



Measuring the impact of institutional and territorial drivers for an efficient and smooth Mobility as a Service (MaaS) implementation: a global analysis

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Abstract

Urban mobility plays a key role for the promotion of the socio-economic development of a country. Particularly, MaaS platforms are important for those daily journeys made by travellers that must be in a place by a certain time. Although, MaaS is the natural evolution of older supply models, it has a revolutionary impact on people's lives. MaaS can optimize resources, urban space, reduce time spent travelling, lower costs and pollution. The present study aims at estimating the impact of a set of political and territorial drivers on MaaS implementation. The research is carried out using a composite set of indicators – 70 MaaS platforms in over 30 countries – for measuring how MaaS platforms perform in different territories. Results demonstrate a positive relationship between policies incentivising mobility services and business performance on those territories, and string territorial differences across the regions analysed.

Keywords: Mobility as a Service. Mobility Drivers. Transportation policies. Transportation planning. Sustainable Mobility.

1. Introduction

Mobility as a Service (MaaS) is a relatively new concept aimed at optimising and facilitating people's journeys by tailoring the transport options to their needs. It is not a mere app; it is the natural development of mobility services once non-digitalised. MaaS converges business models and new technologies for an overall improvement of transport availability, reduction of prices and enhanced accessibility (Zhang & Kamargianni, 2022) Not only a MaaS platform guides users towards the best commercial offer, but it also issues tickets and convenient payment options for them, provides solutions and user support for overcoming any service incidents or disruptions. It achieves the creation of a fluid journey, *ad hoc* to its users, using collective and shared means and not only – as today nearly always – individual means. MaaS can

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ensure equity for users: everyone is allocated the right type of resources tailored on their personal circumstances and necessities.

The study outlining the scope of this paper has been developed in light of extensive research involving authoritative sources such as academic findings and relevant legal, political and technical literature. The distinguishing factor from previous literature is that the latter has its focus on business models that can make MaaS successful. They don't consider MaaS as anything more than a new technology and set of commercial deals. MaaS reflects the cultural development of a country, of its policy goals and necessities. Its success rotates around a functioning and steady public transport systems, and it depends on the governance model. This paper aims at showing the governance and territorial elements that create an environment where MaaS systems can thrive. Hence, it will analyse quantitatively the drivers capable to accommodate successful MaaS projects. The data collected on several MaaS platforms mirrors the governance styles of the countries they operate in. This paper will provide an overview of the current state of the art, the initiatives taken by national public authorities (PA) and showing the relation between policies and technology for successful MaaS models. The authors collected data from over 70 MaaS platforms operating in 30 countries. This dataset provides an overview of the contexts within which MaaS platforms are successful and will constitute an important guide for future trials, investments, and policies.

2. General reflection of MaaS as a natural development

The focus of the relevant mobility stakeholders must be reducing the impacts of transport by shifting journeys from individual modes to collective and shared transport. Among the population, many do not consider that individual modes are the ones that create the highest negative impacts. Although it appears that cities have enough capacity, the demand is so high that, on average, it is left only 1/4 of the available capacity for shared modes of transportation (European Commission, 2019) Thus, it is necessary to strengthen infrastructures and technologies, modernize fleets, support national champions of collective transport, implement virtuous modal-shift policies, revolutionize the offer. Some academics believe that innovation is key for efficient urban mobility (Goldman & Gorham, 2006). However, the digital transformation must not be intended as revolutionary, but as a natural economic and social change that happens over time. Technological innovation per se is the evolution of the tools used in the past. MaaS is the evolution of the transport paradigm. The data collected should be dealt by following an epistemological approach. Thus, the final goal is to fluidify the transport system in order to allow an integrated and multimodal mobility.

Urban mobility stems from the necessity to move from point A towards point B. Several reasons push people to move within a city, from study to work and entertainment. These reasons are not primarily related to what they want to do, but on what they must do. A person decides the mode of transport based on their financial situation and convenience. For instance, people with a higher income are more likely to use a car even though they live and work nearby a metro station. Likewise, if one's job is nearby the motorway the car could be their mode of choice.

