost, as recipients of information are overstrained. A stepwise and targeted provision of information would help to improve the probability that information is perceived. Municipalities and public transport
organisations agreed with this criticism in the discussions. Yet, they emphasised that it is a question of financial resources and additional personnel, which is not available.

The provision of discounted or free public transport for refugees is little spread. Thirteen percent of the surveyed practitioners indicated that they have a special ticket offer for refugees. The regional transport association, for instance, provides a mobility ticket for refugees in first accommodations that is valid for three months and allows public transport usage in the respective district. Mostly, districts and their local transport operators rely on social tickets according to the German Social Security Code that is provided to people of social need. If the application for asylum is approved, refugees can also apply for this social ticket independently from the nation. Discussants emphasised that institutions, public transport operators, and municipalities underlie strong financial restrictions, which makes discounted or free tickets almost impossible to handle for many districts, as the cost gap has to be filled by these institutions. These tickets underlie a further constraint that creates difficulties for its users: These tickets are usually bound to a district or a federal state. As a metropolitan region with districts in three federal states, it strongly limits mobility, especially when it comes to the usage of further integration offers or language courses that often take place in another district.

Besides public transport, mobility by bicycle plays an important role among the supporting measures: (1) provision of bicycles and (2) bicycle courses. Regarding bicycle measures, institutions act diversely. Participants emphasised the importance of bicycles for daily mobility and as a relevant step towards integration. Bicycles enable flexible mobility and covering longer distances than on foot. They are also a relatively affordable mobility. Consequently, bicycle donations especially in 2015 made it possible to provide bicycles to immigrants. Fifty percent of the questioned municipalities stated that they provide bicycles for refugees. Different models were critically discussed and are applied: free bicycle provision, provision against voluntary labour, or provision against a deposit. Some municipalities and voluntary workers mentioned the experience that bicycles that are given away for free (i.e. as a present) are not valued. They said that bicycles were then often found abandoned in the closer environment. This experience was not confirmed by all municipalities. Because of the negative experience with free bicycles, some municipalities and the related organisations established models based on deposit or on voluntary work. Those who received a bicycle either gave a small amount of money or agreed to support local bicycle repair shops. The second solution is preferred, as it additionally has an integrating factor. Practitioners, furthermore, admitted that in the beginning severe traffic safety issues came up due to insufficient experience of immigrants with road transport in Germany. Therefore, some municipalities decided to make specific road traffic safety courses obligatory for those who want to have a bicycle from the public pool.
Furthermore, municipalities noticed that riding a bicycle is not common among this immigrant group. As a consequence, the demand for bicycles was rather low in the beginning. Therefore, respective courses have been set up. In particular, the traffic police and volunteer organisations offer courses for adults and children. Most women cannot ride the bicycle according to the experience of the course organisers. However, experience also showed that women are rather reserved towards these courses. Besides courses on how to ride a bicycle, volunteer workers offer bicycle tours for immigrants that help them to get to know the environment and where to be mobile by bicycle.

Car-related mobility does not receive attention from the mobility provision perspective. Cars are not relevant for early immigrant mobility. Furthermore, it is not a public duty to enable car mobility. However, some supportive measures are offered. For example, counselling programmes are offered if an immigrant wants to earn a driving licence. Even immigrants who have a driving licence from their home country usually cannot use the licence in Germany. This is because there is no recognition agreement between most of the origin countries of refugees and Germany. As a consequence, the driving licence can only be used for six months. After the expiration of the six months, the driving licences have to be transcribed, which requires a theoretical and practical driving test (ADAC, 2017). However, taking this test requires financial resources that usually do not exist in this group. A subsidy of the driving test is possible if the immigrant can prove employment for more than 12 months and if the driving licence is necessary for the employment. Two of the surveyed municipalities added that regular carpooling activities have been established. However, they are privately organised, not offered by institutions.

From a more general perspective, some of the surveyed municipalities and organisations criticised that they indeed make many offers for immigrants and do their best to communicate these offers, but the demand remains low. This covers bicycle courses as well as information events on mobility. Although this is not an issue shared by all practitioners, it seemed to be relevant, as it was deeply discussed. Discussion showed two causes for this problem: (1) information overload of the immigrants, as mentioned at the beginning of the chapter, and (2) cultural barriers that are difficult to overcome. The role of gatekeepers and multipliers was emphasised. The affected organisations admitted that it helps to work together with immigrants who already successfully use the local mobility offers, letting them spread the positive experience and improving the access to closed immigrant groups.

Furthermore, the participants of the focus groups and the survey admitted organisational problems that came up especially in 2015 and continued to be relevant in the following years. 2015 and 2016 were strong immigrant years. This affected municipalities and administrations from several directions: housing, administrative work, and integration courses. These duties already existed before and were carried out. However, the pressure of demand was many times higher, and administration
was not prepared. Therefore, mobility could not be the centre of attention but had to be, as it is relevant for so many integrational measures. Herewith, practitioners mostly confirmed what has already been stated by research. Many cultural and language problems with mobility existed before but became evident with the large group facing these issues. Most surveyed organisations admitted that they do not have the financial resources or the personnel to provide the measures in the individualised or targeted way that would be necessary to be more effective. At the same time, discussions revealed that municipalities and other institutions of the metropolitan region cooperated little and mostly worked and implemented measures for mobility on their own. This is surprising, as mobility provision strongly benefits from joint implementation and programmes due to synergies and economies of scale. However, this is again a question of resources. Building cooperation requires time and personnel, which are not available.

Finally, some of the surveyed organisations mentioned decreasing acceptance of additional measures for immigrants. It was discussed that in 2015 and 2016 it was a lot easier to establish measures, such as bicycle donations, than it was in 2017. This can be explained by societal and political opinion. However, it must also be admitted that in 2017 the number of applications for asylum greatly decreased. Thus, public pressure was reduced, and attention was again brought to other topics. Daily business was back. Yet, municipalities stated that the need for supportive measures that help immigrants to be mobile still exists.

4.5.1.3 Experience with Immigrant Mobility

As a preparation for the development of the questionnaire for immigrants, a focus group was dedicated to experience with mobility behaviour. As the later questionnaire had to be very easy in language and understanding, this focus group allowed to predefine the necessary questions and response options. However, it must be clear that this focus group contained assumption and hypotheses based on the personal experience of the participants. They gained their experience in their daily work with immigrants. Furthermore, immigrants who were already in good command of the German language enriched the focus group. The later survey among immigrants gave a quantitative indication of the mobility behaviour.

The analysis of the discussions in this focus group indicated that immigrants tend to move in their direct environment and avoid longer distances. The reasons that are named are cost and uncertainty in the usage of public transport. Especially in the less urban areas of the metropolitan region, the discussants emphasised the importance of walking and bicycling. The experts explained that the modal choice strongly varied according the trip purpose. Administrative appointments or integration courses that are often farther away are reached by public transport independently from the location of the accommodation. However, the experts mentioned that the more rural immigrants are accommodated, the less they rely on public transport for other trip purposes, such as daily shopping.
or social activities. The experts indicated that the more rural the environment the immigrants live in, the more they tend to master their social life in the direct surrounding. Immigrants in urban accommodations, in turn, were significantly more mobile and willing to leave their quarter for social activities. According to the experts, coverage with and frequency of public transport strongly influence this behaviour.

Again, it was emphasised that riding a bicycle cannot be assumed as a common ability among the majority of immigrants from the Middle East or Africa. It was assumed that especially women have reservation towards this mode of transport, although it is essential for being mobile, specifically in more rural areas. Car mobility was assessed as irrelevant. However, experts assumed that in a later period of the immigrants’ settlement this could change, as a car has a strong symbolic character. However, financial and organisational restrictions make it unimportant in the early stage.

