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Master Thesis

One app to rule them all?
Assessing mobility service providers for sustainable private Mobility as a Service platforms

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Abstract

Mobility as a Service (MaaS) is changing the way we move from A to B in urban environments and contributes to the sustainable development of transport systems. To implement these integrated mobility ecosystems, strong collaborations between MaaS providers and mobility service providers (MSPs) are of utmost importance. In the current fast-paced and competitive market, finding the "right" partners is essential for MaaS provider to build competitive MaaS solutions. However, decision-making frameworks to assess and systematically select MSP Partners are not available for MaaS providers yet. This paper presents a framework for the assessment of mobility companies based on a literature review and ten expert interviews. The results indicate that Availability, Customer Base, Technical Maturity, Business Value and Financial Status are key criteria to determine the quality of a potential MSP partner. Moreover, sustainability key criteria were defined, namely CO_2 Footprint, Social Responsibility and Quality of Life. In total, 20 indicators categorised in the mentioned eight key criteria are presented. Furthermore, current main challenges, such as the limited availability of data, missing standardisation of Application Programming Interfaces (APIs), and a strong competitive environment, are identified. Lastly, a multi-criteria evaluation scoring model and an MSP matrix are introduced to allow transparent and structured decision-making processes regarding the prioritisation and selection of MSPs.

Keywords: mobility as a service; sustainability; mobility service provider; sustainable urban mobility; partner selection

List of Contents

List of Figures

List of Tables

List of Abbreviations

API	Application Programming Interface
B2B	Business-to-Business
CSR	Corporate Social Responsibility
MaaS	Mobility as a Service
MSP	Mobility Service Provider
OEM	Original Equipment Manufacturer
PT	Public Transport
PTA	Public Transport Authority
SLR	Systematic Literature Review

1. Introduction

In recent years, new digital mobility solutions have been on the rise that offer new possibilities to travel within cities, in addition to local public transport systems. As cities are facing increasing traffic volumes while needing to decrease greenhouse gas emissions, these new mobility services play a key role in developing more efficient and sustainable transport systems (El Zarwi, Vij & Walker, 2017; Utriainen & Pöllänen, 2018). Mobility as a Service (MaaS) emerged as a new mobility concept from the idea of an integrated mobility ecosystem, which places the user in the centre of the transport system (Li & Voege, 2017; Liimatainen & Mladenović, 2018; Utriainen & Pöllänen, 2018). The purpose behind MaaS is combining several transport modes, such as public transport, car sharing, bike sharing or taxi services, for seamless trips, accessible to users through one single mobile application (Kamargianni & Matyas, 2017; Utriainen & Pöllänen, 2018). Integrating public and private transport in an urban mobility ecosystem enables convenient and alternative mobility options for users and represents a competitive choice for private cars (Melis et al., 2017; Utriainen & Pöllänen, 2018).

To develop MaaS solutions, MaaS providers take over a leading role by cooperating with a variety of stakeholders and managing the mobility ecosystems. Digital platforms that aggregate several mobility services are the basis of MaaS and require technical solutions for successful implementations (Jittrapirom et al., 2017). The most important stakeholders next to Public Transport Authorities (PTAs) are Mobility Service Providers (MSPs), as they are giving access to their mobility services and the related data (Lyons, Hammond & Mackay, 2019). Since MaaS providers are integrators and not operating the mobility services themselves, they are dependent on cooperating with the "right" partners (MSPs) to offer the "right" services through their MaaS platform to customers. This intermediary role of MaaS providers comes with two main tasks. First, finding the "right" cooperation partner (MSPs) to build a commercially successful MaaS platform and second, developing an attractive MaaS offering for end-customers (Polydoropoulou, Pagoni & Tsirimpa, 2018; Smith, Sochor & Karlsson, 2018; Stopka, Pessier & Günther, 2018). Figure 1 illustrates a MaaS ecosystem, that includes MSPs from several different transport modes, such as car or bike sharing.

Since the shared mobility market is rapidly growing, a wide range of different MSPs for every mode of transportation is available in many major European cities (Dobravsky, 2019; Li & Voege, 2017). Desktop market research about mobility services in Berlin revealed (see Appendix A) that currently six bike- and micro-scooter sharing services and eleven car sharing services are operating in the German capital. This situation raises two questions: How do these mobility service providers in the mobility market differ? And how do MaaS providers evaluate, prioritise and select the most suitable cooperation partners for the integration into their MaaS platforms? These questions are particularly important since the competitive market situation requires MaaS provider to make the right strategic decisions to exploit synergy effects and growth opportunities by partnering with successful MSPs. Cooperating with high potential players in the mobility market is likely to result in a higher number of customers, transactions and profits, and strengthen the competitiveness of a MaaS platform. Additionally, Polydoropoulou, Pagoni & Tsirimpa (2018) identified partnership risks as a strong financial barrier of the implementation of MaaS which also points out the necessity of appropriate partner selection processes. Furthermore, MaaS providers are currently facing technical obstacles. Application Programming Interfaces (APIs) are not standardised yet, and full technical integrations are associated with high efforts and use of resources for both, the MaaS providers and the MSPs (Polydoropoulou, Pagoni & Tsirimpa, 2018). However, MSPs differ in technical expertise and resources. Whereas some MSPs are developing their solutions inhouse, others depend on third-party providers to create digital products. To summarise, the availability of a wide range of MSPs, the complex technical implementations and the strong competition in the mobility market, require private MaaS providers to optimise partner selection processes to offer customers a valuable product and gain a high level of competitiveness. Particular at the current state, where MaaS is still an emerging concept, cooperating with the most suitable partners might result in competitive advantages and long-term success.

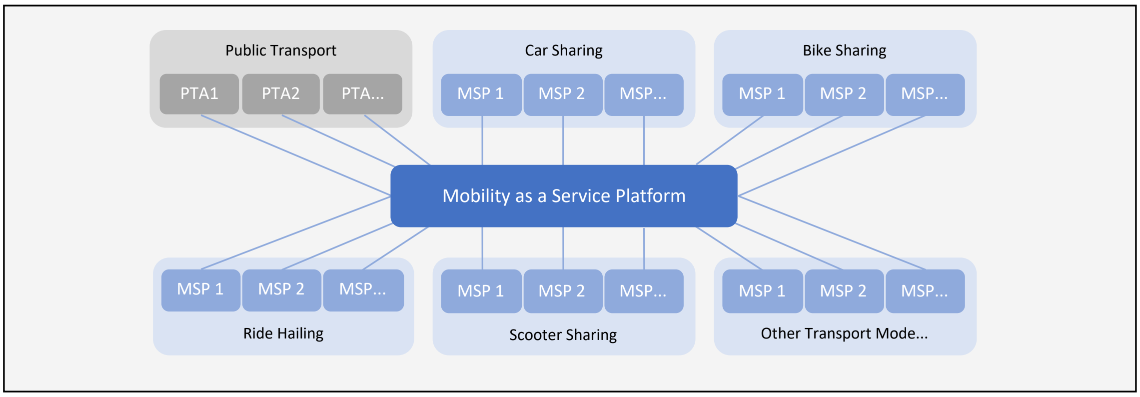

Figure 1: Scheme of a MaaS platform (Own illustration based on Stopka, Pessier & Günther, 2018)

So far, the availability of different MSPs for each transportation mode is rarely discussed by research and frameworks for the assessment of mobility services are not available. There are, however, similar processes applying to the evaluation of suppliers for new product development projects. Within supplier selection, buying companies have to carefully choose suppliers that are capable of delivering new innovative products that positively impact the potential to generate competitive advantages for the buying company (Goldberg & Schiele, 2018). Whereas assessment models for supplier evaluation are available in the literature (e.g. Goldberg & Schiele), the assessment of different MSPs is still a new field and criteria for the evaluation and selection of the "right" cooperation partners for MaaS provider need to be defined.

Consequently, a framework for the evaluation of different mobility players is proposed within this thesis that enables MaaS provider to systematically select the most promising and suitable partners on the mobility market. Key criteria and indicators, such as availability or technical maturity, were developed that define the drivers of the quality of an MSP for a MaaS provider. Additionally, a focus was placed on sustainability aspects, as the development of sustainable urban mobility systems is described as one of the central goals of MaaS platforms in research (Li & Voege, 2017; Utriainen & Pöllänen, 2018). Another reason is that MSPs potentially cause adverse effects on an urban environment. A recent example are micro-scooters (also known as kick-scooters or electric-scooters), which are controversially discussed regarding safety issues, short lifetimes, vandalism and excessive usage of public space (Sikka et al., 2019; The Verge, 2019). Moreover, recent studies and reports are questioning the positive impact of micro-scooters as a first and last-mile solution (Hollingsworth, Copeland & Johnson, 2019; Johnston, 2019). Therefore, a sustainability dimension was added to explicitly point out the strength and weaknesses of MSPs regarding sustainability factors.

To conclude, the research goal was to develop a comprehensive assessment framework for MaaS providers to evaluate MSPs systematically. Key criteria were defined which address both, sustainability aspects as well as the quality of an MSP for a MaaS provider from a business-to-business (B2B) perspective. Finally, the identified key criteria were used to develop an easy-to-use and flexible multi-criteria evaluation scoring model that supports MaaS companies in decision-making processes. Consequently, the research question for the thesis was formulated as follows:

What "partner quality" and "sustainability" key criteria should be considered by MaaS providers when evaluating MSPs for the integration into MaaS platforms?

Furthermore, the research question can be broken down into two sub-questions which reflect the two dimensions of the assessment framework:

1. *What key criteria determine the "partner quality" of an MSP for a MaaS platform?*
2. *What "sustainability" key criteria are crucial in the evaluation process of MSPs?*

First and foremost, the framework serves MaaS providers for decision-making purposes in partner selection by allowing transparent, systematic and data-driven assessments. The proposed multi-criteria evaluation model and the MSP matrix are easily applicable tools that support the business development of a MaaS provider in finding the best suitable partners for long-term cooperations. However, other mobility companies can use the results to perform comprehensive market and competitor analyses. Moreover, the framework can be the starting point to derive concrete actions for improvements in the performance of mobility firms since clear performance indicators are provided. Furthermore, this thesis contributes to research by the development of sustainable mobility indicators for an individual mobility service provider. Since sustainable mobility indicators for whole urban transport systems are already addressed in research, the focus on individual mobility services is still missing (Campos, Ramos & de Miranda e Silva Correia, 2009; Gillis, Semanjski & Lauwers, 2016). However, shared mobility services are becoming increasingly important in addition to traditional public transport. But in contrast to public transportation, these services are often provided by private independent companies. Therefore, the sustainable development of the urban mobility systems does not depend only on local authorities, but also on private MSPs. Consequently, the proposed framework is a first approach for assessing the sustainable development for private shared mobility providers and is a valuable addition to sustainable transport literature.

Within the scope of this thesis, MaaS companies that are concentrating on deep technical integrations (also called full or advanced technical integrations) to provide seamless journeys through one single application for their users are addressed. Deep technical integration means that journey planning, booking and ticketing, and payment solutions are integrated into the MaaS solutions, and only one user profile and one mobile application are necessary to gain access to the entire mobility ecosystem (Kamargianni et al., 2016). Moreover, this study focuses on private MaaS companies. Whereas private MaaS providers are usually offering services across cities and countries, public MaaS solutions introduced by local PTAs are restricted to specific cities. Moreover, private MaaS companies need to consider profitability to a greater extent due to limited financial resources and the need to create a profitable business that can compete in the mobility market. Public MaaS providers are supposed to have a stronger focus on driving the development of MaaS towards societal good and are likely to have easier access to public funding (Smith, Sochor & Karlsson, 2018). However, politics and policies might also play an essential role in the decision-making process of public MaaS providers (Polydoropoulou, Pagoni & Tsirimpa, 2018). Nevertheless, the proposed key criteria and indicators for the MSP assessment are also valuable research for public MaaS providers as the results are useful, for example, to formulate minimal requirements for MSP integrations.

Lastly, it is important to point out that the thesis was written with the support of the private MaaS company moovel Group GmbH based in Germany. The moovel Group is part of a mobility joint venture from Original Equipment Manufacturers (OEMs) Daimler AG and BMW Group. Since the company was founded by Daimler AG in 2013, moovel is a pioneer in developing urban mobility solutions by partnering with cities, transit authorities and customers. Guided by the vision “a world without traffic jams” the goal is to simplify urban mobility and encourage people to switch to shared mobility (moovel Group, 2019). Deep insights into the work of a company that is leading the MaaS field and the support of in-depth expert knowledge along the whole process strengthen the validity and outcome of this paper. Moreover, access to a broad network of partner companies and industry experts allowed gaining a holistic view of the research topic.

The remainder of the thesis is structured as follows. Chapter two describes the methodology of the study, followed by the theoretical framework in chapter three, in which the basic concepts regarding Mobility as a Service and sustainability are briefly explained. Section four discusses the main results and identified key criteria from the collected data regarding the partner and sustainability evaluation. Moreover, the current main challenges and additional findings are addressed. In chapter five, a multi-criteria evaluation scoring model and an MSP matrix are presented, before managerial and theoretical implications, as well as limitations, are discussed. Lastly, conclusions are drawn and recommendations for further research provided.

2. Methodology

In this paper, a qualitative research method is used, as the novelty of the field allows for exploratory research to gain new valuable findings and market insights. An exploratory study is used to find out “what is happening; to seek new insights; to ask questions and to assess phenomena in a new light” (Robson, 2002, p. 59). The phrase ‘Mobility as a Service’ still lacks a commonly accepted definition and shared understanding, which underlines the explorative nature of this study (Holmberg, Collado & Sarasini, 2015). Furthermore, critical aspects of MaaS were not studied yet, and profound insights in implementing the concept in practice are hardly available (Utriainen & Pöllänen, 2018).

