Exploring relevant factors behind a MaaS scheme

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Abstract

Mobility as a service (MaaS) is a newly emerging concept that is mainly focused on user mobility needs. MaaS is expected to reshape the way people travel and improve future urban mobility. However, research shows that there is neither a consensus on an unequivocal MaaS definition nor a universal best way to evaluate and compare MaaS schemes. Thus, given the large differences between MaaS packages, this research provides new insights into what is offered in a variety of MaaS platforms with special concerns related to functionalities and information types, customisation, and possible integration of specific societal goals. For that purpose, various European MaaS providers/platforms were explored under the PriMaaS partnership, composed of heterogeneous regions. Data were aggregated and analysed applying cross-tabulation and clustering techniques. The proposed approach led to relevant factors, such as Payment, Customisation, and Trip Planning. Relationships between platform characteristics and societal goals suggest these can be used as a conceptual foundation. Our study provides a baseline for establishing a conceptual framework to develop sustainable MaaS indicators, which would help citizens using MaaS more efficiently and support MaaS providers and operators in developing sustainable business models.

1. Introduction

Advances in digital communication technology are leading to new mobility services. Being a relatively new concept, Mobility as a Service (MaaS) still does not have a universally adopted definition (Arias-Molinares & García-Palomares, 2020; Hensher et al., 2020; Jittrapirom et al., 2017a). A general vision is that MaaS offers an integrative mobility solution that focuses on user needs, by gathering into a single platform multimodal options within a journey planner and may allow for payments (Hensher et al., 2020). One of the MaaS promises is that the offered mobility services should be an attractive alternative to car ownership (Mulley, 2017; OECD and ITF, 2021). The MaaS key point is to provide into a single platform intermodal trip-planning, booking, and payment services that meet user's mobility needs (Kamargianni et al., 2016; Sochor et al., 2018). Users are the main actors in the MaaS ecosystem (Arias-Molinares & García-Palomares, 2020). In essence, MaaS systems seek a major change in mobility behaviour, provide an attractive alternative to car ownership by offering door-to-door mobility services into a single platform, and at the same time aim to improve the daily lives of people and businesses. Thus, MaaS can be seen as a complement solution towards a more sustainable transport system.

Research around MaaS has received great attention and research interest. However, MaaS business/platforms are just taking the first steps. There are still some issues in comparing and evaluating MaaS schemes (Arias-Molinares & García-Palomares, 2020; Kamargianni et al., 2016; Sochor et al., 2018). Various studies have been focusing on presenting MaaS schemes topology in an attempt to ease the comparison of platforms and business models. For instance, some MaaS schemes were evaluated and compared based on ticket integration, payment integration, ICT integration, and mobility package integration (Kamargianni et al., 2016), in which a mobility integration index was developed based on scores onto these characteristics. However, the developed index to evaluate the level of mobility integration yields a final score that may not clearly show the differences between MaaS offers and its disaggregation may be needed for a clear overview. A MaaS topology was proposed in (Sochor et al., 2018) which roughly defines 5 levels based on integration: 0, in case of no integration; 1, integration of information; 2, integration of booking and payment; 3, integration of service offer subscription; and 4, integration of societal goals. This topology is mainly focused on the customer, provider, and business perspectives, and has been one of the major references in terms of MaaS schemes evaluation. Until now, level 4 integration of policy yields no MaaS scheme examples. In (Lyons et al., 2019), the Levels of MaaS Integration (LMI) taxonomy is proposed based on a user perspective regarding the mobility system beyond the private car. Such a scheme suggests that operational and informational integration are important for users and gives more finely graduated levels of integration than (Sochor et al., 2018) do. However, none of these approaches truly focus on assessing the potential societal effects (e.g., possibly a travel behaviour change favouring less car dependence (König et al., 2016), more inclusive transport network, favouring green modes (Strömberg et al., 2018)) and contribution to sustainability objectives (Hensher et al., 2020).

