The Governance of Demand-Responsive Transit Systems – A Multi-Level Perspective

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Abstract

In the new-generation smart mobility paradigm, mobility-as-a-service (MaaS) systems have shown the most potential to offer integrated mobility platforms. MaaS is essentially an amalgamation of services tailored to match individuals' diverse travel demands, many of which are demand-responsive transit (DRT) or DRT-like, addressing the much-needed last-mile problem of transit systems. Managing a DRT system could be a simple first step in understanding the governance of MaaS, as the two types of system share the common features of flexibility and individualistic, online platform-based service provision. With that view, we deliberate this exploration here, reflecting on the governance of a DRT case study. We borrow from the schools of transition management and industrial economics to elaborate our understanding. Using the framework of the multi-level perspective, we investigate the drivers and barriers for the diffusion of DRT through the (public transit) regime. The main drivers of DRTs are found to be the willingness of local governments and transit operators to implement DRT, whereas the main barriers stem from infrastructure, technology, and market practices. Alignment among the regime elements remain largely partial, which is consistent with our conceptualization of MaaS governance challenges. This research adds to the literature by offering a comprehensive foundation exercise to reflect on the governance of innovative mobility services.

Keywords: Demand Responsive Transit, Mobility as a Service, Multi-Level Perspective, Socio-Technological Transition.

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1. Introduction

1.1 Motivation

Socio-demographic transitions, peak car trends, general regard for environmental sustainability, and the popularity of shared economy and flexible lifestyle have provided a massive impetus for the reconfiguration of urban transportation systems. Facilitated by the breakthrough in the information technology and wireless network sectors, a niche for demand-based public services has been created. Subsequently, transport services have also been reconfigured to suit the flexible lifestyles of individuals. Among this genre of new mobility services, mobility-as-a-service (MaaS) systems (MaaS) have shown the most potential, promising an integrated flexible mobility platform.

MaaS is defined as a "user-centric, intelligent mobility distribution model in which all mobility services are aggregated by an operator and supplied to users through a single digital platform" (Kamargianni and Matyas, 2017). Such an integration of mobility services with one-stop shop offers access to a number of options, such as public transport (PT), car and bike sharing, as well as carpooling. Often, an online platform (usually smartphone apps) enables the planning, booking/reservation, and payment of the requested services. MaaS is regarded as the most promising integrated mobility system – a paradigm shift in daily transportation (Jittrapirom et al., 2017a). Considerable research efforts have also been undertaken that point at a number of advantages of such systems for the primary customers, including personalized offers as well as easy transactions, ease of payment, and journey planning (Karlsson et al., 2017).

Despite having significant social, economic, and environmental benefits for society as well as for individuals, it is not easy to implement MaaS. Firstly, potential users may be reluctant to change their choice patterns due to habit persistence. Secondly, suppliers of transport services may be disinclined to affiliate with these platforms due to a potential loss of revenues and a perceived risk of losing market share due to increased competition between the suppliers affiliated with the platform. In addition, the adjustments required to achieve interoperability may be costly for the firms involved. Finally, public agencies may have to reconsider mode-specific regulations, subsidies, and approaches in order to stimulate the development of integrated mobility services.

Providentially, the introduction of demand-responsive transit (DRT) systems in addition to conventional public transport postulate a viable test case in the implementation of MaaS, as they touch upon all of the above predicaments in a lighter scale. MaaS essentially is an amalgamation of services tailored to match the diverse travel demands of individuals in the context of contemporary shared economy, many of which are DRTs or DRT-likes, such as car-sharing or bike-

sharing schemes. DRTs are perhaps the most important component to achieve successful MaaS integration as they provide a constructive solution to the first- and last-mile problems and complement fixed transit lines in low-demand locales and in off-peak hours. Similarly, given that MaaS is a demand-driven integrated service, it has a plausible association with the operation and governance of DRTs. Managing flexible personalized services of DRT could serve as a first learning step to the governance of MaaS, as they share the common features of flexibility and individualistic, online platform-based service provision (at least such is the case of the first Dutch DRT pilot, Breng flex).

Moreover, we argue that in order to understand issues concerning the transition towards MaaS, we must understand how current transport systems are stabilized through various lock-in mechanisms. Consumer lifestyles and preferences are adapted within the existing supply. On the supply side, this is concerned with investments, economies of scale and networks, infrastructure (bus stops, garages, etc.). In addition, a number of institutional aspects are relevant, including discourses, power relations, and the political networks. These lock-in mechanisms create path dependence that may be difficult to change drastically (Martin and Sunley, 2006). A gradual introduction of these disruptive transit systems may allow the understanding and transition to penetrate through the existing transportation system.

MaaS enables multiple service elements with diversified parameters, stakeholders, and ownership constituents to come together and co-exist as facilitated by MaaS platforms. Accordingly, diligent management and governance of the provisions is a formidable undertaking. Since governance has been shifting to less provision and more management of services and mobility is transitioning to less ownership and more usership domain (Docherty et al., 2017), such knowledge would be crucial in terms of providing insights to facilitate complex mobility management system of MaaS. Much of the success in this transition from fixed to flexible transit system depends on the knowledge transfer. Therefore, it is imperative to understand and evaluate the governance of DRT as part and parcel of managing flexible service provision. These are the primary motivations of the present research.

1.2 What is DRT?

As the name suggests, a DRT is a demand-based public transit system. Essentially it means transport on demand. As opposed to having fixed transit lines operating on fixed routes on a fixed schedule, this service operates when and where users demand it. This is a lucrative option not only for users but also for the PT operators and government to tackle increasing expenses on operating low-demand lines.

In economic terms, DRT offers a horizontal product differentiation in the public transit domain. Industrial economics literature defines horizontal differentiation as offering substitute products (or services) at various combinations of the attribute's proportions. It responds to the taste heterogeneity of the consumers based on which the proportionate combination of the attributes in a product/service vary. A range of substitute products can co-exist in the market, simply because the combinations of attribute proportions appeal to different target consumers. Vertical product differentiation, on the other hand, refers to a class difference among the products where all attributes of the product correspond to a higher or a lower range (Gabszwicz and Thisse, 1986). It is important to understand the product differentiation as it has considerable effects on the operation and management of the service industry. In fixed PT and DRTs the proportion of the attributes (travel time, travel cost, waiting time, comfort, connecting time to access and egress modes, flexibility) vary to cater the taste heterogeneity of consumers. Therefore, we categorize this as a case of horizontal product differentiation. It may lift itself to a vertical product differentiability if and when there is a case of up or downgrading of all the travel attributes.

