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Advancing Mobility-as-a-Service: Lessons Learned from Leading-Edge Public Agencies

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Advancing a Mobility-as-a-Service: Lessons Learned from Leading-Edge Public Agencies

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16. Abstract
This report investigates current trends in the MaaS market in North America and how the public sector can most effectively collaborate with private companies to improve regional accessibility while protecting public interests—such as equal access to transportation and job opportunities, effective traffic management to enable economic agglomeration, and safety. To clarify the opportunities for and challenges of this new technology, I study MaaS programs promoted by three leading transportation authorities: Los Angeles County Metropolitan Transportation Authority (LA Metro), Dallas Area Rapid Transit (DART), and Tri-County Metropolitan Transportation District of Oregon (TriMet). Through a careful review of the literature and in-person interviews with people involved with these three authorities, I draw lessons learned from the ongoing programs and propose three potential directions that transit agencies and local governments can take in developing future mobility strategies related to MaaS.

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Disclaimer

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Advancing a Mobility-as-a-Service: Lessons Learned from Leading-Edge Public Agencies

Executive Summary

Mobility-as-a-Service (MaaS) represents a shift from personal vehicle ownership-based mobility to mobility consumed as a service. MaaS enables users to plan, book, and purchase single or multiple mobility services on one app and enjoy a near-seamless journey. To realize this concept, emerging MaaS players are expanding their businesses in major US cities. While they have improved mobility for many, including those without car access, their rapid proliferation has also sparked heated debates over their potential impacts on safety, equity, public space use, and travel behavior, as well as their near- and long-term effects on traditional public transit services.

This report investigates current trends in the MaaS market in North America and how the public sector can most effectively collaborate with private companies to improve regional accessibility while protecting public interests—such as equal access to transportation and job opportunities, effective traffic management to enable economic agglomeration, and safety. To clarify the opportunities for and challenges of this new technology, I study MaaS programs promoted by three leading transportation authorities: Los Angeles County Metropolitan Transportation Authority (LA Metro), Dallas Area Rapid Transit (DART), and Tri-County Metropolitan Transportation District of Oregon (TriMet). Through a careful review of the literature and in-person interviews with people involved with these three authorities, I draw lessons learned from the ongoing programs and propose three potential directions that transit agencies and local governments can take in developing future mobility strategies related to MaaS.

The rise of a Mobility-as-a-Service and public-private alliances

MaaS definition and market trends

MaaS primarily consists of a MaaS platform and mobility services integrated into the system through Application Program Interfaces (APIs). As shown in Figure ES.1, the MaaS platform entails three layers: Frontend, Retail (Middle), and Backend. The frontend works as an interface with end users through apps and websites, and the middle retail layer manages customer management, E-wallet (virtual shopping cart), order fulfillment, and payment gateway connecting to a third-party's payment settlement system. Then, the backend governs data sharing

between the platform and mobility operators to find out the best route and combination of transport services for each customer.

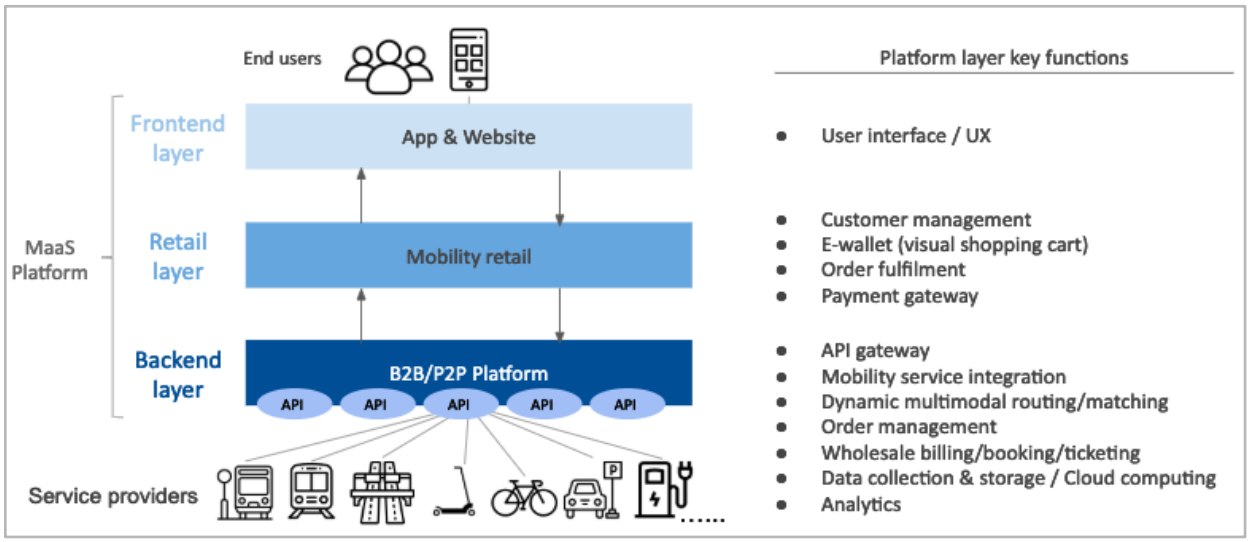

Figure ES.1 MaaS functional structure
(Author-made chart based on Siemens Mobility Division 2016; Smith et al. 2018; Kamargianni and Matyas 2017)

While MaaS is still at an early stage of development in North America, multiple players, such as MaaS platform operators, public transit agencies, transportation network companies (TNCs), trip planners, and automotive companies, are investing in this new technology to become one-stop shops for transportation (Figure ES.2).

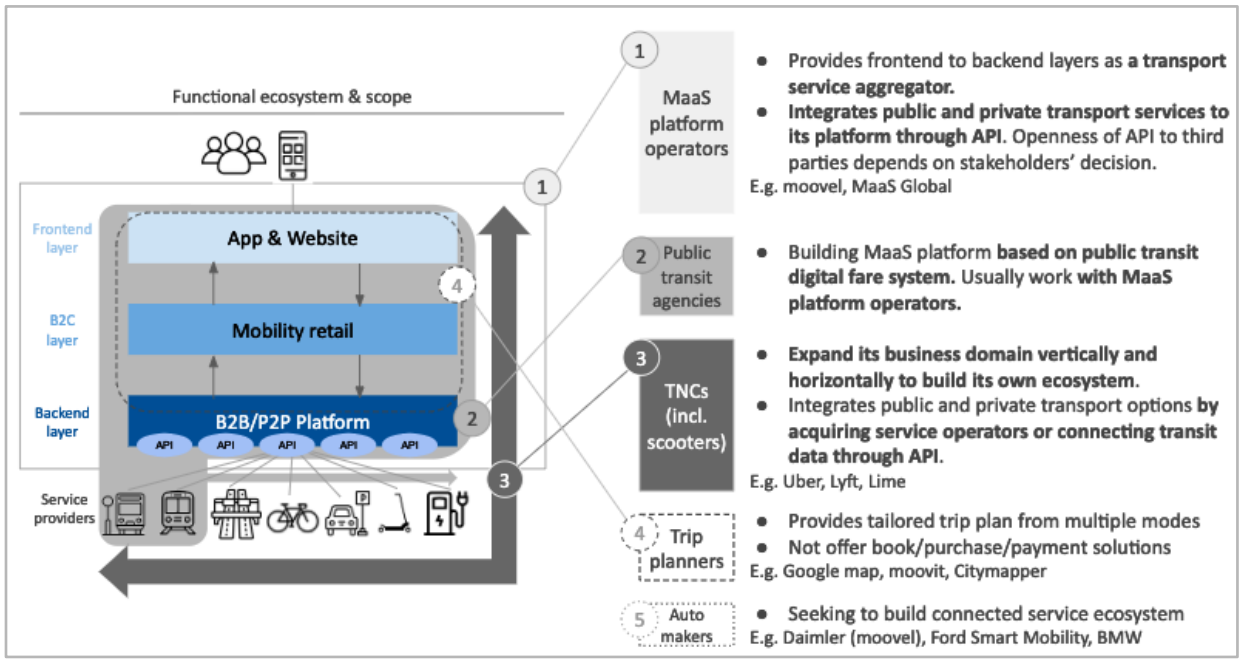

Figure ES.2 Key players in the North American MaaS market
(Author-made chart based on own research)

Benefits and challenges of MaaS in the US

For end users

Even though car-oriented land uses and artificially low costs of driving in the U.S. are unlikely to change meaningfully in the short-term, MaaS still potentially makes alternatives to driving more attractive and reliable in the U.S., where 87 percent of daily trips in 2017 were made by personal vehicles (Bureau of Transportation Statistics 2017). For example, with the details of transit service in real time and various options in hand, users will no longer have to worry about uncertain wait times at stations and stops, especially in off-peak hours and at night, when traditional fixed route services wane. Some studies also suggest that ride-hailing services have enhanced mobility in low-income and minority neighborhoods, which are often underserved by taxis and public transportation (Smart et al. 2016; Brown 2018).

However, most app-based mobility services exclude those without a smartphone, a credit/debit card (a bank account), or with a disability. For instance, TNCs do not have to comply with the American Disabilities Act (ADA), which requires transportation service providers to dedicate a portion of their fleets for customers with a disability. Because TNCs describe themselves as technology companies rather than transportation operators, they claim that the ADA does not apply to them (Reed 2017). Promoting MaaS without addressing these digital, economic, and physical handicaps may disproportionately harm the mobility of disadvantaged people (DeGood and Schwartz 2016; Transportation Research Board 2015; Brown and Taylor 2018).

For transit authorities

MaaS can also help transit agencies achieve some challenging goals: operating efficiency (such as fare-recovery rate) and service coverage, at low-demand times and in low-demand areas. In addition, constrained budgets make it difficult for public transit agencies to meet diverse travel needs, such as first/last mile gaps, high-cost dial-ride paratransit services, and expansive service provision in outlying suburbs. By effectively collaborating with the private sector, new mobility services may help transit authorities achieve these goals without substantial additional investments in transit (American Public Transportation Association 2016).

Despite the many opportunities MaaS offers, recent research on the impact of ride-hailing services on public transit use has shown mixed results. Some studies find that TNCs effectively feed public transit, while others argue that they may take riders from public transit and worsen congestion (Clewlow and Mishra 2017; Hall et al. 2018). Better public transit/private provide integration with MaaS may help to increase the former, though we need further research to conclude how emerging mobility services affect transit ridership.

For local governments (cities)

As shared transportation options become more widespread, local governments are also likely to benefit from MaaS programs. Modal shifts from private vehicles to shared modes could decrease

the number of cars on the street, thereby mitigating congestion and air pollution. Furthermore, ride-hailing may improve public safety by reducing vehicular crashes caused by drunk driving (Greenwood and Wattal 2015; Dills and Mulholland 2017). Nevertheless, as noted earlier, some researchers point out that TNCs may well be adding vehicle miles traveled (VMT) in large American cities. This suggests that, without adequate policy interventions that would reward mobility operators complementing fixed-route transit rather than directly competing with it, users may increasingly replace mass transportation with on-demand door-to-door rides when they can afford to do so.

Public-private partnership for public service provision

A public-private partnership aims to combine the resources of the public sector with those of private companies in pursuit of societal goals. The most common form of public and private collaboration in transit service is contracting with private organizations to operate buses. As a means of managing costs, contracting offers a useful tool for public officials to address the challenging task of doing more with less. But while there are many examples of successful contracting arrangements between public transit agencies and private providers, contracting is not guaranteed to achieve intended outcomes.

Previous research finds that contracting for service delivery yields desired outcomes when: 1) the public and private sectors can specify their rights and duties in a contract by closely collaborating early on, including from a contract creation phase; 2) contracting government agencies can agree on project goals with vendors at the beginning and then monitor vendor performance through effective contract management; 3) the market maintains competitive environments; and 4) project members on the public side can manage internal stakeholders who may have competing interests with the project. (Joaquin and Greitens 2012; Brown and Potoski 2003a; Brown and Potoski 2003b; Ya Ni and Bretschneider 2007).

Findings

The interviews revealed that LA Metro, DART, and TriMet leaders have struggled to keep up with the quickly changing mobility landscape. In working with private firms to develop MaaS solutions, staff at these agencies learned that (1) executives' commitment to innovative solutions, (2) effective contract management (as contract-out theories would predict), (3) failure tolerance, and (4) knowledge spillovers across departments and institutions combined to help them to launch their MaaS programs. Simultaneously, staff experiences also revealed that the lack of technical knowledge, divergent public and private goals, disagreements over data sharing, and rigid public sector business operations inhibited agile responses to fast-evolving technologies and often hindered their MaaS pilots.

Regarding the future role of public transit, this study finds that markets still require public intervention to prevent or mitigate negative externalities, such as limited access to app-based

services as well as increased congestion and emissions. The interviewees suggested that transit agencies and local governments should take the lead in developing a cash-accepting payment platform, which would allow economically and digitally vulnerable populations to access MaaS, and that new regulatory frameworks to guide MaaS operators were needed as well.

Finally, for an effective public-private MaaS partnership, the three case studies indicate that the conventional contract-out model in public transit is less likely to work for this new technology. In the classic contracting-out model, transit operators define the service scope, determine a statement of work for the vendor, create a Request for Proposals, and draft a contract with the selected firm. However, due principally to the lack of public agency technical knowledge about these new services, it is hard for them to do the same things for MaaS contracting. Additionally, the public sector and private companies do not closely communicate when developing a project in traditional contracting-out practices, which makes it difficult for either party to understand one another's interests and establish a mutually beneficial deal in less well-defined and established settings, like MaaS. As such, private partners will likely need to be involved much earlier on when defining service specifications for contracted arrangements.

Implications for practice

Organizational transformation

My literature on and interviews about ongoing MaaS programs suggest that public agencies will need to acquire much great technology knowledge, create a more failure-tolerant culture that encourages learning from failures, and redesigning business operations to allow the testing of new ideas will help public transit agencies be more responsive to the changing mobility landscape.

First, public transit agencies should have adequate expertise to fully understand emerging mobility technologies and markets in order to guide innovations to benefit broader populations in society. To do so, they should learn from their own experiences as well as those of other agencies and then adjust their strategy as situations demand.

Second, creating a failure-tolerant culture in the public sector will not be easy, but is needed. In addition, top executives' support for a new initiative are also essential to successfully implement MaaS. A trial-and-error approach allows transit agencies managers and staff to try and fail until they find the solutions that meet the organization's goals. By testing promising but unproven ideas in real-world settings before full-scaled launches with a partner, public transport authorities can reduce the risk, for example, of wasting finite resources on technologies that may not be mainstream in the future.

Last, operations redesign, especially with regard to the procurement process, also accelerates MaaS programs. Like LA Metro's new procurement procedure "the Unsolicited Proposal," a

joint program development method that allows private companies to submit their proposals and develop services with transit agencies will not just enable them to trial emerging solutions, but also utilize private companies' capabilities more easily. As a result, new processes can shorten sourcing cycle time, thus accelerating learning from experiments.

A new regulatory framework for MaaS

Given the inherent uncertainty in knowing the future, local governments and transit agencies should not focus too much on future prediction when designing regulations; instead, they should adopt an outcome-based approach to policymaking in this fast moving environment. This approach emphasizes what a particular policy or program achieves, such as lower VMT, greenhouse gas emission, or universal access to MaaS services regardless of economic and physical conditions. Having defined the outcomes, an outcome-based model enables transit agencies and policymakers to identify indicators that assess whether a new policy achieves these goals, rather than focusing on particular intuitional arrangements or relationships (Manville and Osman 2017; Kristensen, Groszyk, and Buhler 2002).

As with industries profoundly affected by technological development, such as cryptocurrencies and autonomous vehicles, regulatory authorities should take an adaptive approach to legal reform so that they can search for regulatory sweet spots, where public and private interests are balanced. Such an adaptive approach allows the implementation of laws and regulations to begin before all major uncertainties are resolved, with policies designed to adapt over time based on new knowledge. In other words, in an age of constant and disruptive innovation, lawmaking and regulatory design need to abandon a focus on finality and legal certainty; instead, they should embrace contingency, flexibility, and openness to new ideas and unexpected events (Marchau, Walker, and Duin 2008; Fenwick, Kaal, and Vermeulen 2017).

Local governments and transit agencies can use so-called "soft laws" (e.g., industry guidance, codes of conduct) and "regulatory sandboxes," a temporarily relaxed regulatory framework to test new technologies and business models in a live environment for a limited time (UNSGSA 2018). These two tools can allow lawmakers to try new rules and flexibly modify them if needed without spending months or years developing and implementing "hard laws" and regulations. Consequently, faster feedback loops enable regulators to frequently evaluate policies against set standards, feeding inputs into revising regulations (Eggers and Turley 2018).

Strategic partnership

Unlike the traditional approaches to contracting-out, which generally entail medium- to long-term legal contracts for a fixed period, strategic partnering involves an open-ended, longer-term contract, which sometimes emerges from an informal network like an industry consortium. Thanks to its informal nature, this model allows the public and private parties to communicate more frequently and informally about their needs and innovative service ideas. More dialogue

not only helps fill the goal gaps between the public and private sectors, but also allow transit agencies to better access and utilize the capabilities of private partners. Consequently, strategic partnerships encourage public-private collaboration, making it easier to agree on data sharing policies and business models.

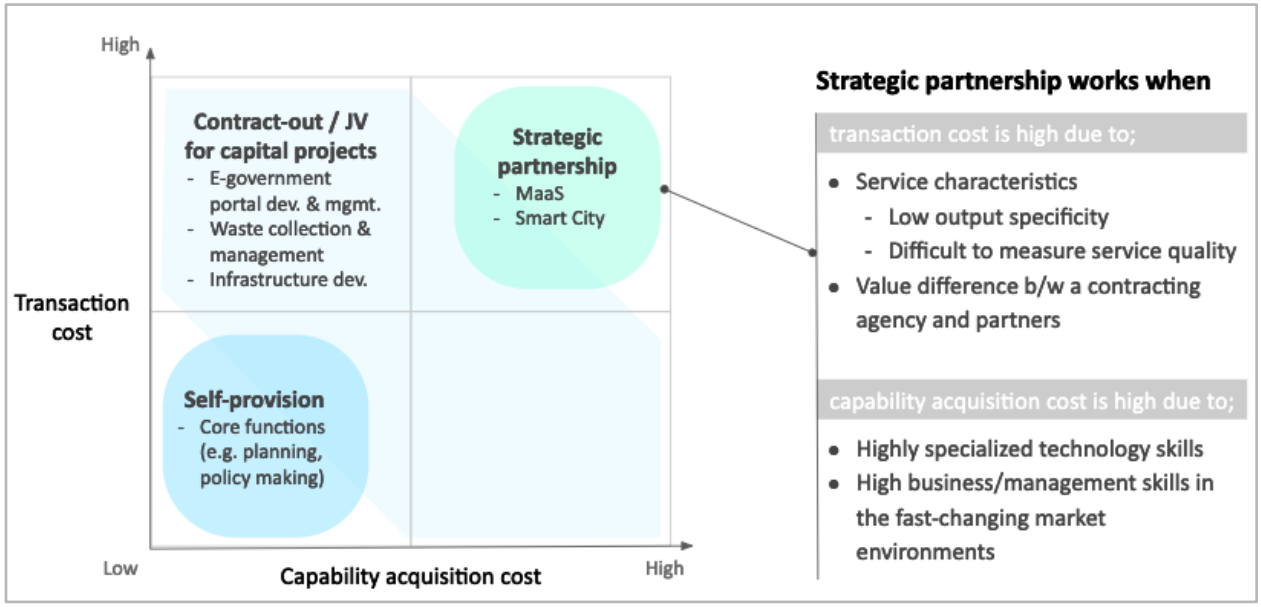

Figure ES.3 Conceptual framework of potential approaches to public-private partnerships
(Author-made chart)

While the strategic partnership model can solve issues inherent in the traditional contracting-out model, the best approach to public-private alliances may vary depending on the nature of services private partners provide. Figure ES.3 lays out the conceptual relationships between contracting-out and strategic partnerships in terms of transaction costs and capability acquisition costs. Transaction costs represent costs associated with the exchange of goods and services in the market, covering information costs, enforcement costs, and bargaining costs (Brown and Potoski 2003b). The information costs include the costs incurred when looking for relevant information and meeting with agents to carry out a trade, whereas enforcement costs represent the costs associated with ensuring that parties in a transaction do not break a contract. The bargaining costs are the costs related to reaching an agreement with parties involved in the deal and drafting a contract (Brown and Potoski 2003b; Skelcher 2005). Another axis is capability acquisition costs, which consist of monetary and time costs needed to gain skills and knowledge for the service provision.

When both the transaction costs and capability acquisition costs of a given service are low, it is rational for the public sector to provide the service directly. On the other hand, if both costs are so high that the total costs associated with the deal exceed the expected benefits from a project, a strategic partnership may work best.

