Towards Mobility-as-a-Service: a cross-case analysis of public authorities' roles in the development of ICT-supported integrated mobility schemes

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Abstract

Automobiles have become counter-productive. Negative externalities resulting from car use have overcome the social benefits automobiles brought when initially introduced. Having shaped most contemporary transportation systems, the automobility regime is known to be hard to revert from. However, as all path-dependent systems, automobility can be subject to tipping points. Among other elements, the Information and Communication Technologies (ICTs) have enabled the development of new solutions having the potential to support a paradigm shift. At the forefront of ICT-enabled developments, so-called ICT-supported integrated mobility schemes have emerged, encompassing smart transportation cards, Integrated Mobility Platforms and Mobility-as-a-Service, that bundle different transport offers together and aim at providing users with a mobility solution of a level of service competitive with the one provided by private cars, ultimately holding the promise of supporting a shift from vehicle ownership to mobility usership and potentially help unlatching transportation systems from the current automobility lock-in.

However, most of those solutions are being proposed by the private sector, which often has different interests than the public sector. While the organization of transport usually falls under the responsibility of public actors, new governance structures are needed in order to make the most out of ICT-supported integrated mobility schemes. Hence, this thesis aims at shedding light on the role that public bodies are playing into the birth of smart cards, integrated mobility platforms and MaaS, and more specifically on the way they are governing their development. A case study strategy was employed in this thesis, where, building on grey literature and semi-structured interviews, the cases of smart cards development in London, integrated mobility platform unfolding in Vienna and Mobility-as-a-Service expansion in Helsinki served as empirical material.

Based on a cross-case analysis conducted using governance and socio-technical transition literatures, the main findings of this thesis are that (i) public transport authorities and state-owned railway undertakings are usually quite reluctant to ICT-supported integrated mobility schemes brought by external actors and prefer developing those by themselves and stay in control or avoid collaborating; (ii) central governments can act as true enablers by developing visions including strong quantitative targets, showing political support for those solutions, acting as matchmakers between public and private bodies, developing legislation, providing funding and steering, and using network governance to make incumbent regime actors change behaviours; (iii) city governments have a greater role to play by setting stronger quantitative-based visions and stop governing by laissez-faire; (iv) ICT-supported integrated mobility schemes should not be understood as magic bullets and must be combined with demand management policies to be truly effective.

By providing thick-descriptions of the nuts and bolts of smart cards, IMP and MaaS development, this thesis contributes to the literature on transport integration, transport governance and socio-technical transitions, and contributes to practice by suggesting fourteen recommendations for public authorities interested in a sustainable and impactful development of ICT-supported integrated mobility schemes.

Keywords

Urban mobility ; transport governance ; public authorities ; socio-technical transitions ; Mobility-as-a-Service

Résumé

L'automobile est devenue contre-productive. Les externalités négatives résultant de l'utilisation de la voiture ont en effet surpassé les bénéfices sociaux introduits initialement. Ayant influencé en profondeur les systèmes de transports actuels, la société contemporaine semble aujourd'hui prisonnière du régime d'automobilité. Cependant, il existe certains éléments ayant le potentiel de créer un changement de paradigme. Parmi eux, les technologies de l'information et de la communication (TIC) ont supporté le développement de nouvelles solutions proposant une alternative à l'automobilité. Au premier plan de ces développements, des solutions de mobilité intégrée facilitées par les TIC (comprenant les Smart Cards, plateformes de mobilités intégrées, et le concept de « Mobility-as-a-Service »), promettent à leurs utilisateurs, en groupant différentes solutions de transport à travers une seule et même interface, une offre de mobilité tendant à être compétitive avec l'automobile. Plus que cela, ces solutions promettent un transfert de la possession de véhicule vers l'utilisation de solutions de mobilité, laissant entrevoir potentiellement la fin de la souveraineté du régime d'automobilité.

Cependant, la plus part de ces solutions sont proposées par le secteur privé qui n'a pas forcément les mêmes intérêts dans leurs développements que le secteur public. Ainsi, de nouvelles structures de gouvernance sont nécessaires afin de garantir un développement pérenne des solutions de mobilité intégrée facilitées par les TIC. Cette thèse vise à mettre en lumière le rôle que les autorités publiques jouent dans le développement des Smart Cards, plateformes de mobilité intégrée et MaaS, et plus particulièrement la manière dont elles gouvernent le développement de ces solutions. Trois études de cas (développement des Smart Cards à Londres, de plateformes de mobilités intégrées à Vienne, et de MaaS à Helsinki), constituent la base empirique de cette étude.

À partir d'une analyse croisée des trois études de cas, réalisée en s'appuyant sur les littératures se focalisant sur la gouvernance urbaine et les transitions sociotechniques, les principales découvertes de cette thèse sont que (i) les autorités d'organisation des transports urbains et compagnies ferroviaires nationales sont souvent contre le développement de solutions de mobilité intégrée par le secteur privé et préfèrent faire les choses par elles mêmes (ou en ayant la main), ou évitent de collaborer avec des parties tiers ; (ii) les gouvernements centraux ont un vrai rôle de facilitateurs a jouer, de par le développement de visions établissant des objectifs quantitatifs clairs, cadres législatifs, clair support politique, et de par l'utilisation d'appareils de gouvernance horizontaux ; (iii) les villes ont un rôle plus important a jouer qu'elles ne le font aujourd'hui, par l'établissement d'objectifs quantitatifs clairs a moyens et longs termes ; (iv) les solutions de mobilité intégrée ne sont pas des recettes magiques, et que pour être effectives elles doivent être combinées avec le développement de politiques influant sur la demande en transport.

En présentant une description riche du jeu d'acteur sous-jacent au développement de solutions intelligentes de mobilité intégrées, cette thèse contribue aux littératures sur la gouvernance des transports, l'intégration des transports et les transitions sociotechniques, et contribue à la pratique en proposant quatorze recommandations destinées aux décideurs politiques intéressés à retirer le potentiel maximum de ces solutions.

Mots-clés

Mobilité urbaine ; gouvernance des transports ; autorités publiques ; transitions sociotechniques ; Mobility-as-a-Service

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Glossary of Abbreviations and Acronyms

AFCS: Automatic Fare Collection Systems

API: Application Programming Interface

C-ITS: Cooperative Intelligent Transport Systems

CPC: Contactless Payment Cards

CPM: Collaborative Public Management

CSD: Collaborative Stakeholders Dialogue

DLR: Docklands Light Railway

EMV: Europay-MasterCard-Visa

ETS: (European Union) Emission Trading Scheme

EU: European Union

GDP: Growth Domestic Product

GHG: Green House Gases

HMA: Helsinki Metropolitan Area

ICT: Information and Communication Technologies

IMP: Integrated Mobility Platform

ITS: Intelligent Transport Systems

MaaS: Mobility-as-a-Service

MLG: Multi-level Governance

MLP: Multi-level Perspective

MP: Member of Parliament

NPA: New Public Management

NPG: New Public Governance

NSI: National System of Innovation

NWS: New Weberian State

NPS: New Public Services

PAYG: Pay-as-you-go

PCI-DSS: Payment Card Industry Data Security Standard

PLJ: Transport System Plan (Helsinki)

PPP: Public-Private Partnership

PSP: Private Sector Participation

PT: Public Transport

R&D: Research and development

RFID: Radio Frequency Identification

RSI: Regional System of Innovation

RTI: Real Time Information

ServPPIN: Public-Private Innovation Network in Services

SLA: Service Level Agreements

SMILE: Smart Mobility Info and ticketing system Leading the way for effective E-Mobility services

SNM: Strategic Niche Management

SSI: Sectoral System of Innovation

SUMP: Sustainable Urban Mobility Plan

TCE: Transaction Cost Economics

TM: Transition Management

UK: United Kingdom

UNFCCC: United Nations Framework Convention on Climate Change

Glossary of Organizations

BMVIT: Ministry of Transportation, Innovation and Technology; Vienna

BTC: British Transport Commission; London

CCC: City Car Club; Helsinki

DfT: Department for Transport; London

DG MOVE: Directorate General for Mobility and Transport; Brussels

EC: European Commission; Brussels

FFG: Austrian Research Promotion Agency; Vienna

FPÖ: Freedom Party of Austria; Vienna

GLA: Greater London Authority; London

GLC: Greater London Council: London

HKL: Helsinki City Transport; Helsinki

HSL: Helsinki Regional Transport Authority; Helsinki

ICLEI: International Council for Local Environmental Initiatives; Bonn

IGLUS: Innovative Governance of Large Urban Systems; Lausanne

ITF: International Transport Forum; Paris

ITSO: International Telecommunication Satellite Organization; Milton Keynes

LPTB: London Passenger Transport Board; London

LRT: London Regional Transport; London

LTE: London Transport Executive; London

MTC: Ministry of Transportation and Communications; Helsinki

NCP: National Coalition Party; Helsinki

ÖBB: Österreichische Budesbahnen (Austrian Federal Railways); Vienna

OECD: Organization for Economic Co-operation and Development; Paris

ÖVP: Österreichische Volkspartei (Austrian People's Party); Vienna

SDP: Social Democratic Party; Helsinki

SPÖ: Social Democratic Party of Austria; Vienna

TfL: Transport for London; London

TRB: Transport Research Board; Washington DC

UITP: International Union of Public Transport; Brussels

UN: United Nations; New York

VAO: Verkehrauskunft Österreich; Vienna

VÖR: Verkehrsverbund Ost-Region; Vienna

VR: Valtion Rautatiet (Finnish State Railways); Helsinki

WEF: World Economic Forum; Geneva

WL: Wiener Linien; Vienna

WS: Wiener Stadtwerke; Vienna

Chapter 1 Introduction

This chapter presents the backdrop to this doctoral dissertation and explains why the selected topic is highly relevant and timely for the world of cities we live in nowadays. After presenting the actual state of urban transportation systems nowadays, the causes underlying their poor condition, and the main trend currently impacting the entire transportation sector, this chapter then frames the research problem that the doctoral dissertation seeks to address, before formulating the associated research question it aims to answer. The chapter concludes by depicting my personal motivations for engaging in this project, the research objectives, as well as the potential contributions to research and practice, and finally outlines the structure of this thesis report.

1.1 Background

Here, the current issues that urban transportation systems are facing, and the current lock in which they are evolving are presented, as well as the challenges and opportunities brought by the digitalization trend. The purpose is to provide a general background for the study in order to better understand its potential impact.

