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A National Approach to Assessing the Impacts of Mobility-as-a-Service (MaaS)

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Abstract

To systematically assess the environmental, economic and social impacts of different types of MaaS, a common evaluation framework is essential. Within the KOMPIS project, a framework is developed with a basis in former projects (e.g. MaaSiFiE and IRIMS), complementary literature studies, and workshops involving different stakeholders. The framework consists of three interrelated levels; a traveller level, an organizational business level, and a societal level. For each level, performance indicators (KPIs) of ecologic, economic, and social impacts have been formulated as well as a specification of the data that must be collected. In addition, for each level a model describes the interdependency between factors termed 'preconditions', 'evaluation/decision' and 'action'. These factors explain and describe background information that is to be collected in order to explain the outcome of impact assessments. The framework and associated data collection tools are available on the KOMPIS project website. In a next phase, feedback is to be provided by MaaS pilots to further develop the framework and related tools.

Keywords

Mobility-as-a-Service (MaaS), impact assessment, travel behaviour, economic impact, social impact, environmental impact

1 Introduction

1.1 Background

The transportation sector must reduce its dependency on fossil fuels and is currently in a phase of global transformation whereby electrification, automation and servitisation are frequently referred to as three key fundaments of a paradigm shift within passenger transportation (Wells, 2010). Mobility as a Service (MaaS), which has received much attention since the concept was introduced in 2014 (Heikkilä, 2014), is commonly depicted as a means to harness the potential of each of these trends in a manner that helps achieve sustainability and climate goals, as well as improve the attractiveness and liveability of urban areas. In the long term, an integrated and sharing oriented mobility system could change car ownerships, lead to a significant reduction in emissions (Shaheen et al., 2009; Chen and Kockelman, 2016) and as a result bring about a number of health benefits (Woodcock et al. 2014).

MaaS draws from new business models that promote sales of multi- and intermodal mobility as a 'function' rather than a product (Williams, 2007, Lisson et al., 2015). It is supported by changes in attitudes among individuals, demonstrated by a growing interest in shared ownership

or non-ownership as well as in health and environmental sustainability. These attitudinal changes are observable via the emergence of, or growth in, new mobility practices such as ride hailing, car and ride sharing (e.g. Shaheen and Cohen, 2013) and studies have shown that these solutions can reduce private vehicle use as well as vehicle kilometres travelled (Martin et al. 2010; Fishman et al. 2014).

However, MaaS is still emerging and definitions and schemes are evolving (Jittrapirom et al. 2017). The number of implementations is still very limited, and, in addition, there is limited empirical evidence showing that MaaS could be a solution to change people's travel behaviours and bring about the envisioned positive impacts. The lack of empirical knowledge on the impacts of MaaS is a critical issue, given current levels of interest in the concept.

At the same time there are numerous ongoing initiatives and pilots within Sweden, across Europe and in locations as diverse as Singapore, Australia and the USA. Among these initiatives, scholars have identified different models of MaaS developments, noting that MaaS can be rolled out by public organisations (typically public transport agencies and operators), by private organisations (typically entrepreneurial start-ups) or by hybrid organisations that comprise some sort of public-private partnership (Smith et al., 2018). Further, different (ongoing) MaaS pilots target different geographical areas (e.g. cities, rural areas) and different types of travellers (e.g. multiple-occupancy households, commuters, employees, tourists). Which types of MaaS will result in what types of impacts? For whom? And why?

1.2 Rationale for an assessment framework

In order to address these questions, it is vital to categorise in a systematic way different types of MaaS. However, there is currently little agreement on how to define MaaS, on what constitutes a MaaS service, or on how to compare and assess different MaaS services. Some authors suggest that MaaS should contribute to sustainability challenges (Heikkilä, 2014; Mukhtar-Landgren et al., 2016) whereas others see it more as a means to fulfil customer needs (Datson, 2016; Kamargianni et al., 2016).