The research design consists of two steps. First, a systematic literature review (SLR) was performed to identify relevant concepts and set an initial framework with evaluation criteria. The papers of Wolfswinkel, Furtmueller & Wilderom (2013) and Webster & Watson (2002) were used as guidance for the review. Furthermore, a conceptual and theoretical understanding of MaaS and sustainable mobility needed to be invested before the interview questions could be designed (Kvale, 2007). Therefore, selected papers of two literature streams were reviewed for identifying criteria for the partner and sustainability evaluation.

The first stream derives from sustainable mobility literature, as one dimension of the evaluation model refers to sustainability indicators. A key paper is the literature review of Gillis, Semanjski & Lauwers (2016), in which the authors identified four dimensions and 22 sustainable mobility criteria. This paper was also the foundation of the report “Sustainable Mobility Indicators – SMP2.0” of the World Business Council for Sustainable Development (WBCSD) to provide cities with a toolset for the evaluation and monitoring of mobility solutions (Gillis, Semanjski, & Lauwers, 2016; WBCSD, 2015).

The second stream derives from supplier evaluation literature, as the second dimension consists of criteria that are defining the quality of an MSP for the MaaS provider. This stream was selected because buying companies are facing similar processes when selecting a strategic supplier for new product development. A key paper was the literature review of Thanaraksakul & Phruksaphanrat (2009), in which the authors developed an extensive set of indicators for supplier evaluation. However, these criteria are questioned and handled carefully within the scope of the thesis and only provide a framework for orientation than a valid proposal. Nevertheless, the indicators were a valuable starting point and basis to conduct expert interviews in the mobility sector. The key search terms for each dimension are summarised table 1, and the numbers of search results for each term is presented in Appendix B. The academic databases Scopus and Web of Science were used as the primary sources for reviewing literature. Furthermore, given the actuality and scope of the research fields, a focus on the publishing years 2011 to 2019 was laid.

Table 1: Related search terms for "Sustainable Mobility" and "Supplier Selection"

Sustainable Mobility and related search terms		**Supplier Selection and related search terms**	
sustainable urban mobility	sustainable transport systems	supplier assessment	supplier evaluation
urban mobility	mobility services	supplier integration	supplier involvement
mobility as a service	mobility service provider	green supplier Selection	sustainable supplier Selection
shared mobility	sustainable transport	partner evaluation	partner selection

2.1. Data Collection Method

Based on the SLR, an interview guide was designed, and individual semi-structured expert interviews were conducted to gain insights on the current developments of the industry and validate as well as extend the initial framework. This method was chosen as semi-structured interviews are a useful method for exploratory and explanatory research and therefore fitting to the emerging field of mobility as a service (Bryman, 2001). Furthermore, specific organisational contexts and different perspectives can be considered, which was necessary given the various stakeholders of mobility as a service. Another benefit is that interviews may lead to areas that were not considered before but add significant value to address the research question (Saunders, 2011).

The interview guides were separated in a general section, an in-depth section about decision-making processes, MSP evaluation criteria and the topic of sustainability. As not only MaaS companies were approached, but also mobility service providers, two different interview guides were developed. These differed slightly in the questions asked to take the two different perspectives in the MaaS ecosystem into account. Whereas MaaS providers were asked about decision-making processes regarding partner selection, MSPs were asked about differentiating factors as well as market and competitor analyses processes and criteria. Both interview guides can be reviewed in Appendix D and Appendix E. In total, ten interviews were conducted with industry experts from different mobility companies. Most of the interviewees held a position in business development, partner management or business strategy. Table 2 summarises the job position and the type of mobility service related to the company of the interview partners.

Table 2: Job position and related transport modes of interview partners

Interview partner	Job position	Mobility Service
Interviewee 1	Head of Business Strategy	(private) MaaS Provider
Interviewee 2	Partner Management Manager	(private) MaaS Provider
Interviewee 3	Business Development Manager	(private) MaaS Provider
Interviewee 4	Business Development Manager	Ride Pooling
Interviewee 5	Manager Strategy & Innovation	Car Sharing
Interviewee 6	Head of Partnership Management	Bike Sharing
Interviewee 7	Business Development Manager	Car Sharing
Interviewee 8	Market Development Manager	Micro-Scooter Sharing
Interviewee 9	PR & Communications Manager	Scooter Sharing
Interviewee 10	Head of Multimodal Platform	(public) MaaS Provider

2.2. Data Analysis

The conducted interviews were recorded and manually transcribed to analyse and process the collected data using a coding procedure. For data analysis, a hybrid approach of inductive and deductive coding, as described by Fereday & Muir-Cochrane (2006) was applied. First, the criteria from the initial framework were used as codes and sub-codes. Appropriate statements from the respondents were assigned and collected for each code to determine the relevance of the initial criteria. Second, the collected data were analysed for additional criteria, that were mentioned by the respondents and added to the codes of the initial framework, including the related statements. Therefore, a broad set of indicators was drawn based on the available data, and the key criteria could be identified.

Furthermore, the additional content regarding market developments, current challenges and other insights given by the respondents were categorised, before developing new codes for each theme. Thereby, valuable information and additional findings were summarised. The results are presented in chapter four. An overview of the coding scheme for the data analysis can be found in Appendix F.

2.3. Scoring Scheme Development based on Interview Results

After the data analysis procedure and identification of key criteria, a multi-criteria evaluation scoring model was developed. Multiple-criteria scoring models are easily applicable tools that can be used to combine, both qualitative and quantitative factors that are relevant for decision making (Moore & Baker, 1969). In this case, MSPs are rated on the selected indicators within a scale from one to five with five as the highest score that can be achieved. Additionally, a specific weight can be assigned for each criterion to reflect the relevance in the decision-making process better. However, a recommended weighting for each criterion is not provided within the scope of this thesis, as a generalisation among different companies and transport modes is hardly feasible. Furthermore, individual or collective preferences of decision-makers need to be considered. After the evaluation process, a total score can be calculated and ranked among other MSPs (Cooper, Edgett & Kleinschmidt, 2001). The necessary steps for developing an evaluation scoring model are illustrated in figure 2.

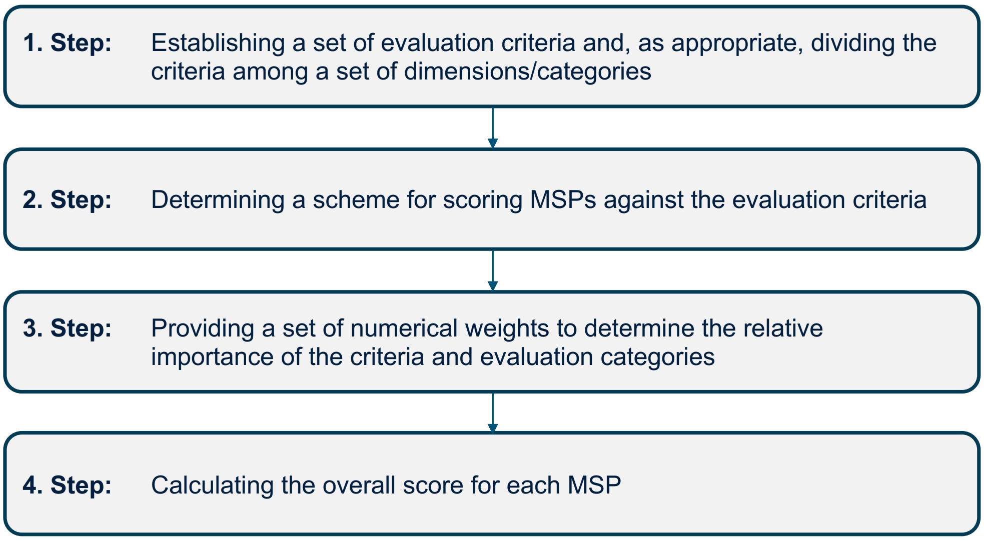

Figure 2: Basic steps of evaluation scoring model development (Own illustration based on Cooper, Edgett & Kleinschmidt, 2001 & Brown, 2007)

3. Theoretical Framework

This chapter contains findings from the literature, an overview of the concept of mobility as a service, a basic description of the concepts sustainability and sustainable mobility as well as indicators for sustainable transport systems and partner selection. Lastly, an initial framework for the evaluation of MSPs is presented.

3.1. Findings from the Literature

In recent years, the number of published papers about mobility as a service is rapidly increasing (Utriainen & Pöllänen, 2018). Moreover, the number of search results for related keywords such as "urban mobility", "shared mobility" or "mobility services" proves the growing importance of the research field in which the proposed thesis is embedded. Figure 3 provides an overview of search results for several chosen search terms on the scientific research database Scopus. Furthermore, exact numbers for search results of key words in Scopus and Web of Science are available in Appendix B.

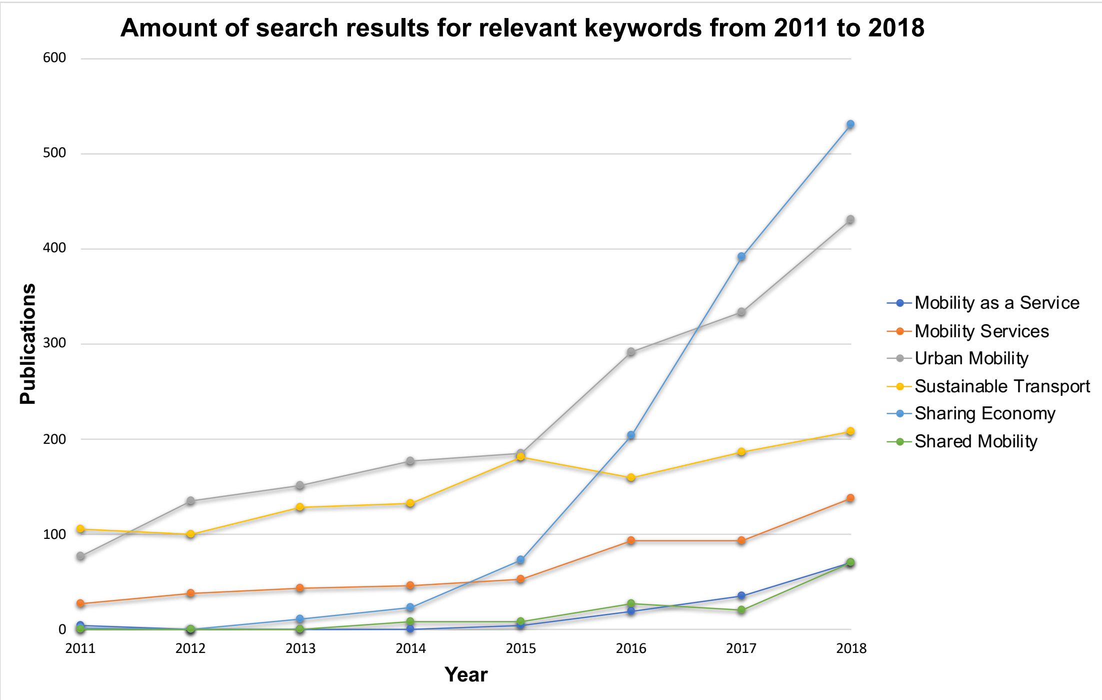

Figure 3: Publications that include key phrases related to MaaS (Own illustration based on search results on Scopus (www.scopus.com), last update: 07.10.2019)

Some of the main findings of the MaaS literature include that:

- MaaS is increasing the use of sustainable transport modes (Sochor, Strömberg & Karlsson, 2015; Karlsson, Sochor & Strömberg, 2016).
- MaaS leads to a higher efficiency of transport systems (Strömberg et al., 2016).
- MaaS enables seamless trip chains by integrating different transport modes (Kamargianni et al., 2016).

- New flexible mobility options (e.g. car sharing) are expected to decrease the popularity of private cars (Giesecke, Surakka & Hakonen, 2016; Karlsson, Sochor & Strömberg, 2016).
- Conventional public transport needs to adapt to a more service-oriented system (Hensher, 2017).
- The public sector plays a key role as an enabler of MaaS e.g. by supportive legislation (Ambrosino et al., 2016).

However, a MaaS provider perspective and deeper insights into the challenge of collaborating with various mobility service companies and creating a sustainable MaaS ecosystem are at the current state and best knowledge of the author not available. Private MaaS providers are driven by profit-maximisation but have to consider social and environmental aspects that are crucial to collaborate with partners and allow sustainable development of urban transport (Sochor, Strömberg & Karlsson, 2015). Sarasini & Lindner (2018) point out that business models of MaaS providers and operators need to be developed in a way that profitable business and sustainable transport services can be integrated (Sarasini & Lindner, 2018). Hence, management tools are needed that allow addressing a broad range of various factors within the decision-making process for the integration of new mobility services.

3.2. The Concept of Mobility as a Service

"Mobility as a Service (MaaS) is the integration of various forms of transport services into a single mobility service accessible on demand." This definition is delivered by the MaaS Alliance, a public-private partnership with the primary goal to "facilitate a single, open market and full deployment of MaaS services" (MaaS Alliance, 2019). Therefore, MaaS is the combination of several transport services for seamless trips, accessible to users in one single application (Utriainen & Pöllänen, 2018). According to Hietanen (2014), the MaaS vision is to see the whole transport sector as a cooperative and interconnected ecosystem, providing services reflecting the needs of customers. Furthermore, the idea behind MaaS is fulfilling the mobility demands of citizens and substitute private car ownership (Hietanen, 2014; Utriainen & Pöllänen, 2018).