1.1.1 State of play

In 2016, it was estimated that 54.5 percent of the world's population lived in urban areas (UN, 2016). Cities are estimated to consume approximately 80 percent of the earth's natural resources and produce a similar share of global CO_2 emissions (WB, 2010). Consequently, it appears relevant to focus on cities in order to address challenges that modern societies are facing, such as climate change or non-renewable resources consumption. As the president of the European Commission, Jean-Claude Juncker, declared in his State of the Union Speech in September 2015, "[The fight against climate change] *will be won or lost on the ground and in the cities where most Europeans live, work and use about 80% of all the energy produced in Europe.*"[1]Thus, targeting urban infrastructure systems, such as energy, drinking water or green infrastructures, that are acknowledged to structure cities into huge "*living organisms*" (Hommels, 2005: 324) can be understood as a strategy contributing to sustainability. Being responsible for emitting between 15 and 20 percent of CO_2 emissions in the EU, and being often referred to as the backbone of cities (EC, 2008) – or the equivalent of what the cardiovascular network would be to a human body (Samaniego and Moses, 2008) – urban transportation systems naturally appear as one of the battlefronts on which climate change fight should take place.

Although most urban transportation systems still enable people to be somehow mobile in their cities, they are not functioning as effectively as intended or thought capable of when originally designed in their early days. Most urban transportation systems are now characterized by congestion that can be defined as a

[1] http://europa.eu/rapid/press-release_SPEECH-15-5614_en.htm (accessed August 29th 2017).

state where people are encountering delays in their trips because the density of transportation flows had become superior to the network capacity. Congestion has severe negative impacts for cities and creates negative externalities from three perspectives. First, congestion has devastating economic impacts. Costs associated with congestion are related to delays, extra-oil combustion costs, vehicle maintenance costs, and traffic accidents. It is estimated that congestion was responsible for a 3–6 percent GDP decrease in cities throughout the 1990s (UN Habitat, 2013). The latest study by INRIX Research showed that total costs linked solely to time lost in congestion for Europe top 25 cities could account for as much as £126.8 billion by 2025. London alone would face £42 billion of lost time by 2025 if nothing is done by that time (INRIX Research, 2016). Second, congestion has damaging environmental impacts, as vehicles tend to take longer than necessary to accomplish a trip, thus emitting more pollutants than what they would have done without congestion. Thus, congestion is responsible for a non-negligible part of CO_2 emissions in urban transportation systems. Last but not least, congestion is harmful from a social perspective, as it introduces stress and, more generally, health issues for drivers as well as other road occupants. More and more congestion is becoming a rising concern in Europe. If nothing is done before 2050, it is estimated that total congestion costs within the EU will increase by about 50 percent (EC, 2011). Congestion is not only a problem in Europe; it is also serious in other parts of the world. For example, congestion costs in 2010 accounted for 4.22 percent of Beijing's GDP (Mao et al., 2012). Of course, solving traffic congestion in cities will not alone be sufficient to tackle climate change and natural resource consumption, but it might help to make cities reduce their environmental impact and potentially help pave the way towards more sustainable cities.

A potential motivating factor is that there seems to be (a lot of) room for improvement. The average car occupancy rate in the global north is as low as 1.25 passengers per cars (Schäfer, 2011), even though most cars are designed to usually accommodate four to five adults. Furthermore, private cars remain unutilized most of the time. Cars are known to be parked for 95 percent of the time, on average (Shoup, 2005). With so much room for improvement, one could rightfully wonder what it is that is preventing policy makers from tackling congestion? As explained below, car ownership and its overarching concept, termed automobility, as well as growing urbanization, can be held responsible for the poor state in which most urban transportation systems are nowadays and for prevailing those to improve in the future.

1.1.2 Underlying causes : automobility and urbanization

Automobility, which is synonymous with single-occupant fossil-fuel powered private cars, supported by a range of institutions and infrastructures, dominating space and responsible for massive environmental resource consumption (Urry, 2008), has been described as one of main socio-technical institution through which modern societies are organized (Böhm et al., 2006). By placing cars on a pedestal and raising them to the level of a cultural symbol, human society progressively entered the path-dependent automobility system (Urry, 2004). Since their early release to the public in the late nineteenth century by German automakers Benz and Daimler (for a full history of the development of cars, see Parissien, 2013), cars have always been associated with values of freedom, speed, masculinity, and social betterment (Sachs, 1992). "*Small penis? Have I got a car for you. If you're going to overcompensate, then by all means, overcompensate*". Those were the words for example used to advertise the new Porsche 911 Carrera 4 in 1989, summing up quite simply the place of the automobile in modern society, which can also be illustrated by the fact that automobile are the major item of individual consumption after personal housing (Sheller and Urry, 2000).

The way automobiles have molded Western cultures and become one of their cornerstones is brilliantly resumed by French philosopher Roland Barthes, who defined automobiles as "*the gothic cathedral of modern times*" (Barthes, 1973). Automobiles had indeed become to modern societies what cathedrals were representing in the Middle Ages; that is, a set of beliefs driving society, and for which the most advanced arts and techniques were employed to represent them materially. Automobility is acknowledged to have coerced people into an intense flexibility (Urry, 2004), and led to the concept of "auto space" (Freund, 1993), being a space unbundled by any travel constraints. Given the promised liberty and freedom brought by the use of automobiles, car ownership has boomed over the last century. For example, the average number of cars per thousand inhabitants across the EU in 2015, according to Eurostat,[2] was almost 500, compared to almost zero a century ago. In the US, car ownership rates have quadrupled since the 1960s (Davis et al., 2016).

The twentieth century has also been marked by another important trend: urbanization. In 2008, following exponential growth (Pacione, 2001), it is estimated that a turning point occurred when, for the first time in history, more than half of the world's population was living in cities. Most of the increase in the urban population is known to originate from migration from rural areas, which is considered to be the most massive migration of modern times (Davis, 1955) and an on-going phenomenon, reinforced by globalization (Douglass, 2000), as the urban population is expected to grow to over 9 billion by 2100 (OECD, 2015). This important increase in urban population has ultimately resulted in an increase in mobility demand, which, combined with automobility, has resulted in new planning practices.

In the 1933 Athens Charter, French-Swiss architect Le Corbusier presented the axioms of the functionalist urbanism current, intending to start planning cities among four functional distinct zones to live, work, enjoy, and circulate. Built on the idea that "*a city for speed (was) made for success*" (Amado, 2011: 3), Le Corbusier's functionalist city positioned the automobile at its center. Le Corbusier's Ville Radieuse, also called the "City for three million", proposed a symmetrical city centered around a central business district made of 200-meter-high glass skyscrapers (Montavon et al., 2006), surrounded by a greenbelt, itself surrounded by satellite housing towns, all crossed by multiple driveways (Hseuh-Bruni, 2015), thus making most of the moves within the utopian city (that some would categorize as dystopia nowadays) dependent on the use of automobiles. Even though the Radiant City was never physically built, Le Corbusier paved the way for the development of car-centric cities, as the functionalist urbanism movement soon became the prominent planning trend of the twentieth century (Bofill and Veron, 1995). Influencing architects and forcing them to integrate parking spaces in most of their building developments (Morrison and Minnis, 2012), the functionalist urbanism quickly made architecture became a function of movement (Sheller and Urry, 2000), pushing even ironically famous architects such as Walter Gropius, Frank Lloyd Wright, and of course Le Corbusier himself, to design their own car prototypes (Amado, 2011). Known to have been shaped by key infrastructural developments (Konvitz, Rose and Tarr, 1990; Hodson et al., 2012), cities were progressively shaped by transportation system developments, themselves shaped by automobility (Sheller and Urry, 2000), ultimately reinforcing their dependence on automobiles. Cities that were once known as pedestrian cities, or transit cities step by step transformed into automobile cities (Newman and Kenworthy, 1999), where the realization of all activities of human life (work, entertainment and living) became entirely dependent on the use of cars.

With car ownership in cities rising faster than transportation infrastructure development (including public transport), roads quickly became saturated with automobiles, resulting in increased congestion. Because of congested city centers, urban dwellers moved from city centers to the suburbs, leading to urban sprawl and ultimately to more people buying cars to commute to work, which reinforced the "Frankenstein-created" automobility regime (Urry, 2004) and made congestion in cities even worse. The concept of transit, defining people's movements as the result of the human body actions, progressively made way for the concept of transport, defined as people's movement relying on external source of energy, and closely associated with the idea of servitude and dependence (Illich, 1973). By reaching a state of "critical velocity", along which individuals were unable to save time on their journeys without negatively impacting others (Illich, 1973), cars eventually became counter-productive, making the transport circulate function of functionalist cities

[2] http://ec.europa.eu/eurostat/statistics-explained/index.php/Passenger_cars_in_the_EU (Accessed August 30th 2017)

progressively cannibalize their live, work and enjoy functions (Robert, 2005). Ultimately, negative externalities resulting from car use, such as road congestion, contribution to climate change and air pollution, as well as injuries and deaths from traffic accidents, overcame the social benefits, such as freedom of movement, that automobiles brought when they were initially introduced (Marsden and Reardon, 2018).

1.1.3 Digitalization : challenges and opportunities

Although path-dependent systems, such as automobility, are hard to reverse from, they are also known to be subject to tipping points and paradigm shifts (Walks, 2015). With new fuel systems, new materials, innovative transport policies, new consumption patterns and smart cards, information and communication technologies (ICTs) were acknowledged to potentially contribute to this paradigm shift by supporting the emergence of the *post-car system* where transport will be made of "*a mixed flow of slow-moving semi-public micro-cars, bikes, many hybrid vehicles, pedestrians and mass transport integrated into a mobility of physical and virtual access*" (Urry, 2004: 35). ICTs have been acknowledged for having supported the unfolding of the "service revolution" (Barras, 1985), which has impacted many industrial sectors, including the transportation industry. They have also enabled a whole array of new transport solutions to take off, thanks to the development of dedicated digital platforms, supported by the rise of smartphones, enabling people to connect more easily to each other, and even in some cases to propose (mobility) services by themselves.

Car-sharing, whereby a dedicated organization makes available to members a fleet of shared vehicles on short-term basis, is one such example. Although such schemes have existed for more than fifty years (see Shaheen et al., 1999), it is acknowledged that developments in ICTs, such as in global positioning systems, and the advent of smartphones have contributed to their wider acceptance (Shaheen et al., 2009). Similarly, car-pooling, which consist of sharing a vehicle between people from a certain origin to a specific destination (Galland et al., 2014), has been available since World War II, but only reached a critical mass of users recently, thanks to recent advances in ICTs (Chan and Shaheen, 2012). One could also mention bike-sharing, where (like car-sharing) a pool of bicycles is made available to customers for short-term use; peer-to-peer car rental, where individuals are able to rent cars from one another thanks to a dedicated app or website; or ride-sourcing, where individuals are able to book rides offered by other car-owners who are not specifically professional drivers. One of the most interesting aspects of those ICT-facilitated mobility services is that those who use them do not explicitly need to own a vehicle to be mobile. Those solutions are basically "servicizing" mobility (Plepys et al., 2015). By using those new transport solutions, users directly have access to the product function, which is to be mobile, rather than the product itself, which would be the vehicle. Although new (digital) mobility modes rely on non-ownership modes, and might therefore be a solution to tackle car-ownership that constitutes one of the underlying issues of automobility, they also raise challenges. Because of their highly disruptive nature, these new mobility modes are also fragmenting the urban mobility landscape. While urban dwellers once had the choice of either using their personal vehicles or public transportation to meet their mobility needs, they now have the choice between a wide new array of ICT-supported mobility solutions, with lower occupancy levels than public transit. Hence, there is a need to develop new governance structures and processes to integrate those new mobility modes into existing public transit systems to ensure they serve the greater good and do not worsen the performance of existing transport systems.