I argue that MaaS projects fit a strategic partnership model because their transaction costs are likely to be higher than other services due to their low output specificity (high information costs), difficulty in measuring service performance (high enforcement costs), and a difference in priority (high bargaining costs). Furthermore, because the market is full of uncertainties due to rapid technological change, the development and assessment of MaaS solutions require high technical and management skills. In short, strategic partnerships provide a means for reducing both transaction and capability acquisition costs, thereby enabling transit agencies to try these new services more easily than before.

Conclusion

Although the public-driven MaaS programs are still in the middle of the experimentation phase, this study reveals that this new technology can help transit agencies enhance access for all of their customers, including carless populations, by closely working with emerging MaaS companies; however, in the current circumstances where much of the built environment is designed to encourage driving, such as with abundant free parking and extensive freeway networks, people are less likely to replace their driving trips with traditional public transit and other mobility services. This artificially low price of driving may undermine efforts and investments made by transit agencies to promote MaaS programs. Therefore, if cities and transit authorities want to reduce solo-driving, they should not only promote MaaS but also bring the price of driving in line with its marginal social costs by directly charging for road use and parking, or indirectly increasing densities (Chatman 2008; Downs 2004; Ewing and Cervero 2010; Ewing and Cervero 2017; Manville 2014; Manville 2017; Nelson 2017; Newman and Kenworthy 2006; Shoup 2016; Taylor 2002; Taylor 2004).

MaaS is still quite new in the market, and its business feasibility remains an open question as most companies in the industry have yet to become profitable, including Uber and Lyft. As such, there is a possibility that MaaS might end up being a short-term tech bubble spurred on by venture capitalists. That said, the public sector should recognize the uncertainty surrounding the industry and evaluate its benefits and costs based on the facts found in their pilot programs, and not on speculations about future technology evolution.

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Appendix

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Abbreviations

ADA:	Americans with Disabilities Act of 1990
APIs:	Application Program Interfaces
DART:	Dallas Area Rapid Transit
EMV:	Europay, MasterCard, Visa
FCA:	Financial Conduct Authority
FTA:	Federal Transit Administration
GIS:	Geographic Information System
GPS:	Global Positioning System
IT:	Information Technology
LA DOT:	Los Angeles Department of Transportation
LA Metro:	Los Angeles County Metropolitan Transportation Authority
MaaS:	Mobility-as-a-Service
MBTA:	Massachusetts Bay Transportation Authority
MOD:	Mobility on Demand
OEI:	LA Metro Office of Extraordinary Innovation
OTP-SUM:	OpenTripPlanner Shared-Use Mobility
TNC:	Transportation Network Company
TriMet:	Tri-County Metropolitan Transportation District of Oregon
VMT:	Vehicle Miles Traveled

1. Introduction

Mobility-as-a-Service (MaaS) represents a shift from personal vehicle ownership-based mobility to mobility consumed as a service. A MaaS platform enables customers to book, plan, and pay for door-to-door trips by using a single app and enjoy a near-seamless journey via a single or multiple travel modes, such as public transit, carsharing, ride-hailing, e-scooters, and shared bikes. To meet consumers' growing need for more flexible and convenient transportation, emerging MaaS players—Transportation Network Companies (TNCs), multimodal trip planners, dockless scooter providers, to name a few—are expanding their businesses in major US cities. While they have improved accessibility for some users, especially people who do not own automobiles, their rapid proliferation has sparked controversy over their impacts on public transit, safety, and travel behavior. Such a fast-changing market poses a challenge to transit agencies, forcing them to rethink about their roles in regional transportation networks.

Maas first appeared in Europe, where it offered a seamless, car-free travel experience by enabling intermodal trip planning, fare payment, and behavioral incentives on a single platform. For decades before that MaaS existed mostly at a conceptual level as the future of transportation technology, but the proliferation of smartphones, improved network connectivity, and advances in Global Positioning Systems (GPS) enabled Uber to launch a ride-hailing service in 2010—the first app-based platform that connected users who needed rides to private drivers (Lagorio-Chafkin 2014). Since then, MaaS has been the subject of heated debates over its potential to revolutionize how we move around.

Currently, we have a wide variety of transportation systems deployed in cities across the US, including carsharing, ridesharing, bike sharing, dockless e-scooters, and traditional public transit services (MaaS Global 2019). These app-based solutions are changing consumers' expectations of transportation systems and spurring demands for more personal, flexible, and seamless travel experiences without a privately owned car. In response to these trends, private mobility providers, such as Uber and Lyft, are investing in MaaS platforms to become one-stop shops for urban transportation. A large selection of mobility services on their platforms enhances customers' access to opportunities by providing more travel options.

Despite the convenience these private companies offer, when it comes to equity, safety, and use of limited public spaces, it is likely not in the best interest of the public to have purely privatized mobility. For example, as recent studies point out, emerging app-based services are leaving the most vulnerable groups of people behind—the unbanked, those without access to digital devices and the internet, and physically disabled people (DeGood and Schwartz 2016; National Academy Press 2018; Brown and Taylor 2018). Furthermore, dockless e-scooters have infuriated many residents by being ridden and parked on sidewalks. As these cases show, while MaaS is a

promising tool that makes alternatives to driving more attractive, its negative externalities harm transportation equity, safety, and efficiency.

This research examines how public agencies can most effectively work with private partners to advance MaaS in a way that improves regional accessibility while protecting public interests— equal access to transportation and job opportunities, efficient traffic flow to enable economic agglomeration, and safety in open spaces. To inform transit agency strategizing, this study analyzes MaaS programs promoted by three leading transportation authorities: Los Angeles County Metropolitan Transportation Authority (LA Metro), Dallas Area Rapid Transit (DART), and Tri-County Metropolitan Transportation District of Oregon (TriMet). All three agencies are currently funded by the Federal Transit Administration (FTA)'s Mobility on Demand Sandbox program to pilot on-demand mobility services and open platforms for payment and multimodal trip planning with private firms. Since experiences with MaaS are limited due to its newness, I gathered data from extended interviews with eight people who work or used to work on the MaaS programs at these three organizations.

In the interviews, I explored goals of their projects and challenges they faced in developing them. Moreover, to gain insights into a public-private alliance best practices, I asked about the ideal roles the public sector can play in the future MaaS markets and about partnership models that would benefit both the public agencies and private companies. The interviews revealed that LA Metro, DART, and TriMet struggled to keep up with the quickly changing mobility landscape. In working with private firms to develop MaaS solutions, they learned that executives' commitment to innovative solutions, effective contract management, failure tolerance, and knowledge/capability spillovers across departments and institutions helped them to launch their MaaS programs. Simultaneously, their experiences also unveiled that the lack of technical knowledge, divergent public and private goals, disagreement over data sharing, and rigid public sector business operations could not respond to fast-evolving technologies and often hindered their MaaS pilots.

The study also shows that the public sector needs to intervene in markets to prevent or mitigate negative externalities, such as the exclusion of those unbanked, without a smartphone, or with a disability from the app-based mobility services. For example, the interviewees emphasized that transit agencies should provide a cash-accepting platform to allow economically and digitally vulnerable populations to access MaaS. Moreover, the respondents pointed out that the current regulatory framework no longer fits the emerging mobility services. Thus, the industry needs a new regulatory framework to rectify market failures, especially the unequal distribution of new services and increased Vehicle Miles Traveled (VMT) caused by TNCs.

Finally, the three case studies highlight that the conventional contract-out model is less likely to work for MaaS. For decades, contracting has been the most popular approach to outsourcing

transit services. In this case, transit operators define the service scope, determine a statement of work for the vendor, create a Request for Proposals, and draft a contract with the selected firm. However, due principally to the lack of public agency technical knowledge, it is hard for them to do the same things for MaaS. Furthermore, the public sector and private companies do not closely communicate when developing a project in traditional contracting-out practices, which makes it difficult for either party to understand one another's interests and establish a mutually beneficial deal. As such, private partners need to be involved much earlier on when defining service specifications.

Based on my findings, I propose three potential directions that transit agencies and local governments can take in developing future mobility strategies: 1) organizational transformation, 2) develop new regulatory frameworks, and 3) strategic alliance building. First, the interview results suggest that transit agencies can be more resilient in these new dynamic environments by acquiring technical knowledge, creating a failure-tolerant culture, and updating operations to implement innovative services. These efforts to transform organizations help the public sector not only adapt their strategies to the situation but also proactively take actions to prevent market failures from adversely affecting vulnerable populations.

Second, in developing a new regulatory system, I argue that policymakers and transportation authorities should take an outcome-based approach. The mobility industry is experiencing rapid technological advancement, and it is impossible to predict how the technology will unfold in the future. In this situation, local governments and transit agencies should not waste their scarce resources on predicting the future and betting on particular technologies that may not become mainstream; instead, they should clarify the outcomes they want, such as equal access to app-based services, less vehicle dependency, or more transit use. Then, they can work backward from the outcomes to find policies to guide private MaaS players toward these outcomes (Manville and Osman 2017). For example, to achieve universal access to MaaS, policymakers and transport authorities can require companies to develop a cash-acceptable system and convert a certain percentage of their fleet into wheelchair-friendly vehicles. To reduce automobile use in congested areas, public authorities can prioritize transit (such with exclusive bus lanes) or increase the costs of driving for TNCs, as well as driving and parking for privately-owned vehicles.

To identify policies that promote desired travel behaviors, lawmakers and transit agencies can take an agile approach because the market landscape, and customer needs, are changing so quickly. Therefore, public authorities can flexibly update regulations as situations demand. To do so, they can use so-called "soft laws" (e.g., industry guidance, codes of conduct) and "regulatory sandboxes," a temporarily relaxed regulatory framework to test new technologies and business models in a live environment for a limited time (UNSGSA 2018). These two tools can allow lawmakers to try new rules and flexibly modify them if needed without spending months or

years developing and implementing “hard laws” and regulations. By repeating through trial and error, the public authorities can eventually find a legal sweet spot in which public interests are protected while not stifling innovations (Jenik and Lauer 2017; Eggers and Turley 2018; Geistfeld 2018). For example, the Finnish government enacted a new transportation industry code in 2017 to encourage open data and system interoperability across different operators. The legislators plan to update this code regularly depending on situations and operators’ feedback (Ministry of Transport and Communications of Finland 2017; Eggers and Turley 2018).

The final recommendation for ideal MaaS public-private partnerships is a strategic alliance. Unlike the traditional contracting-out, which entails a medium- to long-term legal contract for a fixed period, strategic partnering involves an open-ended, longer-term contract, which sometimes emerges from an informal network like an industry consortium. Thanks to its informal nature, this model allows the public and private parties to communicate more frequently and informally about their needs and innovative service ideas. More dialogue not only helps fill the goal gaps between the public and private sectors, but also allow transit agencies to better access and utilize the capabilities of private partners. Consequently, strategic partnerships encourage public-private collaboration, making it easier to build mutually acceptable programs where participating parties share risks and rewards more transparently.

While promoting MaaS, transit agencies should also work with local governments to reduce driving. Considering that over 76 percent of American commuters drove alone to work in 2016 (American Community Survey 2016), people are less likely to replace their driving trips with transit and other mobility services if driving remains inexpensive and convenient thanks to spread-out landforms and abundant free parking and roads. This artificially low price of driving may undermine efforts and investments made by transit agencies to promote MaaS programs. Thus, as scholars have long claimed, if cities want to reduce vehicle dependency, they should increase the price of driving directly by charging roads and parking, or indirectly by increasing densities (Chatman 2008; Downs 2004; Ewing and Cervero 2010; Ewing and Cervero 2017; Manville 2014; Manville 2017; Nelson 2017; Newman and Kenworthy 2006; Shoup 2016; Taylor 2002; Taylor 2004).

This report proceeds as follows. The next chapter reviews existing research on MaaS and a public-private partnership approach common in the transportation field. Then, in chapter 3, I explain the data and methods used in this study. Chapter 4 briefly describes the three case study organizations and their MaaS programs. I present the interview results and discuss the lessons learned from three case studies in chapter 5. Chapter 6 explores implications for practices based on the findings, and then I conclude this research in chapter 7 by reviewing the opportunities and challenges of MaaS for transit agencies.

2. The rise of a Mobility-as-a-Service and public-private alliances

This chapter provides a summary of the academic and consulting literatures on Mobility-as-a-Service (MaaS) market trends and public-private alliance models. MaaS promises to make alternative transport modes more attractive than private vehicles by providing near-seamless multimodal trips and personalized travel planning. However, existing studies find that the benefits of this new technology are not distributed equally in society. Furthermore, transportation scholars examining the impacts of MaaS on traffic found that Transportation Network Companies (TNCs) in some major American cities have attracted people away from public transit, increasing traffic congestion in the process. A growing body of literature on MaaS reviewed in this chapter suggests that to achieve efficient and equitable transportation in increasingly congested cities, we need policy interventions that guide the MaaS market in a way that causes new mobility services to complement existing mass transit networks, not substitute for them.

In addition to regulations, MaaS implementation requires effective public-private alliance building. In the second half of this chapter, I review the existing research on public-private partnership models, with a particular focus on contracting-out of public service provision in the US. Since the 1980s, all levels of government have outsourced a part of their businesses to private companies to reduce operating costs and improve service efficiency. By examining contract-out cases, scholars have identified four key conditions associated with positive outcomes: 1) the public sector specifies a project objective, responsibilities, and level of service quality in a contract; 2) a contracting public agency agrees on project goals and performance with a vendor, and then monitors that performance; 3) market environments are competitive; and 4) project participants in the public sector can manage internal stakeholders who may be against the project (Brown et al. 2006; Domberger and Jensen 1997; Ferris 1986; Hefez and Warner 2004).

2.1. Mobility-as-a-Service evolution and market trends

MaaS concept and functions

MaaS is a relatively new concept that was first developed in European countries in the 1990s. MaaS is a user-centric, sole mobility marketplace, through which nearly all public and private transportation services are aggregated and conveniently consumed based on users' preference. The system enables users to plan trips, as well as book and purchase mobility services through a single digital platform (Kamargianni and Matyas 2017; Arthur D. Little Future Lab 2018). Currently, however, the MaaS concept has not been fully implemented; most urban travelers today need to use multiple tools to plan travel and purchase different transport services. As

transportation scholars point out, such a tedious process to complete a multimodal trip detracts from a customer's travel experience, thus making private vehicles simpler and more attractive, with their direct door-to-door connections (Kamargianni and Matyas 2017; Goodall et. al. 2017).

MaaS will remove these hassles by letting users plan, book, and pay for an end-to-end, multi-mode trip on a single app, aiming to make alternative travel modes more attractive so that urban dwellers opt to abandon their cars. Moreover, by fully integrating multiple mobility options with their real-time data, from public transit and ride-sharing services to walking and biking, MaaS will help cities optimize transportation supply and travel demand (Kamargianni and Matyas 2017; Karim 2017). Because of the potential MaaS presents, city officials, public transportation agencies, and private companies offering mobility services and software are showing increasingly interest in MaaS (Canales et.al. 2017). MaaS deployment and expected outcomes will vary by region or city and are likely to be influenced by local conditions, such as economics, demography, urban geography, current travel patterns, and the quality of the existing public transit services. In order to stimulate cross-border and -sector collaboration, researchers and industry players are seeking to define what roles MaaS should take in urban transportation systems (ARUP 2018; Kamargianni and Matyas 2017; Siemens Mobility Division 2016).

Figure 2.1 below portrays the MaaS ecosystem and the essential functions needed to provide a seamless multimodal experience to end users. It primarily consists of a MaaS platform and mobility services, which are connected to the system through Application Program Interfaces (APIs). The coverage of transportation modes available on a platform can vary depending on the local contexts and regulations. In major US cities, for example, it may range from rail lines, buses, and taxis to e-scooters, shared bikes, and ride-hailing.

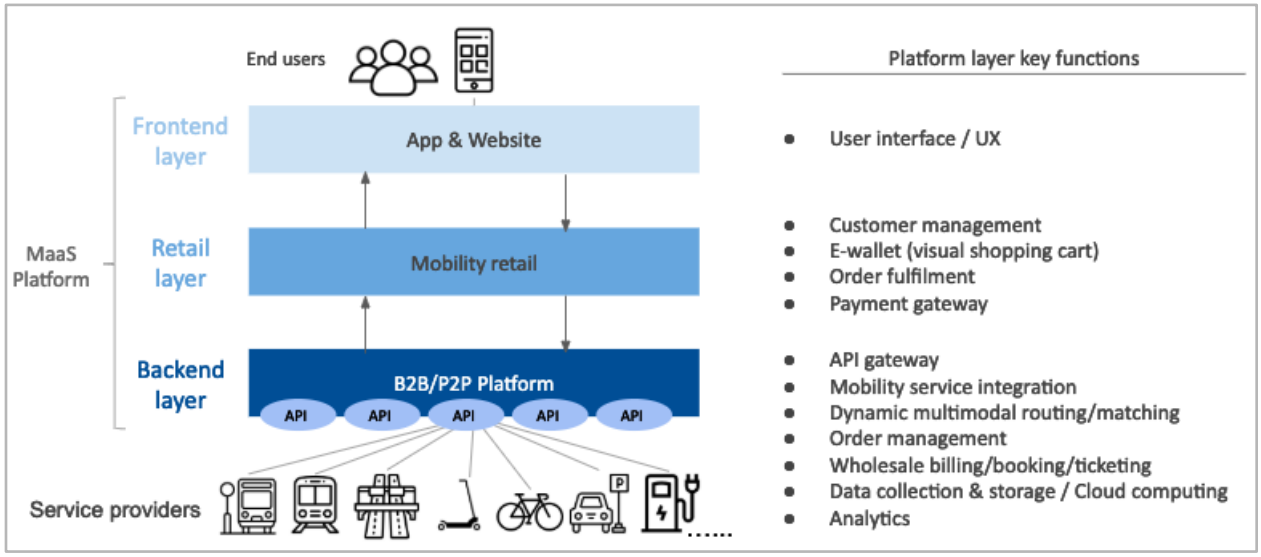

Figure 2.1 MaaS functional structure
(Author-made chart based on Siemens Mobility Division 2016; Smith et al. 2018; Kamargianni and Matyas 2017)

The MaaS platform includes three layers: Frontend, Retail (Middle), and Backend. Mobile apps and websites represent the first layer, working as an interface with end users and manages user experiences. This layer is critical to users' loyalty to a MaaS service as this is the only touchpoint with consumers. If people feel that an app is confusing and inconvenient, they are unlikely to use the app again (Hsiao, Chang, and Tang 2016).

The middle retail layer involves customer management, E-wallet (virtual shopping cart), order fulfillment, and payment gateway connecting to a third-party's payment settlement system. This layer operates as a transportation marketplace where a MaaS platform provider matches each user's trip request with available mobility services based on their real-time conditions gained through the APIs. Furthermore, the retail layer also enables users to select, book, and pay for combined transportation services in a one-stop-shop manner like users do today in Amazon and Expedia.

The final backend layer provides an essential infrastructure of a MaaS platform, where third-party servicers get integrated into the platform and exchange operation data and customer information with the platform. In addition to the data sharing, this layer also calculates the best route and combination of services in real time, manages customer account and billing transaction settlement, and stores transaction data. To ensure safe data processing, the backend layer includes a data security function, such as encryption and access control (Siemens Mobility Division 2016; Arthur D. Little Future Lab 2018; US Department of Commerce 2018).

The scope of MaaS operators varies depending on their capability, stakeholders' interests, and local regulations. For example, Dallas Area Rapid Transit (DART)'s GoPass system offers a mobile app on which customers can plan and purchase public transit services in the region. While the system integrates third-party services, such as Uber and Lyft, in its mobility marketplace, customers still need to open a separate vendor's app once they select the service (Dallas Area Rapid Transit 2018). This is partly due to limited system capability in the backend layer. DART and mobility companies have not agreed on the system and data integration (Interview with DART staff #5).

MaaS platform operating and business model

While the MaaS market is still emergent globally, the Arthur D. Little Future Lab (2018) defines three operating models for a MaaS platform operator as shown in Figure 2.2 below. The first is a holding model. In this model, a MaaS platform operator only aggregates its own services on the platform; thus, customers have to open a third-party app if they want to use services that are not offered by the platform operator. The current platforms of TNCs, like Uber and Via, and of several public transit agencies fall within this category (Arthur D. Little Future Lab 2018; Citron 2018).

As a platform operator further integrates its platform with other transportation options, customers have a broader range of choices on one platform. Under such a situation, the platform provider functions as a broker of mobility services. It provides a multimodal trip guide to each user, combining not only the platform provider's services, but also third-party services. While this model improves customer experience by proposing the best route and perhaps integrating different companies' modes, a separate ticket needs to be issued for a third-party service as its booking and payment features are not fully integrated to the platform (Arthur D. Little Future Lab 2018). The most recent example of this model is Lyft's multimodal planning service deployed in the City of Santa Monica, California. Starting its operation in September 2018, Lyft's new feature proposes multiple options of how to get to a destination, which combines walking, public transit, Lyft cars, e-scooters, and bikes based on real-time conditions. Even though public transit ticketing is not available on its platform yet, Lyft is working to deploy a one-stop transportation app through a collaboration with Santa Monica Big Blue Bus (Bhuiyan 2018a). Uber is also moving in the same direction through an acquisition of bike share and e-scooter companies (Bhuiyan 2018b).