The concept of DRT dates back at least 55 years to when the first feasibility study of demand actuated service was conducted (Bauer, 1971). DRTs have been operational in Finland (Kutsuplus) and USA (Via, Bridj, UberPOOL) since a few years now. Understanding the governance and operation of DRT in the context of transition theories is a novel approach, to which the present research aims to contribute.

1.3 Research Objectives and Approach

This research investigates the potential role and impact of on-demand transit system on the governance of MaaS, as part of a transition towards implementing a comprehensive MaaS system. The primary research question is: What is the role of DRT in facilitating the governance of this transition towards a more integrated and flexible end-to-end mobility services within MaaS?

We elaborate this by means of analyzing a case study – Breng flex – which operates in the region of Arnhem-Nijmegen, medium-sized twin-cities in the southeast of the Netherlands. The first step of MaaS in the case study involves the introduction of DRT services in addition to regular fixed scheduled PT services. Various other modes and mobility services will gradually be affiliated within a MaaS platform, allowing for integrated booking/reservation and payment. In the final stages, the planning options may be added to the services of the platform provider. This order of development is determined in part by the specific target groups of the pilot: commuters and students are usually aware of the transport systems they want to use and demand easy access and payment systems to use such services. To investigate

the above-mentioned question, we evaluate the governance of this DRT to understand its role and contribution to an integrated MaaS system.

The multifaceted-ness of MaaS governance dictates an inter-disciplinary approach in the scientific framework as well. Thus, we borrow from the schools of transition management and industrial economics to elaborate our understanding. We employ the multi-level perspective (MLP) put forward by Geels (2002, 2012), who identified three levels of evolutionary reconfiguration: niches, regimes, and landscapes. MLP provides a heuristic to understand this trajectory, in which any change in one level affect the other.

Using the framework of socio-technological transition management theory of MLP, we evaluate the drivers, barriers, and alignment of the regime elements. Data was collected through primary (interviews) and secondary (documents, reports) sources. The analytical framework (elaborated in Section 4.1) was included in the interview structure, including a brief elaboration of the conceptual framework (Figure 1).

This study adds to the literature by offering a comprehensive framework to reflect on the governance of innovative mobility services with an application to flexible transport. This framework is used to assess the introduction of DRT as a new mobility service from a governance perspective, reflecting on the meaning and role of it towards the governance of MaaS. While most governance literature on MaaS discusses different drivers and barriers with respect to the perceived ultimate integrated mobility propositions, we believe that a bottom-up understanding of the implementation of these services may be more fruitful in realizing a MaaS-system, taking all relevant actors into account.

2. Conceptual Framework

2.1 Multi Level Perspective (MLP)

The governance of DRT in this research will be examined using MLP introduced by Geels (2002, 2004). This approach has emerged as a fruitful middle-range framework for analyzing socio-technical transitions to sustainability and has been used to inform on the governance or management of socio-technological transition (see an overview in Section 2.3). The three levels of the multi-level perspective are niches, regimes, and landscapes.

- Niches are technological incubators in which new innovative practice and breakthroughs are nurtured. They generate new practices and accommodate learning practices of radical innovations.
- Regimes accommodate such radical innovations (and generate incremental innovations). The process is gradual and can be explained by the trajectories of

niche accumulation; that is, by the subsequent application of niche technologies at market or regime domains.

- Socio-technological landscapes are the higher-level representation of overall social, political, technological, and cultural change. Sometimes niches are triggered by changes in the socio-technological landscape.

The nested structure (Figure 1) is important to understand the development trajectory of radical innovations from niche to mainstream. MLP provides a heuristic to understand this trajectory, where any change in one level affects the other. Success of new innovations is largely reliant on embedding them to existing regimes and socio-technological landscape. On one hand, innovations are nurtured in the technological niches; on the other hand, shift in landscapes create tensions demanding regime changes, making way for a 'window of opportunity' for the radical innovations to flourish. Thus, alignment and embeddedness are crucial elements of success of niche practices.

Although the ontological assumptions (Geels, 2004) and methodological breadth has been criticized by scholars (Shove and Walker, 2010; Genus and Coles, 2008), we concur with Geels (2011) that the multi-dimensionality and hierarchical structure is particularly suited to understand the layered structure of socio-technological transitions.

If one considers the technological breakthroughs forming their niche somewhere at a micro level, positively fashioned, and in tune with the overarching socio-politico-cultural landscape, regimes are the yielding ground through which the niches become mainstream. They can be considered as bridges between the homegrown socio-technological niches and the canopy of collective landscape. They frame, shape and polish the niches to meet welfare goals, to uphold public values, and to become successful mainstream practice, with the ultimate goal of facilitating coherent societal transition.

This framework takes into account that transitions in mobility services are about interactions between technology, policy/power/politics, economics/business/markets, and culture/discourse/public opinion. In the present study we employ the framework to understand the governance of DRTs. Governance here has been identified as a co-evolutionary co-operative management of the transition from the scheduled to demand-responsive transit systems.

In the following sections, we will review the application of MLP in transportation research, followed by conceptualizing the case of DRTs within the MLP.