The MaaS ecosystem consists of various stakeholders who are illustrated in Figure 2 and briefly explained in the following. First, the *customers* are the central stakeholder, as shown in the illustration, since the user-centric approach is the core of the MaaS concept. *Infrastructure* refers to customers' mobile devices, the required mobile phone networks and other radio technologies (WLAN, Bluetooth, etc.). A high level of connectivity, secure real-time travel information and cashless payment must be assured. Furthermore, IT platforms, APIs and mobile applications need to be provided. *Data Providers* are a wide range of public and private companies that are responsible for assembling, deliver and update real-time traffic data and navigation (Stopka, Pessier & Günther, 2018). *Transportation Companies* (referred to Mobility Service Providers in this paper) are the most important stakeholders as they provide a broad range of transportation modes, such as bike sharing, car sharing or taxi services as well as public transportation. *Mobility Platform Operators* are the intermediary layer between transport companies and users or amongst the transport users themselves. They collect and analyse data on customers' usage of different transportation modes to understand travel behaviour and patterns. *Trusted Mobility Brokers* manage the data exchange between the mobility service provider, facilitate the APIs and gateways, link the offerings of the various private and public operators and arrange bookings and payments through a single point of sale. Moreover, these third-party aggregators help to overcome data sharing barriers and support cooperation amongst diverse mobility service providers. *Local Public Authorities* develop the framework conditions for MaaS in their cities/regions and seek social benefits, such as reduced traffic, less air and noise pollution and reduced space for parking to increase the citizens' quality of life (Stopka, Pessier & Günther, 2018).

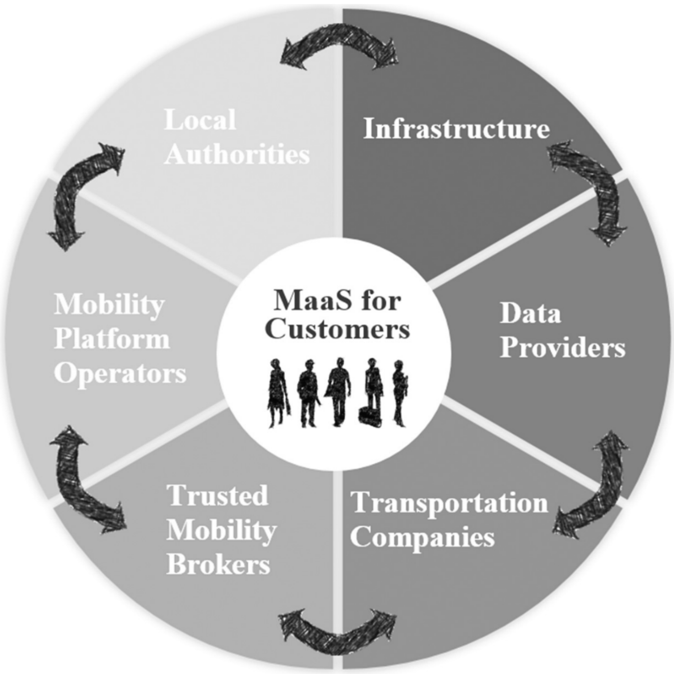

Figure 4: The MaaS ecosystem (Stopka, Pessier & Günther, 2018)

MaaS providers fulfil two leading roles. First, MaaS providers are integrators, as they assemble offerings of the different transport service provider. Secondly, they act as operators, which are offering mobility solutions (mobility packages, subscription plans, etc.) to end-users. Both roles can be performed combined or separately by public or private organisations (Melis et al., 2016; Smith, Sochor & Karlsson, 2018). From a transport operator's viewpoint, a MaaS platform is a great opportunity to exploit unused capacity and leverage integration (Melis et al., 2016). Figure 5 illustrates the positioning of a MaaS provider within the value chain of transportation.

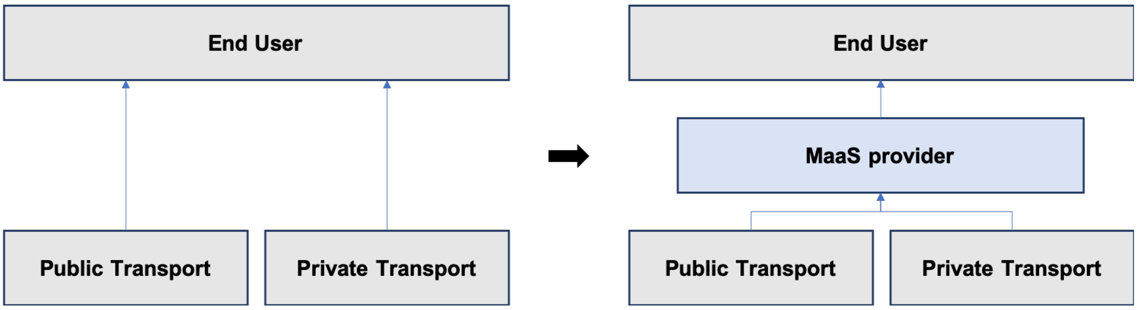

Figure 5: Core roles in current (detached) and (integrated) MaaS value chains (Smith, Sochora & Karlsson, 2018)

3.3. The Concepts of "Sustainability" and "Sustainable Mobility"

In order to define the criteria for the assessment of the sustainability of different transport services, a broader understanding of sustainability, especially in relation to mobility is required. The World Commission provides a commonly accepted definition of sustainable development on Environment and Development (Brundtland Commission): *"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs"* (WCED, 1987, p. 43). The widely used concept of sustainable development is based on the triple bottom line approach, which distinguishes the dimensions economic, social and environmental (Elkington, 1998). These three "pillars" reflect that responsible development needs to consider natural, human and economic capital or in different words the planet, people and profits (Hansmann, Mieg & Frischknecht, 2012; Purvis, Mao & Robinson, 2019). Purvis, Mao & Robinson (2019) point out that a theoretically rigorous description of the three pillars cannot be found in literature, which might be the result of a mixture of broadly different schools of thought regarding sustainability concepts (Purvis, Mao & Robinson, 2019). Consequently, "sustainability remains an open concept with myriad interpretations and context-specific understanding" (Purvis, Mao & Robinson, 2019, p. 681). A well-known approach to operationalise sustainability is the "Sustainable Development Goals (SDGs)" introduced in 2015 (United Nations, 2019). "The Sustainable Development Goals are a political framework of 17 goals and 169 targets across social, economic and environmental areas of sustainable development, which the member states of the United Nations (UN) have committed to making a reality over the next 15 years" (Barclay et al., 2015, p.2). Furthermore, these goals can be used by organisations to derive strategic actions to tackle these goals and foster sustainable development on an organisational level.

Sustainable mobility can be defined as *“the ability to meet society’s need to move freely, gain access, communicate, trade and establish relationships without sacrificing other essential human or ecological values, today or in the future”* (WBCSD, 2004, p.5). David Banister (2008) argues in his often-cited key paper “The sustainable mobility paradigm” that *“policy measures are available to improve urban sustainability in transport terms, but that the main challenges relate to the necessary conditions for change. These conditions are dependent upon high-quality implementation of innovative schemes...”* (Banister, 2008, p.73). He distinguishes between conventional transport planning and a sustainable mobility approach. One of the main differences is the evaluation process, which suggests that conventional transport planning is resulting in an economic assessment of delays and flows, whereas the sustainable mobility approach comes with a broader multi-criteria analysis that takes environmental and social issues into account (Banister, 2008; Gillis, Semanjski & Lauwers, 2016).

3.4. Indicators for Sustainable Mobility

Based on the basic three-pillar concept, various studies derived dimensions for sustainable mobility. Whereas some authors were developing indicators for sustainable transport directly on the three-pillar approach (Campos, Ramos & de Miranda e Silva Correia, 2009; Hansmann, Mieg & Frischknecht, 2012), others were deriving dimensions from the pillar concept (WBCSD, 2015). Gillis, Semanjski & Lauwers (2016) are using a four dimensions approach for the development of their set of indicators. The first three dimensions are stated as follows:

- *Global environment:* the impact of urban mobility on the global environment
- *Economic success*: refers to the contribution of mobility to the welfare of the city
- *Quality of life*: impacts of mobility on the social aspects of urban life, including safety and health (Gillis, Semanjski, Lauwers, 2016)

A fourth dimension called *performance of the mobility system* is added to secure a holistic approach that describes the mobility system consisting of three markets in a comprehensive and systematic way. Figure 6 illustrates the mobility system approach, which includes persons as well as freight being moved around an urban area. The conceptual model represents the interactions within the mobility system approach and distinguishes between three levels of mobility performance:

- *Travel:* refers to the need and ability to travel to different places for different activities within the city; to provide the goods to make the functioning of the activity possible and to move the products of an activity towards other places.
- *Transport:* refers to the transfer of goods and people from A to B and can be performed via different transport modes. Modes are referring to different forms of

organisations (e.g. public versus private), different types of infrastructure (road, rail, waterways and air transport) or different types of vehicles (car, bus, train, tram, scooter, bike, etc.).

- *The transport of goods and people require vehicles and infrastructure*. The word "traffic" describes the actual movement of vehicles across the infrastructure (Gillis, Semanjski, Lauwers, 2016).

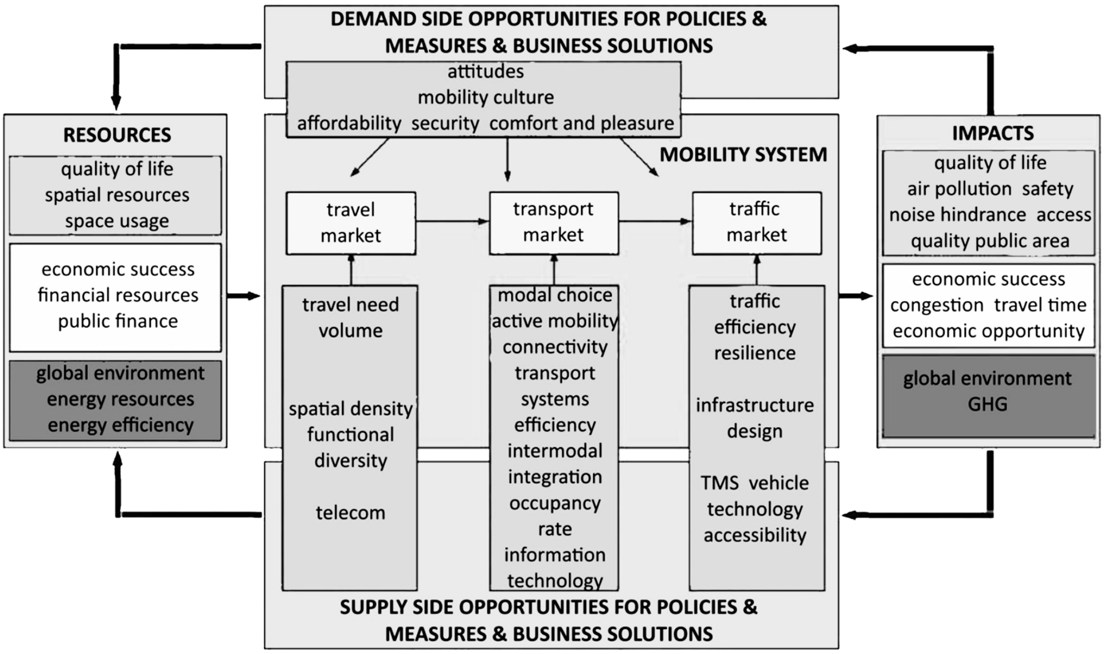

Figure 6: Indicators for mobility (Gillis, Semanjski, Lauwers, 2016)

The differentiation between travel, transport and traffic is relevant for academic research as well as practice since it refers to different markets. In these markets, different types of actors are involved and confronted with different kinds of demand and supply decision. Furthermore, the three markets are interrelated, meaning that mobility solutions offered by the transport companies within one of these markets possibly affect the performance in the other markets (Gillis, Semanjski & Lauwers, 2016). Therefore, every MSP impacts the mobility system of a city and the three described markets by serving travel demand, providing vehicles, using the infrastructure of the city and moving people from A to B.

Based on a literature review, Gillis, Semanjski & Lauwers (2016) present 22 indicators for sustainable mobility in an urban environment. By using the principles of neutrality and transferability, the authors aimed at summarising these mobility indicators across the literature. Moreover, they defined a set that is applicable and replicable in various cultural and socio-economic contexts. Therefore, it can be transferred to successful sustainable mobility measures and policies worldwide (Gillis, Semanjski, Lauwers, 2016).