While digitalization has enabled the development of the above-mentioned ICT-supported mobility solutions, it has also enabled a new way of organizing those solutions vis-à-vis each other. As detailed below, digitalization is enabling the integration of different transport modes, old and new, into different schemes (that constitute what is referred to in the thesis as ICT-supported integrated mobility schemes), which have the potential to support multi-modal travel and might therefore have a positive impact on the performance of existing transportation systems.

1.2 Problem statement and research question

More than creating new mobility modes, digitalization has actually opened new possibilities for transport integration, which could pave the way for more sustainable transport systems. Research has shown that the more complex a trip is, the more likely people are to use their personal vehicles (Hensher and Reyes, 2000), which is currently the only means of transport that allows for door-to-door travel. So, by seamlessly integrating different transport modes, one might decrease the likeliness that individuals will travel with their own cars and enhance their shift towards a combination of more sustainable transport modes. Below are presented the different solutions for transport integration that have been enabled by digitalization.

Firstly, digitalization has enabled the development of Advanced Travel Information Systems (ATIS) that aim to help travelers in "*making better travel choices by providing information regarding the available travel alternatives*" (Ben-Elia et al., 2013). By integrating digital information from different transportation providers into one single platform, ATIS enable users to have access to data about station locations, stations' geographies, fares, real-time locations of the vehicles or timetables from different transport operators. A well-known example of such services is provided by trip planners, where users enter their trip origins and destinations and are given information about all the available transport solutions to realize their trips. Depending on the number of transport operators that have agreed to share their data, trip planners are able to tell their users all possible solutions to reach their destinations in great detail. If users are interested in using public transport, the trip planner is usually able to tell them where to take the next bus, how much it will cost, where to transfer to the metro line, and so on. By providing information, ATIS aim to make non-car based transportation modes more attractive and potentially support the modal shift from private car travel to more sustainable mobility modes.

Secondly, digitalization has also enabled the integration of different payment systems of a complex transportation network into a single fare system, through a dedicated device, often referred to as "smart cards". The number of cities that adopted smart cards in the last decade, mostly supported by RFID technology, has grown exponentially. From only a handful of smart-card-based urban transportation systems in the early 2000s, hundreds of cities have now selected this option. Successful stories of early smart card development include cities like London, Hong Kong, and Seoul. Payment systems in these cities support transfers across transportation modes, ease traffic flow at ticket gates, and enable public authorities to obtain data about public transportation use (Park and Kim, 2013). In other words, payment integration also has the potential to make non-car based transportation modes more convenient, as well as more pleasant for the users, and to support modal shift.

Thirdly, digitalization is capable of supporting the merger of the two above-mentioned integration schemes, in so-called integrated mobility platforms (IMPs), where users have basically access to information, like with a trip planner, but are also given the opportunity to directly book their trips from different transport providers through a single app. By combining information and ticketing integration, those kinds of solutions appear as a real opportunity to induce modal shift from private cars to more sustainable transport modes. Last but not least, digitalization has paved the way for the unfolding of the Mobility-as-a-Service (MaaS) concept, which should be understood as a more advanced version of IMPs, where MaaS operators basically provide their users with mobility packages that bundle all imaginable mobility options, and guarantee them a mobility solution for whatever trip they intend on taking, rendering privately owned cars not necessary anymore to meet their mobility needs. By allowing the development of ICT-supported integrated mobility schemes (smart cards, IMPs and MaaS), digitalization has opened new opportunities to tackle automobility, by supporting a shift from car ownership to mobility usership, and hopefully helps pave the way for the post-car paradigm.

Given their ability to potentially contribute in reducing the number of cars on city roads, and thus their public interest, it is natural that ICT-supported integrated mobility schemes have triggered the interest of public actors. However, the development of such schemes require new skills and knowledge that are not inherent to public organizations. On the other hand, the private sector has already demonstrated its willingness to provide such schemes. Nevertheless, leaving the whole development of ICT-supported integrated mobility schemes to the private sector might also be harmful from a system perspective, as the private sector, driven by business interests, might be more interested to create a market where there actually is *more* mobility, not *less* (Docherty et al., 2017). There is a need for smart cards, IMPs, and MaaS to be successful; that is, to succeed in delivering public value, to be built with mass transit at the center (Currie, 2018), which ultimately requires new forms of cooperation between the private and public sector and, more specifically, new governance structures (Smith et al., 2017). More particularly, as the organization of transport usually falls under the responsibility of public authorities (Banister, 2001), one may wonder what role they are playing in the development of those new solutions, as there seems to be no common posture that public authorities are adopting worldwide. The development of ICT-supported integrated mobility schemes is occurring, but the only question public authorities should ask themselves is whether they want to be a part of it to frame it, or leave it to the hands of private developers that might not have sustainability and public policy targets in mind when proposing their solutions.

Although ICT-supported integrated mobility solutions are quite disruptive in nature, they should ultimately be understood as an opportunity and not as a threat (Marsden and Docherty, 2013; Marsden and Reardon, 2018), which will only be seized if public authorities manage to engage with the private sector through innovative governance schemes. Ultimately, documenting the type of governance structure under which ICT-supported integrated mobility systems have developed might help other cities to better engage down this path, which is why the following research question has been adopted for the present research endeavor.

<u>Research question</u>*: How are public authorities governing the development of ICT-supported integrated mobility systems?*

The answer to this research question will build on three cases[3] of development of such systems in European cities, in order to make other public authorities around the world aware of what has been already done, how it was done and what part of it was a success, thus hopefully helping smoothen the development of future ICT-supported integrated mobility solutions.

1.3 Personal motivations

Here the main motivations underlying the choice of topic for this dissertation, as well as different elements having reinforced it are presented.

I have always been interested in new and disruptive technologies, and more specifically in the array of solutions they could bring to our societies. Our world, particularly my own generation, has been considerably impacted by digitalization, and I was highly motivated to understand how the public sector could extract the most out of a phenomenon – transport digitalization – that was being led by the private sector. How could transport digitalization be shaped in order to benefit the many, rather than a handful of private ac-

[3] The research strategy employed in this dissertation is detailed in the methodological chapter (Chapter 3).

tors? How to avoid lock-ins from which it will be hard to revert from in decades? How to avoid digital transport solutions to follow the same trajectory that society followed with the development of the car, from wonder to subservience and dependence? Helping public authorities get it right and avoid repeating the mistakes of the past when it comes to the adoption of disrupting technologies was one of my main personal motivations underlying the present thesis.

I have also always been passionate about cities. Having been born and raised in Paris, I was quickly fascinated by the dynamics of urban systems. How could such systems function, given their internal levels of complexity and diversity? Why would people be attracted to live in cities, given their continual level of chaos? The bigger the city was, the more intriguing this question became for me. My parents gave me the opportunity to see quite a few buzzing cities while travelling. And I was always hit by the same simple question regarding cities – "*How on earth do they work?*" – which reinforced my fascination for them. More specifically, I was always interested in transportation in cities, and their dynamics, as I always believed they represented the crux of cities' functioning. However, more than just being interested in understanding cities as well as the role of public authorities into transport digitalization, I was interested in making a change. I wanted my research to be useful and help move towards a more sustainable society. I wanted to choose a concrete subject, because I did not want to write a PhD only for the sake of science. I wanted my findings to be quickly usable by decision makers and contribute to ultimately improving the everyday life of people. While I can assume to have partially addressed the two above-mentioned categories with this dissertation, it is perhaps too early to assess the success for the third category. However, I truly hope that public authorities will look at this work and gain insights from it before engaging in the development of ICT-facilitated integrated transportation systems and follow my recommendations.

Here I must underline the importance of the IGLUS (Innovative Governance of Large Urban Systems) project at EPFL in helping me gain a better understanding of challenges associated with urban transportation systems. The IGLUS project was an Executive Master's program launched in 2014, aimed at teaching urban practitioners governance and management of urban infrastructure systems, which I managed from 2015 to 2016 during the first year of my PhD studies. It brought together practitioners and academics from various fields, such as political science, architecture, engineering, economics, public administration and business, interested in learning about governance of urban systems. Students, who were older and more experienced than I was at that time, and whom I was supervising, were given the opportunity to learn from academics and practitioners, from the public and the private sectors to discuss governance of five urban infrastructure systems: energy, housing, water, green infrastructures, and of course transportation. It is by organizing those modules, going on-site, observing with my own eyes, and learning from all those experts, that I understood why I wanted to focus on mobility. The program was organized in six two-week modules that took place in some of the world most vibrant cities, and each focused on one particular urban challenge. IGLUS students (and their coordinators; that was, me) would travel to Mexico City and Guadalajara to focus on social urban challenges, Dubai to look at urban environmental challenges, Istanbul to understand urban cultural challenges, Seoul to get insights on urban technological challenges, New York and Detroit to look at financial and economic challenges of cities, and Dortmund to focus on metropolitan challenges.

In Mexico, which is one of the biggest cities in the world, that has grown tremendously during the last century, I could understand how damaging the lack of public transport services be for a city, and the social consequences of having an institutionally fragmented transport sector. In Dubai, where the city had developed along a two-times-seven-lanes road, also known as Sheikh Zayed road, I became aware of how transportation infrastructures could become lock-ins for cities. I was shocked to discover that missing a highway exit in the city center of Dubai could result in a 15 km detour, which also made me understand how the urban form of a city would influence the development of the public transport system, and unfortunately fail in making it attractive. The city in which I most clearly understood the extent to which private cars could be destructive for cities was undoubtedly Detroit. There, I understood the capacity that cities had to become dependent on cars, so much that it would make them collapse from the inside. It is really in Detroit that I understood how auto-destructive the concept of automobility could be for cities, and how harmful the idea of car ownership could be for society in general. In Seoul, I understood the opportunities that ICTs were bringing to transportation, and in particular how ICT-supported integrated mobility schemes could contribute in reducing private motorized travel.