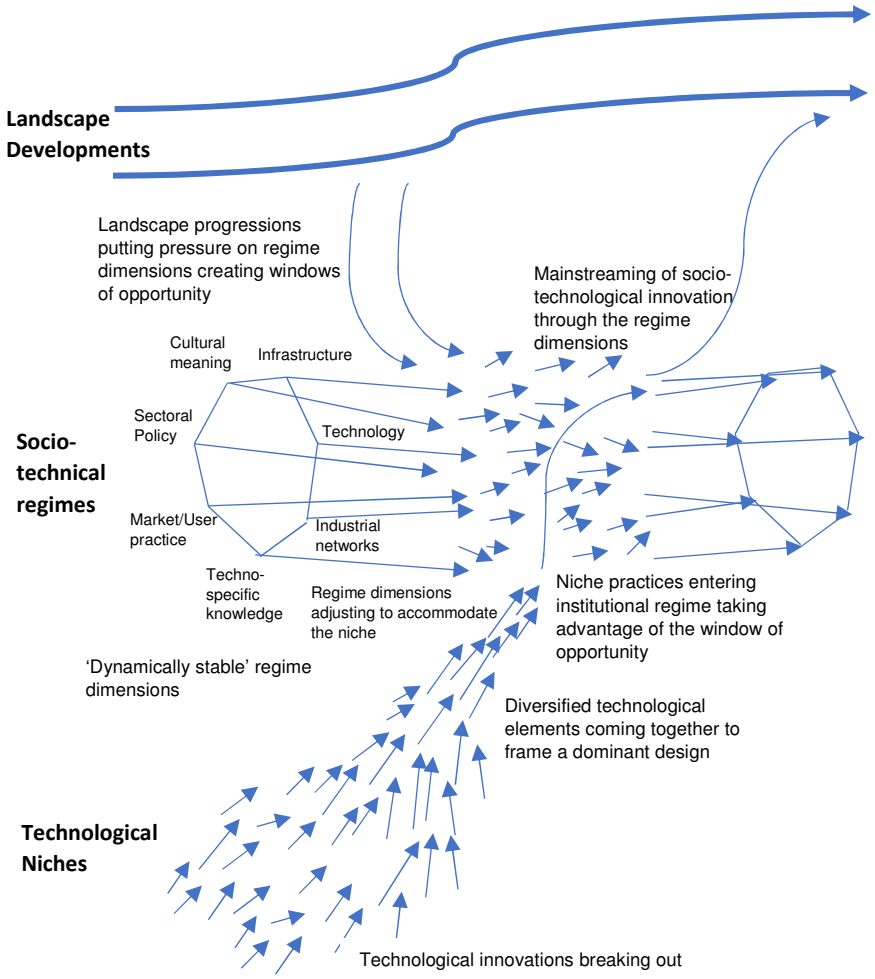

Figure 1: Multi-level perspective (MLP) of socio-technological transition (Based on Geels and Schot, 2007)

2.2 Application of MLP in Mobility

Everyday mobility has been going through numerous episodes of transition over the recent years. Consequently, scholars have been resorting to transdisciplinary concepts of transition management to understand and explain the processes. Not surprisingly, several studies (Geels, 2012; van Bree et al., 2010; Nykvist and Whitmarsh, 2008) have utilized MLP to explain mobility transitions. Geels (2012) himself outlined how MLP can be used to explain low-carbon

transition. He emphasized the usefulness of MLP to capture the co-evolutionary and multidimensional (involving technology, market, policy, culture, etc.) nature of the systematic transition that prevails in transportation. He identified the stability and the emerging cracks on the automobility regime introduced by climate change and environmental concerns. Coupled with intelligent transportation systems (ITS), alternative transition paths were identified to stem from potential niches of intermodal transport, bike/car-sharing, and demand management. Political will and user attitudes have been identified as the drivers of low-carbon transition and barriers to ITS.

In a similar context of low-carbon transition, van Bree (et al. 2010) studied the transition of hydrogen-powered and electric vehicles, addressing emission and environmental concerns. They combined MLP with two scenario analyses on tightening emission standards and rising fuel prices. They also provide some insights on the dynamics of possible transition and discuss the relationship between industry (car manufacturers) and user (consumer) practices.

Similar to the scenario analysis approach (van Bree et al., 2010), Nykvist and Whitmarsh (2008) conceptualized a radical system innovation in transport through three niche routes: technological change, modal shift, and reduced travel demand. They showed the empirical evidence in the UK and Sweden on these three routes and explored the areas of convergence and contradiction. They identified landscape (environmental and economic) pressures and the response of regime dimensions as the necessary conditions of sustainable transition. Among the regime dimensions (Figure 1), culture and infrastructure were found to be responding slowly to landscape developments.

Local spatial, cultural, and political factors have also been noted as keys to determining the transition pathways of similar transport initiatives (Marx et al., 2015). In a comparative study of Brazil and Germany, Marx et al. (2015) showed that different transition trajectory and niche growth patterns would be generated based on local factors, but also firm strategies. In other words, not only the speed but also the direction of technological niches is dictated by how the regime dimensions are swayed.

Moradi and Vagnoni (2018) identified traffic congestion, emission, and parking problems among the major cracks that have emerged from the landscape pressure and destabilized the automobility regime. They studied the driving and restraining role of urban mobility system dynamics and concluded that the drivers of the dominant (automobility) regime are the barriers to the public transit and non-motorized transit regimes and vice versa. Essentially, this implies that environmental concerns are the steering forces of the PT regime, as conceptualized in this study.

All of these studies have highlighted the multi-actor, multi-disciplinary and co-evolutionary nature of transportation sector in one way or the other. What came across in all these studies is that mobility transitions can only be fostered through the mediation among all these actors and stakeholders. Based on the transition pathway, the actors can drive or constrict the socio-technological innovation. To summarize, it is imperative to investigate the response of regime dimensions to the landscape developments and an in-depth exploration of the drivers and barriers in order to understand the transition of socio-technological innovations.

2.3 Contextualizing DRT within MLP

Within the context of socio-technological transition and MLP, we contextualize DRTs where the niche is a new (flexible) mobility service, the regime is the regulatory and institutional domain, and the landscape is the changing perception and demand for flexibility in service provisions.

Niche: Breakthroughs in the IT and wireless network sectors have generated a niche for demand-based public services based on usage of interactive platforms, usually facilitated through smartphone apps (demand-based was already there using phones). This is in response to the dramatic increase in smartphone-based lifestyles where there are apps for just about everything nowadays. The impetus is the switch from fixed to flexible service to accommodate the flexible individualized work-life balance.

Regime: This is the regime of (public) transportation in shifting the regulatory environment within which the changes are taking place; for example, public service contracts or concessions using tendering procedures. There are several factors that could channel the regime shift. Firstly, who owns the idea, the data, and the service are important factors in regime development direction; for example, in Breng flex, is the concept owned by the transit authority that produced the idea or the local government that contracts (and perhaps also finances) the service? Finally, the legal framework could sway the regime development; for example, how the law makes a distinction between bus-services and taxi-services could pave the way for DRTs to fit within this distinction, limiting the innovation.