4.5.2 Mobility Behaviour of Recently Settled Immigrants

4.5.2.1 Sample Description

In total, 96 immigrants completed the survey. Of these, 65% were male, and 35% were female. In 2017, 60.5% of the applicants for asylum in Germany were male and 39.5% were female (Bundesamt für Migration und Flüchtlinge [BAMF], 2018). In 2016, 65.7% of the applicants were male and 34.3% were female (BAMF, 2017a). This makes this sample realistic in terms of gender.

Forty-six percent of the respondents were between 18 and 30 years old; 27% were between 31 and 45 years old; 27% were between 31 and 45 years old; 16% were between 46 and 60 years old; and only 7% were under 17 and 4% over 60 years old. Official statistics of the respective ministry show a slightly different age distribution (taking into account that the statistics use ranges differing by one year compared to our sample; see Table 2): 5.9% of the applicants were between 16 and 18 years old (5.6% in 2017); 1.2% of asylum seekers were older than 60 years (1.7% in 2017); 37.6% of applicants in 2016 were between 18 and 30 years old (30.3% in 2017); and 19.8% were between 31 and 45 years old (18.4% in 2017) (BAMF, 2017a, BAMF, 2018). Data show that the age group of 18–30 years is overrepresented, as well as the group between 31 and 45. However, this can be easily explained: The official statistics have access to the full population of asylum seekers, whereas children were not considered for this survey. Therefore, the group of under-17-year-old respondents is significantly lower than in reality. This, however, does not negatively influence the validity of the sample, as the mobility behaviour of children is strongly influenced by parents or other adults in their environment.

The majority of the sample (70%) comes from the Middle East, and 23% of the respondents come from an African country. These proportions also reflect the fact that Syria has become the most common country of origin of asylum seekers, especially since 2015. Still, 7% did not answer the question about the country of origin or gave misleading answers. This again emphasises the difficulty
with socio-demographic questions in this group. Furthermore, 42% of the respondents arrived in Germany in 2015, which was the strongest immigration year in Germany. Another 26% arrived in 2016, 22% before 2015, and only 6% in 2017. Six percent did not answer the question.

Table 7: Characteristics of the Sample in Comparison to Official Statistics

<table>
<thead>
<tr>
<th>Category</th>
<th>Sample share</th>
<th>Official statistics 2016</th>
<th>Official statistics 2017</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MALE</td>
<td>65%</td>
<td>65.7%</td>
<td>60.5%</td>
</tr>
<tr>
<td>FEMALE</td>
<td>34%</td>
<td>34.3%</td>
<td>39.5%</td>
</tr>
<tr>
<td>Age</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; 17</td>
<td>7%</td>
<td>30.3% (&lt;16)</td>
<td>39.4% (&lt;16)</td>
</tr>
<tr>
<td>18 – 30</td>
<td>46%</td>
<td>5.9% (16 – 18)</td>
<td>5.6% (16 – 18)</td>
</tr>
<tr>
<td>31 – 45</td>
<td>27%</td>
<td>37.6% (18 – 29)</td>
<td>30.3% (18 – 29)</td>
</tr>
<tr>
<td>46 – 60</td>
<td>16%</td>
<td>19.8% (30 – 44)</td>
<td>18.4% (30 – 44)</td>
</tr>
<tr>
<td>&gt; 60</td>
<td>4%</td>
<td>5.2% (45 – 59)</td>
<td>5% (45 – 59)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.2% (&gt; 59)</td>
<td>1.3% (&gt; 59)</td>
</tr>
<tr>
<td>Origin</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MIDDLE EAST</td>
<td>70%</td>
<td>N.A.</td>
<td>N.A.</td>
</tr>
<tr>
<td>EASTERN AFRICA</td>
<td>21%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NORTHERN AFRICA</td>
<td>2%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MISSING VALUE</td>
<td>7%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Year of arrival</td>
<td></td>
<td></td>
<td>Change in first-instance applications for asylum</td>
</tr>
<tr>
<td>Before 2015</td>
<td>22%</td>
<td>+57.9% (2013/2014)</td>
<td></td>
</tr>
<tr>
<td>2015</td>
<td>42%</td>
<td>+155.3% (2014/2015)</td>
<td></td>
</tr>
<tr>
<td>2016</td>
<td>24%</td>
<td>+63.5% (2015/2016)</td>
<td></td>
</tr>
<tr>
<td>2017</td>
<td>6%</td>
<td>-72.5% (2016/2017)</td>
<td></td>
</tr>
<tr>
<td>MISSING VALUES</td>
<td>6%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


4.5.2.2 Short-Distance Mobility from an Immigrant Perspective

Generally speaking, data indicate a strong difference in mobility behaviour between men and women. Data show that around one third of the respondents possess a driving licence in their country of origin. However, driving licences are most common among men. Nevertheless, only seven of the survey respondents are allowed to use the driving licence in Germany. Seventy-three percent of the respondents remarked that they would like to take the test but simply cannot afford it or even afford a car at a later stage. Consequently, it is not surprising that a car does not play any role in the daily modal split. Ninety-eight percent of the respondents indicated that they never or almost never use a car as a driver. However, at least 16% of the respondents stated that a few times per month they are car passenger. Ten percent even indicated that they are a car passenger every week. This statement is also confirmed by the focus group results. Here, it was stated that many integration workers often take the immigrants with them or even bring them to important destinations. The results also show that a taxi is irrelevant. It can be assumed that it exceeds the immigrants’ budget.
If a car is irrelevant for immigrants, other modes of transport (not car-based) must gain importance. Public transport is, therefore, a relevant mode of transport. However, differences can be noticed depending on the location of the accommodation. The more peripherally the accommodation is located, the less the respondents used public transport. Data indicate that 67% of the respondents use public transport on a daily basis, whereas only 40% have the same frequency in peripheral areas. Still, 50% use public transport weekly despite living in a peripheral area. An important reason can be that in peripheral areas the next bus or train station is between 10 and 20 minutes away, whereas in central areas, 75% of the respondents indicated a maximum distance of 5 minutes. These problems are not immigrant-specific but show a general problem of public transport in peripheral areas. It can be expected that this problem increases the more peripherally one lives.

![Figure 6: Frequency of Public Transport Usage according to Location of the Accommodation](image)

Source: Own sample.

Those respondents with a high usage frequency indicated that public transport is flexible and relatively cheap. Fifty percent of the immigrants that never or rarely use public transport indicated that tickets are too expensive. Respondents here generate a contradiction. Whereas some stated that public transport is an affordable mode of transport, others stated the opposite. A specific characteristic of this region must be understood at this point. As the region consists of several districts, depending on the origin and destination, regional borders have to be crossed. Sometimes this leads the public transport user into a new tariff zone, although they have taken only one or two stations. This can disproportionally increase prices. Additionally, respondents indicated language barriers when trying to use public transport. Understanding the ticket machine, the timetable, or selecting the correct ticket are named as the most important difficulties. The confusion about the correct ticket is also reflected in the tickets that are purchased: 47% regularly use a monthly ticket, and 56% regularly use single tickets (which are relatively expensive when regularly using public transport).

Public transport is mostly used for reaching more distant destinations that are too far away for walking. Fifty-six percent use public transport to attend integration courses or for doing their daily shopping. Public transport is also important for reaching official authorities or going to the doctor
(each 55%). In case of leisure, public transport loses relevance. Only 35% indicated that they use public transport. It can be assumed that leisure rather takes place in the immediate environment. Also, religious sites are less relevant (only 31%).