One way to deal with this conceptual uncertainty is to develop a characterisation of MaaS that embraces the fluidity of the concept. This approach has been taken by Sochor et al. (2018; see also: Kamargianni et al., 2016; Lisson et al., 2015), who have developed a MaaS 'topology'. The topology, which builds on differing degrees of integration, consists of different levels. Level 0 refers to the integration of information into services (e.g. multimodal travel planners); level 2 refers to services that facilitate online bookings and payments (e.g. Hannover Mobil); and level 3 refers to the integration of different mobility services into a single, seamless offering that is made available to users via subscription-based smartphone applications (see also: Goldman and Gorham, 2006; Sochor et al., 2015). Level 4 refers to the integration of societal goals such as transport policy objectives and sustainability targets into MaaS ecosystems and services at levels 0-3.

Some mobility services that fit within the lower levels of the topology, such as taxi services and public transport, have existed for a long time. Others, such as car and ride sharing have undergone rapid growth in the last decade following the emergence of ICT-enabled business models (Cohen and Kietzmann, 2014). Even though new mobility services are increasingly seen as a means to shift towards a more sustainable transport system, and are linked to better urban management; improvements in energy efficiency and urban air quality; greater use of renewable

fuels; reduced congestion and improved accessibility (Greenblatt and Saxena, 2015; Greenblatt and Shaheen, 2015; Rydén and Morin, 2005) the actual impacts is not clear.

Previous research on level 3 MaaS has focused on a number of themes related to the development and evaluation of the service concept. These include: 1) experimenting with MaaS via pilots and demonstrations; 2) examining user needs, preferences, motives and satisfaction with MaaS; 3) examining market demand and willingness to pay for MaaS; 4) developing new business models and service offers; 5) examining technological needs and requirements; 6) exploring new structures and standards for data sharing and ticketing; and 7) examining the antecedents of MaaS developments in different cities, regions and countries (Sarasini et al., 2017). Achieving level 4 – the integration of societal goals – implies that MaaS must be assessed in terms of its sustainability impacts. However, given the novelty of level-3 MaaS, its sustainability impacts are not well documented and at present, empirical evidence on the sustainability of MaaS is limited to a few studies that provide indications that MaaS can, for example, encourage more sustainable travel behaviour (e.g. Sochor et al., 2016, Strömberg et al., 2016, Strömberg et al., 2018).

In principle, level 3 MaaS could deliver radical improvements as regards the environmental sustainability of the transport system due to the hypothesis that a MaaS solution can require fewer vehicles, and can thus reduce congestion, emissions and noise pollution – factors that also contribute to economic sustainability gains. Further, the intermodal nature of level 3 MaaS could improve the resilience of the transport system and give users access to wider range of alternatives to fulfil their daily transport needs. Furthermore, MaaS could also act as a base for new innovations that combine transport services, new vehicle technologies and ICT (Sarasini et al., 2016). For instance, MaaS could spur the adoption of vehicle technologies such as hybrid and electric drives, biofuels, fuel cells, and autonomous and connected vehicle technologies (e.g. Wadud et al., 2016). However, these types of gains are not more than hypotheses. For example, while one may logically argue that level 3 MaaS would provide an alternative to private car usage (at least in part) by supporting increased car-pooling / ride-sharing in a manner that reduces congestion and transport emissions, potential rebound effects (e.g. increased travel) may serve to limit the overall sustainability gains (Trafikanalys, 2016).

There is thus a demand for evaluations that assess the sustainability impacts of different types of MaaS services, and which elucidate the ways in which sustainable services can be governed and developed. This is particularly the case among public-sector organisations, who require knowledge and guidance to inform policymaking; and among practitioners in the field who require guidance to assist in the development of sustainable MaaS business models and services. However, robust and systematic assessments that examine the impacts of MaaS in terms of environmental, economic and social sustainability criteria are however lacking.

To enable such a valuation, a framework including key performance indicators and data collection methods is developed within the KOMPIS project (Combined Mobility as a Service in Sweden) which is initiated by the Swedish government's cooperation group for 'Next Generation Travel and Transport'. This initiative provides a national roadmap for the development of MaaS in Sweden. Following the roadmap, an important part of KOMPIS initiative is to assess whether and to what extent MaaS contributes to environmental, economic and social sustainability.