Landscape: The present socio-political climate is characterized by socio-demographic transitions, flexible lifestyle, and changing perceptions towards car ownership (‘peak car’ trend), as well as a general awareness of sustainability. Regard for environmental sustainability (Moradi and Vagnoni, 2018), coupled with antipathy of the use of fossil fuel and the popularity of circular economy, have fostered reconfiguration of transportation systems. At the same time, the rise of social media has led to a flexible lifestyle, mobile working arrangements, and shared

economy. Recent socio-demographics trends have shown a general decline in car ownership (van Wee, 2015; Oakil et al., 2016) and, consequently, more demand for usership and flexible demand-based individualized mobility services. All of these aspects paved the way for the appreciation of public transit and adoption of new forms of public transit that are more flexible and on-demand, yet also sustainable and speak to the preferences of car ownership and use.

Given that the technological niches are coming together to enable DRT to enter the public transit regime, we examine how the regime dimensions are accommodating this transition and responding to the landscape development-induced pressures. Within this context, the model goes on to examine on which dimensions the introduction DRT fits within current regimes and landscapes.

3. Case Study Description: Breng flex

Breng flex, a DRT service operated by Dutch PT provider Connexxion, was conceived and proposed in response to the vision of new and smart mobility solutions of the province of Gelderland. The province set aside a budget for new mobility solutions and invited ideas from transport providers; among these, a DRT system was picked up that was later named as Breng flex. It is therefore financed by the regional government.

The first pilot was launched in December 2016; it was continued through subsequent pilot programs upon positive reception and evaluation (Alonso-González et al., 2018). Breng flex operates in the twin cities of Nijmegen and Arnhem in the Netherlands. It is essentially a bus-stop-to-bus-stop service (as opposed to door to door service) for most of the transit network, with some additional landmark stops noted as 'virtual bus stops' in the app platform; there are a total of 225 stops in the network. The service is territorial at this point of time and does not cross the city boundaries, which means that a consumer cannot use the service to travel between Arnhem and Nijmegen. It operates on a flat rate of €3.50 per person per trip regardless of the distance, travel time, or the socio-demographic profile of the user. Users can pay in advance via the smartphone app or on the vehicle using their debit cards or national travel cards (ov-chipcards). The operating hours are 06:30 to 24:00 on weekdays whereas starting times are 8:00 and 9:00 on Saturdays and Sundays, respectively. Rides can be called and tracked in real time through the designated mobile app only.[3] Seats are guaranteed. The fleet comprises five minibuses (five passenger seats and two wheelchairs) and four electric cars (three passenger seats).

[3] The process is described in a short video in the Breng flex website (in Dutch) https://www.breng.nl/breng-flex/1411

4. Analysis of Breng flex case

4.1 Analytical Framework

The analytical framework was built around the MLP concept. Geels (2012) identified seven dimensions of socio-technological regimes (Figure 1) – infrastructure, market practice, sectoral policy, technology, industrial networks, techno-specific knowledge, and cultural meaning – which form the analytical framework for this research. Those dimensions (Table 1: column A) were then elaborated into elements (column B) specific to the case study. To structure the regime elements, we then introduced the notion of barriers and drivers of socio-technological innovation to the analytical framework (column C). For each of the elements, we carefully investigated the barrier to change and the drivers to success of the innovative mobility system. By doing so, we maintained a certain level of robustness to the analysis. Finally, the alignment among all the elements was evaluated based on the data analysis. A five-point Likert-scale-based scoring system was used to report the findings, where 1 indicated not aligned at all and 5 meant completely aligned (column F). The scores represent how in or out of balance each of the element is to the rest of them. Since Breng flex is not fully operational and running in the pilot phases, only where investment is one-way without any profit return, we have been restrained with the alignment scores. For example, even though certain elements seem to be devoid of any barriers, we did not assign those with a perfect alignment score of five.

Data was collected through primary (in-depth interviews) and secondary (documents, reports) sources. Four in-depth interviews were conducted among a representative of local regional government, an academic expert, a transit (DRT) operator, and a mobility consultant. The interviews conducted were structured based on the analytical framework; that is, broken down into regime dimensions and elements. The respondents were first familiarized with this framework in order for them to understand the context and to discuss the barriers and drivers accordingly. The interview recordings were then analyzed using the above-described analytical framework.

This method helps explain drivers and barriers with respect to next steps of MaaS, which, as a far more complex system, is likely to be disruptive. Understanding the complexities involved in balancing barriers and drivers for a single flexible service would provide a good illustration and foundation for more complex systems. A more elaborate discussion on the findings based on the regime elements is provided below. Here again, the same structure of regime dimensions is followed to report the findings cohesively.

4.2 Findings

The findings of the study are structured along the seven regime dimensions as follows.

- Infrastructure:

Breng flex builds on the established road public transit infrastructure of Connexxion, which is a strong driver of the system. It employs the existing designated bus stops as pick-up and drop-off locations. Where these are lacking, it uses landmarks and facility points such as retirement homes to pick up and drop off passengers. The fleet has been subcontracted out with the responsibility for managing and maintaining the vehicles. Because the fleet size is reasonably small, the existing parking facilities of Connexxion could sufficiently accommodate them as well.

A major incentive, as well as an obstacle, of the Breng flex initiative was network optimization, particularly to manage low-demand transit lines. While frequencies of some fixed transit lines have been reduced, others have been discontinued entirely. For example, the bus line connecting Nijmegen to the peripheral village of Oosterhout has been long under debate and eventually disappeared after Breng flex started, and the frequency of busses to the urban counterpart Wijchen has been lowered. Therefore, network rationalization has been a crucial feature of Breng flex, which posed some challenges in terms of service delivery and marketing and has been tackled through market promotion (Box 1).

- Market acceptance:

Breng flex can be denoted as an improvement to existing PT system of the region with no spatial disparity (Alonso-González et al., 2018). Although only about 60 percent of the initial target of 600 trips per day has been achieved, the development curve has maintained a steep growth. Breng flex has also been successful in attracting car users to its user pool.

The service is popular among elderly people, who generally have a greater appreciation for the guaranteed seating arrangement. Moreover, users from the rural counterparts, where fixed PT lines are infrequent, also constitute a fair share of the user pool after some deliberation (Box 1).