A bicycle is another relevant mode of transport. Around 20% of the respondents indicated that they are able to ride a bike. A gender difference is obvious: Mostly men can ride a bike. Almost no women are able to do so. Still, data show that the bicycle significantly gains importance in peripheral areas. Fifty percent of peripherally accommodated respondents use a bicycle every day and 23% every week. In central areas, only 9% use one every day and 20% every week; 63% of the participants in central areas stated that they never or almost never use a bicycle. Bringing these results together with the usage of public transport, it can be interpreted that immigrants bridge their problems with public transport by taking a bicycle. However, as women have significantly less ability in riding bikes, this group has to live with reduced mobility. Among those who only rarely or never use a bicycle, the reasons are usually that they either cannot ride a bicycle or they do not have one. In contrast to public transport, bicycles are often used for leisure activities but also for local shopping. They are less relevant for official appointments.

![Figure 7: Frequency of Bicycle Usage according to Location of the Accommodation](image)

Source: Own sample.

Finally, walking also plays an important role in the daily short-distance mobility behaviour. Women especially expressed discomfort and uncertainty in the context of public transport and bicycles. For instance, they stated they were afraid of missing the bus station and getting lost. In general, it became clear that women were significantly less confident in moving around. As a consequence, walking is seen as an important way of movement. The focus groups additionally revealed that women sometimes even prefer to walk longer distances than to take a bus because they feel uncomfortable or uncertain. In general, 56% of the respondents stated that they walk several times per day for being mobile, and 20% indicated that they walk several times a week. The most typical purposes are local shopping and leisure.

From research, it is known that modal choice is determined by the attractiveness of the offers. The sole existence of offers is not the only decisive factor. It is also relevant whether the potential users
are informed. The previous analysis has shown that there is a variety of offers. However, municipalities often complain that these offers are not used. Data revealed that especially those immigrants with a relatively short length of stay are rather badly informed and are often unaware of the possibilities. Only 23% of the respondents, for instance, were aware that they can apply for discounted public transport tickets according to the German Social Security Code as valid for people with the need of social support. However, the cost for these tickets varies between cities. There are no standardised rules for these so-called social tickets, and municipalities can freely decide whether to offer such a ticket. In Frankfurt, for instance, the so-called Frankfurt pass, which is the discounted ticket, currently costs around €63 as a monthly ticket (regular €89) (Verkehrsgesellschaft Frankfurt, 2016). Similar prices can be found in other cities of the metropolitan region. As these prices are still relatively high and due to language barriers, it is possible that immigrants do not understand that they receive a discounted price.

Many cities, municipalities, and organisations also offer bicycle courses. Here, participants can learn how to ride a bicycle and how to safely move on the road. Only 17% of the respondents knew that such offers exist, and only 6% made use of the offer. It is remarkable that especially those immigrants who cannot ride a bicycle are unaware of these offers. Yet, this group is specifically interesting in being addressed. Logically, most of the respondents also did not know about bicycle repair shops, where they have the opportunity to get their bicycles repaired for low prices or learn how to repair their bicycle on their own. Likewise, informative brochures are not commonly known among the respondents. However, these brochures are important, as they exist in many different languages and provide information on mobility and transport in the region in an understandable way. Still, these offers require that the target group can read, but this is often not the case. Therefore, these brochures pass by the immigrants without being appreciated. Some respondents stated that they know these brochures but declared that they do not need the contained information to be adequately mobile.

4.6 Discussion
Data of this paper were collected in three steps: (1) focus groups, (2) survey among institutions developed from the focus groups, and (3) survey among immigrants from the Middle East and Africa. From these steps, conclusions on the mobility behaviour of immigrants can be drawn. These insights help to evaluate the effectiveness of measures by municipalities, public administration, or public transport organisations to support immigrant mobility. Contrasting the experience of the mobility supply side with the demand side reveals which measures already work well and have a supporting effect and where strategies are needed to meet the mobility needs of this immigrant group.

Generally, the results revealed that immigrants have different mobility behaviour and do not rely on car mobility. This confirms the results of previous research that emphasised the importance of public transport and walking. Although the research sample was relatively small, carpooling appears as a
relevant mobility option, as already pointed out by previous studies (e.g. Blumenberg & Smart, 2014). Results also showed that municipalities have a strong interest in immigrants being mobile. They need immigrants to be mobile and able to move around to improve the integration process. Again, research is confirmed (Boisjoly & Yengoh, 2017; Li & Zhao, 2017).

Analysis has shown a long list of barriers that limit immigrants’ mobility: Language barriers make it difficult to understand information. Different mobility routines and cultures impede immigrants from directly using local transport systems, because they cannot ride a bicycle or because the ticket system is different in their country of origin, for example. Sometimes gender represents a barrier when culture impedes men and women from participating in joint courses. Analysis revealed that immigrants often do not have the necessary information on tickets or local bus systems; however, this was because the immigrants did not understand it or were unable to filter the necessary information, not because municipalities did not provide information. Data have shown that immigrants suffer from information overload and uncertainty in handling local mobility. Efforts of public administrations and transport planners are immense, such as traffic safety courses, information events, and multilingual offers. Yet, uncertainty and reservations towards mobility remain. Strategies are needed to reduce the plethora of information and instead transfer or provide information that is targeted and understandable for the target group. A stronger activation of immigrants to participate in courses and to overcome scepticism and fear is needed. Experience and knowledge can reduce uncertainty.

However, results emphasised that resources for additional offers are limited, and besides immigrants, non-immigrants also suffer from limited mobility. Many problems that appear for immigrants can be transferred to non-immigrants as well. Mobility in rural areas, for example, is a relevant topic for all. The dependency on cars is an issue for all who cannot drive, including people without a driving licence or without car, children, or the elderly. If additional offers are provided only for immigrants, social dissonance can be caused. This means that although nationality and immigration background are strong criteria that affect mobility behaviour, it is important to find additional criteria that can reveal similarities and lead to new user groups. Joint offers, such as traffic safety and bicycling courses for children of all nationalities and bicycle tours for immigrants and non-immigrants, bring a number of advantages: social integration, improved offers for all, and efficient use of public resources.

Results have shown not only potential for improvements in the provision of mobility but also a need for action in the organisation of mobility for immigrants. Discussions revealed that there is a plethora of initiatives of municipalities or transport operators. However, with the increase in applications for asylum in 2015, measures had to be rapidly intensified. This ad hoc planning led to rather decentralised organisation and measure development. Municipalities, public transport operators, and
other actors that were confronted with a need for action were developed. The data analysis revealed that implementing organisations often feel overloaded, arguing that neither their structures nor their competencies are designed for these tasks. It was revealed that there are no indications or guidelines for municipalities on how to support immigrant mobility and how to structure the work. Voluntary organisations additionally complement the process of support for immigrant mobility (e.g. with information offers, carpooling activities). However, work between the several actors is often uncoordinated or unstructured. Work and measures are set up ad hoc and all based on conscience. Overload of voluntary work and municipalities has to be reduced. Guidelines, structures, and organisation recommendations could help.

Against this background, cooperation becomes an important topic. It was shown that actors mostly act on their own. There is little cooperation or exchange of experience. Some municipalities established round tables that bring together local actors to exchange information. However, little city boundary-crossing cooperation can be found. Experience exchange often ends at the city boundaries. The same can be found for many supportive measures: Actors rarely cooperate and often implement measures on their own, although the whole region faces similar challenges. At the same time, actors stated not to have enough resources to address specific mobility needs. Structures are needed for municipalities to exchange experience and cooperate more easily in mobility provision. Cooperation structures must reflect the fact that mobility crosses city boundaries, and immigrants must be able to cross districts.