The final model is an operator model, which allows for a seamless multimodal trip from planning to payment on a single app. A MaaS platform operator will sell multiple mobility services of its own as well as of third-parties under a single brand. Such a unified branding and aggregation of services enables users to pay for the whole trip and improves customer experience; however, this model also requires the MaaS operator to be liable and accountable for any service faults (e.g. accidents) caused by third-party operators using the platform because it is a seller of a mobility package. Therefore, when a MaaS operator takes the operator model, it will face a tradeoff between a streamlined service and higher business risks (Arthur D. Little Future Lab 2018). A Helsinki-based multimodal app, Whim, provided by MaaS Global exemplifies this model. Currently available in Helsinki, Finland and Antwerpen, Belgium, Whim has a large selection of modes, ranging from public transit, shared bikes, and taxis (within a 5 km radius), to car rental and car sharing. The app offers three packages to end users: pay-as-you-go, monthly subscription with unlimited use, and a mix of both, based on their frequency of transportation use and preference. If a user chooses a monthly unlimited subscription, s/he can take available transportation modes as many times as s/he likes (MaaS Global 2018).

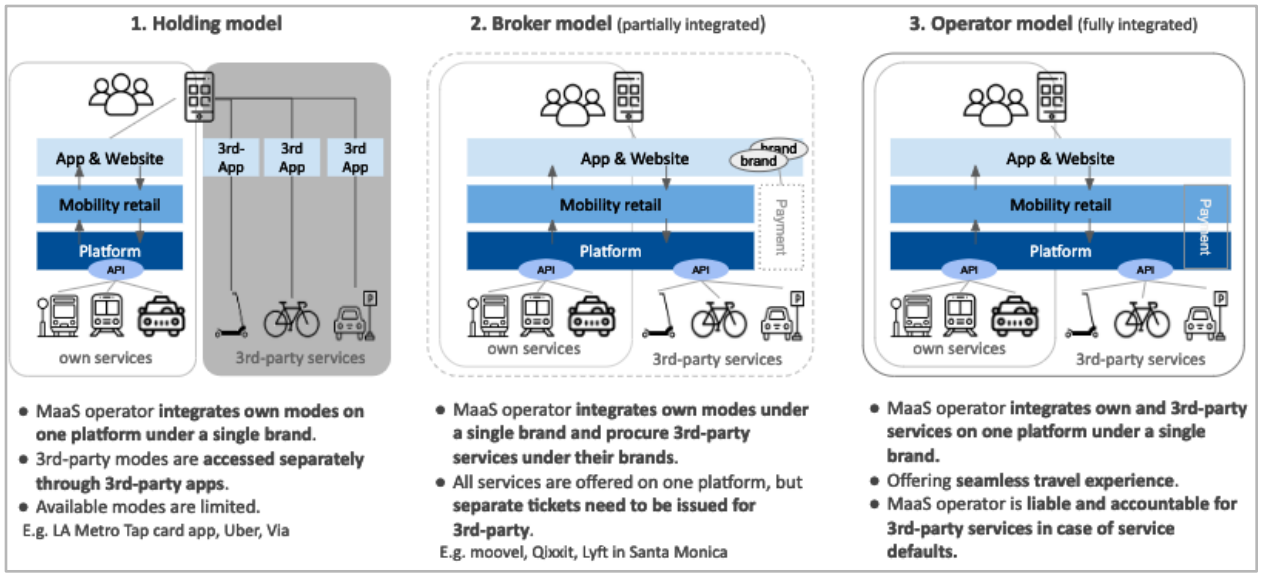

Figure 2.2 MaaS operating models
(Author-made chart based on Arthur D. Little Future Lab, 2018)

The operating model also defines the business model the platform operator adopts. I explore here potential business model options that can be pursued in Figure 2.3. Under the holding model, the MaaS operator's revenue comes from end users who purchase its service. This simple business model is the most common in the current market. The broker model, under which users can select third-party transportation modes on a single MaaS platform, increases the revenue opportunities for companies who operate the platform. On top of the earnings from delivering its service, the MaaS operator gains a platform usage fee from the vendors for the prioritized access to the platform (Arthur D. Little Future Lab 2018).

The operator model involves more complicated monetary transactions than the other two models. As with the broker model, the MaaS platformer can receive revenue from both end users and third-party vendors. However, in this case, the money flow is different from the broker model; users pay service fees for transportation modes provided on the platform directly to the MaaS platform operator. Then, the platform operator splits the income among vendors who contributed to the customer's trip and pays vendors after deducting a platform usage fee. Given its complicated accounting, implementing this business model entails intense negotiation with third-party mobility providers to determine how to split revenues and costs (Arthur D. Little Future Lab 2018).

Overall, the decision over which operating and business models a MaaS platform operator adopts reflects the level of complexity and risk that the operator is willing to manage. When public transit agencies consider operating a MaaS platform as a single transportation marketplace in a city, they must determine which operating and business model serves their interests the best.

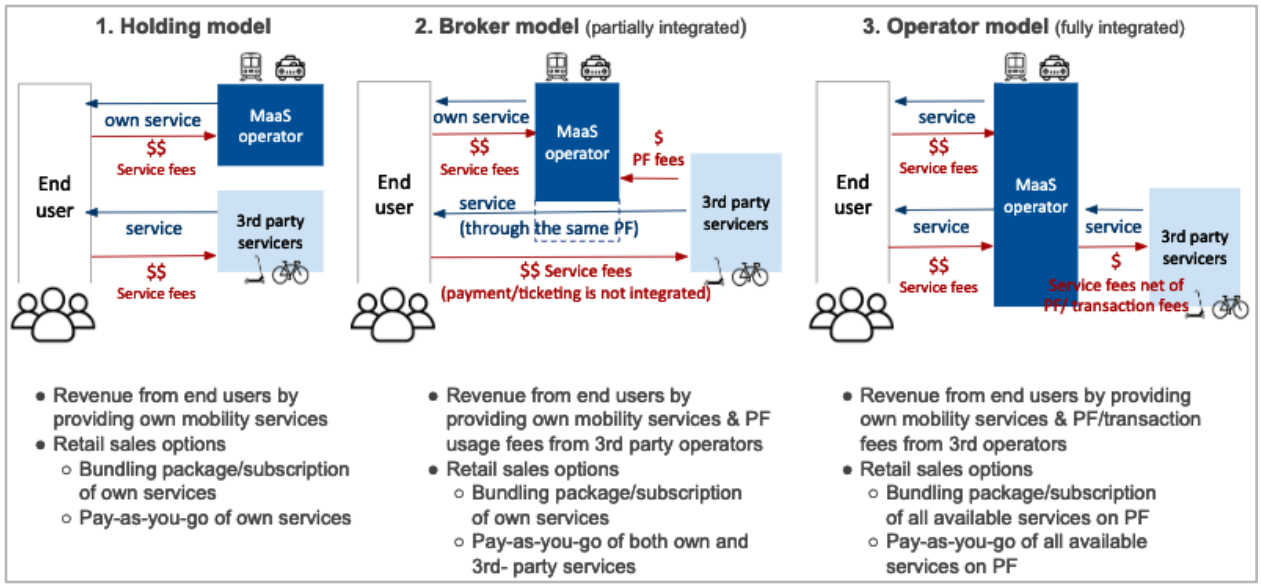

Figure 2.3 MaaS business models
(Author-made chart based on own research and Deloitte Review, 2017)

Global and North American MaaS market trends

As more cities face pressing urban issues, such as increasing population, worsening traffic, and intensifying air pollution, MaaS has attracted more attention from public and private sectors globally as a viable alternative to personal vehicles. Thanks to the enthusiasm for multimodality, the MaaS concept is materializing in some cities in Europe, North America, and Asia.[1]

Over the past five years, multiple multimodal MaaS programs have been implemented in European cities. Most of them are local government- or public transit agency-led initiatives, in which the public sector collaborates with technology and private transportation companies to design and develop a platform (from a frontend to a backend) (Kamargianni and Matyas 2017; Smith et al. 2018). Figure 2.4 below presents some examples of MaaS programs available in Europe. For instance, moovel (a subsidy of Daimler AG) operates a platform and a couple of mobility services in a partnership with several German municipal governments and rail companies. Through a moovel app, users can search for the fastest route and the best combination of travel modes, book a service provided by the Daimler group to the nearest station, and purchase and download public transit tickets on the phone (moovel 2018).

[1] In Asia, despite its extensive public transit networks and digitized fare systems, the multimodal MaaS platform is not yet common. Asian public transit agencies typically provide seamless travel experiences through their apps; however, when it comes to multimodality, they have not integrated other transportation modes. For example, Beeline Singapore, a government-led MaaS program, only allows planning, booking, and paying for tickets of rail and public and private bus services on a single app. For other mobility services, users still need to open third-party apps. The Singaporean government has opened Beeline's platform to the public to accelerate service improvements (Zhang 2017).

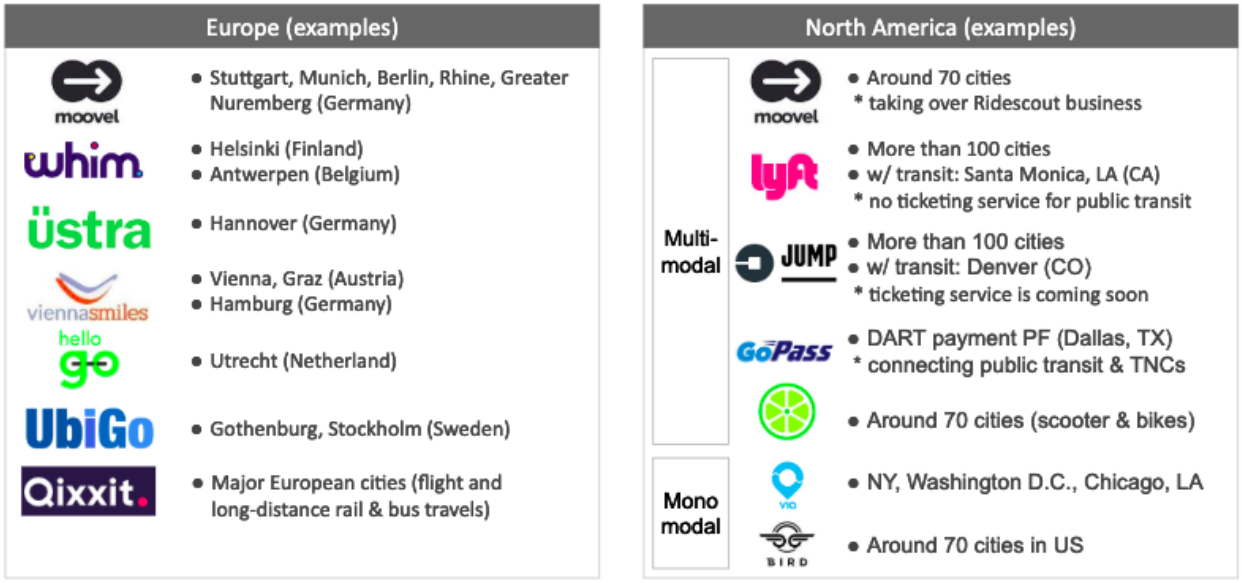

Figure 2.4 MaaS operators in Europe and North America (examples)
(Source: Author's research)

In contrast, North America is still at an early stage of multimodal service development. While there are many emergent MaaS platforms on the market, only a couple of players currently offer multimodal options on a single app. In the US, for instance, Lyft and Uber are expanding their service portfolio from ride-sharing to scooters, shared bikes, and even public transit by integrating transit real-time information. Likewise, some progressive public transit agencies, like DART and Los Angeles Metropolitan Transportation Authority (LA Metro), seek to broaden their catchment area by partnering with private mobility service providers (Descant 2018a; Huang 2017; Interviews with LA Metro #3 and DART #5). As a first step, several transit agencies are launching an open payment platform, which will allow them to offer expanded mobility options to their customers through one mobile app. I will return to this topic later in this report.

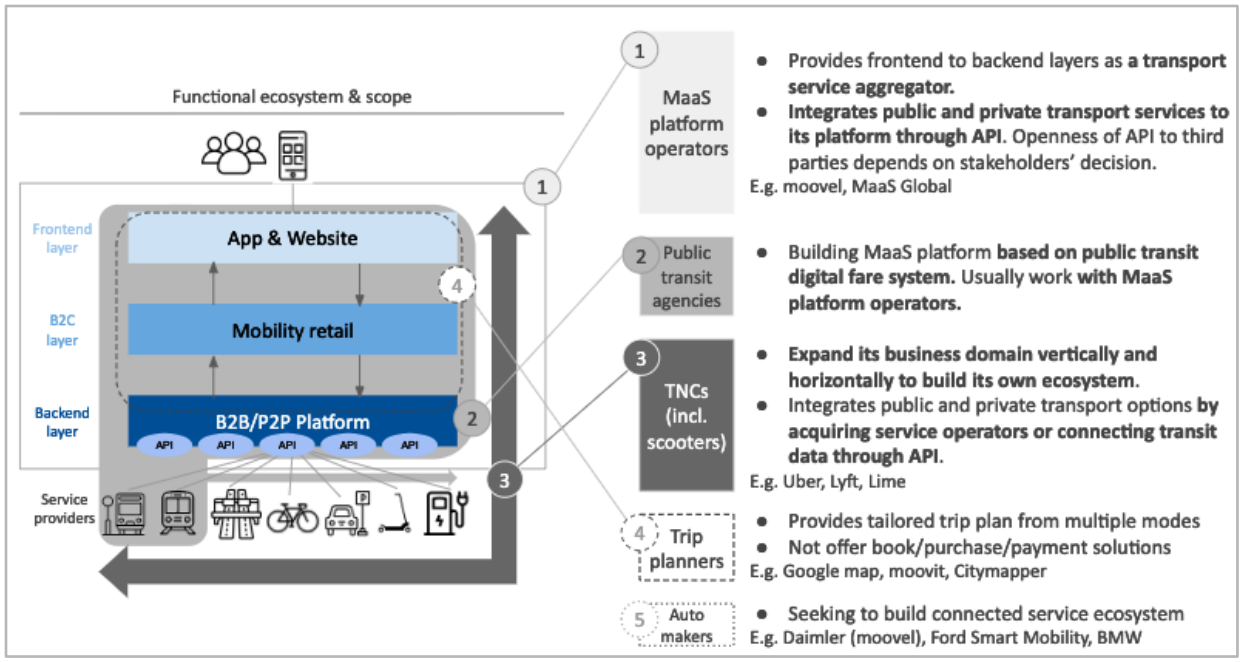

Figure 2.5 Key players in the North American MaaS market
(Author-made chart based on own research)

Figure 2.5 presents a detailed market outlook in North America. In addition to MaaS platform operators, Transportation Network Companies (TNCs), public transportation agencies, multimodal trip planners, and automotive manufacturing companies are also looking at this growing market (Goodall et al. 2017). For example, with more mobility choices available in cities, Citymapper and Google Maps, the globally most popular trip planning services, are evolving their apps to cover all transportation modes in cities, ranging from buses and rails to scooters and dockless bikes. Leveraging its multimodal routing algorithm, the app providers plan to offer a customized multimodal itinerary to each customer in the future (Citymapper 2018; Brasuell 2018).

Automakers may be increasingly central players in the MaaS market as personal vehicles will almost certainly remain the dominant travel mode in the next decade. In addition to building smarter vehicles, car makers have been making big investments in acquiring new mobility service providers, suggesting that they consider MaaS platform operators as competitors. For instance, Daimler AG, a parent company of moovel, has invested in and acquired new mobility providers since 2013 to reshape its business strategy in preparation for the upcoming connected-automated vehicle era (Muoio 2017). Similarly, Ford Mobility, BMW, and GM are aggressively exploring new shared mobility services and business models in urban areas across the US (Automotive World 2018; Shields 2018).

What researchers from both academic and private sectors agree on is that the MaaS market needs some regulations to protect public interests, but also that too much control will impede private

companies' ability to participate in MaaS and innovate. This suggests that finding the regulatory sweet spot where private and public interests are well balanced will be critical to the development of a viable MaaS system (Deloitte Review 2017; Kamargianni and Matyas 2017; Smith et al. 2018; ARUP 2018; Canales et al. 2018).

Benefits and Challenges of Multimodal MaaS platforms in North America

A growing body of research explores the potential of this new technology to solve current transportation issues, such as congestion, the financial hardships of public transit, and social exclusion. However, outcomes of a MaaS program should vary by city or by region as well as by the position of the party participating in the program as each location has its unique travel patterns and historical contexts. Hence, in this section, I examine the potential impacts of MaaS in the North American market from various stakeholders' perspectives, including end users, mobility service providers, public transportation agencies, and local governments.

Table 2.1 below lists the potential benefits and challenges that each party involved in a MaaS ecosystem would gain or face in North America, where driving is the dominant travel mode. The most recent National Household Travel Survey finds that 87 percent of daily trips in the U.S. in 2017 was made by personal vehicles (Bureau of Transportation Statistics 2017). Except for very limited highly density urban-cores like Manhattan, New York, car travel is ubiquitous across the country partly due to the car-oriented built environments (e.g., abundant supply of parking) and infrequent and limited public transit services (Schweitzer 2017). Existing studies have also shown that car ownership substantially increases job accessibility in the US (Blumenberg and Manville 2004; Blumenberg 2004; Ong and Miller 2005). Consequently, only about nine percent of American households did not own a car in 2016 according to the latest data (American Community Survey 2016). Recently, this percentage has been rising among lower-income and immigrant households, who have traditionally comprised the majority of public transit users (Blumenberg 2017; Manville, Taylor, and Blumenberg 2018a).

Parties involved	Benefits	Challenges
End users	· Enjoy seamless and reliable multimodal travel from end-to-end through a one-stop service offering · Gain new mobility options in a transit-underserved area/time · Personalize each trip based on individual preferences and needs	· Equity concern: excludes customers without smartphones, a credit card, a bank account and/or with a physical disability · Data privacy concerns · Safety concerns (e.g., e-scooter related injury
Private mobility service providers	· Expand addressable markets/users · (If not owning a platform) Save the cost of developing and operating a MaaS platform	If not owning MaaS platform, · Lose a direct touchpoint with end users, which is a key to the future business growth · Increase service costs as they need to pay a platform usage fee/commission fee
Public transit agencies	· Increase mobility options at lower cost in a transit-underserved area/time · Increase ridership by combining MaaS as a first/last mile mobility to public transit hubs · (if platform is owned) obtain all mobility service data and optimize traffic in a region	· Lose ridership if MaaS substitutes the existing public transit service · (if not owning a MaaS platform) Increase service costs as they need to pay a platform usage fee/commission fee
Local governments/ Cities	· (if platform is owned) obtain all mobility service data · Reduce private vehicle use and congestion by promoting alternative modes (shared services and transit) · Reduce air pollution · Increase safety by reducing vehicular accidents · Convert parking spaces to more productive land uses and increase density	· Increase congestion if people use TNCs (car-based mobility services) more than public transit · Impair the safety of public spaces due to dockless personal mobilities (e-scooters, bikes) · Potentially encourage a sprawl if people rely on TNCs and abandon public transit.

Table 2.1 Benefits and challenges of MaaS in North America
(Author-made table based on American Public Transportation Association 2016; ARUP 2018; The National Academies Press 2018; Brown and Taylor 2018)

End Users

Even though car-oriented land uses and artificially low costs of driving will not change meaningfully in the short-term, innovative mobility services and multimodality still present the potential to enhance access to transportation for non-drivers. As noted earlier, a MaaS platform enables users to enjoy seamless and hassle-free trips without owning a car. With the details of transit service in real time and various options in hand, users will no longer have to worry about unpredictable wait times at stations and stops, especially in off-peak hours and midnight, when traditional fixed route services wane. Moreover, an expanding array of travel choices will allow users to customize their travel modes based on their preferences and situations. For example, when there are public transit delays, time-sensitive customers can quickly change their trip plans and select the most attractive alternative on a MaaS app (Canales et al. 2018; Toesland 2018). There are also studies suggesting that ride-hailing services provide faster and more economical mobility options in low-income and minority neighborhoods, which are often underserved by taxis and public transportation (Smart et al. 2016; Brown 2018).