User satisfaction was quite high, particularly in the survey conducted by the operators (score 8.2), as a result of which Breng flex also went on to win the Happy

Travelers award of 2017.[4] However, an independent academic survey reports that while users are quite positive about the operating efficiency of Breng flex, they remain apathetic regarding the questions of equity and accessibility (Ali, 2017). These user evaluations should be interpreted cautiously, though, as they were all conducted during the pilot runs, which were operated on a promotion and fixed trip fare of €3.50. Pending revision, this price will change quite substantially to sustain the service in the long run.

> Suspending bus line 3 to the village of Oosterhout and promoting Breng flex instead has been a challenge. To manage the transition and win user acceptance, the marketing team offered free rides to the residents of Oosterhout. Checking the legibility of residency was also made lenient. The strategy proved successful with a significant increase in popularity of Breng flex in the area.

Box 1: Interview excerpt on the strategy to rationalize transit network

Consumer board ROCOV is skeptical about the rationalization of transit networks supplemented through Breng flex. They advocate for the complementary nature of Breng flex to fixed transit lines. Substituting and replacing fixed lines with Breng flex remains a point of resistance and subsequent negotiation among the stakeholders.

- Sectoral policy:

Sectoral policy has been a driver of Breng flex. The increased attention given to reducing both carbon emission and the use of fossil fuel by the European Union and the national government have boasted the promotion of sustainable transit solutions. On a local level, the vision of Nijmegen being the European Green Capital of 2017 and a home for high-speed cycling infrastructures have further incentivized it (Kerr, 2017; Sharmeen and Lagendijk, 2017). As mentioned earlier, Breng flex was conceptualized as part of the mobility vision of the Province of Gelderland. The pilots are also financed by them.

The key component of governance of public services is to uphold those visions. In addition to maintaining carbon emission standards, governance would also maintain equity and justice (Martens, 2016). Since individuals' capabilities and preferences are so heterogeneous that a combination of multiple ethical perspectives of distributive justice should be recognized (Pereira et al., 2017). Among those perspectives the guided principle of distribution should be built on a more nuanced multidimensional framework of accessibility to meet the heterogeneous needs of individuals. DRTs could potentially serve the public transit domain to fill an

[4] Detailed infographics of the survey can be accessed here (in Dutch)
http://www.brengkenniscentrum.nl/blog/wat-vinden-reizigers-van-breng-flex/

important gap to match the need and capability diversity of people. Breng flex has shown some promise in verifying this notion. As mentioned, the service has become increasingly popular among the elderly population, which the transport operator has recognized as a budding target consumer group. On the flip side, it is inequitably pricey for families traveling with children and university students, as the pricing plan does not yet differentiate between socio-economic groups. Under present Dutch PT subsidy regulations, children travel for free or at a discounted fare until the age of 12 and students receive a free university PT deal. These measures are crucial to maintain equity in service provision and to provide accessibility to facilities. The extent to which these measures are incorporated in DRT is a question of service definition and goal established by the provider with agreement to the local governance-related goals, and these have not yet been established in Breng flex.

On the other hand, some crucial elements of sectoral policy have not yet been addressed. The tendering regulation and data privacy guidelines for the fully operational phase are yet to be determined. Firstly, agreements are yet to be made about crucial procedural and administrative treads, such as whether open competitive tendering will be called for and whether DRTs should be budgeted through regular public transport fund. Secondly, data storage, privacy and sharing are currently being controlled by the operator. There is less clarity about if and how the knowledge will be shared to comparable projects in other cities, and no guidelines have been set by the local and regional government regarding the privacy and storage of these data. These issues are primarily been regulated by general transit data guidelines. Those mandates need to be adapted and consequently updated for the platform-based service systems.

- Technology:

Breng flex defines routes by employing smart algorithms that were adopted from Abel[5]. Having a proof of concept of the technology provided a strong technological foundation for the system's efficiency. However, alignment with other data and analytical support systems remains a work in progress. For example, navigation maps miss out on bus lanes in some places, resulting in a mismatch between the app-displayed waiting and pick up time with the actual ones. Also, the business intelligence framework has not been developed to display a consistent dashboard. Such an imbalance among technological spheres is hampering service planning and reliability.

[5]Abel was the first fully electrical fleet operated shared taxi service based in Amsterdam, which was discontinued in 2017 (after operating for almost two-years) on account of market saturation of taxi services.

- Industrial networks:

An important mobility component to meet the heterogeneous need of Dutch societies is the consumer-specific taxi provision serving specific groups like the elderly. Unexpectedly, such taxi associations did not act as a barrier for Breng flex, as the market share of taxis is low in the region. The network of vehicle manufacturers was also of less concern since the fleet was outsourced to another company.

A major barrier here was the Collective Labor Agreement (CLA) for the new service. The providers drew a CLA that is substantially different from that of the bus drivers of the fixed lines. Although the providers argued that the package is quite attractive, it faced considerable resistance from the socialistic labor union, which drew some negative publicity to it. The term 'flex' has a negative connotation to it when associated with labor agreement. Such conflicts are not uncommon when generally associated with the fear of reduction of employment and flexible labor contracts. Research suggests that, if managed properly, the interaction between industry reconfiguration and employment transition can lead to profit maximization when there is a larger share of cross-ownership of services (Fanti, 2013), which is the case here since all the serviced belong to a parent company. However, given the existing shortage of bus drivers in the region, employment cuts do not seem to be likely. More importantly, Breng has managed to get jobs for people with low qualifications for the labor market as a starting position; some may become bus drivers in the future.

- Techno-specific knowledge:

Techno-specific knowledge, literacy, and access is critical for the success of smart innovative solutions (Warnick, 2001). This has been the key to the 'smart cities for smart citizens' debate. The smart mobility domain is no exception; therefore, the policy rhetoric should be supported by 'digital governance augmentation' (Wiig, 2015). IT literacy and user affability remains a challenge for Breng flex as well, particularly reaching specific consumer groups. Breng flex's marketing team has been coming up with smart aids to address these challenges (Box 2).