Although the aim is to have a seamless journey door-to-door, the reality is far from the expectations. This is realizable only by having a collaborative transport system made of collective, shared, and active mobility modes. However, one cannot expect

citizens would abandon their mobility habits for an ideal. Even more so if there is a lack of transport alternatives and safe infrastructures. In the last decades public authorities (PA) have enhanced the capillarity and capacity of the roads, mainly for cars. This led people to believe that using their own private mode of transport is the most efficient way (He & Thøgersen, 2017). In Europe over 82% of commuter trips are made by car, of which the majority is done by one person per vehicle (eurostat, 2020). Eurostat shows that in Europe there are countries with a really high number of car ownership. For instance, in Germany there are over 4.7 million units (Eurostat, 2022). Thus, the availability of a private vehicle in most households dictates the choice (de Jong & van de Riet, 2008). In many realities the car remains the mode with the most connected paths, but in the urban context it lacks efficiency as the average speed a car reaches within a city is of 30 km/h (Movotiv, n.d.). *Plus*, roads' enhancements do not solve the existing issues, they instead generate many more. The private car has an environmental impact relating to the production of harmful pollutants, accidents and noise. At the same time, its coefficient of occupation of public sole is very high. Thus, the most efficient modes are the so-called "active modes": walking and cycling (Transports urbains, 2022).

The preponderance towards private modes of transport is also due to the perception of the waiting times of public transports, its overall travel speed and comfort. There is also a lack of awareness of the costs related to owning a private car. Many do not realise that owning a car costs on average 600 EUR per month, if one considers the investment of an average brand-new car on a span of 10 years (N26, 2023). Comparably to the science fiction novel "*Do Androids Dream of Electric Sheep?*" by P.K. Dick, the car is our society's sheep. Do citizens need a car to conform to society's norms? Nowadays the car represents the status symbol of a person depending on the model one owns, on how powerful the engine is. Spending over 600 EUR a month for a car does not make you cool, it makes you poor. Also, the increasing stigma associated to people using public transport (Fujii, et al., 2001), from being for lower social status, to the worst performance of PT. (Popuri, et al., 2011) (Beirão & Sarsfield Cabral, 2007). Thus, MaaS interface can inform and guide the user towards the best travel option. MaaS is revolutionary in its potential impact on people's perceptions and behaviours. Changing the stigma around non-private vehicles, offering services that can satisfy everyone at any given time.

Furthermore, people tend to choose the most comfortable travel option (Calastri, et al., 2019). This comfort entails considerations of various kinds related to the MaaS platform, such as the application contexts and purposes, the automation degree, the sign-up convenience, payment manners and modes bundles (Ho, et al., 2020). Mobility services' operators should consider the effort for undertaking the movement from A to B, while making that effort seamless as the movement becomes frictionless (Hensher & Xi, 2022). MaaS stakeholders would take as an indication the "inconvenience tolerance", *alias* the maximum acceptable inconvenience cost for users. This is used as quantifiable value for capturing discomfort in shared and public transport modes. i.e., the study showed that the taxi mode had a lower per-unit inconvenience cost (Hensher & Xi, 2022). A seamlessness MaaS system equals to a positive and efficient travel experience for users.

Similarly travel behaviour analysis can be an even stronger predictor for MaaS uptake. For example, if a person uses car-sharing more than twice a month, she is more likely to adopt MaaS than a person who uses the car as their primarily mean of

transportation (Zhang & Kamargianni, 2022). Likewise, people who are already public transport users would be facilitated in their transition to a MaaS platform. However, this aptitude may result in a cannibalization of PT rather than efficiently capturing private transport. Although public transport is, or should be, the core of any MaaS system, frequent public transport users could be less likely to pay for the other services offered by the new platform. This is especially true for low-income individuals and families (Ho, et al., 2018), (Fujii, et al., 2001).