Finally, it is known from research that the geographical location can have a strong impact on mobility behaviour. In peripheral regions, distances even for daily mobility are usually longer, public transport is less frequented, and cars often gain importance. The metropolitan region of Frankfurt Rhine-Main is characterised by diverse spatial structures. There are highly agglomerated areas, such as Frankfurt or Wiesbaden. At the same time, there are peripheral districts and municipalities. Immigrants are mostly accommodated in rather peripheral regions, as there was enough space to establish first accommodations. However, data showed that especially in peripheral regions immigrants have mobility barriers and are less mobile, as also confirmed by research. This raises a planning dilemma: Housing in peripheral areas is significantly cheaper than in city centres, which makes it more attractive to house immigrants in peripheral areas. However, mobility is limited. As a consequence, integration can be disturbed. The challenge is to find strategies to plan mobility and housing in integrated concepts. This not only helps immigrants but generates synergies for all.

The need for action covers more than just mobility demand. Actions are also needed in the whole mobility chain: organisation, cooperation, and provision. Solving these issues, therefore, means integrating demand and supply, bringing together the necessary actors, and providing solutions for municipalities and organisers.
Bringing together these results, strategies can be derived to better improve mobility organisation and provision. These strategies are directed to transport and city planners, transport politics, voluntary organisations, or public administration. The strategies were validated in a focus group. The findings came with five strategic goals. They give indication as to how immigrant mobility can be improved on the demand and supply sides. For each strategic goal, implementation measures can be identified. They are not claimed to be complete but were rated as specifically important for improvements in immigrant mobility provision. Strategic goals can be (1) reducing mobility barriers, (2) using synergies between different mobility user groups, (3) building organisational structures that facilitate the work of municipalities and voluntary workers, (4) strengthening cooperation between crossing city boundaries, and (5) aligning mobility planning with the geographical location and accommodation to impede enclaves or immobility. A detailed overview can be seen in Table 6.

<table>
<thead>
<tr>
<th>Strategic goal</th>
<th>Implementation measures</th>
<th>Addressed actors</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Reducing mobility barriers</strong></td>
<td>1. Incentivising participation in courses, e.g. with bonus point systems</td>
<td>Learning mobility: Organisers of integration courses, voluntary workers, or traffic associations</td>
</tr>
<tr>
<td></td>
<td>2. Information centres on mobility options</td>
<td>Information provision: Transport association and operators, cities, and municipalities</td>
</tr>
<tr>
<td></td>
<td>3. Integrate information on mobility in language and integration courses</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4. Improving information flow, e.g. clear information processing, development of templates for graphical presentation of information, smartphone applications</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5. Reducing fear of public transport, e.g. optimising signage, mobility learning groups, and mobility guides</td>
<td></td>
</tr>
<tr>
<td><strong>Using synergies between user groups</strong></td>
<td>1. Identifying similarities with other traveller groups</td>
<td>Politics and science</td>
</tr>
<tr>
<td></td>
<td>2. Developing mobility offers for immigrants and non-immigrants</td>
<td></td>
</tr>
<tr>
<td><strong>Building organisational structures</strong></td>
<td>1. Development of templates for clear and readable information provision adapted to the target group</td>
<td>Regional and local politics and responsible persons for strategic transportation political decisions</td>
</tr>
<tr>
<td></td>
<td>2. Gaining patronages and drivers for improved mobility offers, e.g. regional politics</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. Defining responsibilities, providing contacts that help implementing organisations</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4. Strengthening voluntary work as a pillar of integration</td>
<td></td>
</tr>
<tr>
<td><strong>Strengthening cooperation</strong></td>
<td>1. Including immigrants in the exchange of experience</td>
<td>Local responsible persons as patronages, e.g. mayors</td>
</tr>
<tr>
<td></td>
<td>2. Strengthening networks</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. Synchronising round tables and similar platforms</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4. Developing communication platforms, e.g. between politics, municipalities, and voluntary workers</td>
<td></td>
</tr>
<tr>
<td><strong>Aligning mobility, geographical location, and housing</strong></td>
<td>1. Assessing the potential of institutionalised rides or carpooling, bikesharing systems in peripheral areas</td>
<td>Federal transport policy, science, funding bodies for public investments, municipalities</td>
</tr>
<tr>
<td></td>
<td>2. Creating safety for all participants</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. Assessing the potential for demand-based services, taking into account different mobility conditions.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4. Mobility points to improved mobility in peripheral areas</td>
<td></td>
</tr>
</tbody>
</table>
### 4.7 Conclusion

Immigrant mobility is a complex topic that requires attention. The analysis has shown that it is important not just for immigrants to be mobile but also that public administration must have an intrinsic interest to enable recently settled immigrants to be mobile and adapt to the local mobility system. Based on data collected in a research project on short-distance mobility of refugees in the metropolitan region of Frankfurt Rhine-Main, mobility needs of refugees in the region were analysed and their barriers were identified. Language and different mobility cultures make it difficult for many immigrants to directly adapt to the local mobility system. It was shown that already today there are many measures to support immigrants in their mobility. However, immigrants are often unaware of their options. This can be explained by information overload. Immigrants often cannot filter the right information. As a consequence, it often appears as if they had never received information. At the same time, municipalities claim that they often do not have enough resources to intensify supportive measures. Results showed that implementing organisations, such as municipalities or transport operators, are often left to their own. There is little help or organisational structure that relieves resources, administration, and voluntary organisations. The analysis showed that there are many public efforts that often do not solve the barriers on the demand side and supply side. Therefore, five strategies were developed that, when implemented, help to better meet immigrants’ mobility needs but also the needs of municipalities and transport operators. The paper thus contributes to a deeper understanding of what the mobility needs of recently settled immigrants from the Middle East and Africa are and how supportive measures from public organisations can help. With strategic goals and the suggested implementation measures, policy makers and public administration receive a guideline for how to improve organisation and planning of mobility supporting measures to their own advantage, since resources can be used more effectively and to the immigrants’ advantage because their needs are met.
5 References


Foreign Countries, Foreign Customs: An Analysis of Short-Distance Mobility of New Immigrants in the Rhine-Main Region in Germany


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6 Appendices


Explanation: The following questionnaire is extracted from the online survey conducted in the project All Ways Travelling which is the basis for the collected data. The survey was conducted in six European countries. The questionnaire was therefore professionally translated in the respective national language. The following questionnaire is the English version.

Survey

1 Welcome
Dear Participant,

the following scientific survey under the direction of Prof. Dr. Alexander Eisenkopf and Dr. Peter Kenning from the Zeppelin University Friedrichshafen, explores your estimation and behaviours of the subject of travel. Please answer honestly. The survey is absolutely anonymous, so that there are no conclusions about your person.

Thank you very much for your participation.

2 Age_quota condition
Please tell us your age:

How old are you?

____ years old

3.1 End page under 18
If under 18: Thank you, this is the end of the questionnaire as you do not fall into the group of people we are looking for.

4.1 Final
Thank you, the survey is finished.

5 Screener
Have you planned a journey of over 60 miles for yourself or others in the last 12 months? (Multiple answers possible)

☐ Yes, I am planning a private journey
Appendices

☐ Yes, I am planning business trips

☐ Yes, I commute more than 60 miles (one way) a day to work

☐ No, I haven’t planned any journeys of over 60 miles (one way) in the last 12 months

6.1 Commuters only

Many thanks for your participation!

Because the following questions relate to journey planning, this is unfortunately a prerequisite for further participation.

7 Destination / planning

How often per year do you plan journeys of over 60 miles for yourself or others with one of the following modes of transport: aeroplane, train, car, bus, ferry?

(Both private and business travel can be included, although each journey must fulfill the aforementioned minimum distance. Overnight breaks or other stops are not included)

_______ times in the last 12 months.

☐ not at all

How often do you plan international/cross-border journeys?

_______ times in the last 12 months.

☐ not at all

Whom do you plan journeys for?

☐ For myself

☐ For others

8.1 If no trip planning during the last 12 months

Many thanks for your participation!

Because the following questions relate to journey planning, this is unfortunately a prerequisite for further participation.