> The marketing team held presentations at nursing homes and elderly housing compounds on Breng flex, explaining user procedures to potential consumers. The interface was also extended beyond smartphones so that a ride can be called through the desktop computer at the reception of such facilities. Moreover, the potential of smart bracelets for these target consumers are also being explored.
>
> (Marketing executive, Breng flex, February 2018)

Box 2: Interview excerpt on the reaching target audience

The research and development remained somewhat internal to Connexxion and agile with some academic research efforts (Haanstra et al., 2017; Alonso-González et al., 2018). Reports are mostly user-centric and remain positive for the pilot runs.

- Cultural meaning:

User perception, reliability, and image development are important components of any new innovative business development, and much attention has rightfully been paid to the product marketing, branding, and perception building. Breng flex is no exception. Proper marketing can respond to product differentiation; it can channel or eliminate false sense of popularity by creating the desired 'image' to the targeted consumers (Tremblay and Polasky, 2002). In accordance with this notion, Breng flex has also strategized creative marketing.

Any new product or service will encounter some apprehension from consumers, mostly related to general uncertainty about efficiency and reliability. In Breng flex's case, there was a false perception that it was an expensive and luxury product. Coupled with the discontinuation of certain fixed lines, this created some negative discernment of Breng flex. As part of breaking this apprehension, a free welcome ride was offered to consumers.

Social networks were also used to bring in more consumers. Research suggests that social networks can stimulate novel choice options through the mechanisms of peer influence (Sharmeen, 2015; Rasouli and Timmermans, 2013). Social campaigns were launched where users can share a unique code to gain exposures through individual's social networks. Service accountability, loyalty to customers, and good customer service was ensured to maintain quality of level of service.

In an attempt to elaborate the governance of DRTs, an alignment score was estimated to each of the elements based on the analysis of the drivers and barriers in each of them. In order to effectively manage the transition of an innovation, a reasonable alignment among the seven regime dimensions is crucial. If one of them is far ahead or far behind, it would put the whole structure off balance. For example, if technology is not aligned with the sectoral policy, or if the cultural meaning is off balance with the techno-specific knowledge, governance of the socio-technological transition would hamper. It is evident from the findings that only a partial alignment among the regime dimensions has been achieved in Breng flex so far. This is not surprising since the DRT service is currently in the pilot phase and a fully operational business model is yet to be formulated. Nevertheless, it gives a good indication of the dimensions that needs attention for the governance of DRTs in the context of a Western country; namely, techno-specific knowledge, sectoral policy, and infrastructure. Not surprisingly, these correspond to the three challenges of MaaS implementation noted in the introduction; that is, reluctance of users, disinclination among transit operators, and local government challenges.

Dimensions of socio-technical regime (A)	**Elements of socio-technical regime of DRT (B)**	**Barriers and Drivers (C)**	**Are the regime components aligned? (D)**	**Alignment Score* (5-point scale; 1 not aligned, 5= aligned) (F)**
Infrastructure	Route network – articulated definition of service delivery	Existing + Virtual bus stops; Network opportunities; Low demand bus lines	Yes	4
	Logistics (vehicles, parking)	Subcontractor deal for vehicle supply and maintenance	Yes	3
	Cost structure (Vs quality and usability)	Too early to evaluate at pilot stage as heavily subsidized; business model in the making	Pending revision	2
Market Acceptance	Market share	Less than expected (60% of target achieved); Growth curve is steep	Partially	3
	Popularity/performance	Popular among car users, elderly, and rural counterparts	Yes	3
	Consumer board acceptance	Skeptical – complement PT not substitute	Partially	3
Sectoral Policy	Central-local govt agreement: characteristic of system/regime: rules and regulation as WP2000	Governed by Province; Not much influence from Capital or legal framework – pilot stage	Yes	4
	Regional transport policy and taxation/subsidies	Province finances pilot; negotiation on regular service budget section, definition and tendering	Pending revision	2
	Public welfare (accessibility, equity) and Service standards	Less attention to equity at pilot stage; Costly for travelling with children; Talks on inclusion of elderly, businessmen and low-demand lines	Pending revision	2
	Data privacy regulation	Contractual competition; Data ownership; Knowledge dissemination	Yes	3

Dimensions of socio-technical regime (A)	Elements of socio-technical regime of DRT (B)	Barriers and Drivers (C)	Are the regime components aligned? (D)	Alignment Score* (5-point scale; 1 not aligned, 5= aligned) (F)
Technology	IT/app development	Built on existing proof of concept (Abel)	Yes	4
	GPS track and trace	Bus lanes are missing in navigation maps	Partially	3
	Data storage and coverage	Struggling with dashboard – Business intelligence	Partially	3
Industrial networks	Vehicle manufacturer	Vehicle supply and maintenance	Partially	3
	Existing private/shared taxi network	Limited resistance from Regio taxi – taxi market share is low	Yes	4
	Labor market/crew/collective labor agreement	Labor union conflict, debate, bad press	Partially	3
Techno-specific knowledge	IT literacy	Tackled with phone and desktop options	Partially	3
	Smart phone use/coverage/cost	Smart aids are being conceptualized	Partially	3
	R&D on demand-driven transit	Mostly internal and agile; Some academic research	Partially	2
Cultural meaning	Perception	Perception of luxury service; Emphasis on marketing and customer care	Yes	4
	Reliability and mutual trust	Vulnerable to IT	Partially	3
	Car dependency	Moderate, approchable	Yes	4

Note: The table is a summary of findings of the data collected during this research on the pilot runs of Dutch DRT system Breng flex.
* The score is based on the analysis of the interviews conducted with the local government and DRT operator.

Table 1: Evaluation of socio-technical regime of DRT – Case study Breng flex

5. Conclusion

This research has investigated the potential role and impact of on-demand transit system on the governance of MaaS, as part of a transition towards implementing a comprehensive MaaS system. From the school of transition

theories, multi-level perspective (Geels, 2012; 2002; Geels and Schot, 2007) was used as the theoretical framework to understand regime resistance. The case of demand-driven transit (DRT) was explored through a case study in the Netherlands to understand and evaluate barriers, drivers, and alignment. Based on the theoretical framework of MLP, seven regime dimensions were explored and analyzed using data collected through in-depth interviews and a literature review. The regime dimensions were further broken down into case-specific (DRT) elements and the concepts of barriers and drivers were introduced to understand potential, uncertainty, and, most importantly, alignment among the dimensions. It is imperative to understand how these dimensions are coherent in order to reflect upon the governance and drawing out possible strategic responses.