While the implementation of a multimodal MaaS platform should in theory narrow the mobility gap between non-drivers and drivers, it raises other concerns regarding equity and data security. First, most app-based mobility service providers go cashless to make money transactions easier and transparent. However, given that lower-income people and seniors are more likely to have lower levels of access to smartphones, the internet (data plan), a credit card, or a bank account, promoting MaaS without addressing these handicaps may disproportionately harm the mobility of these disadvantaged people (DeGood and Schwartz 2016; Transportation Research Board 2015; Brown and Taylor 2018). In the US, for example, smartphone use surpassed 80 percent in 2016; however, there is still an age disparity. While 98 percent of people aged between 18 and 24 own a smartphone, only 46 percent of those aged 65 or older have access to personal digital devices (Pew Research Center 2018). In addition, around seven percent of US households did not have a checking or savings account in 2015, and this percentage was higher among lower-income families with less education whose profiles likely overlap the car-less population (Brown and Taylor 2018).

Similarly, people with certain physical disabilities often face difficulty in using new mobility options. In the current legal framework, for instance, TNCs do not have to comply with the American Disabilities Act (ADA), which requires transportation service providers to dedicate a portion of their fleets for customers with a disability. Because TNCs describe themselves as technology companies rather than transportation operators, they claim that the ADA does not apply to them (Reed 2017). If policymakers will not update the regulations according to the transportation market changes, MaaS benefits will be out of reach for people with disabilities (Transportation Research Board 2015).

TNCs have started to participate in paratransit service mandated under the ADA in cooperation with local governments. A pilot program of Massachusetts Bay Transportation Authority (MBTA) partners with some TNCs, including Uber and Lyft, to offer a mobility option to people with disabilities. Users can request a ride on the same day instead of having to call at least a day in advance, as required for existing paratransit services for those with disabilities. The MBTA subsidizes $13 for each trip (users pay $2 fare and any amount over $15). To enable all users to make an appointment, Lyft provides a call center while Uber distributes smartphones to some customers in need (Schaller 2018).

Another challenge is data security. As more information is processed through a digital platform, customers are more vulnerable to the security of the data they consciously and unconsciously provide to service operators. User data are critical to MaaS platforms to optimize transportation supply and demand in a region. However, because travel information is highly personal (when to go where and how), there is debate over what information can be collected and shared with private companies and local governments. Since the MaaS concept encourages integration across multiple service operators and infrastructure providers, its cybersecurity and data leakage risks will be higher with increased system complexities (Arthur D. Little Future Lab 2018; Gleave 2017).

Private mobility service providers

From a perspective of private transportation providers, MaaS offers two benefits: expanding the addressable market/users and saving the cost of MaaS platform development and operation if they do not own a platform. First, by joining a MaaS platform, service vendors can reach a broader customer base than they could on their own. For instance, bike share programs can access more potential customers if their service is offered as a first-mile/last-mile complement to public transit travel, than if they are only stand-alone services. Also, for vendors who cannot afford to develop and operate their own platform, leveraging a third-party's platform saves them much money (KPMG 2017).

On the other hand, relying on another company's platform may cause some negative consequences to vendors' businesses. Since a MaaS platform is a single touchpoint with end users, transportation service vendors will lose the direct contact point with their customers when offering mobility services through third-party's platform. In the digital economy, direct-to-consumer marketing is critical for executing promotions, promoting sales, and enhancing market share (Bommel et al. 2014). Therefore, loss of direct interaction with users may threaten future business growth.[2] Furthermore, a platform operator will charge platform usage fees to mobility service providers, so the total cost of service provision will also increase.

[2] In some cases, platform operators only provide a data platform and do not hold customers' data shared by mobility service providers. In such a case, the mobility providers usually hold their customer data at their will. However, it completely depends on a contract between a platform operator and mobility vendors.

Public Transportation Agencies

Public transit agencies may also benefit from MaaS through effective collaboration with private mobility providers. Ridesharing services, such as Uber and Lyft, have grown at a remarkable speed since their emergence in 2010. Their penetration into the disadvantaged neighborhoods considerably complements the fixed route transit and taxi services (Brown 2018). In addition, previous research suggests that ride-hail use peaks on Friday and Saturday evenings (between 8 pm and 4 am), when scheduled public transit service is scarce (American Public Transportation Association 2016). Furthermore, in public transportation finance, adding fixed route service to areas and times with low demand often results in the negative marginal revenue (Walker 2011; Schweitzer 2017). Therefore, for public transit agencies facing conflicting goals of operation efficiency (e.g., fare-recovery rate) and coverage expansion in terms of time and areas, new mobility services may help achieve both goals without substantial additional investments in transit (American Public Transportation Association 2016).

However, recent research on the impact of MaaS, especially ridesharing services, on public transit use has shown mixed results. Some argue that new mobility providers effectively complement the existing rail and bus services, while others suggest that they may attract riders from transit and worsen congestion. For example, Hall et al. (2018) show that Uber contributed to transit ridership increase by 5 percent in the US Metropolitan Statistical Areas (Hall et al. 2018). In contrast, Clewlow and Mishra (2017) found that ride-hailing lured Americans from transit and decreased bus ridership by 6 percent and light rail ridership by 3 percent in the US major cities (Clewlow and Mishra 2017). Further, regarding a declining transit ridership, another study argues that increasing car ownership rates among lower-income and immigrant households had more impacts on ridership than ridesharing service in Los Angeles (Manville, Taylor, and Blumenberg 2018a).

Though we need more research to conclude whether or not MaaS actually harms public transportation, effective collaboration between public and private sectors and proper service and regulation design will still be critical for MaaS to making non-vehicle alternatives more attractive to urban dwellers (DeGood and Schwartz 2016). When arranged adequately, MaaS can benefit public transit operators by increasing ridership through extended area coverage and helping to redirect investment back to core transit services.

Local Governments/Cities

As shared transportation options become more widespread, local governments are also likely to benefit from MaaS programs. First, modal shifts from driving to alternative modes should reduce the number of vehicles on the road, thereby relieving congestion, air pollution, fatalities, as well as freeing up valuable land for more productive purposes (than, for example, parking). While a debate over a net impact of shared mobility services is still underway, there are multiple studies

that find that car and bike share services decrease in car ownership and associated emissions (Shaheen and Cohen 2014; Martin and Shaheen 2016). Other research have found that Uber is indirectly benefiting public safety by reducing vehicular accidents and fatalities (Greenwood and Wattal 2015; Dills and Mulholland 2017). While full effects of new mobility services are not yet manifested, MaaS has the potential to encourage travel behavior that aligns to public policy goals, such as improving public safety, health, and economic productivity.

On the other hand, recent studies suggest that ride-hailing services may be worsening traffic congestion and increasing Vehicle Miles Traveled (VMT) in large American cities based on the fact that around half of ridesharing trips are either entirely new trips or trips that would have been made by walking, biking, or public transit (Clewlow and Mishra 2017; Schaller 2018). Without adequate policy interventions that would reward mobility firms focusing on first- and last-miles and spread-out suburbs with few public transportation services rather than directly competing with existing fixed-route transit, users will replace public transportation with on-demand door-to-door rides when they can afford to do so, and congestion and emissions will likely grow.

Despite the multiple benefits MaaS promises, recent research on MaaS points to several potential downsides of this innovation as well. Although private companies are leading the MaaS development in North America, governments need to take actions to guide this technology toward societal goals. I will discuss how the public sector should be involved in the MaaS market in chapter 5.

2.2. Public and private partnerships for public service provision

Public service provision alliances

As new mobility services are proliferating to fill gaps in the current transportation network, private companies are playing a larger role in the creation of public value. In this context, city governments and public transportation authorities are proactively seeking ways to work with new mobility providers. Some of them have already launched pilot programs to take advantage of innovative solutions in addressing pressing transportation issues including a first/last mile gap, high-cost dial-ride paratransit, and expensive service provision in the suburbs. To make the most use of these MaaS experiments, we need a formula for how the public sector can effectively partner with emerging players to improve the welfare of residents (Canales et al. 2018).

A public-private partnership aims to combine the resources of the public sector with those of private companies in pursuit of societal goals. The form of such alliances vary depending on the situation and government' needs, ranging from contracting out of public services to setting up a hybrid organization for risk-sharing between the public and private sectors. When providing public services, governments can choose to realize societal goals by producing services on their

own (the "make" decision) or by using third-party's resources (the "buy" decision). If governments make the buy decision, then they need to decide the best alliance form from among five options: public leverage, contracting out, franchising, joint ventures, and strategic partnership (Skelcher 2007). Table 2.2 below describes the key features of these five forms.

Low — Government engagement (including risks) — High

	Public leverage	Contracting out	Franchising	Joint venture	Strategic partnership
outline	• Governments use this model when seeking **economic development** in their jurisdiction by creating **conditions that may encourage investments from the private sector.**	• Governments use this to achieve **cost reduction, service quality improvement, and management efficiency gains.**	• Governments **transfer management of public entities to the private sector.** • For an infrastructure project, private entities return the ownership of assets to the public sector after a fixed term.	• This model enables the public sector to **access private capital and capability.** The public sector uses this to **transfer risks to private partners** in a capital project.	• This model enables governments to improve management capability and operation efficiency **through a mid- and long-term relationship with private partners** based on **trust.**
mechanism	• Governments provide land for commercial development, tax benefits, and subsidies.	• Governments **contract a third party to provide public services** to citizens..	• Governments **give license to private entities to offer the service.**	• Governments and partners **make a contract which covers cost/ revenue/risk sharing.**	• This mid- to long-term relationship does **not necessarily involve a formal contract.**
example	• Economic development • Urban renewal	• Transit service operation	• Highway management	• Large-scale capital projects	• Smart City consortium • MaaS consortium in EU

Table 2.2 Five forms of public and private partnerships
(Source: Skelcher 2007)

The most common form of public and private collaboration in transit service is contracting with private organizations to operate buses. Contracting-out is a business arrangement between a government agency and a private entity in which the private entity promises, in exchange for money, to deliver certain products or services to the government agency or to others on government's behalf (Ya Ni and Bretschneider 2007).[3] Although contracted services are produced and delivered by private entities, the government still retains control over the activities concerned through monitoring performance, imposing financial penalties, and replacing vendors in case of contract failure (Ferris 1986). Under increasing financial pressure, the federal and local governments have outsourced publicly provided services to the private sector since the 1980s, from garbage collection and policing to bus service operation and e-government system management.

Advocates of contracting out argue that contracting promotes competition in a target market, thereby increasing efficiency, improving quality, and reducing the cost of service provision.

[3] Contracting-out differs from privatization in that the latter entails a transfer of ownership of physical assets from a public entity to a private entity. In other words, privatization always involves the sales of public assets to private organizations. Moreover, privatization is essentially independent from the promotion of competition in service delivery (Domberger and Jensen 1997).

Contracting out removes the monopoly power of the government as the sole service provider by introducing a competitive tendering. In a competitive condition where multiple service providers are willing to sign a contract, the government can expect that a contracting entity will minimize costs while maintaining quality in order to secure contract renewal in the next round of bidding (Ferris 1986; Brown et al. 2006). According to research on government contracting, the decision to outsource public services will likely happen when 1) the monetary and non-monetary cost savings are expected to be greater, 2) governments face the fiscal stress, and 3) the political power of public employees is less powerful (Ferris 1986; Brown and Potoski 2003a; Amirkhanyan et al. 2007).

Moreover, as Information Technology (IT) has become an indispensable part of business processes, governments in the U.S. have increased spending on IT contracts. Proponents of contracting out claim that outsourcing IT functions, such as system development and data processing, has the potential to fill the IT skills gap in most public organizations. The shortage of public sector IT expertise has been a serious issue in developing systems and applications, especially at the local level (Ya Ni and Bretschneider 2007). Moreover, contracting out IT capability helps reduce the risk of system development during times of rapid technological evolution, making future market trends hard to predict. Because of the frequent lack of public sector IT expertise, it would require substantial time and expense for the governments to evaluate market trends and design appropriate systems on their own. By contracting with IT experts, governments can avoid substantial transaction costs and risks associated with the complex IT system implementation (Brown and Brudney 1998).

Overall, contracting offers a useful tool for public officials to deal with the challenging task of doing more with less. Of course, managing the complicated and often politically charged trade-offs of contracting is not easy; it can sometimes result in unintended outcomes that leave everyone worse off. Contracting out is not a one-size-fits-all solution. Therefore, public sector managers need to understand the conditions under which contracting will be more likely to be successful.

Conditions for successful execution of contracting-out in public service provision

As a growing number of empirical studies show, not all contracts yield desired outcomes (Brown and Potoski 2003a). Drawing on these unsuccessful cases, critics argue that contracting out tends to cause accountability problems, sacrifice public interests for efficiency and cost savings, and result in inferior service delivery (Brown et al. 2006; Prizzi 2001). Contracting can fail to deliver expected results due to 1) an incomplete contract problem resulted from difficulty in writing a contract that incorporates all potential scenarios, 2) a credibility issue caused by an information gap between a client and a vendor, 3) less favorable market conditions, and 4) contentious political environments deadlocked by conflicting priorities (Brown and Potoski 2003a).

First, contracting for complex, non-specific services suffers from contractual incompleteness, as when the governments outsource IT functions. In many cases, new system and application development involve complex processes as vendors usually customize some features for clients. Such complex and ever-changing services makes it almost impossible to predict every contingency likely to arise in a contract. Thus, such contracts are often underspecified, which may allow opportunistic vendors to exploit vague arrangements to their advantage at the cost of the government's goals (Brown et al. 2006; Domberger and Jensen 1997). To minimize the risks of opportunism, contracting officers must clarify key performance indicators (KPIs) aligned with a project objective in a contract and monitor vendors' performance constantly.

The second challenge is a credibility concern produced by information asymmetries between client and vendor. This problem, called the "principal-agent problem" in economics, happens when a vendor (an agent) has special knowledge and skills about services and the contracting government (a principal) do not have full information about the vendor's performance. In this context, the agent tends to exploit its information advantages and pursue its interests at the sacrifice of the principal's stake. To prevent opportunistic exploitation, the public sector has to establish rules or mechanisms to allow for constant monitoring of vendors' performance. Incentive and punishment clauses are also effective to govern vendors' behavior (Domberger and Jensen 1997).

The less competitive market can also undermine the outcomes of contracting-out. Effective markets, where multiple service providers are competing for a deal, allow contracting officers to obtain information about prices and service quality of vendors and facilitates penalizing vendors if they fail to meet contract requirements. Further, competition for contracts helps overcome the principal-agent problems described above by promoting transparency in the market and making monitoring of vendors' performance easier (Brown et al. 2006). Conversely, no or less competitive environments will likely exacerbate the information gap, encouraging a vendor to manipulate the contracting government.

Finally, managing competing goals among stakeholders plays a fundamental role in determining the returns from contracting. A public/private alliance often presents the challenge of goal incongruence between the governments and their contractors. Generally speaking, private organizations focus on maximizing profits while the public sector pursues an often diffuse set of public interests, such as equal service distribution for all citizens. So, contracting vendors can be tempted to cut corners if not appropriately monitored (Hefez and Warner 2004). Moreover, the existence of powerful interest groups within public organizations is also crucial to contracting outcomes. If public employees are against outsourcing, as they often are, the prospects for contracting may diminish because they are often politically active and influential on government actions (Ferris 1986).

In summary, contracting out of service delivery yields desired outcomes when: 1) the public and private sectors can specify their rights and duties in a contract by closely collaborating from a contract creation phase; 2) contracting governments can agree on project goals with vendors at the beginning and monitor vendor performance through effective contract management; 3) the market maintains competitive environments; and 4) project members on the public side can manage internal stakeholders who may have competing interests with the project. As these conditions indicate, the public sector's management capacity determines the fate of a public-private venture to a considerable extent. Thus, scholars suggest that the public sector should maximize contracting benefits by investing and strengthening its management capacity (Joaquin and Greitens 2012; Brown and Potoski 2003a; Brown and Potoski 2003b; Ya Ni and Bretschneider 2007).

As reviewed in this chapter, there is a growing number of conceptual analyses of the future direction of the MaaS market and the public-private alliances for MaaS service provision. However, the existing research rarely examines how such collaboration between the public and private sectors works well in the MaaS field, largely due to the newness of the service in the market. Concepts require empirical support to extract meaningful lessons that help both parties to build a mutually beneficial partnerships.

To fill this gap, this study aims to provide empirical evidence drawn from case studies covering the recent MaaS programs promoted by the American public transit agencies. In examining lessons learned from the ongoing MaaS initiatives in the US, I draw evidence-based conclusions about how public transit authorities can effectively partner with private companies to bring about more equitable, efficient, and sustainable urban transportation systems in the future.

3. Methodology and data

This study employs both an extensive literature review (above) and case studies (detailed below) that combine published information from transportation authorities on their Mobility-as-a-Service (MaaS) programs as well as in-depth interviews with people who work in those programs. Given that no empirical research on public-private alliances in the MaaS field is available to date, I employed this qualitative methodology to explore the following:

- MaaS project goals
- Critical factors for the implementation of MaaS programs (mobility services or an open payment platform), including effective collaboration with private technology companies
- The role of public transit organizations in the future MaaS market
- The ideal partnership model between the public and private sectors to promote mutually beneficial MaaS programs

3.1. Literature review

MaaS is still at the early stages of development and has only started to be implemented over the past four years. As with other innovative transportation services, its novelty poses challenges for transportation scholars interested in researching the impacts of MaaS on urban travel behavior and overall transportation networks (Clewlow and Mishra 2017). With no historical literature available, I explore recent studies and market analyses conducted by both academic and consulting researchers to provide an overview of the current market situation and the potential impacts of MaaS on the urban transportation network.

3.2. Case studies: Sampling methodology

The objective of this study is to extract lessons learned from recent MaaS pilot programs carried out by public transportation agencies partnering with private companies in North America. Therefore, the primary sources of data collection in this research come from the United States, where more than 6,700 organizations currently operate shared surface transportation services of various modes (American Public Transportation Association 2018). Of the large number of organizations across the US, just eleven are participating in the Mobility on Demand (MOD) Sandbox program funded by the Federal Transportation Authority (FTA). Founded in 2016, the program aims to test innovative technologies, develop new business models, explore partnerships, and integrate transit and MOD solutions (Federal Transit Administration 2017). I list the participants of this federal program in Appendix B.

I chose the MOD Sandbox program because it is the first public-sector-driven initiative to promote innovative transportation technologies through public-private alliances. Thus, these

organizations have more experiences in public-private partnerships in the MaaS field than others. Furthermore, FTA requires the participating agencies to publish their progress reports quarterly, which enabled me to understand the current project status and issues before conducting interviews.

To examine whether it is in the public interest for transit operators to own and operate a MaaS platform, I focused on organizations that met at least one of these two criteria:

- The organization is developing a platform for trip planning, payment consolidation, or mobility service data integration.
- The organization is integrating its MOD service with a payment or a trip planning platform.

Consequently, I selected the following three transit agencies and their MaaS and payment platform development projects:

- Los Angeles County Metropolitan Transportation Authority (LA Metro):
    - Tapforce open payment platform development
    - On-demand mobility service development to solve first/last mile issues
- Dallas Area Rapid Transit (DART):
    - Integration of GoPass payment platform and ride-sharing services to meet first/last mile travel needs
- Tri-County Metropolitan Transportation District of Oregon (TriMet):
    - Hop FastPass payment platform development
    - Open trip planning platform development to enhance connectivity

These three organizations stand out as front-runners in open payment platform deployment (Federal Transit Administration 2017). Their new account-based payment system will serve as a critical foundation for a future public-driven MaaS platforms because it enables them to integrate any mobility services via Application Programming Interfaces (APIs). Furthermore, consolidating payment of different modes into single payment touchpoint will free users from the tedium of multiple ticket purchasing procedures when making multimodal trips. With these expected benefits in mind, LA Metro, DART, and TriMet each developed new payment platforms in cooperation with technology companies.

3.3. Interviews

Interviews were conducted from November 2018 to February 2019. With the help of King County Metro team, I arranged an interview with eight people in total, seven officials from the selected organizations and with one person from a private mobility technology company. Because all respondents in this study are promoters of MaaS initiatives, their views might be

biased toward pro-MaaS compared to other officials in the transit agencies. Thus, I draw inferences from the interviews with caution.

The interview panels from the transit authorities included three executive directors, two deputy directors or vice presidents, and two staff members. The representative of the mobility company was involved in public partnership programs. I conducted interviews by phone, which typically lasted between 15 and 40 minutes, during which time I asked from three to six questions of each interviewee. I recorded, transcribed, and analyzed my in-depth interviews for their content.

Drawing on previous research, I designed interview questions on their projects and public-private alliance strategy. The questions were open-ended but structured (the number of questions and exact words varied in each interview).[4] The questions are listed in Appendix C.

While all the organizations are still in the midst of working out a MaaS collaboration strategy, all respondents answered the questions and shared their thoughts and experiences. In chapter 5, I analyze the interview results and identify crucial factors to implement a MaaS solution or platform which would be beneficial for both the public and private sectors. I also address questions about MaaS platform ownership and an ideal partnership model to inform successful MaaS development.