9 Complexity / usage

Have you ever not travelled in the past because you found planning the journey too complicated?
Please order these modes of transport according to their average usage on your planned journeys. Please be sure to focus on your main journey routes in the last 12 months. Your total should not exceed 100%.

On your main journey routes...

…how much is a car (personal, company) used in %? ☐

…how much is a car-sharing car or hire car used in %? ☐

…how much is a train used in %? ☐

…how much is an aeroplane used in %? ☐

…how much is a bus used in %? ☐

…how much is a ferry used in %? ☐

10.1 End car 20

Many thanks for your participation!

Because the following questions relate to journey planning, this is unfortunately a prerequisite for further participation.

11.1 Travelling costs

For the following questions, please refer only to these modes of transport: aeroplane, train, bus, car-sharing, hire car and ferry.

How high are the average costs for the entire journey – not only the main journey route?

Average expenditure in Euro (GBP) approx. ☐

12 Choice
In choosing mode of transport for your last journey, what criteria were important for you or the other person?

<table>
<thead>
<tr>
<th>Criteria</th>
<th>1= not at all important</th>
<th>2= partially important</th>
<th>3= Very important</th>
</tr>
</thead>
<tbody>
<tr>
<td>flexibility</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>journey duration</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>reliability</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>comfort</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>availability</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>environmental / climate protection</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>freedom to move around</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>price</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>safety</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>quality of the experience</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>opportunities for taking luggage</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>privacy</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>opportunities to work</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

13 Willingness to switch

Could you envisage changing from the mode of transport used to date to one of the following?

<table>
<thead>
<tr>
<th>Change to car sharing, rental car</th>
<th>1= I can’t envisage it at all</th>
<th>3= I can partially envisage it</th>
<th>5= I can well envisage it</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change to aeroplane</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Change to train</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Change to bus</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
14.1 Least willing to change

Which of the following modes of transport can you least envisage changing to?

- [ ] Change to car sharing, rental car
- [ ] Change to aeroplane
- [ ] Change to train
- [ ] Change to bus

14.2.1 Reasons against booking

Why have you not booked car-sharing/aeroplane/train/bus until now?

I disagree completely

I partially agree

I agree completely

- Because of the lack of flexibility
- Because of the long journey time
- Because of the lack of reliability
- Because of the lack of comfort
- Because of the lack of availability
- Because of environmental/climate protection considerations
- Because of the lack of freedom to move around
- Because of the high price
- Because of the lack of safety
- Because of the poor quality of the experience
- Because of the lack of opportunities for taking luggage
- Because of the lack of privacy
- Because of the lack of opportunities to work
### 15.1 Booking methods

#### What methods do you use for booking your journeys?

<table>
<thead>
<tr>
<th>Method</th>
<th>1= I don’t use this at all</th>
<th>3= I use this partially</th>
<th>5= I use this frequently</th>
</tr>
</thead>
<tbody>
<tr>
<td>Personally, at the ticket counter</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Online booking via PC</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Online booking via smartphone</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Online booking via tablet computer</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Telephone</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Letter or fax</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### 15.2.1 Most frequently

Which of the following booking methods do you use **most frequently**?

- [ ] Online booking via tablet computer
- [ ] Online booking via PC
- [ ] Online booking via smartphone

#### 15.2.2.1 Reasons for booking methods

<table>
<thead>
<tr>
<th>Reason</th>
<th>1= I disagree completely</th>
<th>4= I partially agree</th>
<th>7= I agree completely</th>
</tr>
</thead>
<tbody>
<tr>
<td>Booking is quick and easy.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Availability of the mode of transport is instantly visible.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I can make a comparison without pressure</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
I can book from the comfort of my home.

I can book from anywhere.

The choice is largest on the internet.

I can pay by credit card.

The choice on the internet is normally cheap.

Internet bookings are secure.

15.2.5 Information sources

What sources of information in particular do you use when planning journeys? Multiple answers possible.

- General purpose search engines (google, yahoo, etc.)
- Online travel agencies
- Websites with travel reports
- Transportation company websites (e.g. trains, airlines)
- Travel search engines
- Tour operator websites
- Travel destination websites (e.g. city webpages, tourist information for a destination)

16.1 Scenario

The following scenario illustrates the features of a Multi Modal Information and Ticketing System:

Imagine you are planning an international trip from your hometown to Madrid/Moscow/Athens/Copenhagen/Zurich (randomised) for the next day. The journey starts at home. To find out about the best way to travel to the destination, you now use the multimodal information and ticketing system via your laptop. You type in the home-address and the address of the destination and browse through the results.

Doing so, the multimodal information and ticketing system provides you with any possible and practical/worthwhile itineraries combining all possible travel modes in Europe. It gives you information about travel-time, costs, CO2-emission, travel mode etc. Based on this information you can decide which option you prefer. Finally, you decide to book public transport from the home-address to the main station of the hometown. Then you plan to take the train to the Airport and to...
switch to a flight to Madrid. For the last mile you want to use again public transport from the airport to the final destination.

After booking the trip with just one click, you pay one single amount for the whole journey to the multimodal-information-and-ticketing-system-provider and receive one single ticket that is valid for the whole trip.

During the whole journey, with the help of the multimodal-information-and-ticketing-system-provider it is possible to keep control of the schedules via smartphone and get alarmed automatically in case of incidents or delays that may affect the travel plan. If connections will not be caught, the system provides the traveller with possible alternatives to process with the journey via push-notifications. Booking and ticketing for alternative itineraries are made automatically via smartphone.

17 Scenario questions

Please evaluate this scenario within the following questions.

I agree completely I partially disagree

Using the multimodal journey planner improves my performance in journey planning.

Using the multimodal journey planner in journey planning increases my productivity.

Using the multimodal journey planner enhances my effectiveness in journey planning.

I find the multimodal journey planner to be useful in journey planning.

My interaction with the multimodal journey planner is clear and understandable.
Interacting with the multimodal journey planner does not require a lot of my mental effort.

I find the multimodal journey planner to be easy to use.

I find it easy to get the multimodal journey planner to do what I want to do.

Working with multimodal journey planner makes me nervous.

I’m not sure that my data would be safe.

Assuming I had access to the multimodal journey planner, I intend to use it.

Given that I had access to the multimodal journey planner, I predict that I would use it.

**18 Willingness to switch II**

Please note now:

The multimodal information and ticketing system provides you the possible itineraries with different means of transport, allows you to book and pay a valid ticket for all means of transport and provides you information about possible changes in time table and routing during your travel via your smart phone.

Could you envisage your mode of transport choice changing due to the use of the multimodal travel information and booking system?

| Change to car sharing, rental car | 😊 | I can’t envisage it at all |
| Change to aeroplane | 😊 | I can partially envisage it |
| Change to train | 😊 | I can well envisage it |

| Change to car sharing, rental car | 😊 | I can’t envisage it at all |
| Change to aeroplane | 😊 | I can partially envisage it |
| Change to train | 😊 | I can well envisage it |
Appendices

19 Increased willingness to pay / Benchmark

How much more would you be prepared to pay for the multimodal travel information and booking system compared to the average cost of your bookings until now?

______ %

How much would you be prepared to pay for the service as described? (The fee would grant you use of the multimodal travel information and booking system for 12 months)

_________ Euro (GBP)

Are you aware of a particularly good multimodal journey planning and booking system?

☐ yes  ☐ no

20.1 Benchmark

What multimodal journey planning and booking system from what provider is that?

What do find particularly good about this multimodal journey planning and booking system?