Over the years, many public authorities proposed to constitute the so-called “15 minutes city” (Moreno, et al., 2021). The idea behind this concept is to have essential services at a maximum of 15 minutes away from citizens homes. However, it is absurd to imagine reaching everything that one may need by 15 minutes walking. Implementing a MaaS system entails a city that is so well connected that everything a person may need is reachable in 15 minutes by using any of the available means of transport. Otherwise, the city would undergo a gradual ghettoization which can be harmful to the communities. Thus, the final goal is to have such a well-connected city that people are encouraged to go out, explore and live/experience different neighbourhoods.

Hence, to realise this type of “15 minutes city”, the MaaS system requires at its very core an effective multimodal journey planner (MJP). It needs to conciliate static and time-depending planning methods, while allowing for the selection of the best route and avoiding bias (Jittrapirom, et al., 2017). While having an attractive interface that facilitates its useability, the order in which the travel information is displayed to the user can considerably influence the users’ travel choices (Jittrapirom, et al., 2017). Also related to the algorithm anticipation of the walking or cycling time that in many instances can vary considerably from people who have disabilities, who are elderly, or who are simply not fit. Hence, including customisable options in the MJP will broaden the travel choices for the user, as well as avoiding an unfair competitive market.

Besides, services that allow the user to pay in instalments at no additional cost, like Klarna and Satispay, enable lower incomes to access services that would otherwise be a burden on the household’s economy. Price information and payment option may seem like accessory, but it is essential. If coupled with the indication of travel time, users will take informed choices when planning their journeys. The future of MaaS must consider socio-economic characteristics and city policy objectives. Such an ideal environment can be reached by involving all the interested stakeholders in a judgement-free environment where all ideas and interests are at the very least considered. This would enable the PA to align efforts and to establish legal, technical, and organisational components for a truly multimodal journey.

3. The drivers for MaaS success: structural, territorial, and governmental considerations

The review presented in this section offers a general understanding of the main drivers that affect the travel choices of people in their everyday life. People are influenced by different factors when making their choice for a transport mode. Some of them are directly dependable to the individual choice, some others have a wider ranging approach. For instance, when an individual chooses to take the tram to go to work because of the lower cost, she is taking an individual choice which is influenced by the decision of the local government that invested in the tram infrastructure. This part of the

paper bases its data on existing surveys and academic papers that have investigated people's mobility attitudes.

From the 60s, the research has evolved from a sole quantifiable analysis towards an attitudinal one (Spear, 1976) (Recker & Golob, 1976). Recent papers found that modal choices and attitudes towards urban mobility affect each other to different extents (Popuri, et al., 2011). Although both habitual and rational factors determine the choice of transport modes, the former is more influential than the latter (Chen & Lai, 2011). Academics soon turned to analyse the behavioural process behind individual attitudes (Popuri, et al., 2011) (Shiftan & Ben-Akiva, 2003). These are mostly dependant of exogenous factors (Sprumont, et al., 2014).

Overall, the elements the literature has found as the most relevant to travellers are the mode's reliability, comfort, stress, and safety (Ben-Akiva, et al., 2002) (Sprumont, et al., 2014). People are more likely to travel around if they have mobile platforms that are easily accessible and allow them to plan their journeys ahead of time (Khan, et al., 2020). This willingness changes when one compares tech and non-tech savvy people (Khan, et al., 2020). Knowing what the modes of transport are available, their travel time and cost can really influence one's choice. Following the "*realistic choice theory*", data shows that there is a group of people who are unwilling to change transport mode because firmly believe that such change is unrealistic (European Commission, 2019). Thus, companies tend to focus on those groups that are more change-driven. The former category of people, unwilling to change, are often those people who have no other choice because of the infrastructure built around them (European Commission, 2019). However, as stated above, external, personal, and professional reasons can influence behavioural change. One may start using the bike because the infrastructure is so well built that becomes the smoothest option. Therefore, unwillingness is not a synonym to stubbornness.