Table 3: List of 22 sustainable mobility indicators (Gillis, Semanjski, Lauwers, 2016)

Dimension	Indicators for the Sustainability of Urban Mobility Emissions	Short Name
Global environment	Emissions of greenhouse gases	GHG
	Energy efficiency	Energy efficiency
Economic success	Net public finance	Public finance
	Congestion and delays	Congestion
	Economic opportunity	Economic opportunity
	Commuting travel time	Travel time
Quality of life	Mobility space usage	Space usage
	Quality of public area	Public area
	Access to mobility services	Access
	Traffic safety	Safety
	Noise hindrance	Noise hindrance
	Air polluting emissions	Air polluting
	Comfort and pleasure	Comfort and pleasure
Mobility system performance Mobility	Accessibility for mobility impaired groups	Accessibility for the impaired
	Affordability of public transport for poorest group	Affordability
	Security	Security
	Functional diversity	Functional diversity
	Intermodal connectivity	Intermodal connectivity
	Intermodal integration	Intermodal integration
	Resilience for disaster and ecologic/social disruptions	Resilience
	Occupancy rate	Occupancy rate
	Active mobility	Active mobility

To evaluate each of the indicators, the authors selected the SMART methodology to assess each indicator in an objective and quantified way. SMART describes that every indicator must be specific, measurable, assignable, realistic and time-related. Moreover, the authors introduced several applied measures as well as a favoured method for each indicator (Gillis, Semanjski & Lauwers, 2016). Hence, the literature review from Gillis, Semanjski & Lauwers (2016) provides a valuable and comprehensive framework to develop sustainability criteria, which are suitable to be adapted to the evaluation of mobility service providers.

3.5. Indicators for Partner Evaluation

Next to the evaluation of sustainability aspects, it is crucial to evaluate the quality of the mobility service provider, as they are from the utmost strategic importance for the MaaS company (Stopka, Pessier & Günther, 2018). Similar to strategic supplier selection and evaluation processes, the degree of excellence of an MSP needs to be determined transparently and systematically. In research, “supplier selection is considered a sophisticated, application-oriented, decision-making problem and has received considerable attention” (Chai & Ngai, 2019, p.1). A wide range of decision-making methods and techniques are available to address supplier selection and evaluation processes and the continuing contributions to the topic illustrates the relevance and importance of the research field in practice (Chai, Liu & Ngai, 2013; Chai & Ngai, 2019;

De Boer, Labro & Morlacchi, 2001; Zimmer, Fröhling & Schultmann, 2016). Furthermore, an increase in papers addressing green or sustainable supplier selection can be noticed in recent years (Appendix B). This fact points out the growing importance of including sustainability aspects in supplier selection and decision-making processes of firms (Govindan et al., 2015; Konys, 2019).

Since current MaaS literature points out the cooperative relationship between MaaS providers and MSPs, in this thesis, the term "Partner evaluation" is used instead of "Supplier evaluation" (Polydoropoulou, Pagoni & Tsirimpa, 2018; Smith, Sochor & Karlsson, 2018; Stopka, Pessier & Günther, 2018). Another reason is that all interviewees were in the consensus of a partnership relationship between MaaS providers and MSPs since a strong partnership is seen as a condition to achieve a win-win situation for both parties (Appendix F). Since quality is defined as the "degree of excellence of something", the dimension regarding partner evaluation is called "partner quality" (Oxford University Press, 2019). Consequently, the dimension "Partner quality" defines key criteria and related indicators that are describing the quality of an MSP for the MaaS provider from a B2B perspective. As MaaS providers integrate mobility services offered by a variety of companies and usually do not operate the mobility services by themselves, they are dependent on choosing the "right" partners for providing the "right" services to their customers. Moreover, the complex technical integration requires a selective approach and prioritisation of possible cooperations to allocate the limited resources efficiently. Given the competitive and dynamic mobility landscape, partners need to be identified that are having a high level of quality and competitiveness.

In literature, several assessment frameworks with profound defined criteria and indicators for supplier evaluation are available, such as the "Innovation-Supplier Evaluation Matrix" from Goldberg & Schiele (2018) or the framework for "Sustainable supplier selection and evaluation in supply chains" from Luthra et al. (2017). Furthermore, an extensive supplier selection framework is provided by Thanaraksakul & Phruksaphanrat (2009), who developed evaluation criteria based on a balanced scorecard with integrated Corporate Social Responsibility (CSR). The authors reviewed 76 related papers and therefore provided a comprehensive review of the research field (Thanaraksakul & Phruksaphanrat, 2009). To categorise the identified supplier evaluation criteria, they distinguished between five different perspectives: financial, customer, internal business process, learning and growth, and CSR. Moreover, several measures for each criterion were collected to allow a feasible approach for supporting decision-making (Thanaraksakul & Phruksaphanrat, 2009). An overview of all indicators from the framework is presented in Appendix C.

The dimensions and indicators in the initial framework presented in the following chapter were selected from the literature review from Thanaraksakul & Phruksaphanrat (2009) based on the suitability to evaluate the quality of a partner (MSP) for a MaaS provider. Build on the selected research paper, qualitative research was crucial to adapt and extend these indicators to the mobility sector and the evaluation of mobility companies.

3.6. Initial Framework for the Evaluation of MSPs

Before conducting expert interviews, an initial framework based on the papers described in the previous chapters was developed that served for the development of the interview guide and deductive data analysis. The initial framework consists of eight selected key criteria for the dimensions "Sustainability" and "Partner quality".

First, a set of sustainability indicators was determined based on the literature review on sustainable mobility indicators from Gillis, Semanjski & Lauwers (2016). The evaluation of sustainability indicators is correlated with the transport mode of the mobility service provider. For example, bike and car sharing differ in many aspects and have different characteristics. Nevertheless, only indicators were selected that are resulting in a generalizable assessment framework, that is applicable across different transport modes. Moreover, also MSPs within the same transportation mode have different features, which affects their sustainability performance. For instance, car sharing providers can differ in the type of used engines (electric fleet vs combustion fleet) or bike sharing provider might offer e-bikes instead of more environmental friendly regular bikes (without electric motor). Furthermore, the initial framework contains a broad set of social sustainability aspects to address the impacts of urban mobility on the quality of life for the citizens beyond CO_2 emissions.

Second, the initial partner quality indicators were determined based on the framework developed by Thanaraksakul & Phruksaphanrat (2009), which distinguishes between five different perspectives and in total, 31 indicators. (Thanaraksakul & Phruksaphanrat, 2009). The majority of indicators were selected from the customer perspective, because the importance of the user perspective is also pointed out by researchers, for example, by Lyons, Hammond & Mackay (2019). Moreover, indicators were chosen that are in general applicable as company performance indicators across industries. Table 4 presents the initial framework that combines Sustainability and partner quality indicator for the assessment of mobility service provider. In addition, recommended measures are described as useful information for the assessment process.

Table 4: Initial framework with sustainability and partner quality indicators (Based on Gillis, Semanjski & Lauwers, 2016; Thanaraksakul & Phruksaphanrat, 2009)

Initial framework for MSP evaluation							
Sustainability Evaluation				**Partner Evaluation**			
No.	**Dimension**	**Indicator**	**Possible Measures**	**No.**	**Dimension**	**Indicator**	**Possible Measures**
1	Global environment	Emissions of greenhouse gases	CO_2-equivalents per capita	1	Financial	Financial Status	Market Share, Annual Growth and Revenue
2	Quality of Life (Social)	Noise	The percentage of people annoyed by traffic noise (survey)	2	User perspective	Customer Relationship	Customer Database, CRM activities, Marketing campaigns
3	Quality of Life (Social)	Safety	Traffic fatalities per 100,000 inhabitants	3	User perspective	Customer satisfaction and impression	Brand royalty, Market position, Customer reliance, Market share, Customer feedback
4	Quality of Life (Social)	Accessibility	Size of Operation area/Amount of available vehicles	4	User perspective	Reputation and preferences	Customer references, Position in industry, Firm prestige
5	Quality of Life (Social)	Space Usage	Amount of square metre of direct and indirect mobility space usage per capita	5	User perspective	Attitude & Strategic Fit	Management viewpoint, strategic compatibility
6	Quality of Life (Social)	Comfort and pleasure	Average reported satisfaction about the comfort	6	User perspective	Product Quality/Comfort	Self-testing, qualitative review analysis
7	Mobility system performance	Affordability	Ratio between cost for a single ticket for public transportation and average trip length x price (per minute) for a specific MSP	7	Learning and growth perspective	Desire for business (DFB)	Business growth, Development activity, Goal attainment, Outlook for future
8	Mobility system performance	Intermodal connectivity	Amount of stations/hubs next to public transport stations (U-Bahn/S-Bahn, Train, Bus)	8	CSR	Environmental and social responsibility (ENV	Design for environment, Environmental competency, Environmental policies, Pollution discharge and management, Pollution reduction activity, Social expense and donation

4. Empirical Findings from Expert Interviews

In this chapter, the main results of the ten expert interviews are presented. First, current challenges for MaaS solutions and insights in the mobility market given by the interviewees are discussed before focusing on the identified criteria for the partner quality and sustainability. Lastly, additional findings and implications for further research are pointed out.

4.1. Current Challenges and Developments in the Mobility Industry

The collected data from ten expert interviews revealed several challenges the mobility industry and especially MaaS providers are facing. To better understand how the MaaS concept is implemented in practice and which problems need to be solved, this chapter summarises the general main findings and gives insights into the current developments in the mobility sector.

Rising competition including private and public MaaS providers

The first main finding is that the respondents expect rising competition between public MaaS platforms, introduced by cities or governments, and private MaaS platforms, introduced by start-ups to large tech or mobility companies (Appendix F). Interviewee 4 pointed out: *"...on the topic of mobility platforms I have the feeling that a lot is happening, both on the part of private providers as well as public providers. Many cities want to build their own urban mobility platforms, to promote the topic of multimodality, but also to be the first contact person.*" Moreover, some interviewees indicated that public MaaS providers have certain advantages, such as a higher brand awareness since the local public transport services are usually well known by the citizens (Appendix F). Additionally, MSPs tend to preferably cooperate with public platforms, which was explicitly stressed by interviewee 3: *"...you can say that relatively clearly, if there is a state-subsidized platform or a platform subsidized by the local public transport company in a city, then this platform will be always the first choice of the MSPs".* Hence, it is expected that the future mobility market will be dominated by local public MaaS offerings and a few big players after the market consolidated (Appendix G).

Missing technical standardisations

Another major challenge is the missing standardisation of APIs and the resulting high complexity of technical integrations. As a consequence, the integration of mobility service providers is associated with high efforts and use of resources as it can take up to nine months from the first contact to the launch of the service on the MaaS platform (Appendix F). Most of the interview partners mentioned the challenging technical implementation, an explanation of the issue is delivered by interviewee 1: *"The effort of a deep integration* *is always very high at the beginning, especially since most MSPs do not have a high degree of [technical] maturity, because this use case [integrating in a MaaS platform] was actually not intended for them per se."* Consequently, technical standards are urgently needed to facilitate the implementation of MaaS solutions.

Conflicts of Interest between MaaS providers and MSPs

Moreover, some conflicts of interest between MaaS providers and MSPs were identified that are briefly explained to understand the pain points of both sides better. A first conflict arises from the degree of technical integration. Some of the interview partners who were representing an MSP tended to prefer a deep link solution instead of a full integration. One main reason is the loss of direct contact with the customer and marketing touchpoints which might result in lower customer loyalty (Appendix F). On the other hand, the interviewed employees working for a MaaS provider strongly preferred a deep integration of all MSPs to unlock the full potential of the MaaS application with a seamless journey for their customers. This leads to another pain point which is data ownership. Agreements and contracts are necessary to specify data ownership and how the data will be further processed as it is of high importance for all parties involved, including the customers. When asked for the disadvantages for an MSP when integrating into a multimodal platform, interviewee 5 stressed: "*Clearly the customer loyalty and of course, everyone is trying to grab it [customer loyalty]. That's the big market somehow, to have data, to be able to address customers, to gain information about customers, how they move, what they do, what they use, in order to be able to segment them and use advertising.*" Consequently, policies and agreements are required, that allow all involved companies to access and further process the gained data.

Limited availability of data

Another major challenge is the limited availability of data regarding the usage of mobility apps, which is also addressed by various scholars (Li & Voege, 2017; Polydoropoulou, Pagoni & Tsirimpa, 2018; Santos, 2018). The willingness of mobility companies to share data is rather low, which might be the result of a very competitive market. Even basic information such as the fleet size of a provider (in a specific city) is often rarely available (Appendix F). Consequently, performing market research and market analyses is time-consuming and often estimations need to be used instead of concrete numbers, which was explicitly mentioned by interviewee 7 (Appendix F). Therefore, the limited availability of data also affects the evaluation process of possible MSP partners and has negative impacts on the objectivity of the results.

Dependencies on local regulations and policies

Lastly dependencies on local regulations and policies as well as city characteristics are worth to mention as explained by interviewee 3: *"...what we have already learned, MaaS needs a strong local or regional expression. Every city works a bit differently, every city has its characteristics, every city has different control measures given by policymakers, this is why always a regional platform is required, but of course, there are also many people moving between different cities, and for them it is relatively annoying to register each time again*." The quote illustrates how MaaS companies and MSPs are dependent on the given conditions in a city. To underline this statement, interviewee 1 described the situation in European cities like Madrid, Lisbon and Paris, where almost no regulations for MSPs were in place in the past. These circumstances led to chaotic situations and a rethink by policymakers, who started to introduce the first bans soon after. In comparison to Madrid, the local authorities in Barcelona, for example, restricted shared mobility services to a great extent, which shows the significant differences even within a country (Appendix F). Consequently, mobility companies need to deal with a certain degree of dependencies and uncertainties regarding local policies and need to adapt in case new regulations are introduced. These circumstances can be named "regulatory risks" and are also described by Polydoropoulou, Pagoni & Tsirimpa (2018) as a barrier for the implementation of MaaS. Possible changes in law or regulations are the origin of financial risks in terms of operating costs or investment costs (Polydoropoulou, Pagoni & Tsirimpa, 2018).