In this study, all interviewees were promised anonymity. Throughout this report, names and directly identifiable information have been omitted to ensure confidentiality and the protection of the respondents. In the case study discussion in chapter 5, I cite comments and views of interviewees by referring to them by number, such as;

- LA Metro: Interviewees #1, #2, and #3
- DART: Interviewees #4 and #5
- Tri-Met: Interviewees #6 and #7
- A private mobility company: Interviewee #8.

[4] I did not ask the first question to a person working for a private firm because she was not involved in the targeted projects directly.

4. Case studies

This chapter provides an overview of Mobility on Demand (MOD) programs and account-based payment solutions implemented by Los Angeles County Metropolitan Authority, Dallas Area Rapid Transit, and Tri-County Metropolitan Transportation District of Oregon.

4.1. Los Angeles County Metropolitan Transportation Authority

Los Angeles County Metropolitan Transportation Authority (LA Metro) was founded in 1993 after a merger of Southern California Rapid Transit District and Los Angeles County Transportation Commission (Barret 2014). As a regional transport authority, it oversees transportation planning, policy development, and transit service operations in Los Angeles County, transporting about 1.3 million passengers daily (LA Metro 2019a). The agency also funds local transit operators in the county as well as paratransit programs to continuously improve regional transportation accessibility (LA Metro 2019c).

In 2018, LA Metro published its next 10-year strategic plan to achieve a world-class transportation system that will efficiently and equitably serve the mobility needs of people and business in the county. The strategic plan consists of five goals that together advance the agency's mission:

1. Provide high-quality mobility options that enable people to spend less time traveling;
2. Deliver outstanding trip experiences for all users of the transportation system;
3. Enhance communities and lives through mobility and access to opportunity;
4. Transform Los Angeles County through regional collaboration and national leadership;
5. Provide responsive, accountable, and trustworthy governance within the Metro organization.

Of these five strategic goals, the first encourages LA Metro to partner with private companies to explore more travel options that will meet increasingly diverse mobility needs in the 21st century. By promoting the use of high-capacity mass transit, active transportation, and sharing rides, the organization aims to absorb the anticipated growth in travel demand while mitigating traffic congestion and pollution across the region (LA Metro 2018).

In this context, LA Metro started its MOD program funded by the FTA Sandbox in November 2016. In 2018, the organization unveiled the alliance with Via, an on-demand van sharing service operator, to provide a first/last-mile solution to local customers.[5] In January 2019, LA Metro and

[5] LA Metro partners with Central Puget Sound Regional Transit Authority (Puget Sound) in its MOD program funded by FTA. The combined project originally proposed to work with Lyft. However, due to the goal incongruence between the transit agencies and Lyft, LA Metro and Puget Sound switched to Via, a much smaller firm that was willing to do more tasks than Lyft was willing to do.

Via launched a pilot program to offer shared rides to three selected LA Metro rail stations: North Hollywood, El Monte, and Artesia. In areas near these stations, customers can request a ride by using Via's app or calling over the phone, and Via matches riders with other requesters going to the stations. LA Metro ensures that the service is shared, affordable, on-demand, and accessible to any customers, including people with a disability, a wheelchair, and service animals. LA Metro partially subsidizes the fare using the FTA Sandbox grant to make a ride more affordable than other ridesharing services. In particular, customers participating in the agency's low-income fare program can use the service for free. To encourage Tap card use in the region, LA Metro sets different prices for Tap card users and non-users: Riders using Tap cards can ride for $1.75 while the cost for riders without Tap cards is $3.75 (LA Metro 2019b).

The development of an account-based payment platform also helps LA Metro upgrade customer experience by improving connectivity across transport services. The Tap card system, which was launched in 2007 with Cubic Transportation Systems, currently offers a contactless smart card solution to 25 local transit operators in the county. According to the LA Metro Tap team, the Tap card transaction volume reached 24 million per month in 2016, with over 1.5 million transit passes and $7 million of stored value sold per month (O'Hara 2016). In 2018, the agency launched a new feature called "Tapforce" with Salesforce to transition to an account-based system, which integrates all information into a personal account "Tap wallet" and provides a one-stop shop for payment and sign-ups across all mobility services, including transit, ride-hailing, car sharing, bike sharing, rental scooters, and parking (Descant 2018b). As a first step, the Metro bike share program started to accept payment by Tap card in October 2018 (Descant 2018c). The Tap team also plans to launch a Tap mobile app in 2019, which will offer multimodal trip planning using a Global Positioning System (GPS) and virtual Tap card issuing on the phone (Interview #2).

What makes the Tapforce system unique in the US is its development approach. According to the interview #2, while many metropolitan transit authorities, such as New York, Chicago, Austin, and San Francisco, are building whole new systems to adopt an account-based architecture, LA Metro makes use of the existing system and layers on new features provided by Salesforce on top of the legacy system. The Salesforce layer connects the Tap system through Application Programming Interfaces (APIs), and LA Metro has a middleware that enables both systems to communicate. By adopting this hybrid approach, LA Metro could launch the open payment platform much faster than other organizations, some of which have faced technical issues when implementing promising, but unproven systems. In addition to the shorter development period, LA Metro can add new features at a much lower cost than others. For example, transit authorities in New York and Chicago have spent at least $500 million to replace their entire payment systems. In contrast, the LA Metro Tapforce add-on the TAP card system cost less than $1 million (Interview #2).

Furthermore, Tapforce is expected to boost equity by allowing unbanked populations to pay by cash to top up their accounts at ticket machines or at more than 2,000 stores joining a PayNearMe network in Los Angeles County. This cash option in the system plays a crucial role in enhancing accessibility to app-based MaaS options among economically disadvantaged groups as most MaaS providers require users to pay by a credit/debit card. Tapforce fills this gap by layering on private companies' systems, while enabling Tap account holders to pay for services with their Tap wallets. As noted, LA Metro's mission is to provide a world-class transportation system that enhances the quality of life for everyone regardless of his/her socioeconomic status. Toward this ambitious goal, Tapforce is expected to play a pivotal role in both ensuring transportation equity and expanding high-quality mobility options (Musulin 2018).

The MOD and Tapforce programs are collaborating to transform how LA Metro provides mobility to local communities. Facing a rapid expansion of new transport services and devices over the past decade, some people in the agency began to advocate for a shift in focus to customers and their mobility needs in LA County. As will be discussed later, adopting innovative solutions through a public-private alliance is one way to test a new approach to shaping future mobility networks.

4.2. Dallas Area Rapid Transit

Dallas Area Rapid Transit (DART) was created in 1983 to operate buses, light rail, commuter rail, streetcars, paratransit and vanpool services, and high-occupancy vehicle lanes in the Dallas-Fort Worth Metropolitan region of Texas, the seventh-largest in the US with a sprawling expanse of more than 7.8 million residents (US Census 2017a). As of 2018, the agency transports more than 220,000 every day across its 700-square-mile service area (DART 2019).

Despite its extensive network of buses and rail, many residents face challenges in using the system, due to the enormous, sprawling nature of the region. One study shows that nearly 28 percent of local residents and 24 percent of jobs located within the DART service area are more than a quarter-mile from the closest transit stop (FTA 2018). Because of the first/last-mile problem and car-oriented urban design in Dallas, particularly in its many suburban areas, most people who can afford to own a car and drive do so, resulting in heavy congestion in peak hours. Furthermore, a slight increase in a car ownership (from 89.8% in 2015 to 90.9% in 2016) in the metropolis may be causing a decrease in transit ridership (US Census 2017b).

To overcome these challenges, DART started a Mobility on Demand program in 2017 with funding from FTA, which aims to integrate the existing transit network with new mobility services, such as TNCs and bike share, by leveraging its GoPass ticketing app (FTA 2018). This integration will allow DART customers to access multiple mobility options in one app and plan for seamless door-to-door travel without relying on private vehicles. By weaving private

mobility services into the regional public transportation system, DART seeks to make travel by means other than driving easier, more convenient, and stress-free. (Interview #5).

DART is currently partnering with multiple private companies in developing a feature of multimodal planning, including technology companies for app enhancement and payment integration (Unwire, DoubleMap, PayNearMe), TNCs (Uber and Lyft)[6], local bike share providers, and taxi companies. In February 2019, the agency launched a one-year pilot program with a TNC, providing customers living in target areas with discounted shared rides to and from the closest transit hubs. By leveraging innovative solutions, DART MOD team hopes that the authority can attract not only less affluent transit-dependent populations but also nudge choice riders, who are more likely to be wealthy, to take transit more often than they usually do (FTA 2018).

As shown above, the GoPass app plays a pivotal role in DART's future MaaS strategy. The app was initially launched in 2014 to reduce the administrative and operational cost of handling cash as well as to provide a cashless payment option to passengers. As a one-stop shop for the various transit agencies in the Dallas-Fort Worth region, including DART, Trinity Rail Express, Trinity Metro, and the Denton County Transportation Authority, the first generation app enabled customers to buy a ticket instantly on the phone with a credit/debit card, store and view prepaid digital tickets on the app, and plan transit trips. Consequently, the app could appeal to a diverse and vast audience, according to a DART Progress Report (DART 2015)

Building on the favorable market reactions to the first generation, DART enhanced the app and launched GoPass App 2.0 in 2018 through the FTA's MOD project (Thomas 2018). As mentioned earlier, the second generation advanced the seamless integration of mobility options to provide greater convenience to customers. However, the GoPass evolution will not stop there; DART staff are also working to open an app-based mobility ecosystem to cash-paying customers by adding an account-based e-wallet feature like LA Metro Tapforce does. Thus, with GoPass accounts, users could pay for TNCs with GoPass Tap cards, even if they do not have a credit card or a smartphone. The continual updating of its app will promote not only better usability, but also better social inclusion in the future mobility ecosystem.

4.3. Tri-County Metropolitan Transportation District of Oregon

Since its founding in 1969, the Tri-County Metropolitan Transportation District of Oregon (TriMet) has served the Portland metropolitan area in the State of Oregon. It operates buses, light rail lines, commuter rail lines, and paratransit services, and in addition manages the Portland streetcar system owned by the City of Portland. In 2017, its transit system transported about

[6] DART has collaborated with Uber for a first/last-mile access to transit stops and stations since 2015, allowing GoPass app users to hail a Uber driver via the GoPass app (Jeffe 2015).

271,200 passengers per day. In line with the majority of public transportation operators in the US, TriMet has been experiencing a continuous ridership decline since 2014 (TriMet 2018a).

In order to improve transit usability and enrich mobility options in areas where a bus or train alone does not provide full access, TriMet started OpenTripPlanner Shared-Use Mobility (OTP SUM) project in 2017 with funding from the FTA Sandbox program. The project goals are to: 1) incorporate shared-mobility modes, such as TNCs, bike share, and car share, into TriMet's existing trip planning system; 2) include data about pedestrian infrastructure to improve walking accessibility to and from transit stations; and 3) build a non-proprietary and non-restrictive geocoder in order to lower barriers to entry for public transit agencies to offer trip planning services. By promoting alternative transportation forms with the multimodal trip planner, the agency hopes to reduce driving as well as increase accessibility for transit users (TriMet 2018b).

The OTP SUM project is currently developing the features mentioned above in collaboration with technology companies, including OpenStreetMap communities (open-source geocoder), Conveyal (multimodal open trip planning designer), and moovel North America (multimodal trip and payment app developer). Consequently, the team expects to add an open multimodal planning function to its payment app "Hop FastPass app" sometime soon so customers will enjoy a seamless journey without owning a vehicle (Interview #7).

Along with the MOD project, TriMet launched an account-based, open payment platform in July 2017 to make transit fare payments easier and stress-free. Collaborating with INIT (a backend system developer of the e-fare solution) and moovel North America (mobile app developer), the agency created an open platform that connects any third-parties' systems and applications via open APIs. Thanks to this flexible architecture, the agency can provide riders with a variety of payment options, ranging from a prepaid smart card charged with cash at a ticket machine or grocery store, to a contactless bank card and a smartphone with a virtual Hop card or mobile wallet (Google Pay, Apple Pay, and Samsung Pay). As a result, passengers no longer have to handle multiple tickets or miss a train to buy a ticket before boarding (Herron 2019; INIT 2017; Interview #6).

In addition to greater convenience, the Hop FastPass system offers daily and monthly fare capping so customers do not have to worry about spending more than needed to take transit. When riders pay fares with a Hop account, the system counts total amounts spent in a day or a month. For example, after paying two trips for a day, customers automatically earn a day-pass, and the rest of the rides become free until the next day. This fare-capping feature is particularly beneficial to lower-income people who often struggle to pay upfront costs of a monthly pass.

In short, as the first transit organization in the US to fully implement open payments, real-time fare calculation, and fare capping, TriMet has been pursuing not just a first-class customer

experience with the latest technology, but also equity by offering cost-saving opportunities and a cash-payment option (Altstadt 2019; Interview #5). Incorporating shared mobility modes into the Hop payment platform through the OTP SUM program may further advance both usability and social inclusion and thus make transit more attractive to a wider range of the population.

5. Discussion of findings

In this chapter, I present the interview results, which build on the three case studies in the previous chapter. In what follows, I consider the following research questions:

1) What motivates the agencies to develop Mobility-as-a-Service (MaaS) and open payment platforms with private entities?
2) What conditions help the agencies achieve expected outcomes?
3) What challenges have they faced in carrying out their programs?
4) Based on their experiences, what roles and responsibilities do they think transit agencies should take in the future mobility ecosystem in order to protect the public interest?
5) How should the public and private sectors collaborate in such endeavors in the future?

Through my analysis of the interview results, I identify key success factors for their MaaS initiatives and extract some insights into a future role of public transportation operators and their alliance strategies.

Overall, the respondents recognized that their projects were still in experimental phases, and all said that it was too early to judge whether their MaaS initiatives would bring expected results. Despite the limited results to date, however, analyzing the lessons learned from their experiences so far may provide a useful guide for other transportation authorities that want to explore the opportunity to deploy MaaS programs to meet customers' needs.

5.1. Project goal

My interviewees collectively reported on four key objectives for their projects: 1) equity, 2) connectivity, 3) increasing ridership, and 4) experience accumulation. I consider these each in turn.

Equity
The first and most frequently mentioned goal of their MaaS programs is to enhance transportation equity, in particular by expanding access to new mobility services. As discussed in chapter 2, most shared mobility services are not accessible for those without a smartphone and a credit/debit card.

To overcome this gap, LA Metro, DART and TriMet have developed an account-based payment platform, which enables cash-paying customers to store money in their accounts either at ticketing machines or affiliated shops and pay for mobility services with their smart cards. One interviewee at TriMet said:

> *We can take care of unbanked people. We have more than 500 locations for charging values to a Hop account by cash. And theoretically, in the future, a stored-value transit card will also pay for any of your mobility rides, TNCs, or e-scooters. So we are a gateway for cash-paying customers. That is important. And it is not something that other vendors bring into our established network. (Interview #4)*

To make MaaS more inclusive, several of those I interviewed suggested that their organizations needed to push private partners to figure out a way to make their services accessible and to ensure that benefits from these new solutions are distributed equitably among a broader cross-section of the population.

Better customer experience through connectivity

Overall, the second most frequently-cited goal of the MaaS projects is to improve customer experience with better service connectivity. The current transit system lacks connections with other modes, such as bike share, car share, taxis, and ride-hailing. Due to the fragmented service network, many transit-dependents, most of whom do not own a car, have trouble completing the first/last-miles of their trips and moving about in areas with limited transit services. As such, planners in all three organizations examined here are seeking to integrate all transportation services into one mobile platform in order to centralize billing and trip planning across modes and companies.

LA Metro, for example, is currently working to incorporate multiple mobility services to build up an extensive mobility network across the region. Likewise, DART is integrating their mobile ticketing app, GoPass App, with private mobility services to allow customers to plan and use options that best fit their needs. Interviewee #5 from DART put it this way:

> *[O]ur vision was that we would integrate these services into a single app, which has different modes like Uber and bikes and a payment method, to be able to pay for these first and last mile services as well as transit services. [....]. [O]ur goal is that users have a choice, allowing competition to let various providers, let's say taxis, TNCs, or scooters, to provide a better price or quicker response time. Competition will drive a better product to end users. (Interview #5)*

Increasing Transit Ridership

Building on connectivity goals, interviewees also collectively sought to increase transit ridership by making alternatives to driving more attractive through their projects. Since 2014, transit ridership has been declining across the US, and LA Metro, DART, and TriMet are not exempt from this. Some of the interviewees in this study discussed that TNCs and other emerging shared mobility options might help reverse this trend because these on-demand services can help

improve accessibility of fixed-route transit. One caveat is that there is no research consensus on whether TNCs are reducing transit use or increasing it ―although there is general agreement that the effects of TNCs over time, both positive and negative, are likely waxing as their use spreads geographically and temporally. The general lack of information on TNC use makes it difficult to answer this question, though it likely encourages transit agencies to conduct pilot programs with private mobility companies in order to evaluate their impacts on transit ridership.

For instance, DART-affiliated interviewees #4 and 5 argued that on-demand share services could feed the public transit network and expand its catchment area if collaborated with effectively. Through its MOD project, the agency aims to attract those who rarely or never take transit, most of whom live in suburban areas. In the program, DART defined zones with poor transit service, where people could access a shared ride service subsidized by DART to get them to the closest stations. By limiting service areas, the program encourages customers to use Uber for the first mile or two of the trip and use transit for the remaining leg of the journey, rather than using Uber for the entirety of the trip. The interviewees mentioned that this alliance would enable DART to increase its market share by enticing a larger audience into their transit network without increasing the bus service frequency and routes.

Experience / learning opportunity

The final objective common across the three organizations is a need to learn how to work effectively with private partners in order to design and deliver integrated and mutually beneficial mobility services. Unlike traditional transportation services, like bus and rail operations, new mobility services are primarily developed and operated by fast-growing technology companies. By leveraging ubiquitous connectivity and data, they adjust service supply in real time, frequently modify service and business models, and expand their coverage overnight, often without asking for legal permission (Nurrall et al. 2018). Partnering with such emerging companies in the digital era presents a challenge to public transportation organizations as their approach to service development and market penetration is far different from the private technology firms. As a staff at TriMet put it:

> *That [MOD] project helped us understand the whole picture of how to work with private companies. The most important goal of this project is to help us understand more about what this project means to us and what it would take us to make this [MaaS] happen. It is much harder to understand exactly what it does take to make this [MaaS] happen and to get an agreement in place. (Interview #7)*

Unsure of how the mobility market will evolve, my interviewees emphasized the importance of opportunities provided by the MOD Sandbox to understand issues and to inform their future MaaS strategy. In exploring a partnership with various private entities, they hope to find a way to harness the potential of MaaS in regional transportation networks.

5.2. Critical factors to implementing MaaS solutions with private partners

Through my interviews, I identified four factors that played a crucial role in designing and launching MaaS solutions with private partners: 1) support from top executives, 2) effective vendor/contract management, 3) organization structure, and 4) knowledge spillover.

Top executives' commitment to projects

As the contracting-out theory predicts in chapter 2, most respondents agreed that internal stakeholder management, especially support from board members and executives, had a crucial impact on their project outcomes. In the interviews, respondents mentioned that people in transportation organizations are likely to resist changes and new initiatives, especially when a new project might take passengers from the existing transit lines. In this context, approval from the top management makes it easier for project leaders to justify their initiatives and ask for support from other departments when needed. For instance, all the interviewees from LA Metro pointed out that an important factor in allowing them to deploy MaaS initiatives is leadership. Without the current CEO and his commitment to changing the organization, they believed that LA Metro would not be able to push its innovative pilots.

Some interviews also revealed that the payment platform development projects were less likely to face internal opposition than other MaaS projects. The reason for this difference may be that, for the payment platform, expected benefits are more visible than mobility services, such as efficient fare collection and enhancing connectivity across modes. For example, interviewee #2 at LA Metro stressed that the project to build the Tapforce platform secured support from the board members representing jurisdictions across LA County as well as the LA Mayor's office without any problems.

On the other hand, MOD programs tend to confront opposition within their organizations, in particular from union members, because these projects often switch on-demand micro-transit services over to TNCs, thus threatening the job security of paratransit drivers. Indeed, interviewee #5 from DART acknowledged that some board members questioned the strategy of promoting MaaS due to intensifying objections from the union. While it is not easy for the MOD project members to secure support from paratransit drivers, another interviewee at DART emphasized the importance of showing a prototype of future products to let members of the executive team understand potential benefits, saying:

> *Piloting is a big piece. Piloting would actually enable you to see our products on our platform, having them reviewed and buying out our executive teams. That made us successful so far. (Interview #4)*

Effective vendor/contract management

Consistent with the contracting-out theory I reviewed in chapter 2, vendor and contract management capabilities were also essential to bring about desired results when working with partners. The interviews suggested that the same three actions were especially effective components of their MOD programs: 1) to clarify vendors' duties and service outputs in a contract by leveraging vendors' technology knowledge; 2) to agree on project goals before signing a contract; and 3) to demonstrate the possibility of sanctions if vendors do not comply with a contract.