<table>
<thead>
<tr>
<th></th>
<th>1= I agree completely</th>
<th>4= I partially agree</th>
<th>7= I disagree completely</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clear layout of the choices</td>
<td>☐ ☐ ☐ ☐ ☐ ☐ ☐</td>
<td>☐ ☐ ☐ ☐ ☐ ☐ ☐</td>
<td></td>
</tr>
<tr>
<td>Cheap pricing of the choices</td>
<td>☐ ☐ ☐ ☐ ☐ ☐ ☐</td>
<td>☐ ☐ ☐ ☐ ☐ ☐ ☐</td>
<td></td>
</tr>
<tr>
<td>Very wide range of choice</td>
<td>☐ ☐ ☐ ☐ ☐ ☐ ☐</td>
<td>☐ ☐ ☐ ☐ ☐ ☐ ☐</td>
<td></td>
</tr>
<tr>
<td>Easy to use search function</td>
<td>☐ ☐ ☐ ☐ ☐ ☐ ☐</td>
<td>☐ ☐ ☐ ☐ ☐ ☐ ☐</td>
<td></td>
</tr>
<tr>
<td>Easy to use booking function</td>
<td>☐ ☐ ☐ ☐ ☐ ☐ ☐</td>
<td>☐ ☐ ☐ ☐ ☐ ☐ ☐</td>
<td></td>
</tr>
<tr>
<td>Trustworthy payment process</td>
<td>☐ ☐ ☐ ☐ ☐ ☐ ☐</td>
<td>☐ ☐ ☐ ☐ ☐ ☐ ☐</td>
<td></td>
</tr>
<tr>
<td>Certified trustworthiness</td>
<td>☐ ☐ ☐ ☐ ☐ ☐ ☐</td>
<td>☐ ☐ ☐ ☐ ☐ ☐ ☐</td>
<td></td>
</tr>
</tbody>
</table>
Qualified staff on the customer service phone line

21 Socio-Demographics

Finally, some questions about you:

d) What is your marital status?
- single
- cohabiting
- married
- divorced / widowed

What job do you do?
- self-employed
- employed
- civil servant
- manual worker
- homemaker
- trainee / student
- retired
- unemployed

What is your net monthly household income?

Euro (GBP)

What is your gender?
- male
- female

Thank you for your participation.
6.2 A2: Appendix for ‘Foreign Countries, Foreign Customs: An Analysis of Short-Distance Mobility of New Immigrants in the Rhine-Main Region in Germany’

6.2.1 Focus Group Guidelines

Data collection was part of a German project. Therefore, focus groups were conducted in German. The following appendix contains the guideline for the focus group 1 and 2. Focus group 3 did not have a guideline strategy development was workshop-based. Focus groups discussed on certain topics. The documentation is inserted in the respective chapter.

6.2.1.1 Focus Group 1

Workshop I „Aktuelle Maßnahmen zur Förderung der Nahmobilität von Migranten- Was funktioniert und was nicht“

Einführung

1. Vorstellung der Moderatoren
2. Vorstellung des Projektes „Nahmobilität für Migranten“
3. Vorsprungsunternehmen der TeilnehmerInnen

Themenblock I: Aktuelle Maßnahmen

1. Wie unterstützen Sie die Nahmobilität von Migranten?
2. Gibt es Angebote, welche nur für ein bestimmtes Geschlecht oder bestimmte Kulturkreise ausgerichtet sind? - Aus welchem Grund?
3. Wie werden diese Angebote angenommen?
4. Welche Unterschiede stellen sich im Gegensatz zu den Projekten wo kein Unterschied gemacht wird heraus?

Themenblock II: Akzeptanz der Mobilitätsangebote für Migranten

1. Welche von Ihnen initiierten Projekte fanden bei Migranten viel Zuspruch, welche eher weniger?
2. Welche Gründe könnten es Ihrer Meinung nach geben, weshalb Migranten Schwierigkeiten mit der Nutzung der neuen Angebote haben?
3. Gab es bereits einen Austausch mit Migranten für weitere Ideen und Vorschläge?
4. Was möchten Sie mit den neuen Mobilitätsangeboten für Migranten erreichen?

Themenblock III: Planung und Umsetzung der Mobilitätsangebote für Migranten

1. Was sind die größten Barrieren im Sinne von Organisation, Akzeptanz, politisch oder gesellschaftlich bei der Planung und Umsetzung von neuen Mobilitätsangeboten für Migranten?
2. Konnten diese Barrieren überwunden werden?
3. Wie konnten diese Barrieren überwunden werden?
4. Wo sehen Sie Verbesserungspotenziale bei der Planung und Umsetzung der Nahmobilität für Migranten?

Themenblock IV: Abschluss

6.2.1.2 Focus Group 2
Workshop II: Erfahrungen mit der Alltagsmobilität von Migranten – Verhalten, Wegezwecke,
Verkehrsmittel, Erreichbarkeit, Personengruppen

Themenblock I: Alltagsmobilität und Verkehrsverhalten von Migranten

1. Welche Erfahrungen haben Sie mit der Alltagsmobilität von Migranten gemacht?
2. Sind Ihnen Besonderheiten bei der Alltagsmobilität von Migranten aufgefallen?
3. Gibt es Hinweise auf Wegeketten bei Migranten?
4. Wenn ja, wie zeichnet sich dieses aus?

Themenblock II: Verkehrsmittelwahl

1. Welche Verkehrsmittel werden von Migranten vermehrt, welche eher selten benutzt?
2. Welche Gründe könnte dies haben?
3. Welche Probleme oder Hindernisse sind bei der Benutzung der Verkehrsmittelwahl bekannt?
4. Wo gibt es Barrieren, sodass manche Verkehrsmittel von Migranten nicht genutzt werden können?
5. Haben Flüchtlinge in ihrem Mobilitätsverhalten Vorteile, wenn sie ein bestimmtes Verkehrsmittel wählen?
6. Welche häufigen Wegezwecke von Migranten sind Ihnen bekannt?

Themenblock III: Unterschiede im Mobilitätsverhalten von verschiedenen Personengruppen

1. Haben Sie Unterschiede im Mobilitätsverhalten von verschiedenen Personengruppen erkannt?
2. Wie haben sich diese bemerkbar gemacht?
6.2.1.3 Focus Group 3

1) Synergien nutzen statt das Rad neu erfinden
- bestehende Maßnahmen sammeln - Maßnahmenkatalog
- Migrantenumabhängige Mobilitätsangebote auf Potenziale prüfen
- Nutzerübergreifendes, regionales Mobilitätskonzept entwickeln

2) Hürden von Mobilitätsangeboten reduzieren
- Überforderung durch Informationsüberfluss vermeiden
  - Übersichtliche Informationsaufbereitung
  - Erleichterung der Finanzierung
  - Ad hoc - Informationsbereitstellung durch Apps (Phantogramme oder Landkarten)
- "Angst" vor ÖPNV-Nutzung reduzieren
  - deutliche Kennzeichnung von Haltestellen (insb. Bus)
  - Ausbau der Navigation durch Beschreibung
  - Einführung des Smartphones
(2) Härden von Mobilitätsgeboten reduzieren
- Förderung durch Informationsaustausch vermeiden
- Übersichtliche Informationsabteilung
- Erläuterung der Finanzierung
- Ad-hoc-Informationsbereitstellung durch Apps
  (Infotafeln als Landkarten)
- „Angst“ vor ÖPNV-Nutzung reduzieren
  - deutliche Kennzeichnung von Haltepunkten (z.B. Bus)
  - Austausch der Navigation durch
    - Gesamtschulung
    - Einbindung in Smartphones

- Anreizschaltung zur
  - Steigerung der Teilnahme
    - an Verkehrssicherheitskursen
    - an Fahrradkursen
  - Einbindung freiwilliger Mobilitäts-
    - Losen / Stadtführern
  - Informationspunkte
  - Aufklärung „Täbe“ (regelkonformes Mobilitätsverhalten)
Appendices