In (Karlsson et al., 2020), institutional factors affecting the development and implementation of a MaaS scheme were analysed. The MaaS benefits and impacts are uncertain since MaaS is only taking its first steps (Arias-Molinares & García-Palomares, 2020). MaaS is expected to provide more efficient use of the transport infrastructure and a better user travelling experience (Veerapanane et al., 2018). It was found that while selecting a MaaS application that optimizes the trip based on user-response preferences for transit factors such as convenience, carbon emissions, and reliability, can add significant utility. The assessment of the associated sustainability impacts remains a challenge (Gallo & Marinelli, 2020) and the envisioned sustainable effects mostly rely on the cooperation between transport authorities and operators (Arias-Molinares & García-Palomares, 2020). A recent study reveals that the positive sustainability impacts only emerge at higher levels of MaaS market penetration and uptake (OECD and ITF, 2021). There are plenty of issues that can contribute to this and it is important to have a clear picture of what should be the best set of features in a MaaS system to ensure sustainable mobility. For instance, users are price-sensitive and the MaaS offer regarding a subscription plan is not always fundamental (Ho et al., 2018; Stopka et al., 2018). In (Jittrapirom et al., 2017b), a set of attributes of MaaS platforms is suggested as a baseline to describe MaaS schemes and potential implications on travel demand modelling, supply-side analysis, and designing business models are examined. Various studies suggest a well-established public transport network is crucial for MaaS (Matyas & Kamargianni, 2018). Studies exploring the users' preferences show, for instance, that public transport and car-sharing seem to be preferred modes, while taxi and Uber-like modes are less essential (e.g., (Hensher et al., 2020; Strömberg et al., 2018)). Comfort, travel time, and flexibility seem to be important for users rather than travelling in an environmentally friendly way (Fioreze et al., 2019). Factors underpinning the uptake and potential success of MaaS as a sustainable travel mechanism were explored in (Alyavina et al., 2020). However, this study shows many survey respondents give preference to modes like car-sharing, ride-sharing, and ride-hailing due to convenience and revealed public transport occupancy is a significant concern within the MaaS paradigm. Moreover, the offer related to low occupancy vehicles should be limited for sustainable cities (Wong et al., 2020). Promoting sustainable multimodal options seems to be highly valuable for users (Tsirimpa et al., 2019). For instance, developing city context tailored mobility packages for users can be an effective solution towards a more sustainable and equitable MaaS implementation, by mapping first user mobility needs and exploring city specificities (e.g., involving different transport modes) (Esztergár-Kiss & Kerényi, 2020). Besides, other factors can not be directly controlled on a MaaS scheme such as users' trip purpose, priorities, access to information, digital literacy level (OECD and ITF, 2021).

Based on extant literature, it seems that the relevant factors behind a MaaS scheme should take into account the geographic and demographic context (Butler et al., 2021; Esztergár-Kiss et al., 2020). Therefore, the main goal of this work is to explore factors that can be related to a user perspective (involving functionalities and information types, customisation). This is done by conducting an empirical comparative assessment of mobility services platforms across Europe. Additionally, possible integration of specific societal goals within heterogeneous regions (e.g., incentives, green transport mode options) is also explored. The developed framework can be relevant for citizens, MaaS providers, and policymakers on contributing to improve or implementing more sustainable mobility schemes.