4.2. Results for Partner Evaluation

The results for the identified key criteria for the partner evaluation are presented and briefly described in this section. Five key criteria were derived from the answers of the ten interview partners. However, additional criteria that were mentioned in the interviews are summarised as well to present a broader set of factors that can influence the assessment of MSPs.

4.2.1. Availability

First, the availability of a mobility service needs to be mentioned as the most important key criteria to determine the relevance of an MSP. The collected data underlines the importance of this factor for mobility services, as all interviewees mentioned it. For the analyses of the availability of an MSP, the following indicators are recommended:

- **Presence in target countries**: refers to the countries in which the MSP is present or want to be present in the near future. Logically, a MaaS provider wants to include MSPs that are operating in the same countries or focus on the same geographical areas. Interviewee 1 pointed out that it is crucial to select MSPs that are mapping to their own country and market entry strategy to achieve the highest possible coverage (Appendix F).

- **Presence in target cities:** simultaneously to the target countries, a MaaS provider is also preferably selecting MSPs that are operating in the same target cities. In a best-case scenario, a MaaS provider can offer the integrated MSP in all cities, in which the MaaS provider is operating in (Appendix F).
- **Fleet size (in target cities):** describes the number of vehicles (e.g. cars, bicycles, scooters) of an MSP and is a valuable criterion when assessing the availability of a service in an urban area. Almost all interviewees mentioned this criterion explicitly, which underlines the relevance of the fleet size (Appendix F).

The results of the collected data indicate that the availability of a mobility service plays a key role in the MSP evaluation process. When looking at the availability of an MSP in a specific city, also the density (fleet size in relation to the service area) is an appropriate indicator (Appendix F).

4.2.2. Customer Base

Second, the customer base provides valuable information about the current status and development of an MSP and was mentioned by most of the interview partners (Appendix F). The customer base includes two indicators:

- **Number of active users:** is self-explanatory and refers to the amount of user an MSP has. In this case, "active" defines that at least one transaction was made after registering in the app, and therefore, a full user profile with payment details was created. Interviewee 2 explicitly pointed out that *"if we want to find out which MSPs are the best ones to integrate, for the clients and us, we have to find out how many users each MSP has"* (Appendix F).
- **Number of transactions:** describes the overall number of trips booked over the app of an MSP. It is recommended to add a time component such as average transactions per week, month or year to allow a valid comparison.

The interview partners stressed that data for the mentioned indicators is hardly available and requires to get in contact with the mobility companies to access those numbers. However, MaaS providers should request this valuable information when negotiations are taking place.

4.2.3. Technical Maturity

Third, the technical maturity plays an essential role when evaluating an MSP as the following quote of interviewee 1 demonstrates: *"...and just beside these commercial factors, an important aspect is the technical maturity of the MSP solution, so how easy or difficult is it to deep integrate them or is it even possible to deep integrate them. Because if they are not able to get deep integrated, they are not interesting for us in the end."* Technical maturity refers primarily to the availability of APIs that allow to deep integrate an MSP into a MaaS platform. The interviewed experts agreed that deep integration is currently associated with high efforts and use of resources, as there is no standardised APIs existing yet. Moreover, the technical efforts vary from case to case, depended on the already taken API developments and technical expertise of an MSP. Consequently, a high degree of technical maturity is crucial for both parties, allowing shorter launch cycles and more efficient use of resources.

4.2.4. Business Value

Fourth, the key criteria business value combines three indicators that were mentioned by the respondents and relate to the business model of an MSP. The following indicators are recommended for consideration:

- **Strategic fit:** indicates how the strategies of a MaaS provider and an MSP are fitting together. In particular, the comparability of the expansion and market entry strategy is from greater importance, as synergy effects could benefit both companies as interviewee 1 stressed out: *"...if I have someone who is striving for the same growth path, then this can be a strategic cooperation with entering new markets, supporting each other and leveraging synergies in market entry processes"* (Appendix F).
- **Product quality:** refers to the quality of the vehicles and mobile app of a mobility provider. The provided service needs to be convenient for the customers to be an alternative to the private car or PT. Interviewee 7 mentioned when doing market research to analyse: *"...what vehicles are used? Are they using premium vehicles or "wooden class" [basic car models], where the main focus is to get from A to B with the smallest equipment, etc. What does the vehicle itself stand for in the concept of the company? These are things we compare..."* For the evaluation, app ratings, customer feedback or performing tests are applicable measures (Appendix F).
- **Brand awareness:** "...reflects the salience of the brand in the customers' mind." (Aaker, 1996, p. 114). A recent statistic shows that in the German car sharing market the brand awareness of car sharing providers differ to a great extent and

is dominated by only a few brands, namely car2go (42 %), DriveNow (30 %), Flinkster (22 %) and Stadtmobil (15 %). All other brands were named by less than 10 % of the respondents (Statista, 2018). Moreover, interviewee 5 explicitly mentioned brand awareness as a significant indicator, as a well-known brand is more likely to drive transactions than an unknown brand (Appendix F). Possible measures are available statistics from market research institutes or own market research efforts (e.g. conducting surveys).

4.2.5. Financial Status

Fifth, the information collected by the interviews indicate that the mobility market is currently rapidly growing and very competitive, involving small start-ups to big tech companies and local authorities. Consequently, some companies were pushed out of the market again despite substantial funding, as interviewee 6 pointed out: *"...I believe that the market will consolidate. I can start with bike sharing in China; there was bike sharing company A founded with 1 billion, bike sharing company B founded with 1.2 billion, bike sharing company C with a few 100 million. Bike sharing company C was gone first, bike sharing company B doesn't exist anymore. There are still rarely a few [bikes from company B] in China. Of course, nobody would have believed this, everywhere business models were introduced and then, of course, there is strong competition..."* (Appendix F). Therefore, the key criteria financial status indicates if a company can survive in the fast-paced and competitive mobility market and be a long-term partner for MaaS solutions. However, defining concrete measures for the financial status is challenging, as data availability is low and predictions are hard to make. However, the following indicators are suitable as a valuable starting point:

- **Funding:** Despite the risk of misinterpreting the achieved funding of an MSP, this number can serve as a first indicator of the financial stability of a mobility company. Interviewee 5 suggested relating the received funding to the number of cities an MSP is active or wants to launch their services in the future. (Appendix G). Crunchbase, Inc. (crunchbase.com) and similar online databases are useful information sources for the evaluation.
- **Revenues:** Since a MaaS provider is expecting a profit share when integrating and promoting a mobility service on its MaaS platform, the turnover of a mobility company is an essential indicator for future revenues generated by the MSP for the MaaS provider. It is recommended to take profound revenue forecasts into account, to get a realistic estimation for the future revenues that can be achieved by the MSP (Appendix G).

4.2.6. Additional Identified Indicators

Next to the chosen indicators, the interviewees mentioned several other indicators, that can be used to compare and assess mobility services. These indicators can be used additionally in the evaluation process. Therefore, they are briefly explained in the following:

- **Profitability:** refers to the share of profit a MaaS provider gets when a transaction was made over the MaaS platform, as interviewee 1 explained: *"In the end, it is also a profitability topic...how much commission we can get exactly."* The profitability correlates with the indicator revenue and is more complicated to predict. Furthermore, the agreed share of profits also depends on the negotiation position and skills of the involved companies and employees (Appendix F).
- **Pricing model:** is defining the price strategy and therefore, the prices the provider charge for their services. Respondent 7 answered when asked about the differences between provider: *"...Pricing model, of course, we are relatively unique in terms of our pricing strategy, but of course, we check in which cases you are paying how much for which car sharing provider"* (Appendix F). However, pricing models should be only considered when significant differences between mobility services exist.
- **Operational performance:** refers to the level of operational excellence that can be achieved by an MSP. Interviewee 6 pointed out that some providers differ regarding the workforce and the number of maintenance trips to keep the mobility service running. More efficient operations positively impact cost reductions and the environmental footprint of the service (Appendix F). However, this indicator is hard to assess and should only be taken into account when valid information is available.
- **Charity & Social Engagement:** are projects that are initiated or supported by the mobility company and serve the public welfare. Responded 7 reported, that their company is donating a small amount of each transaction for social or environmental projects (Appendix F).

These additional indicators are not included in the proposed multi-criteria evaluation model presented in chapter 5. However, they are valid to be taken into account and be adapted by the decision-makers to extend the presented indicators.

4.3. Results for Sustainability Evaluation

In this chapter, the main findings and key results of the sustainability dimension are discussed and briefly explained. The topic of sustainability was controversially discussed among the interview partners. In the context of mobility services, sustainability was mostly associated with CO_2 emission and the overall CO_2 footprint of a service or transport system. Other factors related to social or economic aspects, were rarely mentioned by the interviewees. Therefore, it can be assumed that there is still a lack of understanding when it comes to the topic of sustainability. Hence, a better understanding of sustainability aspects, especially regarding urban mobility, requires further research activities and new initiatives. Nevertheless, a positive example was given by interviewee 8, who explained that their company derived concrete actions from the sustainable development goals developed by the United Nations (United Nations, 2019; Appendix G).

Another main finding is that sustainability criteria are often considered as "soft factors" that have little or no influence regarding the decision-making processes of the integration of MSPs into a MaaS platform. Interviewee 3 even pointed out: *"I think that's a fundamental question whether a MaaS platform should be neutral and just provide the customers with information about costs, time, and (if available) sustainability factors or whether a MaaS platform should promote sustainability"* (Appendix H). Therefore, it can be assumed that in the current market situation, other factors, as described in the previous chapters are the dominant variables and sustainability criteria play only a minor role. However, respondent 1 supports the inclusion of sustainability criteria in the decision-making process: *"I think it is important, because we see ourselves as a MaaS platform, as a provider of ecosystems for cities to promote sustainability and also to offer mobility, which takes environmental aspects into account. Therefore, it is crucial to pick the right MSPs"* (Appendix H). Accordingly, the respondents represented different points of view on the importance of the inclusion of sustainability indicators in the MSP evaluation process.

However, among the respondents was a consensus that sustainability is, in general, a very important topic and needs to be considered in the development of a mobility company. For example, interviewee 7 revealed, that their company is primarily using vehicles with small engines and automatic transmission to reduce the CO_2 emissions and noise pollution to a minimum and avoid speeding. Interviewee 6 pointed out the long product lifecycle, which is achieved by a simple but robust design, and the optimised operations that also reduce CO_2 emissions as less maintenance trips are required. Interviewee 4 explained, that their whole fleet consists of electric or hydrogen cars, and therefore, all rides are emission-free (Appendix G). These examples prove that MSPs are investing and considering sustainable aspects, which underlines the growing importance of environmentally friendly mobility. To allow a better reflection of sustainability aspects in the evaluation process, in the following, recommended key criteria and indicators are briefly discussed.

4.3.1. CO_2 Footprint

The CO_2 footprint plays a significant role and can be seen as the dominant key criterion for the assessment of the sustainability of mobility services. The data analysis demonstrated that CO_2 emissions are the first mentioned and most discussed factor when asked for sustainability criteria. A recently published paper by Hollingsworth, Copeland & Johnson (2019) can be seen as a benchmark to analyse the overall CO_2 footprint of mobility services. The authors examined the environmental impacts of micro-scooters using a life cycle approach and compared the results to other modes of transportation (Hollingsworth, Copeland & Johnson, 2019). Therefore, the following indicators, which elements were also partly mentioned by the interviewees, are recommended:

- **CO_2 emissions from usage or charging (electric vehicles):** refer to the emissions produced while the usage of a transport service or in case of electric vehicles indirectly while charging.
- **CO_2 emissions from materials & manufacturing**: In the micro-scooter life cycle analysis from Hollingsworth, Copeland & Johnson (2019) materials & manufacturing was the main driver and responsible for half of the CO_2 emissions per passenger-mile (Hollingsworth, Copeland & Johnson, 2019). This finding underlines the importance of including this component in the CO_2 footprint calculations.
- **CO_2 emissions from operations (maintenance, collection & distribution):** refers to the emissions caused by vehicles used during operational activities, such as collecting, distributing or maintaining the fleet. As a positive example, interviewee 6 pointed out that their operations are very efficient and therefore, CO_2 emissions are minimised by reducing maintenance trips as much as possible.

By taking these three parameters into account, a comprehensive CO_2 life cycle analysis can be performed, resulting in a meaningful evaluation score of the CO_2 footprint of an MSP. However, the lack of available data and information might be a blocker to carry-out such an in-depth analysis.

4.3.2. Social Responsibility

Next to the CO_2 footprint, social aspects play a crucial role when evaluating the sustainability of mobility service providers. Social aspects were categorised into two key criteria within this study. First, a brief introduction of recommended indicators for social responsibility is given. These were partly derived from the initial framework, but also expert opinions:

- **Labour relations:** refers to the working conditions of all employees throughout the supply chain and operations, including fair payments or health and safety procedures. Interviewee 10 stressed out: *"It is important to us that the mobility providers also meet the social standards as an employer, keyword minimum wage, and so on. Especially as a public provider, this [minimum wage] is the first social aspect, which we really value"* (Appendix G).
- **Accessibility:** defines the accessibility of a mobility service and is related to the fleet size and service area. A primary measure is vehicles per km^2 (service area divided by the fleet size) to describe the density. However, this number doesn't take into account that a large service area allows more people to access a mobility service and therefore, benefits the citizens outside the inner city. Furthermore, accessibility refers to the possibility for people with disabilities or limited mobility options (e.g. pregnant women) to be able to use the services of an MSP. Therefore, the density, service area and barrier-free access need to be taken into account for the assessment of this indicator (Appendix G).
- **Affordability:** refers to the ability for every citizen to afford using the mobility services. It is a fundamental aspect of social sustainability, which was pointed out by interviewee 8: *"...and it's also about the prices, that in the future our services can be regularly used by low or normal earning people because they can use it, for example, in combination with a public transport ticket, which makes it more attractive"* (Appendix F). An applicable measure is the comparison of the price for the average travel distance with a particular mobility service with the price for a single ticket for public transportation. PT prices usually include revenue, profit and social welfare maximisation considerations and are therefore an appropriate benchmark (Borndörfer, Karbstein & Pfetsch, 2012).