First, as discussed earlier, public agencies often face an incomplete contract problem when drafting a contract for mobility solutions or IT systems. The FTA's MOD Sandbox Demonstration helped LA Metro to overcome this issue. Based on the demonstration directives, LA Metro was able to adopt a collaborative approach to contracting by working alongside the private mobility partner to design a scope of work and negotiate a contract to support the scope. In the standard procurement process, transit authorities lay out details for contracted services and ask private firms to submit proposals. This works well for infrastructure development projects or outsourcing transit operation because the deliverables and tasks to complete them are well know; however, this model does not work if the agencies do not have expertise in services for which they are contract contracting. The collaborative approach undertaken by LA Metro, discussed above, addresses this problem.

This approach bears similarities to the Unsolicited Proposal Policy developed by LA Metro Office of Extraordinary Innovation (OEI), which encourages private firms to propose services that would help LA Metro achieve its goals. If the agency wants to implement proposed ideas, companies work with OEI to do so (though it may not be with the original proposing company). Conceptual (Phase I) and detailed (Phase II) unsolicited proposals can help OEI inform its approach, which will influence its solicitation and, ultimately, its contract. OEI also uses tools developed in major capital Public-Private Partnerships to increase private sector involvement, get the private sector engaged earlier in projects, and incentivize their performance.

Additionally, this new approach has brought another benefit to LA Metro. The new procurement method eliminates the Request-for-Information and Request-for-Price phases of the procurement process. As a result, the agency can speed up project development and increase the number of potential MaaS projects in its pipeline.

Secondly, the interviews revealed that projects were most likely to achieve expected outcomes when public agencies and contractors agreed on the project goals and contractual conditions prior to the start of the project. Of course, it is not easy to find a common goal between the public and private sectors because both parties often have different objectives. To address this

problem, interviewees suggested that close communication before signing a contract helped the transit agencies to at least understand the one another's motives in order to come to some level of consensus.

The case of TriMet Hop FastPass development explains why it is important to clarify non-negotiable conditions with vendors before starting negotiations. When contracting a system vendor for the Hop FastPass system, TriMet staff made clear that it would hire a private company to develop a back-end system and APIs, but TriMet would own the system and make it open to the public.[7] Although many private companies hesitated to lose the property rights of their products and the future business opportunities they might entail, TriMet held its line throughout the process. After tough negotiations with candidate companies, the agency contracted with a vendor, INIT, to write and design the backend account system and APIs that could make the system available to the public. By publishing its data and encouraging third parties to develop transit-related services, TriMet reached a larger audience than it would have otherwise. With the genuinely open architecture, the agency ensured that the benefits from the advancement in technology were brought to the public.

Last, transit agencies should be capable of monitoring their suppliers' ongoing performance and penalizing them for unsatisfactory performance. The TriMet Hop FastPass project, again, offers a good example. As mentioned above, TriMet owns the backend system and APIs so that it can hire different companies to add new features or operate the platform without talking to the backend developer. Interviewee #6 from TriMet explained why the agency did this:

> *[T]he system integrator, our backend provider, could not hold us hostage going forward. We hope to continue to have a great relationship with them, but if we don't feel that they are performing well, we can keep with the existing system and hire another vendor to maintain the APIs or we can bring someone to enhance it. [...] We accepted the system and still have the vendor accountable for the system. We have a service level agreement in which we require the vendor to maintain APIs if they don't work. We have set up KPIs to measure the performance of the system and the number of errors that can be acceptable. (Interview #6)*

By separating the ownership of the system from the vendor, TriMet implicitly signals contractors that it can switch companies at any time if the suppliers' performance does not satisfy the contract. This embedded sanction system in the contractual relationship is effective at preventing vendors from taking advantage or breaking their contract. Additionally, such a flexible relationship with suppliers fosters competition in the procurement process, which also makes vendors more honest and productive in their jobs in order to win another contract in the future.

[7] TriMet has a long history of supporting an open-source and open data. The agency has published their transit operating data online since 2005 (McHugh 2013).

Failure-tolerant culture and new organization

In large, established organizations, innovation often encounters resistance and fails before accomplishing anything. Even if an organization hires people with an innovative mindset, it is not easy for them to change the culture of an entire organization. Setting up a separate entity inside an organization is one solution to address this challenge. LA Metro, for example, established OEI in 2016 to explore new ideas and technologies to improve mobility in the region. The office has a direct reporting line to the CEO, who started the office, and has been empowered in a number of ways: specific functions, assigned budget, a high level of visibility both externally and internally. Interviewees #3 and #8 agreed that it is important to create a safe space for innovative ideas inside a transit organization. Indeed, pushback to changes from employees at LA Metro regularly happens, and people outside of OEI are often reluctant to take risks given the frequently high sanctions for failure in the public sector. To mobilize cooperation from those skeptical about the potential of MaaS, OEI takes risks and responsibility for the failure of new initiatives, so it does not fall principally on other LA Metro departments.

Knowledge spillovers

Transit agencies were originally designed to operate trains and buses; thus, most of them do not have the skill sets in-house to manage and develop technology-driven MaaS solutions. TriMet overcame this technology skills gap by bringing IT and Geographic Information System (GIS) teams to the meetings with private partners for their MOD project (Open Trip Planner development). These two departments have considerable knowledge and experience in open-source and data-related contracts (more than ten years), so they could help the MOD team lead the data discussion and draft the agreement with the private partners. Thanks to their contribution, their MOD project did not need to establish everything from scratch and could cut down the time needed to reach a consensus with partners.

DART and LA Metro took a different approach to access technological knowledge. In addition to the IT department, both agencies also relied on private partners who had good relationships with them from previous projects. For example, DART has been working with a mobile ticketing provider Unwire for the GoPass app development. Because of its rich experience with mobile apps, payment solutions, and digital platforms, the company helped DART find partner candidates and evaluate new transport players in the market. Given that the software is continuously changing, it is essential that transit authority leaders grasp the latest technological innovations accurately to make informed strategic decisions. Having a knowledgeable partner on board is one way to supplement their capabilities.

The FTA also provides valuable assets to transit agencies interested in doing MOD pilots, such as a framework on how to partner with technology companies and a knowledge-sharing portal across public organizations. By making use of these assets provided by other organizations,

public transportation agencies can reduce the risks of failures and uncertainty associated with new MaaS programs.

5.3. Challenges faced in the projects

Although I reviewed some positive aspects of the public-driven MaaS programs in the previous section, the interviews also revealed some challenges that transit authorities must overcome to promote MaaS solutions without sacrificing the most vulnerable populations.

Skills set gap
Aware of their limited ability to manage MaaS, my interviewees emphasized that public officers should learn technology and business trends both on their own and through their partners, so they can figure out a way to deal with new services more proactively in the future. The accurate understanding of the current mobility landscape and a clear vision of the future MaaS ecosystem are crucial for policymakers and transit operators to design regulatory frameworks and update regional transit networks in ways that improve regional accessibility as a whole.

Managing divergent public and private goals
Despite the values conflict between the public and private sectors, both parties need to work toward a consensus. Unfortunately, in the MaaS field, most of my interviewees said that the private partners did not have a good understanding of how transit operates and why working with transit agencies requires time-consuming procedures. A staff at LA Metro put it, referencing her experience with Via:

> *Public agencies have a process that ensures transparency. It can be also difficult for our private partners to understand. [...] [P]rivate companies are not familiar with the processes that public agencies are required to do. The process has been a new experience for via, so LA Metro needs to educate them. (Interview #3)*

One interviewee from TriMet agreed with this view, saying:

> *Educating the private sector on how transit operates is the biggest challenge. It is a very different business model. It is totally a different mindset, but it does not mean that the public sector and the private cannot work together. (Interview #6)*

As mentioned above, having a different mindset does not necessarily mean that both parties cannot work together for common goals. Indeed, LA Metro and Via successfully built a strategic partnership in 2018, through which they serve customers who need rides to and from nearby stations. As interviewee #3 at LA Metro clarified, in this deal, Via expects to expand its customer base in Los Angeles more quickly by using LA Metro's brand, while LA Metro looks for a reliable on-demand mobility, which can be booked both online and by phone as well as by

accepting payment by credit and debit cards. Continuous dialogue between two parties on the business model, service design, and pricing—subsidized by LA Metro—allowed them to reach the consensus needed to launch a year-around pilot program.

Nevertheless, it is not easy to create a mutually beneficial business model, especially financially. Since most innovative transportation companies are young and small in size, they are likely to be financially vulnerable, even if venture capitalists back them. Without a solid financial foundation, they are mostly concerned with whether working with the public sector will eventually bring monetary rewards in the medium or long term. Of course, not all companies expect only a financial return from public-private partnerships, and each firm has different leadership and strategy to penetrate target markets. However, as long as they are a private enterprise, creating a profitable business is mandatory to remain in the market. Interviewee #8 from a private mobility company expressed the view that the public and private actors need to find a way to share risks and costs associated with a project, so that not all the liabilities are transferred to private partners.

Disagreement over data sharing policies

Another controversy arises regarding data sharing policies. Not every private company is willing to share data, especially customer information and service-use history. Thus, disagreements over data are common in public-private MaaS projects. In such situations, it is essential for the public sector to clarify why they need to acquire and publish private provider data to best serve the public. However, interviewee #7 from TriMet pointed out that in many cases, the public sector is not sure about what data are helpful and meaningful for them to improve the quality of public services. In the TriMet Open Trip Planner project, a vague understanding about data on the public side sometimes hindered negotiations for data sharing agreements.

Furthermore, interviewees from DART brought up another data issue facing the organization. Interviewee #5 found that technology companies, especially TNCs, oppose to a data sharing agreements because they are concerned that by giving data to the public sector, their customer base and other confidential information could be shared somehow with competitors. Because of this skepticism about the public data sharing scheme, TNCs do not provide detailed data about trips and fleet locations to the degree that DART would like them to. He described the situation in this way:

> *TNCs perceive that customers that would generate their core information are their customers, that is 'our customers.' And they want to protect their customers from competitors in the name of data protection. (Interview #5)*

To solve this issue, DART promotes the full integration of all mobility services into the GoPass App to collect data from TNCs and other mobility providers through APIs. However, this

approach raises another challenge: technologies that DART needs to have to make this happen belong to TNCs, and they do not make these assets available to the agency in the current contractual relationship. DART is continuing to discuss this issue with TNCs in an effort to reach a consensus; however, if there is no neutral and secure data platform that ensures data confidentiality, private companies may see little reason to share their customer information with the public.

The lack of an adequate regulatory framework

Creating a new regulatory framework on MaaS presents another challenge to transit authorities. Currently, there are no regulations or industry guidelines for defining the roles and responsibilities of MaaS providers, including service level requirements, safety and insurance standards, and compliance with the Americans with Disabilities Act (ADA). This loophole in the legal system allows emerging mobility providers to offer more convenient services at a lower cost than taxis and more convenient services at somewhat higher cost than transit. It is true that consumers appreciate better and cheaper travel options; however, in the face of the rapid boom of shared mobility options, observers warn that this unfair competition resulting from uneven application of the law will adversely affect transit ridership as MaaS becomes more popular among a broader population (Flores and Rayle 2017; Rayle et al. 2015; Schaller 2018). As such, my interviewees collectively expressed the view that the public sector needs a set of rules that will not only protect consumers from market failures, but also encourage MaaS operators and private vehicles to prioritize the most space efficient mode—mass transit—in busy traffic corridors.

Need to update business operations to adapt to market changes

If transit agencies want to embrace innovations in their transport networks through cooperation with private partners, updating their business operations to follow technological trends is crucial to an alliance outcome.

The TriMet Hop FastPass created new payment transaction rules and business operations to adopt a Europay, MasterCard, Visa (EMV) standard, a global standard for cards equipped with computer chips and technologies to authenticate transactions. In a transit use case, a card transaction (authentication and authorization) should ideally complete in 500 milliseconds (0.5 seconds) so that customers can touch and go through a gate with their phone using a credit card in a mobile wallet. However, when TriMet kicked off the project, 500 milliseconds were much shorter than the typical card transaction norm, and furthermore, multiple rules did not allow instant payment authentication for various security reasons.[8] To overcome these challenges, TriMet staff spent 18 months and countless meetings with the card companies and vendors involved in payment operations to update a set of rules and guidelines for a transit use case. With

[8] The authentication process entails various procedures to ensure that a transaction is not fraudulent in order to protect cardholders as well as merchants (Kagan 2018).

new rules and operations customized for the latest technology, TriMet Hop FastPass freed users from a tedious ticket purchasing regime and made taking transit easier and faster than before.

5.4. Role of transit agencies in the future MaaS ecosystem

My interviewees expressed uncertainty about how transit agencies should redefine their roles and shape the future MaaS market in a way that achieves public policy goals. However, I was able to draw three lessons from the interviewees' experiences to inform future policy in this area. First, as discussed previously, a cash-accepting payment platform owned by public organizations can enhance mobility access for unbanked and digitally marginalized populations.

Another insight is that transit authorities and local governments can take a more active and assertive roles in guiding the MaaS market evolution. They sometimes intervene in markets to fix or avoid market failures. While private enterprises drive the current MaaS market, there is a room for the public sector to exercise influence on the market conditions through regulations and regional transport planning guidelines. For example, some local governments in California, like the City of Oakland, have successfully guided scooter providers toward equally serving lower-income neighborhoods by using a permit system, which allows companies to do business if they meet the city's transportation principle (Nelson 2018; Rudick 2019). As this example shows, governments and public transport authorities can encourage MaaS companies to get aligned with broader transportation policy goals by utilizing their power to govern public space.

Then, how should the public sector regulate MaaS ecosystems? Interviewee #8 from a private mobility firm said that public transit agencies should not only define the roles and responsibilities for private sector MaaS players in the market but should also identify where public transit can surpass other modes in transport efficiency as mass transportation. Such principles will also allow the public sector to define the future regional transportation system that they want.

Lastly, the interviews revealed diverse views and opinions about the ownership of the MaaS platform. While some interviewees said that MaaS platforms need to be owned and controlled by transportation authorities, others were less certain that the authorities should focus scarce resources on these technologies. For example, interviewees from TriMet were interested in an idea that transit agencies would control a MaaS platform to optimize regional traffic while acknowledging some challenges associated with that. One interviewee from TriMet put it this way:

> *In the best scenario, the regional public entity is an ideal integrator of all these modes. A challenge will grow as private entities team up and offer multiple modes. Their way to set up is not generally going to be making decisions solely based on the public good. That is a struggle currently going on inside public*

> *agencies, even if public agencies make statements that they believe in MaaS and want to provide MaaS, and will be an integrator of multiple modes. But the challenge really is having us leverage capability to do that. (Interview #7)*

Another interviewee at TriMet pointed to the neutrality of public authority when thinking about who should own a MaaS platform, saying:

> *We can manage platforms where people can use to plan travel. Theoretically, we are a trusted entity. We can be a sort of an arbitrator for revenue settlement between companies. (Interview #6)*

DART has adopted a similar position to TriMet, arguing that a public transportation authority should join the MaaS market and lead data integration of all mobility services in its service region. Interviewee #4 at DART emphasized the importance of adapting to changes around them, referring to another industry's case:

> *It is a kind of a story of Blockbuster vs. Netflix [...]. When streaming services became popular, Blockbuster did not look at the technology that they were facing. So, Netflix conquered the market. Considering this example, as a transit agency, we know that mass transit is not going anywhere, but it's going to be heavily influenced by all these changes and software, and things are coming out. So, if we don't say that new thing is happening in Mobility as a Service, we're going to get invested behind. That is how we see them to fail. (Interview #4)*

Conversely, a staff of LA Metro was more cautious, questioning whether the organization should aggressively invest in a skill set required to be a MaaS platformer. As she put it:

> *In order to be an entity that is able to develop and operate a kind of a platform, it is required to have a skill set to do so. It is not sure yet if LA Metro is the best to be equipped and manage it. Regarding MaaS, it requires some kinds of many different modes which might compete. OEI is having a discussion on how to optimize transportation and be aware of conjunction with these different types of modes. (Interview #3)*

In addition to the capability gap problem, another LA Metro interviewee (#1) was also concerned about the risk of a monopoly. He stated that if the public-owned MaaS platform dominated all the traffic information collected from service providers, it could harm competition and limit customers' choice, thus lowering their welfare. For this reason, he speculated that a public-operated MaaS platform might coexist with privately managed MaaS platforms regulated by the local authority.

5.5. Ideal partnership models

The public sector adopts the public-private alliance for the benefits that arise from the combination of public and private resources, such as complementary skills and knowledge, synergy, and economies of scale. Public agencies have the credibility and power to regulate economic activities, whereas private companies are good at technology development and innovation needed to improve our life. Therefore, collaboration of both sectors is expected to bring better outcomes to them as well as society by supplementing each other.

Interviewees report that they are still exploring how to partner with private companies to successfully provide mobility services as well as develop MaaS platforms. Interviewee #3 from LA Metro shared her insight into the potential alliance strategy based on her experience with Via. In the MaaS area, each side of the public-private partnership should take on the risk and responsibility that the other is unequipped to handle: small startups need the public sector to take on more financial risks, but the public sector needs these startups to distribute services equally across a city even though expanding geographic coverage sometimes adversely affects the bottom line. For this reason, she suggested that the conventional contracting-out model would not work well when working with mobility service providers. Policymakers and transport authorities can be more creative in setting up a partnership that would help both entities reach their goals.

Conclusion
The success factors and obstacles clarified in the interviews suggest that transit agencies may need to transform themselves in response to changing circumstances required by MaaS. In such uncertain market environments, a better understanding of technology and market may help agencies fine-tune their strategies and effectively update regulations. Case studies also illustrate that local governments and transit agencies need a new set of rules to mitigate negative externalities of MaaS while ensuring better mobility access for those without car access.

Finally, as to the question of alliance strategy, the interviews suggest that the traditional contracting-out model is less likely to work for mobility services, primarily due to its low output specificity, which prevents the public agencies from defining a clear statement of work and evaluating contractors' service performance. Thus, if the public sector seeks to develop and manage MaaS with private partners, we need a new alliance framework that allows for a win-win relationship for both the public and private parties.

6. Implications for practice

This chapter discusses implications for both policymakers and transit authorities seeking to maximize the potential of MaaS to enhance accessibility and reduce vehicle dependency. I present three possible directions—organizational transformation, new regulation development for MaaS, and strategic partnership building—that the public sector could consider in designing their future MaaS strategy.

6.1. Organizational transformation

Some public transit operators are making use of the Federal Transit Administration (FTA)'s Mobility on Demand (MOD) programs to explore their next steps in the Maas arena. There are two potential scenarios for them. First, if they find that the benefits of MaaS to their transit network are unclear, it may be better for them to take a wait-and-see strategy. Or second, if they conclude that emerging mobility services and technologies can help them achieve their goals, they may want to actively promote collaboration with private firms to implement new services. Whichever path they take, the public sector should understand these technological trends and their impacts on travel behavior and regional transportation systems in order to fine-tune their strategy.

Organizational transformation entails acquiring technology knowledge, creating failure-tolerant culture encouraging to learn from failures, and redesigning business operations to allow testing new solutions. First, transit agencies can effectively influence the direction of a MaaS market, which is currently driven by the private sector, by augmenting their technical and market knowledge. As discussed in the previous chapter, this knowledge will help the agencies assess the impacts of new services and take actions to minimize their negative externalities. Furthermore, the understanding of technological trends and consumer needs will enable the agencies to evaluate proposed solutions and design services that users appreciate.

This suggestion does not mean that transit organizations should become like Transportation Network Companies (TNCs). TNCs are technology companies whose competitiveness comes from having sufficient numbers of drivers and passengers and the quality of the matching algorithm—matching drivers and riders more efficiently and calculating faster routes depending on real-time traffic. Thus, they hire high-skilled engineers to innovate at a faster pace than competitors. In contrast to TNCs, transit agencies typically do not develop innovative systems in competitive markets. As a result, I argue that the agencies should have adequate expertise to quickly and accurately understand what happens in the mobility landscape in order to guide innovations to benefit broader populations in society. To do so, they should learn from their own experiences as well as those of other agencies and then adjust their strategy as situations demand. As revealed in the case studies, transit agencies can not only utilize their private assets (their IT

and GIS departments' capabilities) but also leverage their partners' technical expertise in the sourcing and project development processes. In addition to the internal resources, transit operators can also access other agencies' resources through the FTA, including frameworks tools used in the MOD Sandbox programs. By tapping these opportunities, transit agencies and policymakers can familiarize themselves with the latest technological trends.

While institutional capacity building prepares public agencies to incorporate innovative ideas, understanding technological trends and new business models is not sufficient to implement MaaS programs. The second component of organizational change is to encourage learning from failures. It is not easy to identify which MaaS solutions will meet local travel needs the most in the future. In such situations, betting on a specific service without evidence entails significant risk of wasting resources (Manville and Osman 2017). A trial-and-error approach will skirt this danger by allowing public agencies to test the potential of new mobility services in a real-world setting before they officially implement them with a partner.