1.3 Purpose

The purpose of the paper is to present this multi-level evaluation framework that can be used across different MaaS pilots/projects to systematically assess the environmental, economic and social impacts of different types of MaaS pilots on an individual, organisational and a societal level. The assessment framework is believed to be beneficial for comparisons of different MaaS pilots, levels of service integration, business models, policies and regulations in implementing and developing MaaS.

2 The development process

The framework, which this far focuses on 'everyday travel' including trips to and from work or school, leisure activities and trips to work, is developed in an iterative design process by a team representing different disciplines and perspectives (the authors) in dialogue with MaaS pilots using the framework and its instruments.

The basis for the work was provided by the outcome of (primarily) two former projects; Mobility-as-a-Service for Linking Europe, MaaSiFiE (e.g. Karlsson et al., 2017) and Institutional Frameworks for Integrated Mobility Services, IRIMS (e.g. Mukhtar-Landgren et al., 2016). A common denominator between the projects is a hierarchy consisting of three levels: an individual/citizen/user level, a business/organisational level, and a societal level. In the case of IRIMS, the three levels form the basis on which enablers and barriers to the development and implementation of MaaS can be understood. In the case of MAASiFiE, the three levels and associated key performance indicators (KPIs) related to environmental, economic and social impacts, provide the basis for the evaluation and assessment of the impact of MaaS.

In order to further develop the framework, and in particular the KPIs, a workshop was completed with different stakeholders, such as public and private service providers, representatives for municipalities, transport authorities and researchers. The participants were asked to formulate key questions that they wished to find answers to regarding the impacts of MaaS. These questions were then grouped and analysed by the multi-disciplinary research team and clustered according to the three levels (i.e. a user/traveller, a business/organisation, or a societal level) and to what extent they concerned environmental, economic, and/or social impacts of MaaS. These were defined as:

- 'Ecological impacts' include its impacts on the environment in the form of, for example, reduced energy use, air pollution and greenhouse gases, and land usage (e.g. reduction of areas for parking spaces for private cars)
- 'Economic impacts' include costs and revenues, in terms of time and money as well as the cost for maintaining a healthy transport infrastructure.
- 'Social impacts' include, for example, changes in citizen's access to the transport system and to different places of interests such as work, school, healthcare.

As a next step, for each of the three levels the research team developed a model which describes the interdependency between, on the one hand, environmental, economic, and social effects and, on the other hand, (i) the actions that result in these effects, (ii) the evaluation/decision processes that preceding these actions, and (iii) the preconditions for the decisions. New KPIs were then formulated and data collection methodology including instruments were specified.

This include standardised questionnaires be distributed to users/customers as well as to service providers during different stages of service introduction and establishment.

3 The framework

The framework relies on a system perspective where activities on an individual traveller level, an organisational level and a societal level are considered to create preconditions for and affect each other (see figure 1).