4.3.3. Quality of Life

The second category of social aspects refers to the impact of an MSP on the quality of life for the people living in a city and has a collective characteristic. The following group of indicators is suggested:

- **Noise pollution:** refers to the noise caused by a mobility service. Even if this factor is difficult to assess, interviewee 6 confirmed that noise is considered by their company: *"Smaller engines, less power, less noise, on the one hand. Smaller engines, less power, less speeding on the other hand. I mean when you put our Car X next to a Car Z, the Car X is for the urban environment, for all pedestrians, which are walking next to the road, in general, safer*" (Appendix F). Furthermore, traffic noise is one of the main pollutions that affects the quality of life of citizens in urban areas and is, therefore, a valid sustainability indicator (Alías & Socoró, 2017).
- **Urban space usage:** represents the proportion of land use, taken by the mobility service. An applicable measure is space usage per vehicle multiplied with the fleet size in a city. Cars, for example, require more space for parking than other transport modes such as micro-scooters or bicycles and consequently, block public urban area which could be used for other purposes (Gillis, Semanjski, Lauwers, 2016).
- **Safety:** refers to the safety aspects of a mobility service. On the one hand, safety initiatives such as a safety onboarding in the app or providing helmets and other equipment are valid measures. On the other hand, reported accidents in connection with a specific transport mode could be considered to assess safety aspects (Gillis, Semanjski, Lauwers, 2016).

To conclude, the mentioned social indicators represent a broad set of sustainability aspects and are valuable additions to the evaluation of the CO_2 footprint of a mobility service. However, further studies are required to validate the described indicators and further define appropriate measures.

4.4. Additional Findings from Collected Data

In this chapter, additional findings from the collected qualitative data are briefly presented. A central question that was asked every interview partner was related to the relationship between a MaaS provider and an MSP. All interviewees agreed on the preference of a partner relationship, as close cooperation is required to create benefits for both companies. Interviewee 7 explained: *"I see that for my part - and I also speak for the company - as a partnership. We are in close exchange with our aggregators, of course, we are trying to make optimisations, or in case we have launches, we do promotions with special offers for new customers on these platforms. It is really a togetherness, so to say, which results clearly in a win-win situation. It is definitely my approach to communicate on eye level and a partnership level with the aggregators and MaaS solutions"* (Appendix F).

A second interesting industry insight is that MSPs are also evaluating the available MaaS platforms and have decision making processes in place for choosing suitable and promising partners. Interviewee 4 mentioned that *"every day we get a new request to integrate us into a platform XY"* (Appendix F) and interviewee 3 confirmed that also MSPs perform evaluation processes to decide for the most relevant MaaS players (Appendix G). Therefore, MaaS platforms need to be attractive and provide an added value for MSPs; otherwise, collaborations are hardly feasible in the competitive mobility landscape.

However, this might do not apply to public MaaS platforms introduced by cities and public transit authorities. As outlined by interviewee 3, local governments have several leverages for the sustainable development of a cities' mobility system. Important control instruments are regulations, which can have substantial impacts on the mobility service providers operating in a city. For example, restrictions for specific areas, such as airports, could apply when an MSP is not cooperating with a cities mobility platform. On the other hand, providers with electric vehicle fleets might be permitted access to specific public spaces, which are not accessible for vehicles with combustion engines (Appendix F). These examples underline the controlling function of cities and PTAs and the dependencies mobility companies are facing. Moreover, it raises the questions if a MaaS platform should be preferably implemented by local authorities instead of private companies. However, this question is left open for discussion and further research.

5. Framework for the Evaluation of MSPs

In this chapter, the proposed evaluation framework based on the identified and recommended indicators in chapter four is presented and explained. Furthermore, managerial and theoretical implications are given, and the limitations of the conducted research discussed.

5.1. Multi-Criteria Evaluation Scoring Model and MSP Matrix

Based on the developed framework, this paper presents a management tool for the evaluation of MSPs, that is generalised among transport modes. The tool is suitable for supporting managers in decision-making processes in MaaS companies, but also for market and competitor analyses of mobility providers. The framework consists of two parts. First, the partner is evaluated, resulting in the partner quality score and second, the sustainability of an MSP is evaluated, resulting in the sustainability score. The proposed multi-criteria evaluation scoring model is illustrated in figure 7. A central finding of the collected data is that sustainability factors are rarely considered during assessment processes of mobility services and often primarily associated with the CO_2 footprint. The proposed management tool includes additional sustainability key criteria and indicators that allow a more comprehensive evaluation of sustainability aspects.

The partner evaluation consists of five key criteria, namely *Availability*, *Customer Base*, *Technical Maturity*, *Business Value* and *Financial Status*, which are divided into 12 indicators for the assessment. Furthermore, the sustainability evaluation consists of three key criteria, defined as *CO_2 Footprint*, *Social Responsibility* and *Quality of Life* composed of 9 indicators. Consequently, the score for both dimensions can be calculated and analysed separately. A weight for each indicator was not defined in the boundaries of this thesis, as a generalisation among different applications and focus areas of mobility companies is hardly feasible. However, the weighting of each indicator can be easily defined by users of the tool and therefore, flexibility and adaptability are guaranteed. For the rating scale, a five-point Likert scale is recommended with five as the maximum score that can be achieved.

Partner Evaluation				Transport Mode 1			
No.	**Key criteria**	**Indicators**	**Weight**	**Score MSP 1**	**Result MSP 1**	**Score MSP 2**	**Result MSP 2**
1	Availability	Presence in target countries	Tbd.	Scale 1-5	Weight x Score	Scale 1-5	Weight x Score
		Presence in target cities					
		Fleet size					
2	Customer Base	Number of active users					
		Number of transactions					
3	Technical Maturity	Degree of technical maturity					
4	Business Value	Strategic fit					
		Product quality					
		Brand awareness					
5	Financial Status	Funding					
		Revenue					
		Partner quality score ∑	**1**	**Sum_1 MSP 1**		**Sum_1 MSP 2**	
Sustainability Evaluation							
No.	**Key criteria**	**Indicators**	**Weight**	**Score MSP 1**	**Result MSP 1**	**Score MSP 2**	**Result MSP 2**
1	CO^2 Footprint	CO_2 emissions from usage/charging	Tbd.	Scale 1-5	Weight x Score	Scale 1-5	Weight x Score
		CO_2 emissions from materials & manufacturing					
		CO_2 emissions from operations					
2	Social Responsibility	Labour relations					
		Affordability					
		Accessibility					
3	Quality of Life	Noise pollution					
		Urban space usage					
		Safety					
		Sustainability score ∑	**1**	**Sum_2 MSP 1**		**Sum_2 MSP 2**	
		Total Score ∑		**Sum_1 MSP 1 + Sum_2 MSP 1**		**Sum_1 MSP 2 + Sum_2 MSP 2**	

Figure 7: Multi-criteria evaluation scoring model for MSP assessment

For the evaluation process, it is necessary to point out that some of the indicators are quantitative (e.g. number of active users) and can be set in relation to each other, while other indicators need to be evaluated qualitatively based on available information and knowledge (e.g. strategic fit). Therefore, the score of each indicator needs to be handled carefully, and the most objective measure should be chosen for the assessment.

Furthermore, a matrix with four quadrants is presented, which allows a visualised comparison of the assessed MSPs. The matrix consists of two dimensions, “Score for Partner Quality” and “Score for Sustainability”, which reflect the results from the evaluation scoring model. As illustrated in the matrix (figure 8), the scores can be assigned to four quadrants, which differ between:

(1) MSPs with high Partner Quality and high Sustainability Score
(2) MSPs with high Partner Quality and low Sustainability Score
(3) MSPs with low Partner Quality high Sustainability Score
(4) MSPs with low Partner Quality and low Sustainability Score

The matrix supports the decision-making process and sets the sustainability dimension on an equal level with partner quality when comparing MSPs. Even if the results of the interviews indicate that the partner quality is the dominant dimension in decision making, the matrix incentivises decision-makers to consider both dimensions equally.

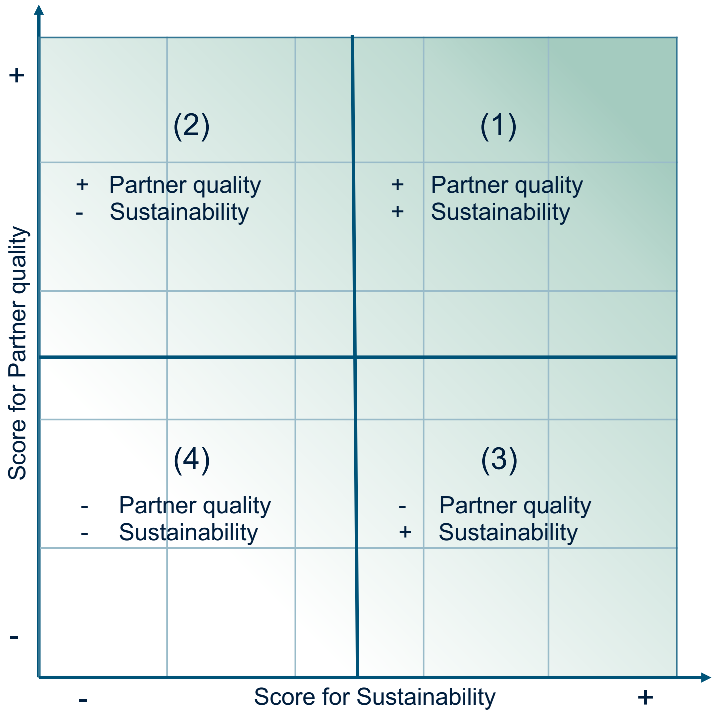

Figure 8: The "MSP Matrix"

Based on the position of an MSP in the matrix, strategic recommendations can be drawn. MSPs in quadrant (1) should be a top priority for MaaS companies because these companies are scoring well on both dimensions. Since the partner quality is the dominant dimension, MSPs in quadrant (2) are supposed to follow on the priority list. Nevertheless, considering the partnership relation between a MaaS provider and MSP, further actions could be discussed to improve sustainability performance. The MSPs in quadrant (3) have a high sustainability score but are not relevant players in the mobility market yet. Therefore, it is suggested to keep track of the companies' developments as the mobility market is very dynamic, and the competitiveness of firms potentially increase within relatively short time periods. The same applies to MSPs in quadrant (4). However, these companies need to improve on both dimensions.

The proposed key criteria and indicators were reviewed, discussed and validated with a top management member from the private MaaS provider moovel after the multi-criteria evaluation model was developed. Whereas the relevance and importance of all indicator were approved, the top management member pointed out that further testing and usage of the evaluation model might lead to a reduction of indicators in case of limited data availability or strong intercorrelation of indicators. Additionally, a test run with a comparison of two car sharing companies was performed. The test illustrated that some indicators, such as fleet size and revenue, are quantitative and can be put in relation to each other. In contrast, indicators, such as strategic fit or labour relations, require a qualitative assessment based on the knowledge base of decision-makers. Table 5 provides an overview of examples that indicate a high or low score of the presented indicators. Moreover, data that is not publicly accessible, for example, the number of transactions, need to be requested by the MaaS provider. Attention needs to be paid to the precise definition of weighting for each criterion according to the company's preferences and knowledge base. However, the developed multi-criteria evaluation scoring model is valid to be adopted and further tested by mobility companies.

Table 5: Examples of high and low scores for the proposed indicators

Partner Evaluation				
No.	**Key criteria**	**Indicators**	**Example of a high score (5)**	**Example of a low score (1)**
1	Availability	Presence in target countries	MSP is present in all target countries	MSP present is only present in only one target country
		Presence in target cities	MSP is present in all target cities	MSP is present in one or none target city
		Fleet size	Above average fleet size (in comparison to competitors) in target cities	Below average fleet size (in comparison to competitors) in target cities
2	Customer Base	Number of active users	Very high (in comparison to competitors)	Very low (in comparison to competitors)
		Number of transactions	Very high (in comparison to competitors)	Very low (in comparison to competitors)
3	Technical Maturity	Degree of technical maturity	High technical expertise & in-house developments	No technical expertise, no in-house developments
4	Business Value	Strategic fit	Company strategies are compatible (e.g. similar market entry strategies)	Company strategies are not compatible
		Product quality	Top-quality vehicles & mobile app	Low-quality vehicles, mobile app needs improvements
		Brand awareness	The Brand is well known in target cities	The Brand is not well known in target cities
5	Financial Status	Funding	Received a relatively high amount of fundings	Received a relatively low amount of fundings
		Revenue	Very high (in comparison to competitors)	Very low (in comparison to competitors)
Sustainability Evaluation				
No.	**Key criteria**	**Indicators**	**Example of a high score (5)**	**Example of a low score (1)**
1	CO^2 Footprint	CO_2 emissions from usage/charging	Zero emissions (e.g. bike)	High emissions while usage
		CO_2 emissions from materials & manufacturing	Environmentally friendly production along the supply chain	High emissions during production along the supply chain
		CO_2 emissions from operations	High degree of operational excellence (reduced maintenance trips)	Extensive use of resources for maintenance required
2	Social Responsibility	Labour relations	Employer carefully considers all labour relation topics, such as minimum wages etc.	Uncontrolled Subcontractors, low wages and/or bad working conditions
		Affordability	Affordable to all citizens	Affordable only to upper class
		Accessibility	Big service areas including suburban areas, large fleet size	Small service area (only inner citie), small fleet size
3	Quality of Life	Noise pollution	No noise pollution (e.g. micro-scooter)	High degree of noise pollution
		Urban space usage	Small vehicle size, vehicles are strategically well placed	Big vehicle size, blocking of a high amount of parking lots
		Safety	Safe vehicles, Safety precautions (e.g. helmets, safety instructions)	No safety equipment or precautions

To summarise, the presented multi-criteria evaluation scoring model and the MSP matrix are easily applicable management tools, that allow systematic and transparent decision-making in partner selection processes. Moreover, the tools can be used for market and competitor analyses. In order to keep track of the business developments of potential partners, it is recommended to check and update the available data for evaluation processes regularly.