The time spent travelling door-to-door becomes a determining factor when the journey is repeated daily or several times per week, particularly in the urban scale. The longer the journey, the more important is for it to be smooth. This means that a person will be more likely to spend 30 minutes driving rather than cycling or catching the bus (Tyrinopoulos & Antoniou, 2012). Although raising PT prices could allow PA to reinvest these economic resources towards ameliorating the infrastructures, Taylor et al. found that high fares play as a deterrent factor for commuters, even when the service is frequent (Taylor, et al., 2009). Some other studies highlighted that the more a neighbourhood is dissonant, the more likely is for commuters to use their own private vehicle (Schwanen & Mokhtarian, 2005). Demonstrating that the lack infrastructure is per se a driver for ownership and use of private vehicles. This disparity of results among studies is determined mainly by the diverging territories where the studies have been performed. Some have been conducted in context with a lack of infrastructures for PT, others have a culture of shared modes.

Younger generations tend to make sustainability considerations for their journeys (Outwater, et al., 2003). The environmental impact can have several facets, it can entail volumetric pollution, accidents, and effects on biodiversity. It also entails the deceptive narrative of a sharing economy in the transport system. There is indeed another side to the sharing economy. If on one side its impact is very much positive because allows the reuse of materials, it also means that companies use it for advertising and selling their own products. For instance, there are some carsharing companies that are directly owned by car manufacturers. There is no sharing economy in that as the cars are still

manufactured by the companies that then offer the car-sharing service. This is one form of greenwashing. Mobility centres aimed at optimizing the implementation of local actions are gaining increasingly recognition (Tyrinopoulos & Antoniou, 2012). There are many examples of such centres and projects internationally. For instance, the SMILE project introduced good practices in citizens' lives aimed at improving the quality of their environment while meeting their needs (CIVITAS, 2014). Mirroring projects are present all around the world, from SMART in Singapore to IMR in the US. These are all examples of soft law actions, non-legally binding activities aimed at studying and influencing behaviours.

In the MaaS context, the role of governance is key to establish rules that facilitate the integration of public and private mobility services. The PA must ensure a balance when regulating as excessive regulation hinders innovation (Giuffrida, 2023). The PA is there to guarantee an equitable use of public assets by foreseeing social and technological needs. This support is pivotal for drafting laws that encourage investments from the private sector, encourage an innovation culture, and encompass social and environmental objectives.

When defining governance in the mobility context, and particularly for MaaS, one should divide it into three levels. The macro level reflects the core social and political objectives. It comprehends formal aspects as policy instruments and laws, and informal aspects as political visions, innovation, and environmental goals. The meso level reflects the actions that regional and local governments take for MaaS. An example is the regulation for parking at stations, or transport subsidies. Last, the micro level relates to actions taken for incentivising or disincentivising the individual towards MaaS. For instance, congestion charges for disincentivising cars in the city centre, and subsidies for environmentally friendly travel behaviours. Subsidies are expected to be as dynamic as MaaS technologies, and they should not support unnecessary projects. Hence, although these three levels are the standard for the organisation of governance, there is no defined model. Each country has its own which is moulded around the participation of the private sector.

To lodge the change in people's behaviour, PA need to have a clear understanding of what are the drivers for their mobility. This is achievable through trials and studies aimed at analysing the market segmentation and define the targets groups based on their propensity to change modes of transport. This is not sufficient if the infrastructure in place is not adequate and safe to use (European Commission, 2019). MaaS is a great tool for advertising different modes of transport. Hence the development of new quantitative studies supporting the level of acceptance of MaaS by users is necessary.

Returning to the opening concept of this paper, MaaS is the development of previous offline services, and as such it must use successful strategies as dynamic and differentiated pricing. This will enable the MaaS platform to better coordinate demand and supply, avoiding losses from inelastic markets. The exposure given by the platform to small transport operators can lower the power asymmetries among operators. Citizens' stances towards emerging mobility technologies and services may differ according to their characteristics, contexts, and objectives. A comprehensive understanding of the dichotomies between several mobility technologies and services will contribute to inform policy decisions about the sequence of priorities for launching and developing them further (Zhang & Kamargianni, 2022). Hence, it is important to strike a balance between private interest (business opportunities) and the public sector interest (maximise societal benefit).