3. Organisationsstrukturen aufbauen, um Städte / Gemeinden / Freiwillige zu unterstützen
   - Vorlagen / Templates für
     - Bedarfsrichtige und regional angepasste Informationen - aufbereitung
   - Prozesse und Ansprechpartner für Ehrenamtliche erarbeiten
   - Verantwortlichkeiten klären
   - Ehrenamt und Freiwillige: Nutzen attraktiv gestalten
Kooperationen und Austausch stärken

- Synchronisierung und Abstimmung von örtlichen Arbeitskreisen
- Runde Tische einrichten
  - Politik, Gemeinden, Ehepartnerschaft
  - Initiativen
  - Involvierte in der Integrationsarbeit und Migranten
Appendices
6) Wohnen und Mobilität - integrierte Planung

- Stärkung der autoabhängigen Mobilität
  - Stadt / urbaner Raum
  - ländlicher Raum
- Berücksichtigung der Fahrerschein- und Autobesitzquote unter Migranten bei Unterbringung
- Bedarfsverkehr aufgrund neuer "Wohnorte" neu ermitteln
- Beim Bau neuer Quartiere / Siedlungen Mobilitätspunkte planen
  ⇒ Mobilität für alle zugänglich machen
6.2.2 Questionnaire for Institutions

Umfrage zur Nahmobilität von Migranten im Rhein-Main-Gebiet

Sehr geehrte Damen und Herren,


Wenn Sie noch Fragen haben, stehe ich Ihnen gerne unter den untenstehenden Kontaktdaten zur Verfügung

Email: isabella.geis@iml-fraunhofer.de
Tel.: +49 69/ 668 118 302
Mobil: +49 1522 1590796

Für Ihre Unterstützung unserer Befragung möchte ich Ihnen bereits im Voraus freundlich danken.

Mit freundlichen Grüßen,

Isabella Geis
Fragebogen zum Thema „Nahmobilität von Migranten“

1. Welcher Körperschaft gehören Sie an?
   - Land
     Name des Bundeslandes:
   - Kommune
     Name der Kommune:
   - Verkehrsverbund/-gesellschaft
     Name des Verbundes / der Gesellschaft:
   - Verkehrsunternehmen
     Name des Unternehmens:
   - Träger anderer öffentlicher Belange
     Namlich:
   - Mobilitätsverein
     Name des Vereins:
   - Ehrenamtliche Organisation
     Wenn ja welche:

2. Wird in Ihrer Institution ein spezielles Angebot für die Mobilität von MigrantInnen entwickelt oder realisiert? (Wenn ja, weiter mit Frage 3)
   - ja
   - nein

Wenn nein aus welchem Grund nicht?:

3. Welche Gründe gab es dafür, neue und innovative Mobilitätsangebote für MigrantInnen zu planen?
   - Starker Anstieg der Zahl der MigrantInnen
   - Verstärkter Fokus auf der Integration von MigrantInnen, Selbstverpflichtung
   - Auftrag von Seiten der Politik
   - Fördermaßnahmen

Projektleitung: Isabella Geis
Tel.: 069 / 668 118 302
Email: isabella.geis@iml.fraunhofer.de
4. Welche Mobilitätsangebote für Migrantinnen wurden geplant, welche Angebote tatsächlich umgesetzt?

Allgemeine Informationen zu Verkehrsregeln

<table>
<thead>
<tr>
<th>Angebot</th>
<th>Geplant</th>
<th>Tatsächlich umgesetzt</th>
<th>Nicht geplant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Verkehrssicherheitstraining</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Angebote zur Verkehrserziehung von Kindern und Jugendlichen</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Übersetzung der deutschen Verkehrsregeln in andere Sprachen</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sprachen: Klicken oder tippen Sie hier, um Text einzugeben.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sonstiges: Klicken oder tippen Sie hier, um Text einzugeben.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Angebote bezogen auf den motorisierten Individualverkehr

<table>
<thead>
<tr>
<th>Angebot</th>
<th>Geplant</th>
<th>Tatsächlich umgesetzt</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Vermittlung von Verkehrsregeln für MIV-Nutzer</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Finanzielle Unterstützung bei der Erlangung des Führerscheins</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aufklärung zu alternativen Möglichkeiten der MIV-Nutzung (z.B. Carsharing/ Mitfahrzentralen)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sonstiges:</td>
<td></td>
<td></td>
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</table>
### Radverkehrsangebote

<table>
<thead>
<tr>
<th>Angebot</th>
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<th>Nicht geplant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vermittlung von Verkehrsregeln für Radfahrer</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Verkehrssicherheitstraining für Radfahrer</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Radfahrkurse für Kinder und Jugendliche</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Radfahrkurse für Erwachsene</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kostenlos zur Verfügung gestellte Fahrräder</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kostenlos zur Verfügung gestellte Leihräder</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kostenlose Reparatur von Fahrrädern</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sonstiges:</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Angebote bezogen auf den öffentlichen Personennahverkehr

<table>
<thead>
<tr>
<th>Angebot</th>
<th>Geplant</th>
<th>Tatsächlich umgesetzt</th>
<th>Nicht geplant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kostenlose Nahverkehrsfahrsccheine</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aufklärung über Liniennetzplan, Fahrpläne und Tarifoptionen</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aufklärung über die Nutzung des ÖPNVs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Übersetzung der Tarifoptionen Sprachen</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sonstiges:</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Projektleitung: Isabella Geis  
Tel.: 069 / 668 118 302  
Email: isabella.geis@iml.fraunhofer.de
5. **Welche Schwierigkeiten sind bei der Etablierung von neuen Mobilitätsangeboten für Migrant:innen aufgetreten?**

- Angebote wurden nicht so stark wie erhofft angenommen
- Spezielles Fachwissen auf Seiten der Institution fehlte
- Keine gesicherte Finanzierung
- Fehlende Kooperation mit Partnern
- Kein ausreichendes Marketing
- Unzureichende Informationsmaterialien
- Zu wenig Kapazitäten
- Nicht überwindbare Sprachbarrieren
- Sonstiges:

6. **Welche weiteren Ideen haben Sie für ein transparenteres, attraktives Mobilitätsangebot für Migrant:innen?**

Vielen Dank für Ihre Teilnahme!
6.2.3 Questionnaire for Immigrants

**Befragung**

**Hinweise zum Ausfüllen des Fragebogens**

Möglichkeiten zu **Mehrfachantworten** sind durch eine Glühabirne gekennzeichnet.

Dies bedeutet, dass mehrere Kreuzchen gemacht werden können.

Hier ein Beispiel:

![Mehrfachantworten](image)

**Alle anderen Fragen können nur mit einem Kreuzchen beantwortet werden!**

Für Antworten, die bei unserer Auswahl nicht mit dabei waren, haben wir einen Strich gemalt. Dort kann die Antwort notiert werden.

Hier ein Beispiel:

![Sonstiges](image)
Befragung

Auto / PKW
Befragung

1. **Ich habe einen Autoführerschein...**
   - [ ] ja
   - [ ] nein

2. **Ich darf diesen Führerschein auch in Deutschland nutzen.**
   - [ ] Ich habe keinen Führerschein
   - [ ] ja
   - [ ] nein

3. **Ich habe ein eigenes Auto...**
   - [ ] Ich habe keinen Führerschein
   - [ ] ja
   - [ ] nein

4. **Ich möchte ein eigenes Auto haben...**
   - [ ] Ich habe ein eigenes Auto
   - [ ] ja
   - [ ] nein
Befragung

5. **Ich fahre Auto...**
   - [] jeden Tag
   - [] jede Woche
   - [] mehrmals im Monat
   - [] nie oder fast nie

6. **Ich bin Mitfahrer...**
   - [] jeden Tag
   - [] jede Woche
   - [] mehrmals im Monat
   - [] nie oder fast nie

7. **Ich fahre mit dem Taxi...**
   - [] jeden Tag
   - [] jede Woche
   - [] mehrmals im Monat
   - [] nie oder fast nie
Befragung

8. Ich nutze das Auto / das Taxi...

☐ jeden Tag / jede Woche / mehrmals im Monat weil...