5.2. Managerial Implications

The proposed assessment framework consisting of a multi-criteria evaluation scoring model and an MSP matrix is a valuable approach for decision-making in partner selection for MaaS provider. Based on a literature review and ten expert interviews, the most relevant indicators could be identified, that are defining the partner quality and sustainability performance of an MSP for a MaaS provider. Therefore, managers can apply the tools in practice to systematically evaluate and select the most suitable cooperation partners. The transparent process also supports the responsible managers by having fair and reliable methods in place. Furthermore, the capability of managers to provide feedback about decision processes to potential MSP partners by having clear partner selection criteria is another valuable advantage. However, since the tools are very general and meant to be applicable across transport modes, further testing of the evaluation criteria is necessary. With additional data from practical executions, an even more focused approach might evolve.

Furthermore, the evaluation scoring model and identified criteria are applicable for market and competitor analyses since they allow an in-depth performance comparison of different players in the market. The interviewees working for an MSP pointed out that being up to date and tracking the developments of companies in the mobility market is an essential task in business development departments (Appendix H). Therefore, the multi-criteria evaluation model can be adapted to the purposes of MSPs and serve as a systematic market analysis tool. However, the fast-paced market requires to update and discuss the data and information used for evaluation processes regularly. Additionally, mobility companies can use the assessment framework to identify strength and weaknesses of the firms' performance in comparison to their competitors. Thus, potential areas for improvements and optimisations are revealed, and further actions to strengthen competitiveness can be derived.

Lastly, the identified sustainability criteria are providing a broad set of indicators that need to be considered in MSP evaluation processes. While sustainability is still mostly associated with the CO_2 emissions or the CO_2 footprint of an MSP, other aspects are taken less into account. However, especially social aspects play a crucial role in the sustainable development of mobility ecosystems next to a CO_2 lifecycle analysis. Consequently, managers are required to facilitate a broader understanding of the sustainable development of their mobility services among their employees. Moreover, it is recommended to give sustainable aspects a higher consideration in decision-making processes to meet the basic principles of mobility as a service and sustainable urban mobility.

5.3. Theoretical Implications

This thesis contributes to current MaaS literature by providing an assessment framework for the partner selection of private MaaS provider. While researchers already discussed the necessity of close cooperation between MaaS providers and MSPs, partner selection processes in building MaaS platforms are not addressed yet (Mukhtar-Landgren et al., 2016; Sochor, Strömberg & Karlsson, 2015). The proposed decision-making tools are the first approach to adapt multi-criteria decision-making methods from supplier selection literature to the partner selection in the mobility sector. Build on the presented results, further studies which examine partner selection processes in mobility ecosystems can be performed. In particular, the definition of appropriate measures for the selected indicators is a substantial research field. Moreover, further research is necessary to examine the relationship between MaaS providers and MSPs since cooperations are possibly associated with conflicts of interest which impact the long-term perspectives of both companies.

Furthermore, selected sustainable urban mobility indicators used to assess the entire transport systems of a city were adapted to an individual MSP. In recent years the available mobility options within a city increased by the introduction of shared mobility services from private and public providers. Therefore, cooperations between several public and private providers are necessary to optimise urban transport systems and provide the citizens with an attractive transport alternative to the private car. Hence, the future sustainable development of transport systems is not only depended on public authorities but also private mobility companies. As a consequence, the proposed indicators are a valuable addition to current sustainable transport literature and allow to assess providers apart from PT systematically. Furthermore, every available MSP contributes to a cities mobility system and affects people's mobility patterns. Therefore, investigating how these MSPs are influencing the sustainable development of urban transport systems is an interesting research field. In addition, the proposed indicators are useful to define performance indicators for MSPs. For example, the indicators availability or technical maturity are crucial in the business development of MSPs. Hence, success factors for MSPs can be derived from the presented results.

Lastly, the key question on how public and private MaaS providers can work together to implement MaaS solutions across cites and countries needs to be pointed out. Since the introduction of several different MaaS platforms from local authorities and private companies might not be sufficient in the long-term, overarching integrated concepts are required to achieve a fully integrated MaaS concept. This is, in particular, a challenging and crucial research field, which deserves the attention of researchers.

5.4. Limitations

The results of the conducted research have some limitations. The proposed framework is based on in-depth expert knowledge and a systematic literature review. However, it was only very limited applied in practice. As the framework aims in being applicable across different transport modes, further testing is required to validate the defined indicators. As some of the indicators are correlating, such as “number of active users” and “number of transactions”, further testing in practice might lead to a reduction of indicators and an even more focussed framework.

Furthermore, breaking down sustainable mobility indicators of whole transport systems to an individual mobility service provider is a challenging task, that requires further research based on this thesis. The collected data from the interviews revealed that in the mobility sector, sustainability is mainly associated with the reduction of CO_2 emissions. Consequently, other sustainability aspects were less mentioned by the interviewees and are primarily based on indicators presented by Gillis, Semanjski, Lauwers (2016). It is suggested to conduct more research that includes a comprehensive consideration of sustainability dimensions to lay the foundation for a shared understanding across industries.

Another limitation is the lack of available data, which is affecting the determination of appropriate measures. The provided measures for the proposed criteria in this paper are valid starting points; however, measures for indicators such as “Affordability” and “Urban space usage” require information that is hardly available to the public. As a consequence, the evaluation needs to be performed by an individual or team assessments based on existing knowledge instead of a data-driven evaluation. Therefore, objectivity is only given to a certain degree, and wrong interpretations or estimations by responsible employees might have negative impacts on the results.

Lastly, the qualitative data collection in the form of interviews was conducted with selected respondents working in companies based in Berlin. Therefore, certain biases cannot be excluded. As mentioned before, cities differ regarding available mobility services and regulations to a great extent, which can influence the opinion and perceptions of the citizens. For further research, it is recommended to include experts from different geographical areas to gain new insights and perspectives, especially on the topic of cooperations in MaaS ecosystems.

6. Conclusion

This study presents a comprehensive framework for the evaluation of mobility service providers along the dimensions partner quality and sustainability. First, the proposed indicators allow MaaS providers to systematically evaluate and select suitable cooperation partner for the integration into MaaS platforms. Thereby, a first approach to address the topic of partner selection for MaaS ecosystems was introduced. The practical implementation of the management tools allows MaaS provider to carefully select sustainable and high performing MSPs, reduce the risk of technical complications and strengthen the competitiveness of the MaaS platform. Second, the assessment framework is suitable for market and competitor analysis purposes and potentially reveal areas for improvements for a firm in the mobility sector. Additionally, sustainable mobility indicators were adapted from entire urban transport systems to individual MSPs, which is a valuable contribution to existing literature given the growing importance of shared mobility in sustainable urban development.

In total, 20 indicators were identified and categorised into eight key criteria based on a systematic literature review and ten expert interviews. The results regarding the partner quality indicate that *Availability*, *Customer Base*, *Technical Maturity*, *Business Value* und *Financial Status* are the key criteria that are defining the quality of an MSP. For the sustainability dimension, the *CO_2 Footprint*, *Social Responsibility* and *Quality of Life* were identified as the key criteria. It is worth to mention that sustainability factors still play a minor role in decision-making processes and are mainly related to the CO_2 footprint. This fact calls for further research and incentives to create a better understanding of sustainable development related to urban mobility. Based on the results, a multi-criteria evaluation scoring model is proposed, which enables managers to assess the performance of MSPs systematically. Additionally, the MSP matrix is a helpful tool to visualise and compare the performance scores among different MSPs and derive strategic recommendations.

Furthermore, conclusions can be drawn on the gained expert knowledge and collected data from the interviews. One current key challenge is the limited availability of mobility data and beyond, the lack of willingness of companies to share collected data with the public. Further initiatives to lay the foundation for data-sharing agreements and open data platforms between all mobility providers are necessary, despite the intense competition in the market. Since MaaS platforms are associated with high technical complexity, standardised APIs are required to accelerate technical integrations and reduce project management efforts and need for resources. Lastly, the rapid growth and change in the shared mobility market need to be pointed out. In recent years many new mobility players evolved and entered the transport market, but also traditional car manufacturers and global companies are developing new digital mobility solutions. As integrated concepts are crucial for future developments, it can be foreseen that MaaS will take over a key role in creating sustainable mobility ecosystems that meet the demands of future generations.

Lastly, fields for future research are recommended. Since this thesis focused on private MaaS provider, further research should address the differences in the selection process of partners between private and public MaaS providers. Public MaaS providers are expected to focus to a greater extent on social welfare when developing MaaS solutions, whereas private MaaS providers tend to seek a certain degree of profitability. Therefore, it is likely that selection processes and criteria differ. Moreover, the advantages and disadvantages of MaaS offerings from private or public organisations are worth to investigate scientifically. Further studies could provide essential insights into how MaaS solutions can be optimally implemented to drive sustainable developments. Another critical question is how the proposed framework can be adapted to other parts of the world, such as North America or China. As conditions and cultural factors are very different in many countries, other criteria might be crucial in decision-making. Potential differences may apply from both the customer and the B2B perspective. Since MaaS is still a very new concept, the examination of differences among geographic regions is an interesting research field. Finally, the origin of private MaaS providers is potentially influencing the decision-making processes in partner selection. For example, MaaS solutions could be offered by traditional OEMs (e.g. car manufacturers) or companies with a different industry background, such as Uber or Google. Therefore, differences in decision-making processes might occur related to the origin and initial intentions of private MaaS providers. To summarise, selecting suitable partners for MaaS ecosystems is still a new research field. However, partnerships are an essential element of MaaS ecosystems, and more insights are needed that address the relationships of different MaaS stakeholders.

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Appendix

A. Market Research: Mobility Services in Berlin

To underline the relevance of the thesis, it is worth to have a closer look at the mobility market developments in the German capital Berlin. With the sharing economy trend, a growing number of different mobility services were established in the city. For example, currently (last updated on 29.09.2019) six different bike- and micro-scooter sharing provider and eleven different car sharing companies are competing within the urban area of Berlin. An overview of the available services distinguished by transport mode is presented in figure 9.

Mobility Service Providers in Berlin (Last update: 29.09.2019)					
Bike Sharing	**Scooter Sharing**	**Car Sharing**	**Ride Hailing**	**Car Pooling**	**Micro-ScooterSharing**
Nextbike	Coup	Share Now (former Car2Go & DriveNow	Free Now (former mytaxi)	Clevershuttle	Tier
LimeBike	Emmy	miles	Uber	BVG Berlkönig	Circ
Jump (by Uber)		WeShare	Taxi Berlin		LimeScooter
Mobike		Sixt Share	Taxi Deutschland		Bird
Lidl-Bikes (by DB)		Flinkster (by DB)	Taxi.de		Jump (by Uber)
Donkey Republic		Ubeeqo			Voi.
		Oply			
		Stadtmobil			
		Greenwheel			
		Cambio			

Figure 9: Mobility services in Berlin (BerlinOnline Stadtportal GmbH & Co. KG., 2019)

Additionally, a range of multimodal mobility platforms was already introduced, such as the “Jelbi” app from the local public transport provider BVG or the app “REACH NOW” by the private company moovel. The following table shows the available multimodal platforms, including the covered transport modes.