There is a positive link between implementation of policies that facilitate urban mobility and the usage of mobility services (Bos I, 2005) (European Commission, 2019). One study assessed the impact of policy measures aimed at discouraging the usage of the car for door-to-door trips. It found that these policies have positively affected the use of park & ride alternatives (Bos I, 2005). (Tyrinopoulos & Antoniou, 2012). In some other instances, the government informs people about a service but fails in making it appealing to them. They might be aware that there is a new tramline nearby their house, but they are not keen to use it. People seek comfort in their journeys, even people who are inclined towards public transport choose cars because they are discouraged by crowded mobility modes (Tyrinopoulos & Antoniou, 2012). The modal shift will happen through the right incentives. Lately, several countries and municipalities are offering public services for free or at nominal price. However, the prospective of having a sustainable transport mode at a more convenient price is not appealing to some citizens when the offer is not appropriate. There are multiple projects that have showed the positive impacts of these types of initiatives. For instance, the “Bambini project” creates books and toys encouraging active modes for children (European Commission, 2019). Another example is the “MOBI project” that targets employees’ mobility (European Commission, 2019). The adhering companies wanted to ameliorate their corporate image, while motivating employees by flagging environmental and quality of life concerns. These types of projects are the perfect example of soft measures that PA can take.

The abovementioned literature testifies the extensive academic effort made worldwide for employing activities and initiatives that can ameliorate urban mobility. However, there is great disparity among results, which mirrors territorial and cultural differences of the analysed countries. A more driver-specific analysis is due to have an overview of the drivers for MaaS implementation development. Therefore, the third part of this paper is aimed at meeting this demand. According to the literature review, particular attention has been paid to the relationship between mobility choices and the urban environment. The present paper adds another dimension to the exiting literature by adding the link between drivers and effective MaaS implementation.

4. Data analysis of the drivers incentivizing MaaS implementation

Precedent literature focused on applying holistically their territory-specific findings, rather than understanding the underlying drivers for implementation. The final part of this paper is a driver-specific analysis for MaaS implementation. The dataset of this study comprises over 70 MaaS applications in 30 countries. From these data, the authors depicted graphically their findings. For completeness and transparency, this analysis comprises MaaS platforms that are active in more than one city in several countries. Although the majority of MaaS platforms operate in the European union, the data collected is not restricted to the European market as significant examples can be found internationally.

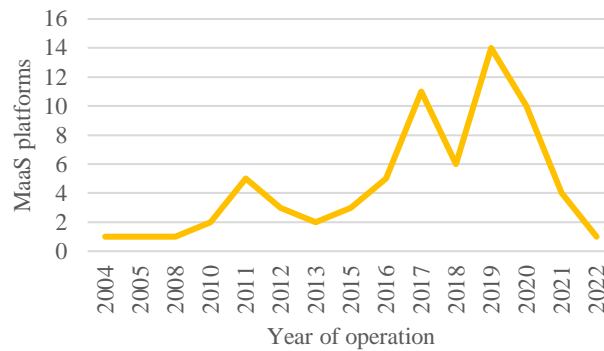


Figure 1: Historical series of counting of operations of MaaS services

Figure 1 shows that although some of the platforms under analysis are as old as 2004, most projects started between 2017 and 2020, with a strong decrease in the following two years, probably due to the effects of Covid-19 pandemic.

4.1 density of the population

This section investigated quantitatively whether the territorial context impacts on the successfulness of MaaS projects. The authors decided to focus on the density of the population of the cities where the MaaS platforms operate in, rather than the countries. This to avoid slipping of the final results. However, the analysis has shown that there aren't any clear correlations between countries' density of population and MaaS' success. There is a slightly higher number of MaaS platforms in countries with higher density, but this does not seem to be of relevance. For instance, Paris with over 20000 people per km² has the highest number of active platforms among the ones under analysis. However, less densely populated cities, like Brussels and Vienna, have a considerable amount of active and successful MaaS platforms.