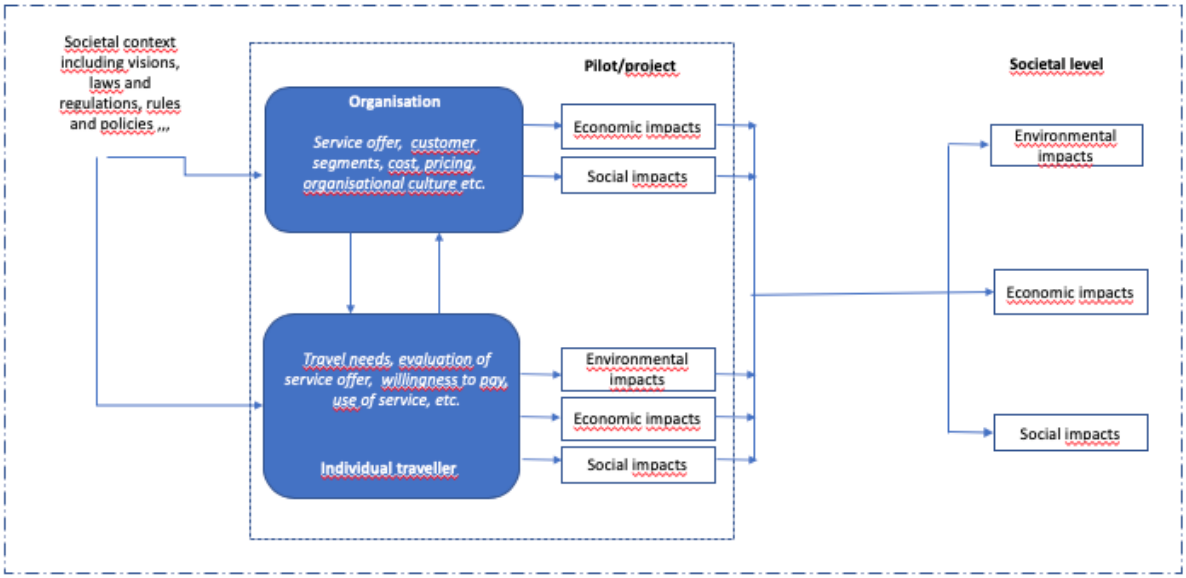

Figure 1. Basic building blocks of the KOMPIS evaluation framework. A more developed model is provided in Karlsson et al. 2019.

3.1 The individual level

The individual level refers to travellers/commuters using MaaS services. In order to address the KPIs on this level (examples provided in Table 1) the framework relies on data about, for example individuals' travel behaviour and travel patterns. These behaviours are dependent on a number of factors including demographic aspects such as household size, income and education. Other factors are related to the users' need for transportation, such as distance between home and workplace versus the transport solution offered, for example by a MaaS service. Assessing transport needs versus the MaaS offer (incl. means of transport offered, cost, debiting principles, etc.) the individual's decision on whether to adopt the solution depends on the degree to which the service is perceived to fulfil the transport needs or not. A key concept is here 'perceived action space', i.e. the space that the individual perceives to have in relation to the choice of modes of transport, travel times, etc. (see e.g. Strömberg, 2014). Based on this perceived action space. one and the same solution can thus be adopted by one individual and rejected by another.

Table 1. Examples of environmental, economic, and social impacts on the individual level.

KPI	Description	Unit	Data collection
Number of trips per month	Total number of trips per individual and month incl. commuter trips but excluding long-distance holiday trips	# of trips	Travel diaries / travel app
Monthly expenses for travelling	The total cost per month for the individual's everyday trips incl. trips by public transport, taxi, car, moped/motorcycle, and cycle	SEK (or corresponding)	Questionnaire to users
Perceived accessibility to destinations such as work/school, etc.	The degree to which the user perceives that the transport system is designed in a way that makes it easy for him/her to reach destinations such as work, school, shopping, etc.	Rating on a scale	Questionnaire to users

3.2 The organisational level

The organisational (or business) level refers to the organisations (public and private) or companies that design, mediate and deliver the MaaS service. The design of the service influences the impacts on an individual level - environmental (e.g. travel behaviour), economic (e.g. cost) and social (e.g. accessibility) impacts. However, one of the most important aspect on the organisational level is the economic or business sustainability of MaaS. The framework relies here on the business model of the service provider(s). Two processes are described. The value creation process depends on the interaction between the organisation and the different customer segments, or user groups, identified on the individual level in that the different needs and preferences of different segments determine how the organisation can create value through the service offer. The value capture process also relies on an understanding of the customers/users and for example their willingness and ability to pay for the service. In addition, together with the value creation process and the value catching process, the characteristics of the organisation per se (culture, strategies, goals, etc.) shape the action space for business innovations. The assessment of the economic effects of the service is based on an analysis of these (and other) factors. In addition, on this level the framework includes social effects in terms of, for example new jobs. The framework suggests furthermore that environmental impacts are achieved not on the organisational level but indirectly, on the individual level, through for example including in the service offer more environmentally friendly alternatives, such as electric vehicles. Table 2 provides examples of economic and social impacts related to the organisational level.