2. Methodology

The present study was conducted within the scope of the Interreg Europe Project PriMaaS - Prioritizing low carbon mobility services for improving the accessibility of citizens. The objective of the PriMaaS is to improve the regional policy instruments with respect to the introduction of MaaS, which can contribute to low-carbon transport policy-goals, social inclusion, and increased levels of accessibility. This is mainly done through international cooperation and exchange of experience collaborations between European regions with heterogeneous characteristics (different levels of connectivity, public transport network, development challenges, and needs, etc.). Within the PriMaaS partnership, a fundamental step regarding the current MaaS readiness level of each region is to explore existing mobility platforms for each region. Therefore, the objective of this paper is to survey the mobility services available in each region of the PriMaaS consortium and compare each region state of play. For that purpose and based on the above-mentioned literature review, data regarding the main attributes of each MaaS/mobility platform were collected. A data matrix was constructed, focusing on several variables, in an attempt to better understand characteristics and to be able to compare platforms. The specific objectives of the presented analysis are to:

- highlight the most common variables among the studied MaaS platforms;
- reveal possible correlation and relationship between variables;
- explore the possible contribution of different variables to societal goals.

The methodology followed in this paper relies on a survey of a set of 118 mobility services available in each PriMaaS region. For that purpose, each Project Partner (University of Aveiro (Portugal), Intermunicipal Community of the Coimbra Region (Portugal), TTS Italia (Italia), Intelligent Transport Systems Romania (Romania), University of Applied Sciences Erfurt (Germany), Timisoara Municipality (Romania), Liguria Region (Italia), eGovlab - Stockholm University (Sweden), Council of Tampere Region (Finland) and South East of Scotland Transport Partnership (United Kingdom)) filled a table, that besides information related to operational status, public or private transportation services, available platform (app, website), focused on the following factors, considered here crucial information: “Multimodal Level”; “Geographic Coverage Level”; “Pay as you go”; “Regular Trip”; “Subscription”; “Trip Planning”; “Booking”; “Ticketing”; “Payment”; “Personal/Smart Data”; “Customisation”; “Discount in Ticket Price”; “Discount in Mobility Services”; “Environmental Concerns”; “Comfort/Inclusive”. We further include other variables to better assess the possible fitting of the platform available services to a societal goal, namely, reducing car ownership; accessible, inclusive transport network; affordable transport for any individual; and more sustainable transport systems. A classification of the platforms was also proposed based on the widely used 0-4 MaaS level topology (Sochor et al., 2018).

The analysis involves two types of categorical data: nominal and ordinal. Hence, cross-tabulation is used since it is a useful technique to analyze the relationship between two or more categorical variables. A clustering technique was applied based on the dissimilarity measure Gower distance. Such distance allows measuring how different two categorical records are. In particular, we performed agglomerative hierarchical clustering using the complete linkage method that usually returns a more informative and interpretable structure. The objective was to understand if some similarity patterns between existing MaaS platforms can be highlighted across the regions. Based on the Elbow method, it seems reasonable to set to seven the number of clusters. Additionally, the contribution of each platform characteristics to each cluster was investigated. Several packages from the open-source software R were used (e.g., FactoMineR, ggplot2, dendextend, cluster).

3. Results and Discussion

3.1. Descriptive analysis

Surprisingly, only 36% of the mobility services platforms operators are under the public sphere. Approximately 70% of the studied mobility service platforms present one transport mode, while only 2% present 5 modes (bus, rail services, shared services, plane/ferry, soft modes). In terms of geographic coverage (whether a platform is urban, rural, national/international), practically half of them are city-centric. Most platforms present trip planning and payment functionalities (60 and 68%, respectively), and a quarter of them provide the option for a subscription. Regarding the personalisation and customisation functionalities, these represent more than 60%. The existing incentives for passengers are somewhat residual. Most of the incentives are related to the possibility of getting a discount to use further in other mobility services, either in public transport or e-mobility services or even in shared mobility services. These are followed by discounts for selected groups either in terms of age or in terms of the number of tickets to buy (companies, groups). Surprisingly, only 14% of the studied platforms offer some incentives regarding the promotion of independence of vulnerable and disable people. And the picture is worst concerning environmental reasons, with very few platforms (7%) promoting the use of more sustainable transport modes (e-mobility solutions). The results related to the different types of societal goals in which the provided services in a platform might fit were obtained by considering four major classes of societal goals: reducing car ownership, more affordable transport, more accessible, inclusive transport network, and more sustainable transport systems. These generally are related to the General Goal Agenda 2030 to make cities and human settlements inclusive, safe, resilient, and sustainable. Practically, 15% of the platforms can be considered that contributes to reducing car ownership, 20% can contribute to a more accessible, inclusive transport network, while approximately 27% of the platforms can be associated with the remaining societal goals equally. Figure 1 shows the frequency on each MaaS level integration as defined in (Sochor et al., 2018) within the studied regions.