I should also mention that my participation in the IGLUS modules helped me convince myself that the subject of digitally integrated mobility was relevant. Going all over the world with IGLUS comforted me in the thinking that my research was actually worth doing, timely, and would have an impact for cities, either now or in the near future. For example, I could see that the solution would have a positive impact in Mexico. The city is indeed already equipped with a developed public transportation network, as well as informal transport system, but it is quite fragmented, and not always as easy to use as one would wish. Simplifying the ticketing and information system for all modes of transport would be a real advance in making shared transport modes more successful in the Mexican capital city. Of course, there are lots of different initiatives to be conducted in parallel, but the one of ICT-supported integrated mobility is definitively worth looking at. Similarly, digital integrated mobility would have an important impact in polycentric metropolitan regions that already have a developed public transportation system. Dortmund is part of the Rhine Ruhr region, and commuting between the different nucleuses of this metropolitan region is really frequent for inhabitants. However, local transportation systems are not always well integrated with regional transportation systems, which makes car travel look sometimes more convenient and easy to use. Here again, where shared transport solutions are available but not well integrated, digital integration of transportation modes can have a real advantage. The IGLUS experience also helped me understand that what I was looking at would not be a magic bullet for every city around the globe. For example, I understood that it would be pointless to try implementing it in cities like Detroit or Dubai, where no performant public transportation systems exists, and where dwellers are much more dependent on their cars than anywhere else. But what I could be sure of after having attended six modules of the IGLUS Executive Master's program was that public authorities are somewhat lost in the whole transport digitalization wave, and although they acknowledge the benefits that such solutions might bring, many of them are slow to move and sometimes reluctant to do so. Given the diversity of cities that were in the IGLUS portfolio, it made me confident that the research question I was planning to adopt could serve a great number of cities around the world. Of course it would have its limitations, as it will be detailed later, but it could help make cities better places to live in.

During my time as IGLUS program coordinator, I also had responsibility for supervising some of the IGLUS students' master's theses. This gave me the opportunity to supervise the thesis of transport practitioners from major transportation authorities that were interested in working on the governance of urban transportation systems. The variety of backgrounds of those students, as well as the plurality of subjects they were interested in exploring, also allowed me to look into transport-related themes that I might not have crossed otherwise. Although not directly related to my PhD topic, I learned a lot from the IGLUS master theses I supervised and I am grateful to those IGLUS graduates who agreed to work with me.

Having been able to co-edit with Prof. Matthias Finger a book focusing on the governance of smart transportation systems, also comforted me in my choice of research. The book (Finger and Audouin, 2019) focuses on new governance structures for automated, electric, shared and integrated mobility, and gave me another opportunity to learn more about how modern societies are embracing (or sometimes not) tech-pushed disruptions happening in the transportation sector. I could see that for all that is happening in the mobility scene, digitally integrated mobility systems are a way to re-harmonize transportation systems, and must be looked at by all public authorities in major cities, encountering disruptions in their long established transportation sector. I am grateful to everyone who contributed to this work and I learned a lot from them.

Last but not least, I should mention an episode of my personal life that might have boosted me in the choice of my topic. When I started my PhD, I did not have a driving license and was therefore not fully aware of the various shades of the automobility concept, especially why humans were so attached to cars and why automobiles had become the ultimate symbol of social success. In order to better understand it (and also because I was going to need it for some planned holidays where no other mobility options where available), I decided to start my "driving license journey" during the second year of my PhD. Getting a driving license in Switzerland is a fairly lengthy exercise. First, the whole process takes about eight months, assuming that you obtain your driving license at the first attempt. It then costs about 2500 CHF, which is quite expensive compared to the monthly income of a PhD student. Last but not least, you have to complete quite some steps before being finally able to take the exam, such as passing the first aid certification, theory classes, and a lot of driving lessons, which is very time-consuming. Getting my driving license was not the smoothest journey I undertook, as I could not really feel myself in synch with my driving instructor. I would always remember when driving on a highway where we were almost the only ones, and when we were going fast enough from my point of view, he told me: "*Come on, put the pedal to the metal, enjoy yourself!*". Although I did not enjoy accelerating for the sake of it, it made me realize the extent to which people were attracted to speed, and to this false notion of freedom, from which they would become enslaved. I did not feel any excitement going faster than other drivers and risking my own life, nor challenging the speed limit, but I understood at that point that I would never be as fascinated by cars as my driving teacher was. More specifically, it made me aware of how important it was to make others understand and realize how dangerous the concept of automobility was, and to make public authorities discover ways of potentially exiting it. I also realized how lucky I was to live in a city (Lausanne, Switzerland) where I did not need a car to meet my mobility needs and where I could do everything with public transit, human-powered mobility modes, and ride-booking services. I finally got my driving license (at the first attempt), but instead of seeing it as a reason to buy a car (as many young people still do), I swore to myself that I would do everything in my power not to buy a car for the rest of my life. This is why I became so passionate about ICT-supported integrated mobility schemes, which hold the promise of making car-ownership useless.

Below, the research objectives of this thesis, as well as the potential contributions to the literature are detailed. This chapter ends by ultimately shedding light on the main concepts used in this thesis and the structure of the present report.

1.4 Research objectives and contribution

1.4.1 Research objectives and contributions to practice

As explained above, digitalization is massively impacting transportation systems, and might be a game-changer in terms of their sustainability, by enabling new modes of mobility and, more specifically, potentially reducing the need for urban dwellers to own cars. Nowadays, public authorities are somewhat overwhelmed by digitalization (da Rosa and de Almeida, 2017), being pushed by the private sector, and need pointers in order to know where to go and to reap the full benefits of this thoroughgoing transformation. It is possible that if public authorities lose this window of opportunity brought by the digitalization of transportation (Marsden and Reardon, 2018), things might well evolve only in the interests of the private sector, which appears to have lower interest when it comes to sustainability of cities. As digitalization is pervasive and it seems that no cities will be saved from it, public authorities need concise and thoughtful recommendations in order get the digital integration of their transportation systems right and avoid technological and social lock-ins, as history has showed us with our love of the automobile. Therefore, the major objective of this thesis is to come up with a list of recommendations, to help public authorities frame the development of digitally integrated transportation systems so that they benefit the many and ultimately pave the way for the post-automobility system. Those recommendations primarily target mature cities, but will of course be of interest for cities that will reach such stage of development in the future. Talking about getting the digitalization of transportation right for some cities in developing countries might be well perceived as putting the cart before the horses. However, those cities will evolve, probably quicker than one would expect, and will be soon confronted with issues that more mature cities are facing nowadays.

1.4.2 Potential scientific contributions

The contribution of this thesis is threefold.[4] First of all, it aims to contribute to the literature on transport integration. Indeed, as it will be explained, most of this literature has been interested in looking at the impact of transport integration on the performance of existing transport systems. However, very limited research has been conducted to look at the processes leading to transport integration and the development of integrated transport schemes. Secondly, it seeks to contribute to the transport governance literature. Most of this literature has been interested in measuring the impact of particular governance tools on the performance of transport systems. But limited research has been conducted to understand the politics of development of a particular transport technology such as ICT-supported integrated mobility schemes. Thirdly, this thesis aims to contribute to the socio-technical systems transition literature. Much of the research done into that field has looked at the development and diffusion of specific technological innovations (EVs, shared mobility, etc.), but almost none has looked at the development of ICT-supported integrated mobility schemes.

1.5 Clarification of the main concepts

In this thesis are used a number of terms that might be understood differently depending on the reader's background and professional orientation. It seems important to clarify the meaning of each of those terms in order to avoid misunderstandings and confusion. Thus, below, a definition of each of those concepts is provided. The terms are ranked alphabetically below.

Digitalization is, according to the Collins English Dictionary the process by which information is transformed to become easily read by computers.[5] It is an important concept to bear in mind in this thesis as all the innovations looked at are basically enabled thanks to digitalization of transportation.

Governance refers to "*the system through which a kind of order is achieved among several actors who are interacting with each other about a common issue (which is of mutual interest for the involved parties) even though they might have conflicting interests*" (Razaghi and Finger, 2012: 7).

Information and communication technologies (ICTs) are defined as a "*diverse set of technological tools and resources used to communicate, and to create, disseminate, store, and manage information*" (Blurton, 1999: 1). It is thanks to ICTs that the entire digitalization process is occurring.

[4] This is explained in more detail in the Literature Review chapter (chapter 2)
[5] https://www.collinsdictionary.com/dictionary/english/digitize (accessed September 15th 2017)

Innovation can be simply and broadly defined as "*the generation, acceptance and implementation of new ideas, processes products or services*" (Thompson, 1965: 2). For that matter, ICT-supported integrated mobility schemes, by their novel nature, can be understood as innovations.

Institutions refer to "*the rules of the game in a society*" (North, 1990: 3), including both formal (laws enforced by the state) and informal rules (codes of conduct, conventions). It is important to highlight that institutions in this work do not refer to organizations, as may be the case in other literatures.

Integrated mobility platforms (IMPs) can be defined as unique platforms that integrate information and payment systems from different transportation providers, through the use of the ICTs, allowing users to instantaneously book their trips, and pay at their point of use. IMPs do not guarantee their users freedom of mobility, which is why they are different from the Mobility-as-a-Service concept, and thus not used interchangeably in this thesis.

Lock-ins can be defined as a state in which an individual or an entity might not be able to evolve because of past decisions it has made. For example, the Paris subway ticketing system relies on turnstiles, which can be understood as a lock-in regarding mobile ticketing. Indeed, the Paris transportation authority would need to change all of its turnstiles to make them able to read mobile tickets.

Mobility-as-a-Service (MaaS) is defined in this thesis as formulated by the father of the concept, Sampo Hietanen; that is, as a "*co-operative, interconnected eco-system, providing mobility services reflecting the needs of customers, met over one interface and are offered by a service provider bundled in to a package – similar to mobile phone price-plan packages*" (Hietanen, 2014: 3). MaaS must not be used interchangeably with IMPs (defined above), although this is often done in practice.

Mobility refers to the "*ability to move or be moved freely and easily*"[6] (Oxford Dictionary). Thus, it does not represent the action of moving or being moved, but rather the possibility to access geographic places independently of time.

Multimodality is used in this thesis interchangeably with the term intermodality. The concept of multimodality refers to a combination of "*more than one transport service for making a trip, being combinations of private transport and public transport services or combinations of public transport services*" (Van Nes, 2002: 9).

Path-dependency refers to "*the causal relevance of preceding stages in a temporal sequence*" (Pierson, 2000: 252). In other words, path-dependency appears when the array of choices an entity (or individual) is limited by choices it/he/she has made in the past, even though those past decisions might no longer be valid or relevant.

Public authorities. refer to "*government or public administration, including public advisory bodies, at national, regional or local level (…) performing public administrative functions under national law, including specific duties.*"[7]

Smart cards are plastic pocket-size cards with an embedded chip, which can store and in most of the cases process data, through RFID technology (Pelletier et al., 2011). They are very often used for automated fare collection systems across different transportation modes by public transportation authorities. In this thesis the term smart cards is used to talk about smart transportation cards.