4.2 Mode of transport

The MaaS platforms under analysis offer a pool of modes of transport. The data regarding the modes of transportation has been analysed by creating macro categories. Sharing services include bike sharing, car sharing, moped sharing, and scooter sharing. The main difference between sharing services and rentals is the amount of time the modes of transport are used consequently. For this reason, the analysis has distinguished between the two. Renting transport modes comprises the renting of mopeds, bicycles, cars, and scooters, but also car clubs, car hire, carpooling. Further, there are several accessory services not necessarily related to the mobility market. These are included in the additional services category: air travel and "Demand Responsive Transport" (DRT), car washes, charging stations, chauffeur and taxi, couriers, school busses, demand-responsive transit, events, filling stations, hotels, lounges, meeting venues, petrol prices, car park information, power banks stations, shuttles, ski-pass, refuelling and electric-vehicle charging. Public transport includes ferries, light rail, coach, rail, metropolitans, busses and trams, regional public transport. Parking includes park & ride, park & bike, parking with valet services, and permit for urban congestion charging zones. The last main categories of transport are On-demand shuttles, Taxi and Flights. It emerged from this analysis that many MaaS platforms are opened locally by bigger

aggregators of mobility service providers. For instance, “MaaS global” launched different MaaS platforms worldwide.

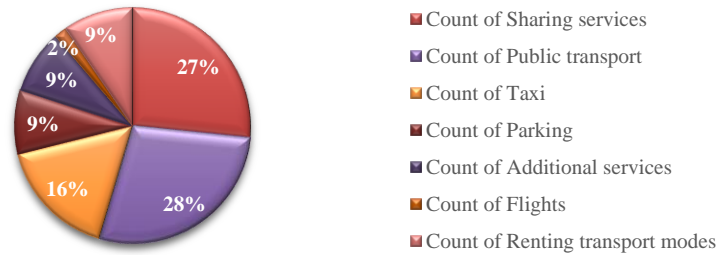


Figure 2: Services offered by MaaS platforms.

As Fig. 2 shows, out of 74 platforms, 28% offer public transport modes and 27% offer sharing services. This demonstrates that public transport is at the core of any MaaS system. Taxis are a key accessory service for the PT, as they can meet the needs of elderly and disabled people when PT cannot. Indeed 16% of MaaS platforms offer Taxi services. Although only 9% platforms offer additional services, this is an important data to considerate in future research as they can, potentially, influence the choice of platform and mode as it further eases citizen’s everyday life.

4.3 Levels of integration of MaaS platforms

There are 5 levels of integration (0: No Integration; 1: Integration of information; 2: Integration of payment; 3: Contractual integration; 4: Policy integration), the lack of which obliges citizens to use several apps for one journey. How many people do really download all the apps of the services available in their city? The disposal of a range of modes does not guarantee an attractive mobility offer. The only effective solution is for the stakeholders to cooperate, have a supportive PA who defines the rules of the game, and bears in mind the service convenience for users. Soft measures can shape the policy environment as much as legal acts can. The data in Fig.3 shows that most of the platforms have merely payment integration. 19% of the MaaS apps are integrated at level 1, meaning that they simply show the possible options. Lastly, the fact that only 1% of the MaaS platforms are integrated at level 4 shows the overall lack of political and legislative incentives.



Figure 3: Level of integration of MaaS platforms

The data in Fig. 4 shows that the highest number of active platforms are in France. However, the graph also shows that countries like Finland, Canada and France are the countries that reach the highest levels of integration. This mirrors the advanced level of policy implementation in the urban mobility context. For instance, France has a higher level of integration compared to other countries. The majority of the MaaS platforms are

integrated at level 2, indicating that they sell the mobility services directly from their platform.