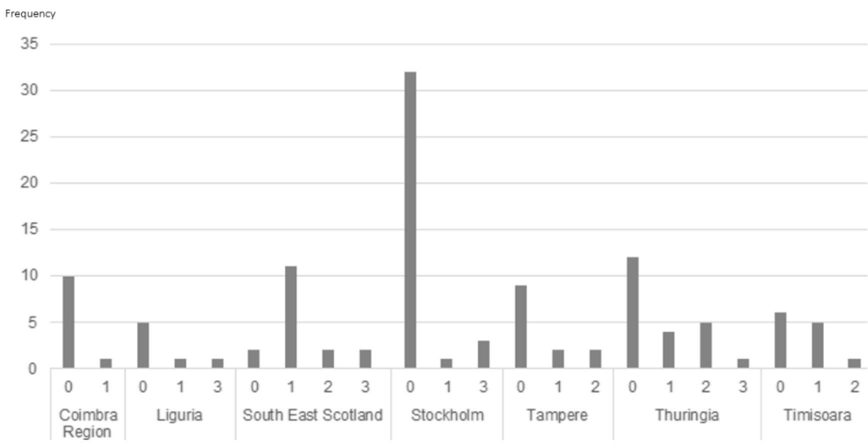

Fig. 1. Classification of the mobility services platforms using the topology proposed by (Sochor et al., 2018).

Following (Sochor et al., 2018) MaaS classification approach, approximately 65% of the studied platforms do not present any integration – Level 0, while only 7 platforms (6%) belong to level 3. It can be observed higher levels of integration in Sweden; Scotland; Liguria; and Germany, while very low levels of integration in Coimbra Region, in Portugal.

3.2. Relationships among variables

In order to assess the relationship between the different attributes, we performed cross-tabulation. Results show significant findings at a 95% confidence level. In particular, it was found a moderate association between the MaaS level and the societal goal reducing car ownership (Chi-square = 12.001, p-value = 0.007, Cramer's V = 0.319). However, it was found that the percentage of platforms that do not fit this societal goal is higher, independently on the MaaS level than those within this societal goal. There is evidence that lower levels of integration are associated with societal goals. There were found associations between MaaS integration level and these two societal goals (moderate association, Chi-square = 16.543, p-value = 0.001, Cramer's V = 0.374; relatively strong association, Chi-square = 20.801, p-value = 0.000, Cramer's V = 0.420, respectively). We can also conclude that there is evidence that the Maas level of the platform and the societal goal associated with the sustainable transport system are related. In particular, it was found a moderate association (p-value = 0.024, Cramer's V = 0.279). A moderate association between the societal goal of reducing car ownership and the multimodal level of a MaaS platform was also found (p-value=0.008, Cramer's V=0.341). Moderate associations were also found between the pair of features: sustainable transport options and discounts/incentives to mobility services; MaaS integration level and multimodal level; MaaS integration level and ticketing options; and payment with booking options (p-value = 0.025, Cramer's V = 0.175; p-value = 0.030, Cramer's V = 0.292; p-value = 0.016, Cramer's V = 0.263); and p-value = 0.004, Cramer's V = 0.309, respectively).

3.3. Clustering analysis

The number of clusters to be considered was investigated through the Elbow method (Fig. 2a). The most meaningful result in terms of the optimal number of clusters is 7, thus, it was considered to group the data into 7 clusters. The hierarchical clustering seeks to identify homogeneous clusters iteratively and it results in a hierarchical classification tree. Therefore, based on this consideration, the hierarchical clustering takes the form represented in Figure 2b.