[6] https://en.oxforddictionaries.com/definition/mobility (accessed on September 15th 2017)

[7] http://inspire.ec.europa.eu/glossary/PublicAuthority, accessed on September 14th 2017

Socio-technical systems are systems in which technological components and people are in interaction and influence one another, within a given environment (Ropohl, 1999). Urban transportation systems rely on technical components (vehicles, traffic signs, infrastructure, ticketing systems, information systems, fuel systems, etc.), as well as human components (urban dwellers having specific mobility needs and behaviors) that interact with one another, which is why they are considered as socio-technical systems.

Systems are can be seen (Ackoff, 1997: 421–422) *"as a set of two or more interrelated elements of any kind (…) Therefore, it is not an ultimate indivisible element but a whole that can be divided into parts. The elements of the set and the set of elements that form a system have the following three properties:*

- *Every possible subgroup of elements in the set has the first two proper ties; each has a non independent effect on the whole. Therefore, the whole cannot be decomposed into independent subsets. A system cannot be subdivided into independent subsystems.*
- *The properties and behavior of each element, and the way they affect the whole, depend on the properties and behavior of at least one other element in the set. Therefore, no part has an independent effect on the whole, and each is affected by at least one other part.*
- *The properties, or behavior, of each element of the set have an effect on the properties or behavior of the set taken as a whole."*

Transport integration should be understood in this thesis as the "*pursuit of synergies*" (May and Roberts, 1995) and the removal of barriers between different transportation modes, to favor multimodality.

Transport, according to the Oxford Dictionary, is defined as the action of taking or carrying "*people from one place to another by means of a vehicle aircraft or ship*."[8] It originates from the Latin words "trans" (meaning across), and "portare" (to carry). Transport must not be confused with "mobility", and this thesis intends to respect this differentiation.

1.6 Structure of the thesis

This thesis is structured in six main chapters. After the introductory chapter (Chapter 1), which aimed to set the stage and present the thesis' main research question, readers are provided with a review of the three main bodies of scientific literature that this thesis aims to contribute to (Chapter 2): (i) transport integration, (ii) transport governance, and (iii) socio-technical transition studies.

Chapter 3 then presents the methodology adopted to answer the research question this thesis focuses on, as well as the research strategy, the case selection, data collection, data analysis, and case analysis processes employed. Chapter 3 will also provide readers with the overall research design, as well as the necessary steps taken by the researcher to ensure the quality of the research, and finally the way research ethics were considered in the dissertation.

In Chapter 4, the three longitudinal descriptive cases studies this thesis builds on are presented, which constitutes the empirical material of the present research endeavor. The chapter starts with (i) the case of smart cards development in London, followed by (ii) the case of IMP development in Vienna, (iii) the case of Mobility-as-a-Service unfolding in Helsinki.

[8] https://en.oxforddictionaries.com/definition/transport (accessed on September 15th 2017)

In Chapter 5, the three cases are analyzed using two different conceptual frameworks. The cases are first analyzed using a framework that builds on the governance and innovation management literature (i). In a second time the three cases are comparatively analyzed using a framework building on the socio-technical transition literature (ii).

The thesis concludes with Chapter 6, in which the results of both analyses are combined into a list of recommendations geared at policy makers interested in framing the development of ICT-supported integrated mobility schemes, to make the most out of those. Contributions to scientific literature are also emphasized. This last chapter also sheds light on the limitations of the present research endeavor and ultimately proposes leads for future research to be conducted.

Chapter 2 Literature review

In this chapter, I begin by presenting the way I selected the three different bodies of literature to be reviewed for the present research endeavor. Then, I review the literature on transport integration to highlight its shortcomings vis-à-vis this thesis' research question. In a third section, I review the literature on transport governance to shed light on the lack of research existing on the study of the governance of development of ICT-supported integrated mobility schemes. In a fourth section, I review the literature focusing on the mobility transition studies and again show that almost no research has been undertaken about the subject I aim to explore. In a fifth and last section I sum up the existing research gap of the three reviewed bodies of literature and highlight how the present research might contribute to those.

2.1 Introduction

As explained in the introductory chapter, this thesis aims to answer the following research question: *How are public authorities governing the development of ICT-supported integrated mobility schemes?* This chapter aims to show that this question has not yet been treated and that the topic is currently under-researched. By highlighting the lack of research existing on the topic, this chapter also aims at shedding light on the potential contributions this thesis might make to the scientific literature.

To emphasize the research gap surrounding the research question, several bodies of literature have been reviewed. First, it is important to explain how those bodies of literature were selected. To build this literature review chapter, a so-called "*cascade approach*" was adopted. From the review of one body of literature, and more specifically from the analysis of what this literature did not cover, other bodies of literature were determined and reviewed, and so on. In other words, the literature selection process has actually been organized as a sequence, where the justification of looking into a particular literature actually came from the presentation of the shortcomings of the previously reviewed literature. Hence, it was only after having reviewed the first body of literature that the second body of literature could be selected; and only after the second body of literature was reviewed the third body of literature could be identified.

The first term of the research question looked at in the literature selection process was "*integrated mobility*", which resulted in the review of the literature focusing on transport integration. Given the lack of research in this literature focusing on research questions close to the one this thesis seeks to address, the literature focusing on transport governance was reviewed, motivated by the words "*public authorities governing"*. Again, due to the lack of studies looking at the development of ICT-supported integrated mobility schemes in the transport governance literature, a third body of literature focusing on system innovations, or sociotechnical transitions, and more particularly on the mobility transition was identified and reviewed, motivated by the terms *"development of ICT-supported [solutions]".* Still, a very limited number of studies looking specifically at the governance of development of ICT-supported integrated mobility schemes were identified.

Consequently, this chapter is organized as follows. First, the literature focusing on transport integration is reviewed. This sub-part concludes by highlighting the research gap existing in this literature that is to say lack of research looking at the governance of development of smart cards, IMPs and MaaS. Secondly, the literature focusing on transport governance is reviewed before again highlighting the research gap existing about the study of ICT-supported integrated mobility schemes unfolding. Thirdly, is reviewed the literature on socio-technical system transitions, and more specifically on the so-called mobility transition, to again show that no studies from that literature have yet looked at the governance of development of smart cards, IMP and MaaS. In a fourth and last part, the lack of research existing about the processes of development of ICT-supported integrated mobility schemes in all the three bodies of literature reviewed in this chapter is summarized, and potential contributions of the present thesis to literature on transport integration, transport governance and socio-technical transitions are highlighted.

2.2 Transport integration literature

Transport integration has been described as "*one of the most important means to advance sustainable transport and sustainability more generally*" (Givoni and Banister, 2010: 1). Consequently, it has generated a lot of interest from transport scholars. Transport integration can be understood in several different ways (Janic and Reggiani, 2001). For many scholars, transport integration can be understood as a scale, composed of different steps (Hull, 2005; Potter and Skinner, 2000). The first of those steps relates to modal (sometimes called functional) integration, which is concerned with enabling multimodal (sometimes called intermodal) journeys, by combining different travel modes so they become complementary to one another in order to offer a robust alternative to private motorized travel. The second step, known as integrated transport and land-use, refers to the integration of transport and planning in order to influence transport behaviors and potentially reduce the need to travel. The third step, known as social integration, essentially concerns the integration of all possible stakeholders into transport policy making. The last step, referred to as integrated transport policy, deals with the integration of environmental, economic, and transport policies in order to maximize the performance of transport systems.

ICT-supported integration schemes, which are the prime focus of this thesis, mainly deal with the combination of different transport modes; that is, modal integration. Thus, while the importance of the three most advanced steps of the transport integration ladder (integrated transport and land use; social integration; and integrated transport policy) is acknowledged, only the literature focusing on modal integration will be reviewed in this section. First is reviewed the sub-literature focusing on traditional modal transport integration steps. Then, the sub-literature focusing on ICT-supported integration solutions is reviewed. In a third time, the barriers and challenges listed in the literature in order to move towards modal integration are summarized. Finally the shortcomings of the transport integration literature vis-à-vis the research question this thesis seeks to answer are summarized and the second body of literature constituting this literature review chapter is introduced.

2.2.1 Traditional modal integration

The lack of integration between different transport modes has often been identified as one of the biggest issue for the definition of an alternative to private motorized transport (Pitsiava-Latinopoulou and Iordanopoulos, 2012). To tackle this issue, the concept of intermodal transport (sometimes also called mixed-mode commuting or multimodality) has been proposed. Defined as "*the use of more than one mode of transport within one journey*" (Givoni and Banister, 2010: 5), intermodal transport has often been presented as a possible way to offer a door-to-door alternatives to private motorized traffic, and for its potentially positive environmental impacts and efficiency gains, and as a way to cope with growing transport flows (Bontekoning et al., 2004). As the term suggests, intermodal transport implies the integration of different transport modes with one another within a journey. Consequently, the term modal integration has been proposed as a means of achieving intermodal transport.

Below, the sub-literature that has focused on modal transport integration approaches that were historically employed (termed traditional modal integration) before recent developments in the ICTs is reviewed. In particular are reviewed works that have been focusing on the notions of physical integration, network integration, timetable integration and fare integration. Then, studies that have looked specifically at ICT-supported integration solutions (defined as digital integration) are reviewed. Finally, a summary of the main barriers emphasized by scholars in terms of reaching modal integration, both for traditional and digital integration steps is given.

- Physical integration

Physical integration is perhaps the first step to modal integration and existed well before the term began to be used by academics. It relates to the design and planning of the physical elements of the transportation network in order to facilitate intermodal journeys, which has been acknowledged to be beneficial to non-private motorized transport ridership (Givoni and Rietveld, 2007). The concept has been used for the architectural design of transport stations in order to enable users to physically transfer from one transport mode to another. Examples of physically integrated transport infrastructures are transport hubs that are actually nodes of a given transportation network (that is, where different transport routes intersect), such as park and ride (P+R) facilities, or light-rail stations located on bus routes and where transfers from one to the other are physically possible. Quantitative research has been conducted in order to understand the impact of physical integration on existing transportation systems. For example, Kuby et al. (2004) used data from US cities to demonstrate that P+R facilities and light-rail stations that were connected with other bus routes were positively correlated with increased light-rail ridership. Quantitative and qualitative research has also been conducted to understand what were the key success factors to have a performing transport hub. For a comprehensive view, see the book edited by Monzon and Ciommo (2016) entitled *City-HUBs: Sustainable and Efficient Urban Transport Interchanges*. According to Ubbels and colleagues (2013), the key physical factors for a successful transport interchange are the position of the hub in the transportation network, its surrounding urban environment, the possibility for all users (elderly, children, disabled, people with large luggage) to access the place, easy way-finding and barrier-free accessibility. Looking at interchanges in Athens, Pitsiava-Latinopoulou and Iordanopoulos (2012) concluded that the probability of having people transfer from one mode to another in a transport hub was linked to the number of public transport modes serving it, of course, but also to the spatial location of each mode's platforms and their physical connectivity. Hine and Scott (2000) added that the quality of the waiting environment, the levels of security, and the quality of signage were also to be considered in the assessment of the effectiveness of a transport interchange. Last but not least, research has been undertaken to better understand the factors of appreciation of the population for physical integration of transport. According to Hernandez et al. (2016), focusing on the case of a transport hub in Madrid, an interchange is more likely to be successful, from the population's perspective, depending on its level of comfort, the number and variety of shops, as well as the readiness of the interchange in case of emergency situations. Looking at the physical integration of bike infrastructure and public transport, Pucher and Buehler (2009) showed that in some major US cities, there was growing demand for bike-and-ride facilities (creation of bike parking at public transport stations or installment of bike-carrying elements in buses or train), which was usually unsatisfied, sending a clear signal to decision makers to build more of those. The need to physically integrate bicycles and BRT was also emphasized by

Deng and Nelson for the case of Beijing (2013). However, scholars have also highlighted the need to consider network integration when considering physical integration, as having one without having the other would not make sense.