Table 6: Multimodal mobility platforms operating in Berlin (Own illustration based on market research; last update 29.09.2019)

Multimodal Platform	Public Transport	Car Sharing	Car Rental	Bike Sharing	Scooter Sharing	Micro Scooter	Ride Pooling	Ride Hailing
Jelbi (BVG)	1	1	0	1	1	1	0	0
REACH NOW (by moovel)	1	2	0	1	0	1	0	1
SIXT	0	1	1	0	0	1	0	1
Uber	0	0	0	1	0	1	0	1

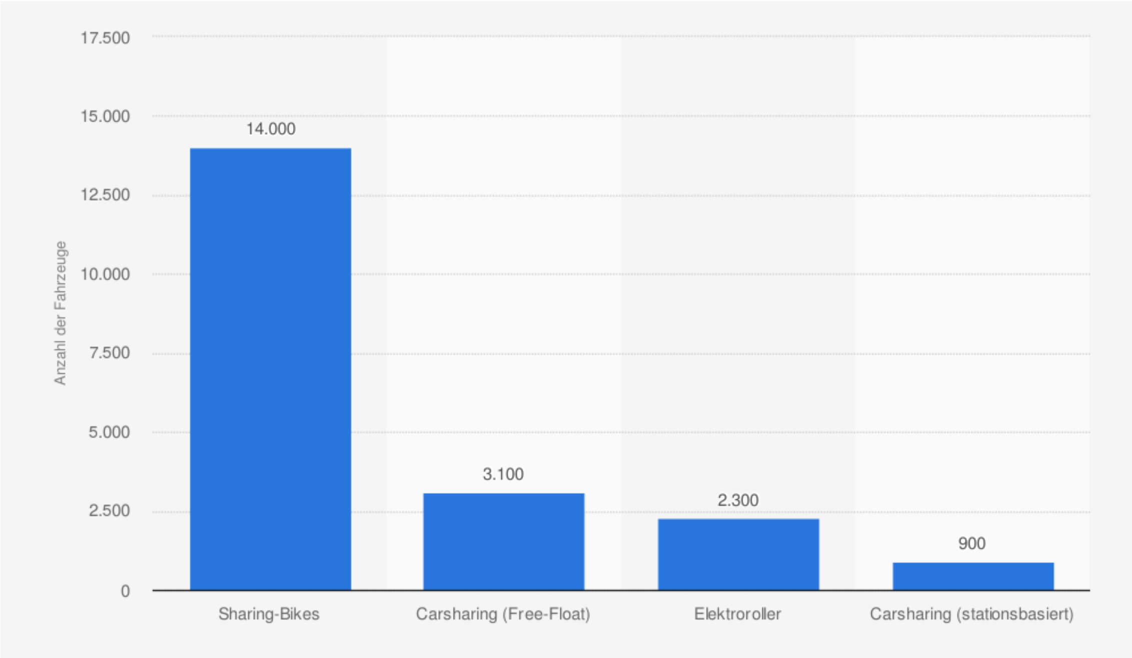

Figure 10: Amount of car-, bike- and scooter sharing vehicles in Berlin in July 2019 (eMobilitätOnline, 2019)

Furthermore, figure 10 shows the distribution of vehicles among the different sharing services. It can be seen that Sharing Bikes are by far the most available shared vehicles, which can be explained by lower investment costs in comparison to car sharing. However, the overall fleet sizes are continually increasing, and it can be foreseen that more and more shared vehicles will be available in the near future.

To summarise, the presented figures and statistics illustrate the current market situation and the number of different providers in Berlin. As new companies are entering the market frequently, a competitive mobility landscape evolved in Berlin, which is pointed out as a central challenge for MaaS providers and MSPs in this thesis.

B. Number of Search Results for Key Terms

In the following table, the number of search results for key phrases related to "Mobility as a Service" and Supplier Selection" on the academic databases Scopus and Web of Science (database: core collection) are shown.

Table 7: Number of search results for key terms on Scopus and Web of Science

Mobility as a Service and related search terms

Scopus

Year	Mobility as a Service	Mobility Services	Urban Mobility	Sustainable Transport	Sharing Economy	Shared Mobility	Sustainable Transport Systems	Sustainable Urban Mobility	Mobility Service Provider
2018	70	138	431	208	531	71	35	60	5
2017	36	94	334	187	392	21	34	43	2
2016	19	94	292	160	204	27	23	40	5
2015	4	53	185	181	73	8	26	21	0
2014	1	46	177	133	24	9	24	18	2
2013	1	44	151	129	11	1	15	15	3
2012	0	38	135	100	1	0	18	18	1
2011	5	28	77	106	2	1	20	5	2
Total (2011-2018)	**136**	**535**	**1782**	**1204**	**1238**	**138**	**195**	**220**	**20**

Web of Science (Core Collection)

Year	Mobility as a Service	Mobility Services	Urban Mobility	Sustainable Transport	Sharing Economy	Shared Mobility	Sustainable Transport Systems	Sustainable Urban Mobility	Mobility Service Provider
2018	44	77	296	180	442	49	7	50	2
2017	19	41	292	164	341	24	10	37	1
2016	18	46	279	176	162	22	8	48	1
2015	6	32	164	160	52	8	7	23	1
2014	0	20	108	104	13	9	6	14	0
2013	0	7	66	84	3	1	5	3	0
2012	0	7	63	59	0	0	5	9	0
2011	1	6	24	64	1	1	2	2	0
Total (2011-2018)	**88**	**236**	**1292**	**991**	**1014**	**114**	**50**	**186**	**5**

Last update: 07.10.2019

Supplier Selection and related search terms

Scopus

Year	Supplier Selection	Partner Selection	Supplier Evaluation	Supplier Assessment	Partner Evaluation	Green Supplier Selection	Sustainable Supplier Selection	Supplier Integration	Supplier Involvement
2018	391	105	71	11	13	39	36	35	19
2017	319	107	74	12	12	32	12	28	25
2016	304	103	66	8	9	21	7	26	14
2015	286	113	50	10	8	23	7	19	21
2014	322	107	70	10	8	14	8	17	27
2013	264	116	58	15	14	9	3	36	28
2012	233	101	63	6	7	5	3	14	18
2011	270	114	63	5	8	4	3	19	29
Total (2011-2018)	**2389**	**866**	**515**	**77**	**79**	**147**	**79**	**194**	**181**

Web of Science (Core Collection)

Year	Supplier Selection	Partner Selection	Supplier Evaluation	Supplier Assessment	Partner Evaluation	Green Supplier Selection	Sustainable Supplier Selection	Supplier Integration	Supplier Involvement
2018	376	128	62	10	6	40	29	29	21
2017	327	142	53	6	7	25	14	30	21
2016	311	150	49	3	6	18	7	21	22
2015	287	139	44	7	4	20	6	17	20
2014	311	102	39	4	3	9	3	15	20
2013	287	90	33	7	0	5	1	30	18
2012	224	90	32	7	2	1	3	14	12
2011	179	82	38	2	5	2	2	12	20
Total (2011-2018)	**2302**	**923**	**350**	**46**	**33**	**120**	**65**	**168**	**154**

Last update: 17.10.2019

C. Supplier Evaluation Criteria

Table 8: Overview of supplier evaluation criteria from the literature review of Thanaraksakul & Phruksaphanrat (2009)

FINANCIAL PERSPECTIVE

Criteria	Measures	
Economical aspect (ECN)	- Currency fluctuation - Economical policies - GDP growth	- Growth deferring - Local price control - Tax and custom duties
Financial status (FNS)	- Annual profit and growth - Annual revenue and growth	- Financial stability - Fiscal outlook - Market share

CUSTOMER PERSPECTIVE

Criteria	Measures	
Amount of past business (PSB)	- Core competency - Customer base - No. of customers	- Renowned customers
Attitude and strategic fit (ATD)	- Management viewpoint	- Strategic compatibility
Customer relationship (CTR)	- Customer database - CRM activities - Customer retention	- Marketing campaign
Customer satisfaction and impression (CSI)	- Brand royalty - Customer reliance - Customer feedback	- Market position - Market share
Geographical location (GEO)	- Accessibility - Information technology	- Distance - Trade barrier and tariff
Packaging and handling ability (PKG)	- Product carrying - Standard package compliance	
Performance history (PMH)	- Awards and expertise - Commercial Ability - Production schedule	- Response to market
Repair, services and follow-up (RSF)	- Convenience - Problems solving - Response to change	- Satisfaction on service - Service speed
Reputation and references (REP)	- Customer references - Firm prestige	- Position in industry
Warranties and claim policies (WCP)	- Warranty time range - Satisfaction on claims	

INTERNAL-BUSINESS-PROCESS PERSPECTIVE (IBP)

Criteria	Measures	
Cost (CST)	- Circumstantial cost change - Compliance with Cost Analysis system (CCA) - E Compliance with sector price behavior	- Cost reduction activity - Cost structure - Cost consistency - Low initial cost - Reasonable cost
Delivery (DLV)	- Conformance receipts - Consistent delivery - Delivery speed	- On time delivery - Quantity compliance
Flexibility and reciprocal arrangement (FLX)	- Conflict resolution - Flexibility of production system - Order change response - Responsibility to volume change	- Short setup time
Innovation and R&D (INV)	- Design capability - Expenditure on new technology - Invention lead time	- Product development capability and time - Technological support
Management and Organization (MGT)	- Level of command and compatibility - Management attitude - Organization structure	- Vision, mission, and policy
Product reliability (PRT)	- Conformance functions - Product life	
Production facility and capacity (PFC)	- Capacity flexibility - Capacity planning - Development speed - Production planning	- Responsibility to market demand
Quality (QLT)	- Conformance quality - Incoming rejection - Prompt response - Rejection rate	- Remedy for quality problems - Quality philosophy - Quality staff capability
Quality system (QTS)	- Database and traceability - QC and QA system	- System Certification
Technical capacity and support (TCS)	- Future technology - Technology deployment	- Technological capacity - Technology utilization

LEARNING AND GROWTH PERSPECTIVE (LNG)

Criteria	Measures	
Cultural congruence (CTC)	- Cultural difference	- Feeling of trust
Desire for business (DFB)	- Business growth - Goal attainment	- Development activity - Outlook for future
Domestic political stability (DPS)	- Government shift and term length	- Public policies
Information technology and communication system (ITC	- Compatibility of system - Ease of communication	- Information sharing - Information technology
Labor relations record (LRR)	- Clarity of job definition - No. of employees	- Occupational education activity - Organization structure
Personnel training and development (PTD)	- Occupational test - Professional education	- Training activity - Training Expense
Safety awareness (SFT)	- Accident statistics - Emergency plans	- Safety equipment and prevention
Terrorism risk (TRR)	- Attacked likelihood	- Emergency plans - State reliance

CORPORATE SOCIAL RESPONSIBILITY PERSPECTIVE (CSR)

Criteria	Measures	
Environmental and social responsibility (ENV)	- Design for environment - Environmental competency - Environmental policies	- Pollution discharge and management - Pollution reduction activity - Social expense and donation

D. Interview Guide for MaaS Providers

Interview Guide

Interview partner: Name (company)

Brief introduction to the topic. What is the master thesis about?

Interview questions:

General Questions about Mobility as a Service (MaaS)

1. What is your opinion about the current/future development of MaaS?
    a. Do you think MaaS will be a dominant concept in the future?
2. How do you think will the competitive landscape for mobility services evolve?
    a. What are the main competitors? (e.g. will we see different MaaS platforms compete?)
3. Where do you see differences between public and private MaaS provider?
4. How do you see the relationship between a MaaS provider and a Mobility Service Provider (MSP)? (e.g. like customer/supplier relationship, partnership, etc.)
5. What makes a MaaS platform successful?

Decision-making Process & MSP Evaluation

1. How do you select new MSPs for the integration in the MaaS platform?
    a. Which processes/tools do you have in place or do you use?
    b. What are the current key criteria when selecting new MSPs?
    c. What are the measures for these criteria?
    d. Can you provide a ranking of the mentioned criteria?
2. What are the main challenges in the decision-making process?
6. From your point of view, should a MaaS platform try to integrate as many services as possible or would be a selective approach be beneficial? (choosing all vs. choosing the best)
7. Do you see any risks or difficulties when integrating a new MSP?
8. Do you and how do you take track of the performance, improvements or developments of your MSP portfolio?

Sustainability Criteria

1. From your point of view, how important is it to include sustainability criteria in the decision-making process?
2. From a sustainability perspective (dimensions: economic, social, ecologic), which criteria need to be considered when evaluating or selecting an MSP?
3. What are the most relevant sustainability aspects from your point of view?

Concluding/Final questions

1. What are the requirements for a decision-making tool to be useful in practice?
2. Would you prefer a qualitative or quantitative (a specific score) evaluation approach?

E. Interview Guide for Mobility Service Providers

Interview Guide (MSPs)

Interview partner: Name (Company)

Brief introduction to the topic. What is the master thesis about?

<u>Interview questions:</u>

General questions about Mobility as a Service (MaaS)

1. What is your opinion about the current/future development of MaaS?
    a. Do you think MaaS will be a dominant concept in the future?
2. How do you think will the competitive landscape for mobility services evolve?
    a. What are the main players? (e.g. will we see different MaaS platforms compete?)
3. How do you see the relationship between a MaaS provider and a Mobility Service Provider (MSP)? (e.g. customer/supplier relationship, Partnership, etc.)

Cooperation between MSPs and MaaS provider

1. What are the advantages and disadvantages for an MSP to cooperate with MaaS platforms?
2. Which criteria are you considering when deciding to cooperate with a MaaS platform or not?
3. <u>Optional:</u> Which departments & employees are involved in the decision-making process?

Market Research/Analysis

1. Where do you see the main differences of the MSPs competing in your specific market (e.g. car sharing market)?
2. Do you and how do you screen your competitors and other players on the mobility market?
3. Which specific criteria do you use for comparison between different MSPs in your market? Which criteria are the most relevant ones?
4. How do you track the performance or improvements of the MSPs in the market?

Sustainability

1. When it comes to sustainability, where do you see the main advantages/disadvantages of your transport mode (e.g. car sharing) in comparison to other transport modes (e.g. e-scooter sharing)
2. To which extent do you consider sustainable aspects (economic, environmental, social) in the development of your product/company?
3. Which sustainability criteria do you find most important regarding sustainable mobility?
4. Which tools or processes are in place to track the sustainability performance of your company?
5. What are the most relevant sustainability factors for mobility services from your point of view?

Concluding/Final questions

1. Do you have any open questions or comments on the discussed topics?

F. Data Analysis – Coding Sheets (separate file, confidential)

Please find the coding sheets for the data analysis of the expert interviews in a separate document (confidential).

G. Interview Transcripts (separate file, confidential)

Please find the transcripts of the expert interviews in a separate document (confidential).