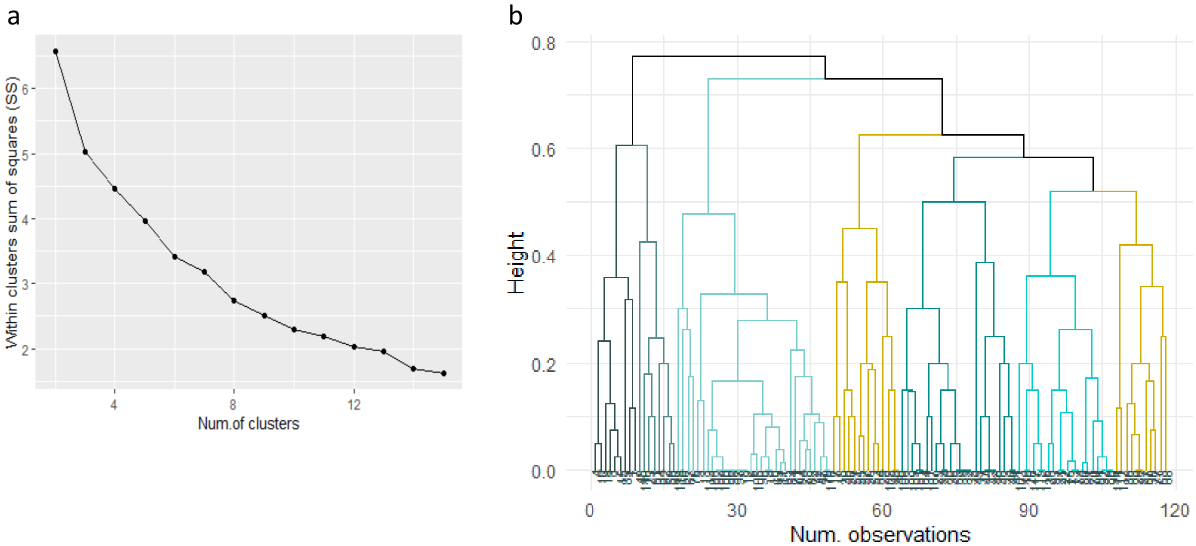

Fig. 2. a) Optimal number of clusters using the Elbow method; b) Distribution of the platforms across the suggested 7 clusters, highlighted in different colours.

The threshold dendrogram is an efficient way of describing the sequence of the generated clusters and it supports the selection of the best number of clusters considering such data. The vertical axis represents the dissimilarity between clusters. This is represented in Figure 2b and the order of the mobility platform numbers on the leaves shows the similarity between them. For the particular case of a cutoff around the threshold of 0.6, seven clusters are obtained.

The data displayed in the heatmap presented in Figure 3, following a hierarchical clustering of 7 clusters, allow us to see the relative number of observations (platforms) within a cluster.

Fig. 3. Distribution of the platform characteristics across 7 clusters.

This heatmap gives us the relative proportion of observations (platforms) per variable within each cluster, i.e., it possibly allows to derive some common patterns for platforms within a cluster. The dataset has several variables with various attributes, so, we would like to shorten this for visualization. Some of the original attributes were aggregated to ease this task. Based on these results, it seems that:

- the Geographic coverage does not pose a significant contribution in dividing data into clusters;
- Pay-as-you-go, Regular Trip options, and the possibility of Payment, as well as Customisation and Trip planning, are indicative of being very relevant factors for all clusters;
- Cluster 1 is mainly composed of platforms of multimodal level 2 and by the functionalities of Pay-as-you-go, Trip planning, Smart data, Customisation and also the incentive related to Discounts in Mobility Services; while Cluster 2 is in general, mainly composed by the opposite attributes and significant contribution of platforms of all multimodal levels;
- Cluster 3, for instance, is mainly composed of platforms with the lowest multimodal level, with Pay-as-you-go, Booking, Payment and smart data options;
- for instance, Cluster 5 is mainly composed of medium levels of multimodality, Geographic coverage, and Smart data, but by high levels of Customisation and Ticketing, and any Tariff option is also relevant.