- Network integration

Network Integration is closely related to physical integration and is concerned with the design of the overall transport network so that modes become complementary to one another. Network integration specifically deals with the classification of transport routes, across different modes, into different categories. This way, the capacity of each branch of the transportation network is decided depending on their function (feeder or trunk routes), avoiding over- or under-dimensioning the transportation network branches' capacity. A growing number of public transport scholars have focused on the impact of network integration on the overall efficiency of the public transport system. For example, Hidalgo (2009) looked at network integration as part of the bus reform in Sao Paulo and concluded that network integration could lead to reduced travel times for users, and increased attractiveness of the public transport system. Similar results were reached for Allen's (2013) study of Seoul bus reform. Similarly, the lack of network integration has been pointed out as a cause for network inefficiencies. For example, Wright (2011) stressed the importance for public authorities to redesign their entire bus network when introducing bus rapid transit (BRT) systems. According to Wright, it is very likely that BRT systems will under-perform if no network-integration is conducted with the existing transportation system.

- Timetable integration

Research has also been conducted on timetable integration, which is acknowledged for having an effect on transfer times, total travel times, and therefore on the likeliness of people to undertake intermodal journeys. For example, it has been assessed by the NSW Ministry of Transport (2008) that waiting and transferring times were among the main reasons why citizens would be reluctant to combine several modes when commuting. Similarly, Litman (2010) demonstrated that public transport users spent approximately 10–30 percent of their travel time waiting to board for their next connections, which highlighs the potential benefits of better timetable integration. Thus, research has been conducted to emphasize the effects of timetable integration from a system-wide perspective. For example, Buehler and Pucher (2011) showed that the regional coordination of timetables in Germany contributed to an increase in public transport ridership. Similar results were found by Cascetta and Pagliara (2008), looking at the development and integration of the regional metro system in Naples.

- Fare integration

Last but not least, scholars have conducted research on fare integration. Defined as the integration of fares on a given public transportation system, fare integration is supposed to "*cut barriers to transit access, encourage participation in monthly pass programs, and potentially serve as new revenue sources for transit agencies*" (Goldman and Gorham, 2006: 267). As for other modal integration steps, academics have been mainly interested in understanding the impact of fare integration on public transport ridership. An early study from Pucher and Kurth (1995) focusing on Germany, Switzerland, and Austria concluded that fare integration could be held responsible for increasingly attracting public transport riders, and for participating in stabilizing, if not increasing, public transport ridership. Looking at Madrid, Matas (2004) found that the implementation of an integrated fare system was synonymous with a 15 percent increase in underground trips and over 7 percent in bus trips. Abrate and colleagues (2009) studied the impact of fare integration implementation in Italy and found that it was positively associated with increased public transport patronage. Looking at Haifa in Israel, Sharaby and Shiftan (2012) showed that fare integration was also associated with increased public transport patronage. Last but not least, Hirsch et al. (2010) demonstrated that the introduction of integrated fare systems, supported by the magnetic strip MetroCard in New York, resulted in 20.3 percent increase in public transport ridership on weekdays and 24 percent on weekends from January 1997 to June 1999. Research was also conducted to understand the economic benefits of integrated fare systems. In that regard, Opurum (2009), for example, demonstrated that the introduction of the MetroCard in New York could allow siginificant savings for the public transport authority.

As mentioned in the introduction, digitalization has been (and is still) massively impacting transportation, resulting in a whole new array of modal integration possibilities. Those solutions have triggered a lot of interest from transportation scholars, as it will be explained below.

2.2.2 Digital integration

ICTs can be seen as having created a twofold disruption of the transportation sector (see figure 2.2.1). On the one hand, they have enabled the creation of new transportation solutions, such as car-sharing, carpooling or ride-booking, relying on the exchange of data between transport providers and users (Audouin and Finger, 2019a). Although some of those transport solutions have existed for several decades, it is really with the advent of ICTs that they have become so popular (Shaheen et al., 2009; Chan and Shaheen, 2012). Consequently, research has been carried out to understand the impact of those solutions on existing transportation systems. For a detailed view of how ICT-supported mobility modes impact people's mobility, see Meyer and Shaheen (2017). On the other hand, ICTs have supported the creation of the so-called data-layer (Finger and Razaghi, 2017), constituted of different data from various transport operators (newly developed thanks to ICTs, or old ones that have jumped into the digital transport wagon) and users, as well as dedicated algorithms, on top of which new services can develop including new modal integration solutions. Those new digital integration solutions, that are constitute togeteher ICT-supported integrated mobility schemes, are smart cards, IMPs, and ultimately what is referred to as Mobility-as-a-Service (MaaS).

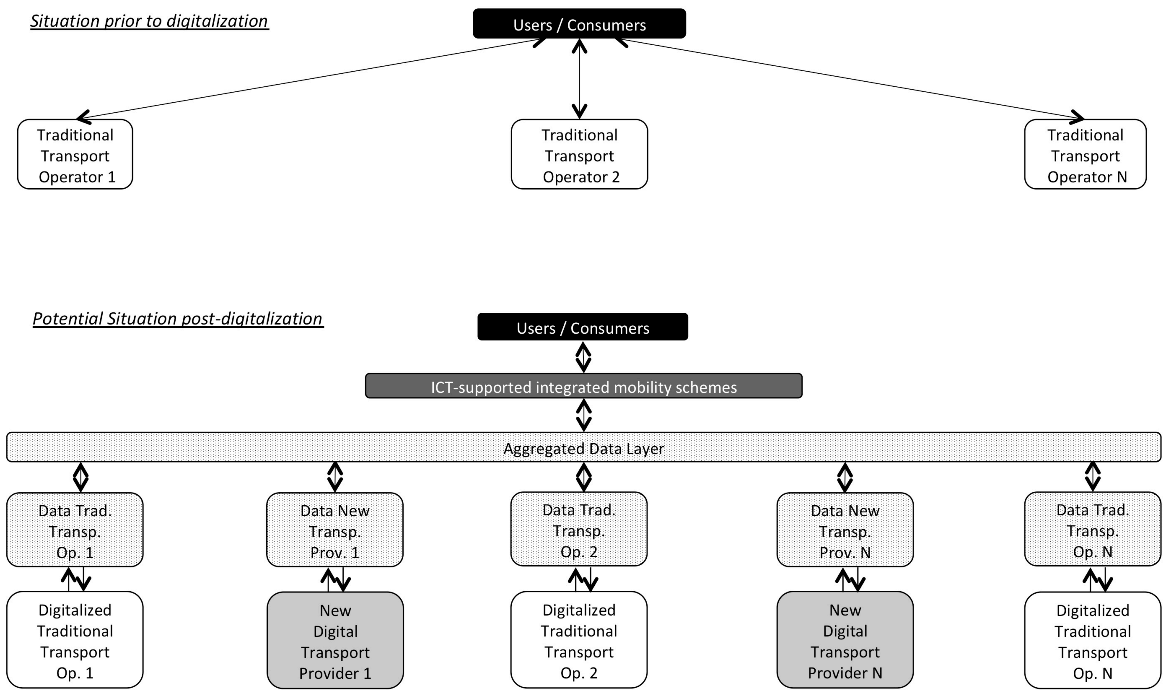

Figure 2.2-1: Impact of digitalization on transport services (author's elaboration)

Those different levels of digital integration basically depend on two inherent components: digital integrated ticketing, and digital integrated information systems, on which research has been undertaken and is reviewed below.

- Smart Cards

Smart cards can be seen as the first of those digital integration schemes. Also referred to as electronic ticketing, e-ticketing or smart card automated fare collection (SCAFC) systems, smart cards are able to store and process data, making them suitable for identification, authorization, and payment (Pelletier et al., 2011). By turning power and data signals into high-frequency electricity and being able to receive electrostatic bonds from the reader (Park and Kim, 2013), smart cards utilize radio waves to transfer and receive data from an RFID tag or label through a dedicated reader. Although, in theory, smart cards might not be linked with an integrated fare systems (Douglas, 2009), this is rarely the case in practice. Hence, smart cards are often referred to as a more advanced version of the traditional fare integration strategies (Goldman and Gorham, 2006). Supposed to increase user convenience by integrating tariffs through the transportation network (Estache and Gómez-Lobo, 2005) and cut fare collection costs for transport authorities (Pelletier and al., 2011), these "re-usable tickets" (Blythe, 2004) have triggered a lot of interest from scholars from a wide array of sectors.

As smart cards are supposed to enhance multimodality, research was conducted to understand the extent to which this was actually the case. For example, looking at data from the Oyster card in London, Seaborn et al. (2009) found that at least 23 percent of underground journeys taken by Oyster users were actually combined with bus segments, thus confirming the hypothesis that smart cards were enabling multimodal travel. Academics have also been interested in understanding the impact of smart cards on existing public transportation systems. For example, Shockley et al. (2016) showed that the introduction of smart ticketing system in Los Angeles was positively associated with reduced dwell times for buses, enabling increased travel speeds, and hence encouraging increased ridership. Research has also been conducted to understand the impact of smart cards on travel behaviors. To that effect, Ellison et al. (2016), looking at Sydney, found that despite some differences between social groups, most subjects tended to switch from cars to public transport, and trains in particular, after the introduction of a smart card. Still, according to those authors, the introduction of the Opal card in Sydney has produced a decrease of around 10 minutes in the length of car trips per person per day. However, scholars have also pointed out the difficulty of clearly relating smart card implementation to increased ridership and car use reduction, as other factors can also be held accountable. Although Ellison et al. (2016) had no doubt that smart cards are more beneficial than traditional paper tickets, the real impact of smart cards on ridership still needs to be better explained. For example, according to Joslin and Morris (2013), although Metrorail ridership increased in Miami between 2008 and 2012, following the introduction of the EASY smart card, it is difficult to isolate the effect of smart card implementation from other factors such as improved economic climate or increased fuel prices.