The findings of our case study suggest that the regime elements are only partially aligned with each other. In particular, responses of infrastructure, sectoral policy, and techno-specific knowledge remain marginal. Recall that the case study (Breng flex) is at its pilot stage now and the fully operational business model is yet to be finalized and agreed upon. Quite substantial learning elements are achieved through the pilot runs that would add value to the dynamic adaptation of public transit systems.

The main drivers of DRTs are the demand for flexible and efficient transit options, the willingness of the local government and transit operators, the finances to back up the initial investment for operation, marketing, and research to comprehend demand and supply repertoires. On the other hand, the barriers stem from the readiness of IT, pricing strategies, market share, techno-specific knowledge of users, and labor market resistance.

Although there is limited scope for DRTs to argue a vertical product differentiation to road transit systems, it can certainly present a compelling case of horizontal product differentiation. Using proper market incentives, it can add the dimensions of personalization and flexibility to the road public transit systems. However, careful strategizing would be crucial here as it is a case of horizontal product differentiation; intra-industry trade may hamper economies of scale and labor participation (Aturupane et al., 1999). Achieving a stable market equilibrium with horizontally differentiated products is less frequent as it is more prone to preferential choice of consumers (Gabszwicz and Thisse, 1986).

The upcoming business model for the fully operational phase of Breng flex should be carefully drawn taking all these factors into consideration including learning from the example of the discontinued shared taxi service Abel operated with a complete electric fleet in Amsterdam (van der Veer, 2017), which was suspended in 2017 on account of cost inefficiency. It would be crucial to understand how to balance operating capacity and service delivery. A dynamic pricing strategy can be applied to sustain service delivery with creative incentivization to manage pick up

and waiting time (Amirgholy and Gonzales, 2016). Moreover, DRT providers can deploy pricing strategies based on the sustainability and environmental awareness concerns. A Spatial Duopoly model application demonstrates how general awareness for the environment could affect the pricing strategies and market shares of competing products (Conrad, 2005).

DRTs could be an important part to enhance public transit service and ensure seamless connectivity by particularly serving low demand lines and connecting low-density urban counterparts. It is, however, debatable how reliable these services would be if offered as a substitute to regular public transit on account of both efficiency and accessibility these may offer. The prospects in general are quite promising given proper spatiotemporal service coverage in terms of not only filling but as well as complementing public transit system to enhance accessibility.

The perceived role of DRTs could be a crucial first step to the integrated mobility as a service system particularly with respect to acquiring knowledge and experience of operating and managing flexible transit systems. They can contribute by addressing people's heterogeneous flexible demand profile particularly to serve rural and off-peak counterparts of daily urban systems. Breng flex has showcased a viable example of DRT generating several spin offs within the country as well. One rather key aspect however remained disregarded so far, which is knowledge sharing and dissemination. Development of a knowledge network would be a valuable platform not only as a source of information but also to document best practice examples. National legal frameworks could play a role in enabling that knowledge base.

DRTs present a foundation exercise to understand flexible transit management of MaaS. Having said that, we would reiterate that in MaaS, DRTs are one of many components. The success of MaaS depends on mutual coherence and alignment among all those components. MaaS would be much more extensive having a range of services supplied by public-private operators meeting the demands of diversified heterogeneous consumers. The complexity is quite high, as was also evident from operational MaaS platform evaluations (Karlsson et al., 2016). For example, in the evaluation of Swedish MaaS system UbiGo, Karlsson (et. al., 2016) identified regulations and institutional mandate as one of the major barriers. This was not found to be a barrier for Breng flex. Therefore, the findings of this research can be indicative only and cannot be generalized for MaaS. A DRT system offers a practical example of managing a flexible demand-based transit system. The knowledge base acquired from such a case is quite valuable in terms of achieving an efficient MaaS system. To elaborate further, a DRT would require a single business model whereas a MaaS would thrive on a business ecosystem fed by many such models. There is little likelihood of cross-ownership of services. A recent study on the potential MaaS system for the Nijmegen–Arnhem region has illustrated the complexities and uncertainties of using a dynamic adaptive policymaking approach (Jittrapirom et al., 2017b). Therefore, the business models need to be carefully thought through for the development of the business ecosystem (Ebrahimi et al.,

2018; Kamargianni and Matyas, 2017). Likewise, the interrelation among the stakeholders – that is, service providers, users, and the data/platform owners – should be carefully scrutinized for the success of MaaS (Meurs and Timmermans, 2017).

This research offers a detailed evaluation of DRTs under the robust framework of multi-level perspective. It explores the perceived role and prospects DRTs in transitioning towards a flexible and integrated mobility ecosystem of MaaS, analyzing the barriers, drivers, and alignment of the regime components from a governance point of view. It contributes a mid-level perspective, adding to the user-centric evaluation research of DRTs. The study is limited to one case study at its pilot phase, with limited stakeholder involvement. Other case studies of fully operational DRTs in comparable contexts would provide further insights. MLP can also be used with a similar analytical construct to evaluate the governance of MaaS. This remains on the future research agenda as a plausible next step for this evaluation.

References:

Ali, A. (2017) BrengFlex: How efficient is it from a user's perspective? , Radboud University

Alonso-González, M. G., Liu, T., Cats, O., van Oort, N., & Hoogendoorn, S. (2018) 'The Potential of Demand Responsive Transport As A Complement to Public Transport: An Assessment Framework and An Empirical Evaluation.' *97th Annual Meeting of Transportation Research Board*. Washington D.C.

Amirgholy, M., & Gonzales, E. J. (2016). Demand responsive transit systems with time-dependent demand: user equilibrium, system optimum, and management strategy. *Transportation Research Part B: Methodological*, 92, 234–252.

Aturupane, C., Djankov, S., & Hoekman, B. (1999). Horizontal and vertical intra-industry trade between Eastern Europe and the European Union. *Weltwirtschaftliches Archiv*, 135(1), 62–81.

Conrad, K. (2005). Price competition and product differentiation when consumers care for the environment. *Environmental and Resource Economics*, 31(1), 1–19.

Docherty, I., Marsden, G., & Anable, J. (2017). The governance of smart mobility. *Transportation Research Part A: Policy and Practice*.