The trial-and-error process is often described as "PDCA cycle"—Plan, Do, Check, and Action—, in which organizations plan a concept, test the idea, review and analyze the effects of the idea, and apply lessons learned to a next action so they can continually improve their services (Johnson 2016). The most important point in the PDCA method is to encourage organizations to tolerate failures in order to learn from them so they can acknowledge which solutions work in a real-world environment. As such, the team should be allowed to try and fail until it finds the best solution to meet the organization's' goals. If the prevailing institutional culture does not have tolerance for failure, creating an independent entity inside the existing organization can open a room for a new culture to grow.

Nevertheless, establishing a new entity is not enough; top executives should protect the entity so it can try new things without worrying about sanctions. In general, public officials and politicians avoid risks of failure because one mistake may occasion high political costs, which can ruin careers. Hence, the public sector is more likely to avoid testing new ideas than in private firms (Hikichi and Beimborn 2006; Wilson 1989). Cultivating a new failure-tolerant culture is not easy, especially for established, large organizations like metropolitan transportation authorities (McGrath 2011). However, to judge if new solutions might help them achieve their goals, transit agencies should create spaces for trial and experimentation in order to learn from both success and failed cases. If the majority of employees are risk-averse, the top executives' commitment to change ensures that a new team can try innovative services without concerns about penalties.

The LA Metro Office of Extraordinary Innovation (OEI) offers a good example of how creating a new group under the CEO can drive change inside a giant public organization. Established by the CEO in 2016, LA Metro OEI is responsible for experimenting with innovative solutions to make regional mobility more accessible and sustainable. The CIO who leads OEI once shared

that he learned a lot from previous mistakes, which helped OEI understand which solutions and ideas worked and why (LA Metro OEI 2018). As this case shows, an independent entity with top executives' support can provide a safe space for innovative ideas and failures, thereby encouraging constant improvement of services in response to changing market needs.

The last component of organizational transformation is operation redesign. When public transportation authorities pilot new technologies or solutions to improve their service usability and accessibility, they can maximize the benefits from these changes by reforming their business operations simultaneously. For example, as noted earlier, LA Metro's new procurement procedure, the Unsolicited Proposal, enables OEI to be exposed to more innovative ideas than it could solely with conventional procurement processes. Since 2016, OEI has received 117 proposals and reviewed 114 concepts, of which 5 projects have completed a proof of concept to test the effects of the services (LA Metro OEI 2018). By revising the process, the agency could not just expand the opportunities to trial promising but unproven solutions, but also utilize private companies' capability through a joint program development. As a result, the new procedure shortened sourcing cycle time, thus accelerating learning from experiments.

However, process redesign is not an easy task. Sometimes transit agencies alone cannot reform business operations just because they do not have the authority to do so. For instance, in the public sector, procurement operations are in many cases controlled by local governments. Thus, regional transportation operators cannot launch initiatives like LA Metro's Unsolicited Proposal process. In this case, they need to involve local governments to revise the existing process or propose delegation of procurement authority to them. Whichever path they take, it takes time to implement new operations. Moreover, even in the LA Metro, the introduction of the Unsolicited Proposal was a long and bumpy road. One LA Metro member told me in the interview that the procurement reform had faced fierce opposition from colleagues when developing Unsolicited Proposal framework (Interview #1).

In summary, case studies in this research suggest that transit agencies and policymakers should take steps to prepare themselves to respond to changes. Especially, the public sector should have adequate knowledge about emerging services and capability to evaluate them. Organizational transformation described above will broaden the possibilities for public organizations to be active players in the market, and not passive victims of advances in technologies driven by private companies.

6.2. New regulatory frameworks for MaaS

Knowledge of new technology and consumer demands also helps local governments and regional transit agencies to inform new regulations for MaaS. As mentioned earlier, no one can easily predict how MaaS will unfold in the next decade. Under such uncertainty, local governments and transit agencies should not focus too much on future prediction when designing regulations;

instead, they should adopt an outcome-based approach to the policymaking. This approach emphasizes what a particular policy or program achieves; for example, lower vehicle miles traveled (VMT) or universal access to MaaS services regardless of economic and physical conditions can be an outcome. Having defined the outcomes, an outcome-based system enables transit agencies and policymakers to identify indicators which assess how well a new policy achieve these goals (Kristensen, Groszyk, and Buhler 2002).

According to a recent study, attempts to predict the innovation outcomes tend to lead to significant and costly errors because in many cases, those forecasts have been incorrect throughout history (Manville and Osman 2017). As such, organizations' betting on a particular scenario may risk wasting resources. An outcome-based approach helps policymakers and transit agencies avoid this unfortunate consequence. By determining ultimate goals first, authorities can account innovations taking many forms, as their goals remain constant. So, the public sector should start from outcomes they want and work backward from these goals to identify policies that will help steer MaaS players in that direction. Otherwise, policies favoring a particular technology without an end in sight may have an unexpected consequence as did automobiles in the US, with car supremacy a central feature of urban life (Manville and Osman 2017).

Local governments and public transportation authorities may pursue different goals. For local governments, these can be to enhance accessibility while reducing carbon emissions from transportation. For public transit operators, alternatively, their goals can be more related to their business—increasing transit use rates (or ridership) and equal service provision for all. They can agree on broad goals, such as increasing regional mobility and promoting more sustainable modes; however, once they get to operational objectives, their targets may likely conflict with each other. For example, in spread-out suburban neighborhoods with few transit services, local governments would prefer to support TNCs to provide local residents with an on-demand mobility option although this proposal may decrease transit ridership. Despite the contradictions described, both government officials and transit agencies need to design a policy tool to achieve the mobility landscape they want. So, how should they identify appropriate policies that steer the MaaS market toward these defined goals?

In industries profoundly affected by technological development, such as cryptocurrencies and autonomous vehicles, regulatory authorities across the world began to take an adaptive approach to legal reform so that they could find a regulatory sweet spot where public and private interests were balanced. The adaptive approach allows implementation of laws to begin before all major uncertainties are solved, with the policy being adapted over time based on new knowledge. In other words, in an age of constant and disruptive innovation, lawmaking and regulatory design need to abandon a focus on finality and legal certainty; instead, they should embrace contingency, flexibility, and openness to new ideas and unexpected events (Marchau, Walker, and Duin 2008; Fenwick, Kaal, and Vermeulen 2017). Because the adaptive approaches

encourage trial and error in real-world environments, it offers faster feedback loops than the conventional lawmaking process, which in general takes months or years. More rapid and frequent feedback loops, in turn, enable regulators to frequently evaluate policies against set standards, feeding inputs into revising regulations (Eggers and Turley 2018).

Local governments and transit agencies can utilize two legal tools to rethink regulations for MaaS. The first is a so-called "soft-law" approach. This is comprised of a variety of non-binding norms and techniques, including "instruments or arrangements that create substantive expectations that are not directly enforceable, unlike 'hard law' requirements such as treaties and statutes" (Marchant and Allenby 2017 p112). According to this explanation, soft laws can cover industry self-regulation, guidance, codes of conduct, and third-party certification. While not legally binding, the soft-law framework has two advantages over hard laws when thinking about emerging technologies. Firstly, given that soft laws are not promulgated by the government, their informal nature allows regulators to modify them quickly in response to changing circumstances and address issues as they arise. Secondly, the soft-law system helps decrease rule-making time and costs on the public side by asking private companies to create rules and guidelines based on the governments' instructions. In this case, regulators just need to define the scope of issues to be addressed and develop broad principles. Then, industry leaders establish their standards and codes of conduct in a way that they are aligned with the government principles (Eggers and Turley 2018).

Finland offers an example of how a soft-law approach can be applied to the transportation field. In 2017, the Finnish government created a new transportation code "The Act on Transport Services" covering taxis, transit, roads, and goods transport. In the face of digitalization of urban transportation, Finnish officials recognized the need to reform the existing regulatory framework that strictly regulated each sector separately, thus preventing multimodal trip planning. To create an integrated transport system of different services, the government decided to remove those old laws and establish a new code that incorporates all mobility modes into one piece of legislation. The new Act provides a framework for a more efficient arrangement of passenger transport, such as open data requirements and system interoperability. By defining guidelines covering all transportation sectors, the government aims to level the playing field for different modes and achieve their MaaS vision in the real world. The Act is currently being drafted in three phases and will be updated periodically (Ministry of Transport and Communications of Finland 2017; Eggers and Turley 2018).

The second tool that the public sector can use to implement the adaptive approach is "regulatory sandboxes." Regulatory sandboxes help regulators understand new technologies and collaborate with private firms to develop appropriate rules for emerging products, services, and business models. The private sector, including both startups and established companies, can also benefit from sandboxes, as they can launch and test new ideas and technologies in a live environment.

The idea behind the sandbox is to provide a safe space for innovative products and services without being forced to comply with the applicable set of regulations. With this experimental environment, lawmakers seek to foster innovation by lowering legal barriers and costs for testing emerging technologies, while ensuring consumer safety (Jenik and Lauer 2017; Eggers and Turley 2018).

The financial industry has seen a rapid increase in the adoption of sandbox programs all over the world. In particular, the United Kingdom has been a pioneer in the use of sandboxes to develop new legal frameworks. Its Financial Conduct Authority (FCA) started the first regulatory sandbox for the financial technology or fintech industry in 2016. Eighteen firms offering the fintech services participated in the program to test their products and business models in the market, with the appropriate consumer and investor safeguards. After a one-year sandbox program, the FCA found that the sandbox approach encouraged fintech startups to develop business models that mitigated risks for consumers, as well as facilitated investor funding due largely to reduced regulatory uncertainty (Jenik and Lauer 2017; Eggers and Turley 2018). By creating a live laboratory, the FTA could not only gain detailed feedback from service providers, consumers, and investors, but also promoted innovations in a safer environment than ever before.

6.3. Strategic partnership

As discussed earlier, the contracting-out model less likely fits new mobility services for several reasons. First, as a result of the public sector skills gap, defining service specifications (output) of MaaS solutions becomes more difficult than the conventional transit service. Case studies in this research revealed that the public sector can solve this issue by asking private firms to define new service concepts and specifications together; however, for most of regional transportation authorities without such formal or informal networks, drafting a contract for share mobility services without partners' help will incur high costs to gain information.

Second, for mobility services it is more difficult to evaluate service quality than with transit services. When outsourcing a part of their service to private companies, transit agencies set Key Performance Indicators (KPIs) to be aligned with their goals, so contractors are guided in the same direction. For instance, most of the bus contracts include a punctuality rate, customer complaints per boarding, bus revenue collection rate, and the number of major defects, to name a few (Randall, Condry, and Trompet 2007). In contrast, the contributions of new mobility services to transit agency's goals are uncertain because they may not directly increase transit ridership through their service. So, if transit agencies contract with a TNC to replace or supplement their existing services, they can only set indirect KPIs, such as the number of passengers taking rideshares to/from near transit stations. In other words, the means of measuring performance is unclear. Unfortunately, the impacts of these new services on transit networks are unclear as well, so transit operators (and transportation scholars) are not sure how these services should be evaluated.

A third reason is a goal gap between transit agencies and mobility service providers. Unlike commonly outsourced services where contractors replace local governments to offer the same service (e.g., bus operation, waste management), MaaS players, when contracted, do not provide the same functions that contracting transit agencies provide. TNCs, for instance, offer on-demand shared rides by using a sedan or van (usually supplied by freelance drivers), but do not operate fixed-route buses. Because of this difference, service goals of TNCs tend to diverge from those of transit operators. Furthermore, private enterprises are less likely to agree on goals with the public sector if doing so will adversely impact on cash-flow.

In the contracting-out framework, both parties have little chance to communicate in a project development phase. As discussed in the chapter 5, this lack of communication, especially about business models and data sharing policies, is a principal reason for goals mismatches and negotiation deadlocks. In order to avoid project failures, transit agencies should establish dialogue as a place to compromise with private firms on data and business models.

The last issue is the high costs of new capability acquisition. Transit agencies do not have the skill sets needed to develop MaaS service specifications and evaluate proposed ideas in a procurement process. One potential way to fill this capability gap is to hire technical specialists, but it may be costly if the services and technologies they invest will not be a mainstream in society. Given that their resources are finite, they should not waste scarce money in anticipation of events that may not occur.

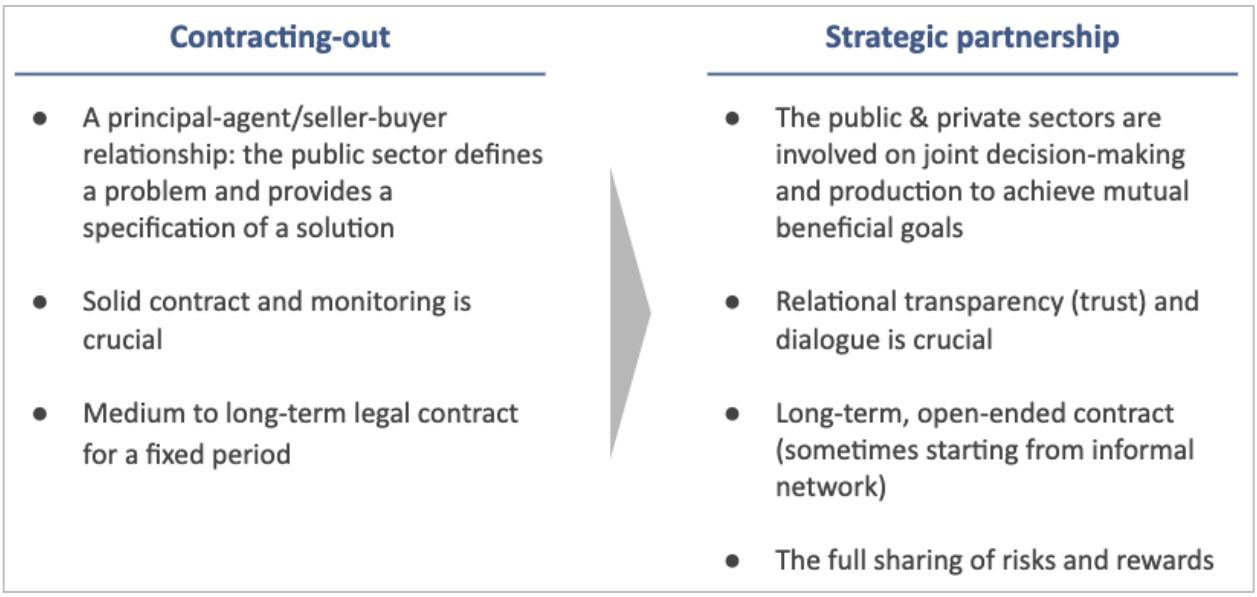

Figure 6.1 Comparison of a contracting-out model and a strategic partnership model
(Author-made chart based on Skelcher 2005)

All factors listed above hinder transit agencies from adopting new mobility services. To overcome these challenges, they should consider strategic alliances rather than sticking with the contracting-out model. As described in Figure 6.1 above, strategic partnerships differ from contracting in three ways. First, a contractual relationship is characterized as a seller-buyer relationship, and the former has to do everything from problem settings to service specifications. By contrast, when both parties are in a strategic partnership, they communicate often and decide how to develop a project jointly. Second, as a large body of research clarifies, in the traditional contracting-out cases, vendor management is crucial to successful project management (Brown and Potoski 2003 a; Brown et al. 2006; Domberger and Jensen 1997; Prizzi 2001). On the other hand, because strategic partnerships do not necessarily entail legally binding contracts, they emphasize trust and a continuous dialogue among stakeholders. The third difference is the timeline of a relationship. A contracting-out model usually involves a mid- to a long-term legal contract, which is effective for a fixed period. So, if the contract is not renewed, the partnership is also dissolved. Alternatively, a strategic alliance assumes a long-term, open-ended contract, which often starts from informal networks. As such, public agencies and private firms can maintain a connection even when they are not in a contractual relationship.

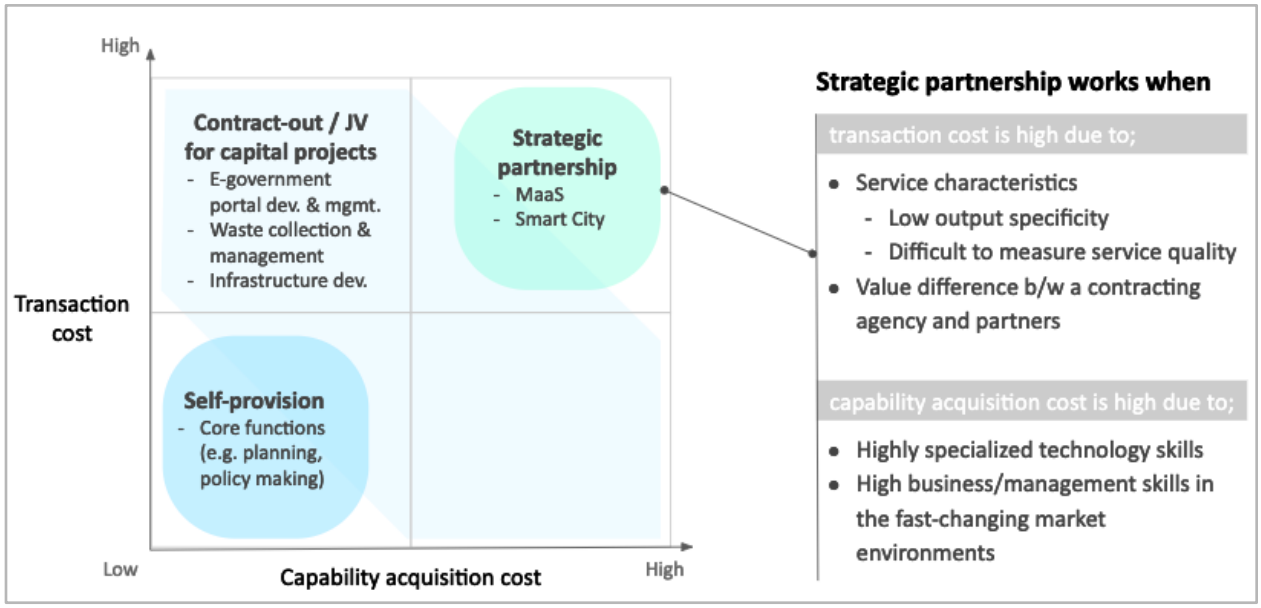

Figure 6.2 Conceptual framework of potential approaches to public-private partnerships
(Author-made chart)

While the strategic partnership model can solve issues inherent in the contracting-out model, the best approach to public-private alliances may vary depending on the nature of services private partners provide. Figure 6.2 lays out the conceptual relationship between contracting-out and strategic partnerships in terms of transaction costs and capability acquisition costs. Transaction costs represent costs associated with the exchange of goods and services in the market, covering information costs, enforcement costs, and bargaining costs (Brown and Potoski 2003b). The

information costs include the costs incurred when looking for relevant information and meeting with agents to carry out a trade, whereas the enforcement costs represent the costs associated with ensuring that parties in a transaction do not break a contract. The bargaining costs are the costs related to reaching an agreement with parties involved in the deal and drafting a contract (Brown and Potoski 2003b; Skelcher 2005). Another axis is capability acquisition costs, which consist of monetary and time costs needed to gain skills and knowledge for the service provision.

When both the transaction costs and capability acquisition costs of a given service are low, it is rational for the public sector to provide the service directly. On the other hand, if both costs are so high that the total costs associated with the deal exceed the expected benefits from a project, a strategic partnership may work best.

I argue that MaaS projects fit a strategic partnership model because their transaction costs are likely to be higher than other services due to their low output specificity (high information costs), difficulty in measuring service performance (high enforcement costs), and a difference in priority (high bargaining costs). Furthermore, because the market is full of uncertainties due to rapid technological change, the development and assessment of MaaS solutions require high technical and management skills. In short, a strategic partnership provides a means of reducing both transaction and capability acquisition costs, thereby enabling transit agencies to try these new services more easily than before.

The benefits of the long-term strategic partnership are not limited to cost reduction. Strategic partnering also provides an infrastructure of cooperation across sectoral boundaries. This foundation of informal and formal networks can stimulate communication among stakeholders and lower the hurdle to reach an agreement. I will now present how a strategic partnership can influence the public-private collaboration in MaaS programs, using cases of joint project development, data sharing policy, and business model planning.

Firstly, long-term partnering makes it easier for transit agencies to adopt joint project development in a procurement process. Figure 6.3 below illustrates how a service development (sourcing) process in strategic partnering contrasts with that in a contracting-out model. Unlike the contracting-out approach, a strategic partnership allows transit agencies and private companies to be in an informal relationship before signing a contract, enabling both to access each other's assets (e.g., capability, knowledge, regulation-making discussion) throughout a service planning process. By fully leveraging available resources in a network or a consortium, joint project development not only encourages skill/knowledge exchange and enhances mutual understanding but also shortens the time to the market. LA Metro OEI's procurement process is close to this model although it does not create a consortium.