Most of the added value of smart cards compared to traditional fare integration is acknowledged to rely on what could be done with all data gathered through automatic fare collection systems. Researchers have highlighted the opportunity to use smart card to extract data to ultimately measure transit supply and demand indicators (Trépanier et al., 2009). Specifically, smart card data have been presented as potentially enabling managerial activities for public transport authorities. Pelletier et al. (2011) emphasized the potential of smart cards to provide transport authorities with data to ultimately calculate performance indicators (operational management), adjust levels of service, upgrade the network (tactical level), and plan accordingly (strategic management). Similarly, Slavin and colleagues (2009) showed that data from automated fare collection systems could be used to grasp a better understanding on travel behaviors in large transit systems, and potentially help make better predictive models. Ortega-Tong (2013) demonstrated that smart card data could also be used by public authorities to better understand who was using their services. By looking at the data from Oyster use in London (frequency of travel, journey start time, activity duration, origin frequency, travel distance, and mode choice), the author managed to differentiate between eight different user clusters, from everyday regular users to weekend occasional users, or weekday rail occasional users, for example. Lathia and Capra (2011) showed that smart card data could also be used as a way to assess the population's response to a specific travel incentive, again illustrating the richness of the analysis that could be made out of smart card data.

- Integrated Mobility Platforms (IMPs)

While digitalization has enabled new integrated ticketing schemes (smart cards), it has also favored the integration of information coming from different transport providers, which has ultimately led to the development of integrated mobility platforms. Thus before looking in depth at research conducted on IMPs, the sub-literature focusing on information integration is first reviewed.

Traveler information has existed for a very long time and has served two important functions (Le Squeren, 1991). On one hand, traveler information is known to potentially minimize public transport inconvenience, by allowing people to plan their trips and accomplish them accordingly to their plans. On the other hand, traveler information might be utilized as a way to promote more environmentally friendly alternatives to the use of private cars, and potentially help making regular car-users shift towards more sustainable modes of transport. Traveler information is known to have deeply evolved thanks to digitalization. ICTs are seen as having enabled the development of advanced travel information systems (ATISs) that aim to help travelers in "*making better travel choices by providing information regarding the available travel alternatives*" (Ben-Elia et al., 2013). In particular, ICTs have enabled the development of real-time information (RTI) that provides confidence and reassurance to travelers (Beecroft and Pangbourne, 2013) and can be potentially displayed on two different medias. On one hand, it can be displayed on signage stops, stations or interactive kiosks. On the other hand, RTI may be displayed on smartphones or other web-based services, for example through public transport trip-planner apps. According to Brazil and Caulfield (2013: 93), "*Unlike previously available information sources, smartphone technology enables users to access individual and trip specific information both pre-trip and en route in real time*". Studies have looked at the social acceptance of such services. For example, focusing on the use of "On the Go" interactive information kiosks in New York, Kamga et al. (2013) found that such systems were used most at transit hubs accommodating large numbers of travelers, and that they participated in giving a positive impact of the public transport agency. However, the authors pointed out the risk of those systems widening the digital divide, as they required older generations to get familiar with their use. Research was also carried out to understand the impact of such services on transit ridership. Looking at New York, and isolating external factors such as modifications in service, change in fares or other independent socioeconomic factors, Brakewood et al. (2015) found that the implementation of a web-based RTI system could result in increased bus ridership figures.

But while digitalization has also supported the creation of innovative mobility modes, few traveler information systems have integrated their related information with public transport information (Kenyon and Lyons, 2003). Similarly, few apps have been developed to compare driver information with public transport information, which could potentially help car users shift to more shared modes of transport (Lyons, 2001). As a result, so-called meta-journey planners (sometimes referred to as integrated multimodal travel information [IMTI]), supposed to integrate information from both public and private transport solutions, have developed and been studied. For example, research has been conducted in order to understand the customer expectations of IMTI (Grotenhuis et al., 2007). Given that those IMTI are relatively new, very few studies have analyzed the impact of IMTI on modal shift from car to shared mobility modes. Pronello et al. (2017: 2683) looked at the Optimod app in Lyon and found the app did not "*produce any change in the use of car, motorcycles, bicycles and bike sharing*". The authors also discovered that soon after the app's introduction, only a few users were actually using it on a daily basis. In their opinion, this is mainly due to the fact that the app users were Lyon residents and were therefore used to certain trips, such as commuting, which meant they did not need an IMTI system to accomplish most of their journeys. As Ben-Elia and Avineri (2015) would put it, the low success of IMTI might well be due to experiential information (EI), which is the kind of information that people gain by learning and experience. It has also been shown that the willingness to pay of customers to have access to travel information is generally relatively low (see, for example, Wolinetz et al., 2004). Ultimately, Lyons (2006) stated that while the ICTs have supported the development of multimodal information systems, the impact of such systems on people's mobility behavior is far from evident. There does appear to be a lack of evidence to prove the ability of ATIS to support modal shift towards more sustainable transport modes. For Lyons et al. (2012), as most of the travel undertaken by people is local and routine, ATIS are not consulted as often as one might think. Even though there might be a better initiative for people to travel, people are used to their travel routines and are quite reluctant to change behaviors. In other words, people seems to be "*adopting 'good enough' travel options rather than optimum (utility-maximized) solutions*" (Lyons et al., 2012: 280), even in the digital transport era.

The second interesting feature of integrated mobility platforms pertains to their ability to integrate payment for different transport solutions (payment integration), as well as to integrate transport tickets from different transport providers (ticketing integration). IMPs are sometimes referred to as multimodal information and ticketing systems (MMITS), combined mobility services (CMS), or combined integrated mobility platforms (CIMP). Those integrated mobility platforms are basically digital platforms, accessible on smartphones, where users are given the possibility to enter their trip origin and destination, choose between different private and public transport options available to realize their journeys (which can be a combination of several modes), pay on the app, and get the ticket necessary to use each of the transport modes they have booked. Research was conducted to understand the public acceptance of IMPs, and its impact on people's mobility habits. Geis and Schulz (2016) looked at the European project "*All Ways Travelling*" and found that public acceptance was generally high, but associated with a relatively low intended behavioral change. According to the authors, IMPs might even produce a reverse effect on car users, making them keener to use their cars than shared mobility modes. Looking at the UBIGO field operational test, Sochor et al. (2015) found that 93 percent of the surveyed participants were satisfied with the proposed solution, and 97 percent were interested in continuing to use it.

As the term IMP is frequently – and incorrectly – used interchangeably with MaaS, we now look more deeply into the MaaS literature in order to shed light on the differences between the two concepts, which are not very clear at the moment. Because there is not an extensive body of literature available on the subject due to the novelty of the topic, both practitioner and academic literatures about MaaS are reviewed below.

- Mobility-as-a-Service (MaaS)

Although the subject of MaaS has not been on the table for a long time, it has gained significant momentum amongst transportation experts. Initially introduced to the public at the 2014 Intelligent Transport Systems (ITS) European congress in Helsinki, the subject first gained the interest of transportation practitioners before becoming one of the most up-to-date subjects for transportation scholars. Leading transportation journals such as *Journal of Transportation Research Part A*, *Research in Transportation Economics*, and *Transport Reviews* have all published papers about MaaS in the last two years. There has also been a growing number of special issues focusing on MaaS in esteemed transport journals, such as *Transportation Re-*

search Part A, Transportation Research in Business and Management, and *Travel Behaviour and Society*. Most reputed transport conferences have all added a MaaS track in their recent editions, including the European Transport Conference (ETC), Transport Research Arena (TRA), and the Transportation Research Board (TRB). Last but not least, one might observe the unfolding of academic conferences entirely dedicated to MaaS, such as the 1st IcoMaaS[9] (international conference on Mobility as a Service) that happened in Tampere (Finland) in November 2017.

The term MaaS is actually somewhat older than one might think. It was first used, in the transport field, in a bachelor thesis from Twente University from 2008, to present a system of carsharing that could help solve traffic issues in the Netherlands (Poolen, 2008). Although the solution proposed at that time was closer to car-pooling than the idea of digitally integrated mobility, the author already had in mind to develop a solution that would favor mobility usership over car ownership.

Originating from the new category of model, enabled by cloud computing, known as *Everything-as-a-Service*, referred to as XaaS, such as Software-as-a-Service (SaaS) or Infrastructure-as-a-Service (IaaS) (Banerjee et al., 2011), the term MaaS was first used by academics from the telecommunication sector, to describe a mobile wireless network that can have its building blocks opened up and controlled by third-party entities, enabling the birth of new type of services. In the transport sector, the term is acknowledged for unfortunately suffering from a clear definition (Jittrapirom et al., 2017). It has been used in some studies to define what should actually be defined as IMPs (e.g. Sochor et al., 2015). In some other studies, MaaS refers to a new transport paradigm, being an evolved version of the IMPs (Ruutu et al., 2017). Other perspectives on defining MaaS have adopted a rather scalar approach, with different MaaS "levels" (Sochor et al., 2017; Kamargianni et al., 2016). For others, Mobility-as-a-Service is actually about service level agreements (SLAs) (Catapult, 2016), meaning that the MaaS operator will guarantee its customers a mobility solution from anywhere to anywhere at any time, which is not the case with IMPS, which only bundle different transport solutions into one single package, but do not guarantee their users that they will have access to a mobility solution whenever and wherever they need.

Research has been conducted to highlight the potential benefits associated with MaaS. For example, in a report co-financed by the European Union, Civitas (2016) presented MaaS as having the potential to cut transport costs for users, improve transport system efficiency and ultimately tackle congestion. According to POLIS, MaaS is presented, if realized successfully, as a way to potentially "*reduce environmental impacts and provide customized mobility options and better accessibility to people with disabilities or reduced mobility*" (Polis, 2017: 7). As summed up by KPMG (2017), MaaS might well have the potential to change entirely the way people travel, and how transport is organized.