Ebrahimi, S., Sharmeen, F., & Meurs, H. (2018) 'Innovative Business Architectures (BAs) for Mobility as a Service (MaaS)-Exploration, Assessment, and Categorization Using Operational MaaS Cases' *97th Annual Meeting of Transportation Research Board*. Washington D.C.

Fanti, L. (2013). Cross-ownership and unions in a Cournot duopoly: when profits reduce with horizontal product differentiation. *Japan and the World Economy*, 27, 34–40.

Gabszwicz, J. J., & Thisse, J.-F. (1986). On the nature of competition with differentiated products. *The Economic Journal*, 160–172.

Geels, F. W. (2002). Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case-study. *Research Policy*, 31(8–9), 1257–1274.
Geels, F. W. (2004). From sectoral systems of innovation to socio-technical systems: Insights about dynamics and change from sociology and institutional theory. *Research Policy*, 33(6–7), 897–920.
Geels, F. W. (2011). The multi-level perspective on sustainability transitions: Responses to seven criticisms. *Environmental Innovation and Societal Transitions*, 1(1), 24–40.
Geels, F. W. (2012). A socio-technical analysis of low-carbon transitions: introducing the multi-level perspective into transport studies. *Journal of Transport Geography*, 24, 471–482.
Geels, F. W., & Schot, J. (2007). Typology of sociotechnical transition pathways. *Research Policy*, 36(3), 399–417.
Genus, A., & Coles, A.-M. (2008). Rethinking the multi-level perspective of technological transitions. *Research Policy*, 37(9), 1436–1445.
Haanstra, A.-M., van der Pool, E., & van Weert, A. (2017) 'Eerste Monitoring- & Evaluatierapportage Breng flex'. Nijmegen: HAN.
Jittrapirom, P., Caiati, V., Feneri, A.-M., Ebrahimigharehbaghi, S., González, M. J. A., & Narayan, J. (2017a). Mobility as a Service: a critical review of definitions, assessments of schemes, and key challenges. *Urban Planning*, 2(2), 13.
Jittrapirom, P., Marchau, V. A., & Meurs, H. (2017b). Dynamic Adaptive Policymaking for implementing Mobility as a Service (MAAS). (Paper presented at the European Transport Conference, Barcelona)
Kamargianni, M., & Matyas, M. 96 (2017) 'The Business Ecosystem of Mobility-as-a-Service' *67th Annual Meeting of Transportation Research Board*. Washington DC: Transportation Research Board.
Karlsson, M., Sochor, J., Aapaoja, A., & Eckhardt, J. (2017) 'Mobility-as-a-service: development of a tentative impact assessment framework' *International Conference on Mobility as a Service (ICOMaaS)*. November 28–29. Tampere.
Karlsson, M., Sochor, J., & Strömberg, H. (2016). Developing the 'Service'in Mobility as a Service: experiences from a field trial of an innovative travel brokerage. *Transportation Research Procedia*, 14, 3265–3273.
Kerr, L. (2017) A tale of two green cities. Exploring the role of visions in the development of green infrastructure in two European Green Capital Cities. Radboud University
Martens, K. (2016). Transport justice: Designing fair transportation systems. Routledge.
Martin, R., & Sunley, P. (2006). Path dependence and regional economic evolution. *Journal of Economic Geography*, 6(4), 395–437.
Marx, R., de Mello, A. M., Zilbovicius, M., & de Lara, F. F. (2015). Spatial contexts and firm strategies: applying the multilevel perspective to sustainable urban mobility transitions in Brazil. *Journal of Cleaner Production*, 108, 1092–1104.
Meurs, H., & Timmermans, H. (2017) 'Mobility as a Service as a multi-sided market: Challenges for modeling' *96th Annual Meeting of Transportation Research Board*. Washington D.C.

Moradi, A., & Vagnoni, E. (2018). A multi-level perspective analysis of urban mobility system dynamics: What are the future transition pathways? *Technological Forecasting and Social Change*, 126, 231–243.
Nykvist, B., & Whitmarsh, L. (2008). A multi-level analysis of sustainable mobility transitions: Niche development in the UK and Sweden. *Technological Forecasting and Social Change*, 75(9), 1373–1387. doi:https://doi.org/10.1016/j.techfore.2008.05.006.
Oakil, A. T. M., Manting, D., & Nijland, H. (2016). Determinants of car ownership among young households in the Netherlands: The role of urbanisation and demographic and economic characteristics. *Journal of Transport Geography*, 51, 229–235.
Pereira, R. H., Schwanen, T., & Banister, D. (2017). Distributive justice and equity in transportation. *Transport Reviews*, 37(2), 170–191.
Rasouli, S., & Timmermans, H. (2013). Influence of social networks on latent choice of electric cars: a mixed logit specification using experimental design data. *Networks and Spatial Economics*, 1–32.
Sharmeen, F. (2015) Dynamics of social networks and activity travel behaviour Eindhoven University of Technology
Sharmeen, F., & Lagendijk, A. (2017). Cycling Practices through the Lens of Innovation Biographies. (Paper presented at the Asia Pacific Cycle Congress, Christchurch)
Shove, E., & Walker, G. (2010). Governing transitions in the sustainability of everyday life. *Research Policy*, 39(4), 471–476.
Tremblay, V. J., & Polasky, S. (2002). Advertising with subjective horizontal and vertical product differentiation. *Review of Industrial Organization*, 20(3), 253–265.
van Bree, B., Verbong, G. P. J., & Kramer, G. J. (2010). A multi-level perspective on the introduction of hydrogen and battery-electric vehicles. *Technological Forecasting and Social Change*, 77(4), 529–540. doi:https://doi.org/10.1016/j.techfore.2009.12.005.
van der Veer, D. (2017) Public transport and mobility on-demand Research on the efficiency of on-demand taxi service Abel. Radboud University
van Wee, B. (2015). Peak car: The first signs of a shift towards ICT-based activities replacing travel? A discussion paper. *Transport Policy*, 42, 1–3.
Warnick, B. (2001). Critical literacy in a digital era: Technology, rhetoric, and the public interest. Routledge.
Wiig, A. (2015). IBM's smart city as techno-utopian policy mobility. *City*, 19(2-3), 258–273.