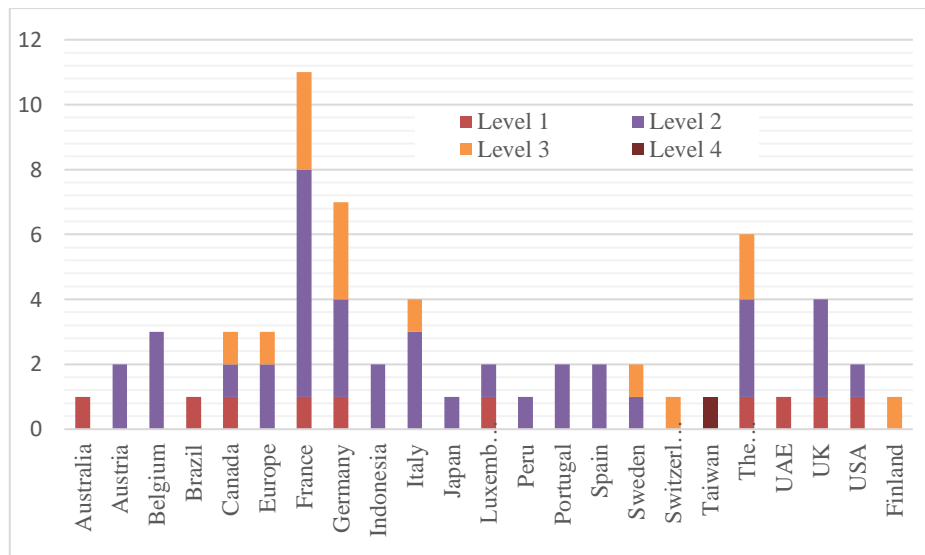


Figure 4: Number of MaaS systems and level of MaaS integration per country

5. Conclusions and further developments

This research paper contributes to the existing literature by critically analysing the drivers put in place for implementing MaaS in urban environments. It started from setting the concepts behind MaaS systems, it continued by reviewing the existing literature, and it lastly highlighted the key drivers that affect modal choice and their links among territories and social factors. The results of the data analysis revealed that institutional and organizational characteristics are the key factors that influence a smooth implementation of MaaS systems. The findings of this paper can be strategically used for shaping future policies and trials. To avoid disparity of results, there cannot be one perfect MaaS model that fits all. There are so many factors that play an important role in MaaS development. For this reason, the best approach to take is for PA to initiate a careful analysis of the existing modes of transport, the system's inabilities, and needs. Identifying the drivers of urban mobility for each city ensures equity and equality for everyone. People must always have affordable, decent, and comfortable journeys.

At this stage, private-public partnerships (PPP) are essential as they can allow for homogeneity among the different forms of transport. The solutions that PPP present must be designed to endure time and technology changes. The ultimate shift that MaaS needs is a cultural one, from ownership to usership. People must be gently pushed towards new ways of moving around the city they live in. This process takes time and requires a widespread explanation of the benefits. In a nutshell MaaS requires captivating yet effective app features, variety of mobility services and payment packages. This makes the offered services tailored to the user needs and preferences. If experience lives up to the user's expectations, they will daily use MaaS platforms for their daily journeys.

The passage from analogical to digital services must be smooth for both young, and especially older demographics. There are already in place some pilot projects foreseeing

this transition. If adopted by all PA, they can aid in the MaaS implementation process. The MaaS app itself must provide real-time information to the user while offering payment packages that can satisfy all wallets and display all mobility services that are on the market. This, coupled with policies and regulations along with a familiarisation process will simplify people's lives, decrease the environmental impact, and enhance city's efficiency and capacity.

Although the literature review highlighted that habitual and rational factors greatly influence users' choice, the cultural-specific elements of one country can change extensively the listed findings. Thus, PA should, on one side, consider the aforementioned elements, while not disregarding territory-specific analyses when implementing policies (Musolino, et al., 2022). As exemplified by fig.3, tailored policies and studies to the territory are pivotal for developing MaaS integration. The disparity in the studies' results shows that an ad hoc governance system is fundamental to properly mirror the needs of the local population. Hence, linking policies and regulations with a familiarisation process will simplify people's lives, decrease the environmental impact, and enhance city's efficiency and capacity. Enabling and facilitating MaaS systems is evolutionary.

CRedit authorship contribution statement. Mario Tartaglia: Conceptualization, Methodology, Supervision, Writing - review & editing. Elodie Petrozziello: Investigation, Methodology, Data curation, Formal analysis, Writing - Original Draft, Visualization.

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