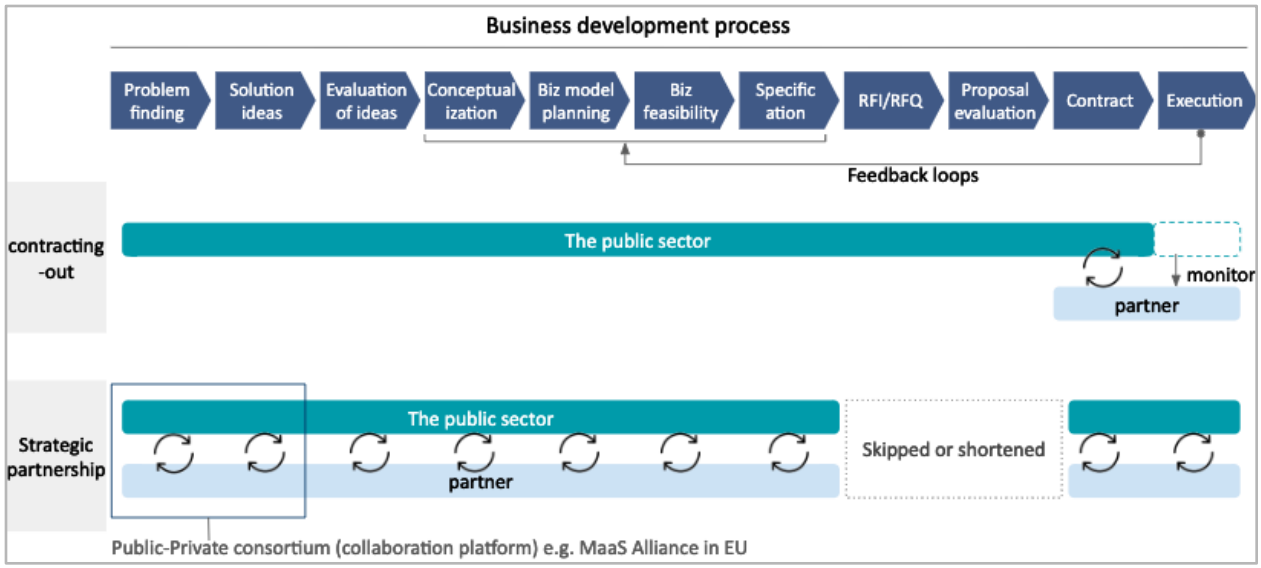

Figure 6.3 Business flow in a contracting-out case and a strategic partnership case
(Author-made chart)

Secondly, building trust through a long-term relationship may resolve the conflicting motivations of stakeholders. Continuous dialogue with private companies helps public agencies find a compromise regarding a data standardization and data sharing policy. In Europe, for example, municipal governments, transit operators, and MaaS operators formed a Mobility-as-a-Service Alliance, a public-private consortium, to create a standard for the European MaaS market. The organization is proposing a regulatory framework, including data standardization, for full deployment of MaaS services across Europe (MaaS Alliance 2019).

The US has also seen the progress in terms of data agreements. Los Angeles Department of Transportation (LADOT) became the first municipality to sign a data sharing contract with electric share scooter companies in November 2018. Jump (under Uber), Lyft, Lime, and Spin partnered with the transportation data platform Remix to share standardized data with LADOT that they collected during a one-year scooter pilot program. In this case, both public and private sides successfully agreed on what data to be handed over for what purposes by communicating closely. By utilizing data, LADOT will examine how dockless scooters are used to inform policy decision whether to make the scooter pilot program permanent and where they should increase bike lanes and racks across the city (Pyzyk 2018). Even though ride-hailing services are not incorporated in this data platform, this example suggests that an informal network or a consortium with MaaS companies will activate data discussions, enhancing the prospects of the public-private data sharing agreement.

The last example is business model development. As noted previously, in a strategic partnership model, the public and private sectors contribute their skills and assets to a joint project and complement each other to achieve the common goals. They also decide how to share rewards and

risks jointly. If the program goes well and generates profits, both parties gain monetary return from the venture; however, if it fails to attract customers, both parties take on debts. In today's private-public partnerships in the US, no case fully shares risks and rewards, because public agencies cannot operate programs for profit, nor can they take on high financial risks (Interview #3).

Figure 6.4 describes one potential business model based on the LA Metro's pilot program with Via (slightly modified by the author). In it a transportation authority and a partner can exchange both monetary and non-monetary resources through a program. In a financial form, for example, the public side may subsidize programs (capital and operating costs) as well as specific customers eligible for public support, whereas a private partner develops a platform, provides vehicles and drivers, and runs the service. At the same time, in a non-monetary form, the public sector may offer its political power (permits and public space regulations), brand/credibility, and low-cost funding due to the tax exemption in exchange for customer data and technological and management capability of the partner. In return for these contributions, each program compensates each party, either through monetary rewards, project experiences, new skills, or customers' feedback relevant on the service quality.

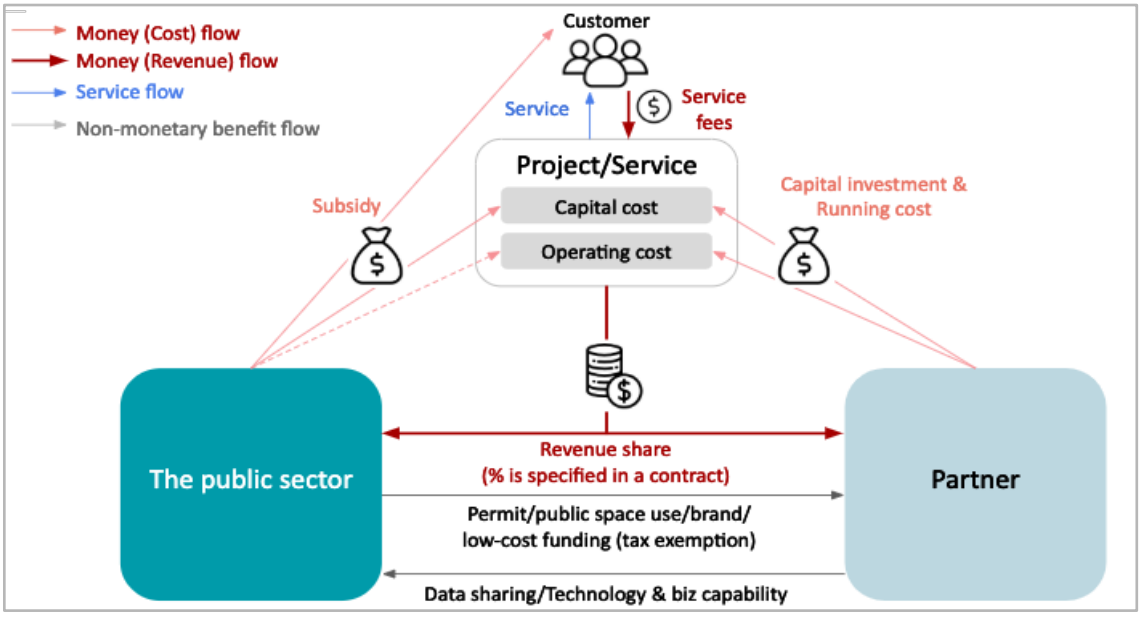

Figure 6.4 Example of a business model for a joint program
(Author-made chart based on the LA Metro and Via case)

Conclusion

This chapter presented potential directions that transit agencies and local governments could take in the next decade to better serve local travel needs. Institutional transformation, new regulation planning, and strategic partnering might solve some issues facing transportation authorities in their MaaS initiatives. However, we should not draw hasty conclusions. Because MaaS is still a

new technology, its effects on transit services and travel behaviors are not yet clear. So, obviously we need further study to determine if MaaS will help transit agencies to achieve their goals of increasing mobility options, making transit more convenient and reliable, decreasing travel costs without a car in a region, and thereby, increasing the relative cost of solo driving. Likewise, the implications discussed in this chapter also need further empirical evidence to examine if they are effective in maximizing the benefits of MaaS while preventing its negative consequences. If regulations of MaaS, for example, can guide private mobility companies and users toward the public goals, transit agencies might not need a public-private alliance. Unfortunately, the currently available data do not suggest which scenario may occur in the near future.

7. Conclusion

This study analyzed MaaS programs promoted by the three transit agencies in the US: Los Angeles County Metropolitan Transportation Authority (LA Metro), Dallas Area Rapid Transit (DART), and Tri-County Metropolitan Transportation District of Oregon (TriMet). In facing the rapid technological change, these three organizations are exploring the potential of MaaS to improve transportation equity and increase mobility in their service areas with the cooperation of the private sector. Although their programs are still in the middle of the experimentation phase, the interviews with the project members revealed that executives' commitment to pilots, effective contract management, an organization having a failure-tolerant culture, and knowledge spillover played crucial roles to move their projects forward. However, and simultaneously, respondents discussed issues that they had to overcome in advancing their MaaS visions, including lack of technical and business knowledge about MaaS, divergent goals between the public and private sectors, disagreement over data sharing, rigid legal frameworks and operations that did not fit the market trends. These lessons suggest that acquiring new knowledge, restructuring the organization, and updating operations may help transit agencies respond to the changes more quickly and proactively.

Further, the interviews also indicate that the MaaS industry needs a new policy framework to prevent or avoid certain negative externalities, such as excluding economically and physically vulnerable populations from the app-based service networks. While broader transportation is mostly outside the control of transit operators, they can still influence a legal structure by leveraging their first-hand MaaS experiences. In policy discussions, local governments and transit agencies would be wise to start from the outcomes they want—an equitable and efficient transportation system where mass transit works as a backbone. Clarifying transport system goals and transit's core service areas helps the public authorities find out where and how they should incentivize private MaaS players to fulfill unmet travel needs.

Finally, this research explored the potential of strategic alliances for future MaaS initiatives. MaaS's characteristics—low output specificity, difficulty in measuring service performance, and conflicting goals of various stakeholders—makes it hard for transit operators to define service specifications and draft contracts by themselves. Formal or informal dialogue with private firms can not only bridge the skills gap but also enhance the mutual understanding needed to find common interests among stakeholders. Proposing a strategic partnership does not suggest that transit agencies should not own their MaaS platforms; instead, they should carefully evaluate the benefits and costs of developing their own platforms based on information obtained from partners and their MaaS experiments.

MaaS is still in the early stages of development, and its business feasibility remains an open question as most companies in the industry have yet to become profitable, including the largest

players: Uber and Lyft. As such, there is a possibility that MaaS might end up being a short-term tech bubble spurred on venture capitalists. The public sector should recognize the uncertainty surrounding the industry and evaluate its benefits and costs based on the facts found in their pilot programs, and not on speculations about future technology evolution.

Appendix

A. Future scenario of MaaS platform evolution

While a variety of MaaS platforms have debuted around the world, the Arthur D. Little Future Lab (2018) categorizes market development scenarios into three patterns at a city level as shown in Figure A.1. Key differentiators between them are the owner of the platform (especially the backend), the degree of a public transportation agency's control over the platform, and the openness of the platform to third-party mobility vendors.

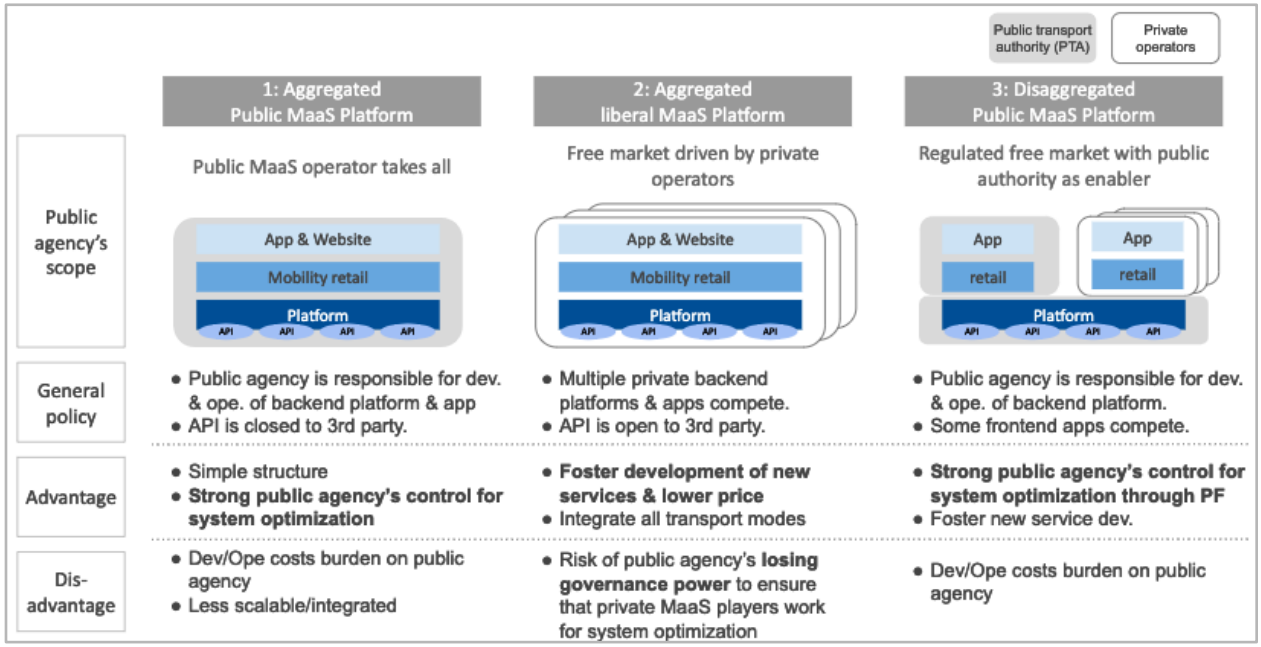

Figure A.1 MaaS platform market evolution scenarios
(Author-made chart based on Arthur D. Little Future Lab 2018)

The first scenario is a publicly-controlled MaaS ecosystem, in which a public transportation agency is responsible for the development and operation of its system. The transit agency likely designs a unique platform based on its regional needs and control regional transportation. Under this scenario, third-party services are usually aggregated to the platform under conditions favorable to the public transportation agency (e.g., data disclosure to local governments). A distinct advantage of this pattern is robust public control over the MaaS platform, which allows city officers and transit agencies to promote transit usage through an itinerary planning and flexible fare pricing algorithm. Nevertheless, this public-takes-all model has some downsides. First, the public transportation agency has to bear the cost incurred from platform development and operation. Second, a public-driven initiative may fail to implement a multimodal MaaS concept if private transportation providers do not join the platform (Arthur D. Little Future Lab 2018). In the global context, Hannover (Germany) and Dubai (UAE) follow this scenario.

The next scenario contrasts the first one: The private sector competes in a free market. In this liberal scenario, multiple privately-owned platforms and frontend apps compete for more users and integrate both public and private mobility services into their platforms through open APIs. The market-driven approach will likely benefit consumers by broadening mode choices and lowering travel cost through competition. However, without adequate oversight by public agencies, private MaaS platforms would likely prioritize profits and may not serve public interests (e.g., the safety of service users). Similarly, if private MaaS providers always gave priority to ridesharing or taxi-hailing over public transit in trip planning, MaaS would end up reducing transit ridership and increasing car usage (Arthur D. Little Future Lab 2018; Smith et al. 2018). MaaS Alliance, a public-private collaboration initiative from Europe to create a common approach to MaaS, is promoting a market-based scenario in the hope of implementing a single and open market MaaS platform globally. Currently, Uber, Cubic, Via, moovel, MaaS Global, and some European city governments and transportation agencies lead the initiative (MaaS Alliance 2019).

The final scenario is a regulated free market. There are multiple frontend apps provided by private companies, but public transportation agencies control a backend platform, which is open to third-parties through APIs. As such, the whole MaaS system can keep a competitive environment while regulating private companies' acts that may run counter to public interests. This hybrid pattern of the first and second scenarios is currently in place in Vienna (Austria) and Gothenburg (Sweden) (Arthur D. Little Future Lab 2018). LA Metro is also pursuing this market scenario with its new cloud-based payment platform, Tapforce. LA Metro staff imagine the future of the region's transportation with the flexible MaaS fare system controlled on a backend system. For example, LA Metro can incentivize people to take discounted alternative modes rather than driving a car on a bad air day (Meeting of the Minds 2018).

B. The Mobility on Demand Sandbox projects

The Federal Transit Administration (FTA) funds eleven projects across the US as of February 2016.

State	Project sponsor	Project outline	Objective	Funding (USD)
AZ	Regional Transportation Authority of Pima County	Adaptive Mobility with Reliability and Efficiency project: integrating fixed route, subscription based ridesharing and social carpooling services into an existing data platform to provide affordable, convenient, and flexible service.	To fill a first/last-mile gap, To mitigate congestion	$669,158
AZ	Valley Metro Rail, Inc.	A smartphone mobility platform development project: integrating mobile ticketing and multimodal trip planning to cover ride-hailing, bike-sharing, and carpooling.	To enhance equitable access to a multimodal transport system	$1,001,000
CA	City of Palo Alto	Bay Area Fair Value Commuting Demonstration Project: trying to reduce solo driving from 75 percent to 50 percent by utilizing a multimodal trip planning app, workplace parking rebates, and analytics.	To mitigate congestion	$1,085,000
CA (& WA)	Los Angeles County Metropolitan Transportation Authority	Two-region mobility-on-demand partnership project: offering a ride with Via for trips originating and ending at select transit stations to solve a first/last-mile issue	To fill a first/last-mile gap	$1,350,000
CA	San Francisco Bay Area Rapid Transit	Integrated carpool to transit project: providing an app to help carpooling matches around BART stations for transit riders, including customers with a disability.	To fill a first/last-mile gap, To improve access to transit for people with a disability	$358,000

FL	Pinellas Suncoast Transit Authority	Paratransit Mobility on Demand Demonstration project: offering more cost-effective on-demand paratransit service by utilizing a central dispatch software.	To improve cost efficiency of a paratransit service	$500,000
IL	Chicago Transit Authority	Integrated Fare System—From Transit Fare to Bike Share project: incorporating the local bike share service Divvy into CTA'S existing transit trip planning app.	To fill a first/last-mile gap	$400,000
OR	Tri-County Metropolitan Transportation District	Open Trip Planner Shared Use Mobility project: building a platform integrating transit and shared-use mobility options.	To fill a first/last-mile gap	$678,000
TX	Dallas Area Rapid Transit	First and Last Mile Solution project: integrating ride-sharing services into its GoPass app to improve access to transit.	To fill a first/last-mile gap	$1,204,000
VT	Vermont Agency of Transportation	Vermont Statewide Transit Trip Planner project: Building an online trip planner (app) for both fixed and flexible transit service to improve access to transportation information, including for people with a disability.	To fill a first/last-mile gap, To enhance equal access to mobility	$480,000
WA	Pierce County Public Transportation Benefit Area Corporation	Limited Access Connection project: Connecting Pierce Transit local service, Sound Transit regional service, and local ride-sharing companies to increase regional transit use.	To fill a first/last-mile gap	$205,922

Table A.1 List of MOD projects funded by FTA
(Source: the FTA Fiscal Year 2016 Mobility on Demand Sandbox Program Projects)

C. Interview questions

I asked the following questions in the interviews.

1. What is your project's short-term and long-term goal?
   For this question, I provided respondents with the following options as goals of public transportation service.
   a. Economic (help grow the regional economy by improving transportation accessibility)
   b. Social (enhance equity and safety, or reduce congestion)
   c. Financial (increase revenue by reviving ridership, decrease the capital/operating cost for transportation service enhancement)
   d. Operational (improve service/cost efficiency)
   e. Political (enhance political support for alternative modes to private cars)
   f. Environmental (reduce emissions by making alternative modes more attractive)

2. What do you think is a critical factor for your project to implement MOD services and/or a new payment platform with private companies which work for the goals you mentioned above?
   For this question, I presented some examples to respondents.
   a. Political factor (shareholders management such as top executives/board members' commitment, etc.)
   b. Economic/financial factor (enough budgets for a project, a less costly project, etc.)
   c. Vendor management factor (shared goals between the public and private sectors, a flexible contract, adequate vendor monitoring, etc.)
   d. Market factor (competitive market, the existence of private companies willing to work with the public sector to achieve public policy goals, etc.)

3. What challenges have you faced when moving forward with your project with private companies?

4. What do you think should public transportation agencies be involved in the development and operation of MOD services and/or MaaS platform in the future to protect a public interest (equity, safety, and transportation efficiency)?

5. Do you think that public transportation agencies should own their MaaS platform to protect public interests and why?

6. What do you think will be an ideal partnership model between the public and the private sectors to move MaaS forward in the future?

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