Table 2. Examples of economic and social impacts on the organisational (or business) level.

KPI	Description	Unit	Data collection
Profitability	The service provider's net profit margins	%	Assessment based on questionnaire to service provider
Innovation potential	The degree to which the service is perceived to result in (i) new business models, (ii) new forms for collaboration, (iii) new partnerships, etc.	Ratings on a scale	Questionnaire to service provider
New jobs	Number of new jobs as an effect of the introduction of the service	#	Questionnaire to service provider

3.3 The societal level

Finally, the societal level includes an assessment of the accumulated impacts at a city, a regional and/or a national level, that emerge as the results of actions on an organisational and an individual/ household level, i.e. the impacts of MaaS on a societal level are accumulations of impacts on individual and organizational levels. These include ecological impacts (e.g. emissions), economic impacts (e.g. cost for infrastructure), as well as social effects (e.g. quality of life) (see Table 3). The framework takes into consideration also factors that create preconditions for the development of MaaS services (organisational level) as well as use of MaaS (individual level). Examples include congestion charges or parking policies in city centres which may influence individuals' assessment of MaaS service offers, as well as the service providers' choice of business model.

Table 3. Examples of environmental, economic and social impacts on a societal level.

KPI	Description	Unit	Data collection
Emissions of greenhouse gases from transport (or people)	CO_2 emissions from motor driven modes of transport	Ton CO_2 per annum	Calculations based on data collected in travel diaries/travel apps the individual level
Cost for transportation and associated infrastructure	Societal costs per individual and kilometre travelled, for building/ maintaining physical infrastructure for transport.	SEK (or corresponding) per annum	Information from municipalities, regions, etc.
Quality of life	The degree to which citizens experience that the transport system is designed in a way that offers improved	Ratings on a scale	Data collected in surveys on the individual level

4 Limitations and implications

The framework described in this paper, systematically integrates the individual, organisational and societal levels for assessing the sustainability implications of MaaS solutions. By using the

framework, MaaS providers will be able to assess the economical, ecological, and social sustainability implication of different combined mobility offers during early development phases. This would enable MaaS providers to develop their future value propositions and business models with optimal sustainability projections. Moreover, the data generated through for example the surveys, travel apps and/or travel diaries, all associated with the KOMPIS framework, will in the long term be stored in an open national database which will enable longitudinal and cross-sectional research on different topics, such as traveller behaviours, sustainability effects, service development, business models, etc.

The framework and associated data collection tools (i.e. surveys aimed at travellers/ participants, the survey directed to service providers, and the survey directed to the municipalities and/or regions affected by the service) are all available on the KOMPIS project website (currently only available in Swedish). In a next phase, feedback is to be provided by different MaaS pilots to further develop the framework and related tools and the framework will be tested in a number of pilots in Sweden. Further development of the framework consists of translating the framework and data collection tools to English and other languages to be able to disseminate them to other contexts than Sweden.

The framework presented in this paper has focused on combined mobility services that are provided directly to private individuals or households (i.e. B2C applications). Further development of the framework also includes other types of combined mobility services, such as those that address employers as customers and their employees as the users of the service offerings (B2B-E), or those that address housing companies as customers and their tenants as the users of the services (B2B-T). Accordingly, additional KPIs for assessing such B2B applications will be formulated, and surveys to be distributed to companies who are the customers of these services will be developed.

Finally, assessment of the sustainability impacts at the societal level in the current framework is mainly based on the data collected at the traveller and organizational levels, respectively. In particular, the data collected on changed travel behaviour using, for example travel diaries and/or travel apps, is an important basis for calculating the KPIs at the societal level. While some impacts at the societal level can be calculated directly from the data collected, to be able to fully evaluate the societal impacts of combined mobility services, calculations using models and simulations will be necessary. Developing such models is not within the scope of the KOMPIS framework but is something that future research should attend to. These models should include background information from municipalities or regions that are subjected to the pilots (depending on the pilot's area of implementation).

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