The analysis on the association between different features shows that mobility services platforms that allow the functionality of route planning are strongly related to those which present a high level of geographic coverage of the services. This result is aligned with those obtained in (Esztergár-Kiss et al., 2020) in which 30 MaaS services from 14 countries were analysed mostly focusing on the development directions of the MaaS business market. Three clusters were created with specific features and directions of development show for instance, that the group mainly composed by a MaaS system with the route planning functionality reveals that few transport modes can be found, but the geographic coverage should be extensive. Moreover, in both studies, regional similarities were found, in particular considering the analysed mobility platforms from Germany and Finland.

Table 1 reports some examples of the analysed mobility services platforms within each cluster.

Table 1. Mobility services platforms examples.

Cluster	Examples
1	DB-Regio AG, Regio Südost, KomBus GmbH, NaviGoGo
2	Bus & Bahn Thüringen e.V., orariotrasporti, Moovit, Tripshare, SEStran, SMTUC, Transdev, Coimbra.Moveme, NääsMaaS
3	Nextbike, Bolt, GoMore, Movingo, Easybike
4	Sixt, Uber, Elbilio, FreeNow, Trainline, BloxCar
5	Ubigo, Trenitalia, Nysse public transport
6	Voi, Lime, Resplus, Flixbus, TfE M-Tickets, CP – Comboios de Portugal, Moovy
7	Aimo, ATP, BCR eGO, Forth Bike, ALPIO

4. Concluding remarks

This study presents an approach for exploring the relevant factors behind mobility services platforms that can be valuable to better design and implement a MaaS scheme. A comparative analysis of more than 100 mobility services platforms across Europe was conducted and based on similar characteristics, these were grouped into clusters. It was found that most of the MaaS schemes run in urban areas and their level of integration is rather low. Only a few platforms presented higher levels of integration and are established in Sweden, Liguria, Germany, and Scotland. In particular, data suggest distinct clusters, for instance, one cluster is mainly composed of platforms of multimodal level 2 and functionalities related to Pay-as-you-go, Trip planning, Smart data, Customisation, and the incentive related to Discounts in Mobility Services, and another cluster, mainly composed of the opposite attributes and significant contributions of platforms of all multimodal levels. Specific examples on each obtained cluster were presented.

The ultimate purpose of this study is to highlight the characteristics of current mobility services platforms in heterogeneous regions across Europe and to use this to frame the challenges for the future and to further improve them. Setting clear objectives can help evaluate the performance of mobility services and their impacts. The suggested framework paves the way for a better evaluation and comparison of MaaS schemes and can be regarded as a starting point when designing mobility packages with special factors in mind (e.g., geographic context, incentives for more sustainable options). A current limitation is regarding the analysed data. Although the present study covers more than 100 mobility services platforms, the analysis is restricted to European countries. Additionally, the real penetration of each platform was not assessed. Another limitation is clearly that the study is more focused on the user perspective (e.g., evaluation of existent functionalities), while at the business level, financial and economic performance was not considered.

In the future, we intend to use these findings and develop a sustainable MaaS indicator, which will help quantify the effectiveness of MaaS initiatives regarding intermodal journey planner, real-time information, payment, ticketing/booking, and subscription in the form of customised mobility packages in what concerns impacts translated into a level of sustainability of the MaaS scheme. It is expected that future research on a sustainable MaaS implementation yields insights that can be important to help both citizens to use MaaS more efficiently and MaaS providers and operators in conceiving and developing sustainable business models, i.e., find the most robust model and contribute to enhancing adoption of MaaS.

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