☐ nie oder fast nie weil...

☐ praktisch
☐ günstig
☐ bequem
☐ flexibel
☐ spontan
☐

☐ ich habe kein Auto
☐ ich habe keinen Führerschein
☐ keinen Parkplatz
☐ ich habe kein Geld
☐ ich fahre lieber Bus / Bahn / Fahrrad

☐

XXX
Bus / U-Bahn / S-Bahn
9. **Ich fahre Bus / U-Bahn / S-Bahn...**
   - □ jeden Tag
   - □ jede Woche
   - □ mehrere Tage im Monat
   - □ nie oder fast nie

10. **Ich fahre Bus / U-Bahn / S-Bahn...**
    - □ jeden Tag / jede Woche
    - □ mehrere Tage im Monat
    - □ weil...
    - □ nie oder fast nie
    - □ weil...
    - □ günstig
    - □ schnell
    - □ macht Spaß
    - □ ich bin frei
    - □ ich lerne Menschen kennen
    - □ ________________
    - □ teuer
    - □ keine Haltestelle
    - □ schlechtes Angebot
    - □ zu viele Menschen
    - □ ich fühle mich nicht sicher
    - □ Probleme mit der Sprache
    - □ nicht bequem
    - □ Busse / U-Bahnen fallen oft aus
    - □ ________________
11. Ich laufe von Zuhause bis zur nächsten Haltestelle vom....

<table>
<thead>
<tr>
<th></th>
<th>Bus / Straßenbahn</th>
<th>S-Bahn / Zug</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 – 5 Minuten</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Bis 10 Minuten</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>10 – 20 Minuten</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Länger als 20 Minuten</td>
<td>□</td>
<td>□</td>
</tr>
</tbody>
</table>

12. Ich nutze ein...

☐ Ich fahre nicht Bus / U-Bahn / S-Bahn
☐ Einzelticket
☐ Tagesticket
☐ Ticket für eine Woche
☐ Monatsticket
☐ Ich fahre bei meiner Familie oder Freunden mit
☐ Semesterticket
☐ ____________________________
13. Ich fahre mit dem Bus / U-Bahn / S-Bahn zum...

☐ Ich fahre nicht mit dem Bus / U-Bahn / Zug

☐ Amt / Bank  ☐ Arzt

☐ Freunde treffen  ☐ Schule / Integrationskurse / Universität

☐ Einkaufen  ☐ Arbeit

☐ Freizeitziele (z.B. Spielplatz)  ☐ Kirche / Moschee

☐ ____________________________

- [ ] Ich fahre nicht mit dem Bus oder U-Bahn
- [ ] Sprachliche Probleme
  bei:
  - [ ] der Bedienung des Fahrrkartenautomaten
- [ ] beim Lesen des Fahrplans
- [ ] Ticketkauf
- [ ] Fahrer / Personal sind nicht freundlich
- [ ] Zu viele Busse und Bahnen
- [ ] Pünktlichkeit der Busse / Bahnen
- [ ] Das Verhalten der anderen Menschen
- [ ] Ich habe keine Probleme
- [ ] ___________________________
Befragung

Fahrrad
15. Ich kann Fahrradfahren.

☐ ja  ☐ nein


☐ ja  ☐ nein

weil...

☐ ich habe es gekauft
☐ ich habe es geliehen
☐ es war ein Geschenk
☐ ____________________

17. Ich benutze das Fahrrad...

☐ jeden Tag
☐ jede Woche
☐ mehrere Tage im Monat
☐ nie oder fast nie
18. Ich fahre Fahrrad...

☐ jeden Tag / jede Woche / mehrmals im Monat weil...

☐ nie oder fast nie weil...

☐ günstig
☐ ich bin flexibel
☐ schnell
☐ ich habe keine Alternative
☐ ________________

☐ ich habe kein Fahrrad
☐ zu teuer
☐ ich kann nicht Fahrradfahren
☐ ich fahre lieber Auto / Bus / Zug
☐ meine Ziele sind zu weit weg
☐ nicht bequem
☐ ________________
Appendices

Befragung

19. **Ich benutze das Fahrrad für Wege zum**

- Ich fahre kein Fahrrad
- Amt / Bank
- Freunde treffen
- Einkaufen
- Freizeitziele (z.B. Spielplatz)
- Kirche / Moschee
- Arzt
- Schule / Integrationskurse / Universität
- Arbeit
20. *Welche Probleme sind beim Fahrradfahren aufgetreten?*

☐ Ich fahre kein Fahrrad
☐ Fahrrad wird oft geklaut
☐ Fahrrad geht oft kaputt
☐ Ich kann mich nicht orientieren
☐ Ich fühle mich nicht sicher im Straßenverkehr
☐ ________________________________
Zu Fuß gehen
Befragung

21. Ich gehe zu Fuß

☐ mehrmals täglich
☐ einmal am Tag
☐ mehrmals die Woche
☐ mehrmals im Monat
☐ nie / fast nie

22. Ich gehe zu Fuß...

☐ jeden Tag / jede Woche / mehrmals im Monat
☐ weil...

☐ nie oder fast nie
☐ weil...

☐ günstig
☐ ich bin flexibel
☐ schnell
☐ ich habe keine Alternative
☐ __________________

☐ ich habe ein Fahrrad
☐ meine Ziele sind zu weit weg
☐ zu anstrengend
☐ ich fahre lieber Auto / Bus / Zug
☐ __________________

17
23. Ich gehe zu Fuß für Wege zum... 

☐ Ich gehe nicht zu Fuß

☐ Amt / Bank

☐ Freunde treffen

☐ Einkaufen

☐ Freizeitziele (z.B. Spielplatz)

☐ Kirche / Moschee

☐ Arzt

☐ Schule / Integrationskurse / Universität

☐ Arbeit

☐ ____________________
# Befragung

24. *Ich kenne / nutze folgende Angebote:*

<table>
<thead>
<tr>
<th>Angebot</th>
<th>Kenne ich</th>
<th>Benutze ich</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kostenloses / günstigeres ÖPNV-Ticket</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Radfahrkurse</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Werkstätten für kaputte Fahrräder</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flyer zum Thema</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Radfahren</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bus und Bahn</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Verkehrssicherheit in Deutschland</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Verkehrssicherheitstrainings</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Weil  
  - ich kenne sie nicht
  - ich habe kein Interesse
25. Ich finde die Auswahl an Angeboten ...

26. Ich kann mich im deutschen Verkehr gut und schnell bewegen.

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Befragung

Fragen zur Person

27. Ich bin...

☐ Mann  ☐ Frau

28. Mein Alter ist...

☐ bis 18 Jahre
☐ 18 – 30 Jahre
☐ 31 – 45 Jahre
☐ 46 – 60 Jahre
☐ Über 60 Jahre

29. Ich komme aus...

☐ Osteuropa (z.B. Rumänien, Bulgarien, Polen, Tschechien)
☐ Vorderasien (z.B. Syrien, Irak, Iran, Afghanistan, Armenien)
☐ Nordafrika (z.B. Ägypten, Sudan, Libyen, Marokko)
☐ Ostafrika (z.B. Eritrea, Äthiopien, Dschibuti)
☐ Westafrika (z.B. Niger, Mali, Mauretanien)

21
Befragung

30. Ich bin in Deutschland seit dem Jahr...

☐ vor 2015
☐ 2015
☐ 2016
☐ 2017

Vielen Dank für die Unterstützung!
Thank you for your support!

شكرا على الدعم

با تشکر از شما برای شرکت

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