Scholars have also been trying to highlight key elements for MaaS to become a success; that is, MaaS success factors. Basing their arguments on the fact that necessary changes for MaaS to happen are of systemic nature, Kamargianni and Matyas (2017) proposed a business ecosystem that would make it possible to do so, gathering transport operators, data providers, platform providers, ICT infrastructure, insurance companies, as well as universities and research institutions. For Heikkila (2015), key success factors for MaaS to thrive are cooperation among all stakeholders, legislation and regulation, as well as subsidization procedures. In order to see MaaS realized, Ambrosino et al. (2016) proposed the development of flexible and shared use mobility (FSUM) agencies, with the aim of coordinating traditional with ICT-facilitated transportation providers and integrating their data into a single data-layer. According to Giesecke et al. (2016), the likeliness of MaaS becoming a reality relies on four factors: the need to specify and adapt the actual

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9 http://www.tut.fi/verne/icomaas/ accessed on November 14th 2017.

transport offer; the possibility for end users to cut costs using MaaS while keeping an equal level of convenience; the need to encompass traditional with ICT-supported transportation modes; and the need for MaaS to be economically, socially and environmentally sustainable. Li and Voege (2017) made a list of criteria to be considered in order to develop MaaS in a city. Those include the need for a city to have an adequate public transport system, to already have an electronic ticketing option for public transport, and to have all transport providers willing to open their data in a standardized form, as well as accepting electronic payments. In a study commissioned by the Finnish Ministry of Transportation and Communication, Casey and Vallovirta (2016) recommended using public procurement, new regulation models, and developing policies towards open interfaces and data in order for MaaS to become a reality. Karlsson et al. (2017) also proposed a framework for analyzing institutional conditions for MaaS to succeed, at the macro, meso, and micro levels. According to those authors, legislation and taxations are the most important institutional conditions at the macro level; the coordination among stakeholders, the integration of physical infrastructure, the development of the cloud infrastructure, clear business opportunities and appropriateness of business models are key aspects at the meso level, and subjective norms are important institutional conditions at the macro level. Still looking at Sweden, Smith et al. (2018a) stated that it is only by defining a regulatory 'sweet spot', driving innovation, and securing public benefits that MaaS will be able to successfully come to life.

However, as MaaS schemes are still in their infancy, no data is easily available to understand the impact of MaaS on existing transportation systems. Thus, most of the papers found focusing on this topic should be considered more as viewpoints or opinion papers than pure scientific evidences. For example, Hensher (2017) presented his views on how traditional bus contracts would need to evolve if MaaS goes live one day. He argued that the question of whether we will need mode-specific contracts in the future rather than mobility contracts will need to be asked if MaaS becomes a reality. For Hensher (2017), in order to harness the full sustainability potential of MaaS, and avoid another "*icing on the cake*", public transportation will need to be combined with new mobility modes on the future MaaS offer, even though it is not very clear how this will be done. Rantasila (2015) has been interested in understanding the impact that MaaS would have on land use. He claimed that MaaS could increase the efficiency and attractiveness of public transport in urban areas, which might create new transport hubs, and increase the value of the land surrounding those. However, this would imply better coordination among public authorities, and between public and private sectors. Based on a prospective evaluation of the readiness of Australia for MaaS, Somers and Eldaly (2016) developed a MaaS-readiness index, based on urban density population in, and availability of different transportation modes and usage rates in cities, for other cities that would be interested engaging on this path. Some scholars have also looked at the position of traditional actors of the transportation sector vis-à-vis MaaS. For example, Mulley et al. (2018) found that there was high enthusiasm among community transport organizations to jump on the MaaS bandwagon in Australia. While most studies on transport integration have tried to understand its impact on existing transportation systems, research has also been conducted to understand the main barriers towards it, as discussed below.

2.2.3 Barriers towards integrated transport systems

A lot of research has sought to highlight the barriers towards transport integration as transport integration has been described as particularly complex to reach (Schöller-Schwedes, 2010; Timmermans, 2003; Potter, 2010). In particular, May and colleagues (2006) identified four main barriers to go towards transport integration: legal, financial, political, and cultural and technological. Those four perspectives and associated research are reviewed below.

- Legal and Institutional barriers

Scholars have pointed out barriers of legal or institutional nature towards transport integration. Under this perspective, transport integration is acknowledged to be difficult because of legal responsibilities split between different actors, reducing the ability of public authorities to foster integration. For example, it has been acknowledged that transport integration was dependent on country's institutional contexts and on how the transport sector was organized. Edwards (2013) showed that the deregulation of the transport industry in Newcastle, which was synonymous of institutional disintegration between the metro and bus networks, resulted in a decrease of about 10 million metro passengers per year, as it made both modes compete with each other instead of being complementary to one another. Schöller-Schwedes (2010) and Potter (2010) both stated that a transport industry based on competition between transport operators was more likely to go against integration than in favor of it. Supporting this idea, Lyons and Harman (2002) showed that the institutional fragmentation of the UK transport industry could be seen as a barrier to the creation of multimodal traveler information systems; that is, to information integration. Comparing the development and implementation of smart ticketing systems in Seoul and Bogota, Audouin and Finger (2018b) concluded that the more important the institutional reform introduced along the smart card, the greater its impact would be, highlighting the importance of institutional contexts when implementing ICT-supported integrated mobility solutions. According to Holmberg et al. (2015), the main barrier for MaaS to become reality is institutional and lies in the willingness of public transport authorities to get into the MaaS wagon, given the monopolistic position they have occupied for years. More recently, Smith et al. (2018b) investigated the position of public and private actors regarding the existing barriers hampering the development of MaaS in west Sweden. According to those authors, public-private collaborations are essential to see MaaS succeed, but are unlikely to happen due to public actors' internal processes and bureaucracy.

- Financial barriers

Secondly, research has pointed out barriers of a financial nature. That is the case when budget restriction is a reason for not moving towards transport integration. For example, May et al. (2001) showed that the lack of funding was the main bottleneck in infrastructure development for physical integration for 80 percent of the 54 European cities they surveyed. In a report commissioned by the Conference of European Roads Directors (CEDR), König et al. (2016) proposed two main business models for MaaS operators to overcome financial barriers, being the Merchant and Agency models. In the former, the MaaS operator is supposed to get its margin thanks to the discount it would receive by buying transport tickets in large volume to transport operators and selling them at cost price. In the latter, the MaaS operator would be selling tickets at a slightly more expensive price to its customers in order to get a margin on each of the sold tickets. However, the report remains vague on which of those two business models is most likely to be successful in future market developments. To tackle the financial barriers, the MaaS Alliance (2017) proposed that initial investments be provided by public administrations interested in going into MaaS.

- Political and cultural/social barriers

Third, transport academics have highlighted the importance of political and cultural barriers towards transport integration. Such cases occur when a dedicated transport integration measure or technology encounters resistance from the population, or low political support. For example, the lack of political decision was highlighted as a barrier to go towards ICT-supported integration solutions. Ruutu et al. (2017) built a system-dynamics model to assess the impact of certain policies on MaaS development and adoption and found that policies promoting open interfaces and data transferability agreements among MaaS operators might help accelerate platform adoption and reduce the risk of a winner-take-all scenario. Resistance from the population was shown to be a barrier to modal integration. For example, McDonald (2000) showed that the likeliness for a smart card system to really take off was actually dependent on the willingness of public transportation users to embrace the technology and use it. In particular, issues of privacy and security have been pointed out as potentially influencing people's willingness to use those, and hence their successful implementation. Social acceptance was also highlighted as a factor of success for the development of MaaS schemes. In September 2017, the results were released from a survey study conducted on 1125 Finns by the Finnish digital business consultancy firm Solita.[10] The study showed that MaaS had a long way to go before becoming legion, especially given the current (low) awareness of the population for the concept and their likeliness to fully embrace it. According to the study, only 16 percent of the population sample (supposed to represent the overall Finnish population) had ever heard of the MaaS concept and only one out of three Finnish car-owners would be willing to give up their cars if a complete MaaS offer was available. Kamargianni et al. (2018) used survey data to show that social acceptance had to be considered in order for MaaS to succeed. In particular, the authors showed that MaaS was more likely to be easily accepted by younger (urban) people than other social groups.

- Technological barriers

Last but not least, researchers have stressed the need to consider technological barriers to transport integration, meaning that there is no available technology to support this integration measure, or that the technology is vulnerable and thus presents risks for the different stakeholders supporting it. While this is not really pointed out as an issue nowadays for traditional modal integration, there is considerable literature showing the technological barriers to moving towards digital integration solutions. For example, research has been conducted to highlight the potential security breaches of smart cards. According to Berini Sarias (2013), most smart card systems, which are based on MIFARE family of chips, are particularly vulnerable to hackers. Markantonakis et al. (2009) listed the main types of attacks that could be conducted on smart card systems, as well as countermeasures to those. Garcia et al. (2012) proposed a tool that is able to crack RFID protocols a hundred times faster than regular RFID readers, in order to detect RFID breaches and ultimately propose solutions to them. Morbitzer (n.d) recommended that RFID smart card developers use public cryptographic standards to avoid hacks. In Morbitzer's opinion, keeping a cryptographic algorithm secret is not going to prevent pirates from hacking it, and might well actually go into the opposite direction. Research has also been conducted to showcase the potential vulnerability of IMP and MaaS schemes. Callegati et al. (2016), for example, highlighted the need to pay attention to data provenance, data trustworthiness, and service maliciousness when designing the service. Yuan et al. (2016) and Hu et al. (2015) have proposed frameworks to help build more robust and resistant MaaS systems, while trying to preserve the flexibility of the MaaS solution. Nakashima et al. (2017) proposed the use of ambient intelligence processes to support MaaS technical breaches.

2.2.4 Critiques and research gap

Most of the research looking at traditional modal integration development and implementation has been more interested in understanding the impacts of such schemes than in how they are coming to life. Research on "how to go towards integration" has been conducted more from a technical approach. For example, due to the mathematical nature of developing integrated schedules for transit networks, optimization scholars have been interested in the topic. For a review of different models proposed for the design of in-

[10] As of the date of publication of the present thesis, the results of this study had not been published officially. We contacted the author of the study and explained what we were looking at in our research, and he kindly agreed to share the survey data with us.

termodal integrated timetables, see Mohaymany and Gholami (2010) or Guihaire and Hao (2008). However, it seems that almost no studies have paid attention to the governance structures that have supported the birth of modal integration schemes. Exceptions include Kim and Dickey (2006) and Pucher et al. (2005) for the study of Seoul bus reform, where network integration and ticketing integration where introduced; Caris (2015) for a comparison of bus reforms between Rio de Janeiro and Sao Paulo; and Munoz and Gschwender (2008) for an analysis of the failure of the Santiago bus reform, where network integration and ticketing integration were introduced. While most studies on traditional modal integration acknowledge the benefits of modal integration, there seems to be a research gap in terms of how to make modal integration happen, and the roles of each of the involved stakeholders in the process. As explained below, it appears this critique is also valid for studies looking at digital integration solutions.

While most of the studies of smart cards have praised the benefits of automated fare collection systems (Li et al., 2018), few studies, particularly in the transport sector, have looked at processes of development and implementation of smart cards. In transportation studies, most of the research has focused either on the impact of the smart card solution on modal share, or on its acceptance by different social groups, or on what could be further derived from the utilization of this technology. Exceptions to this include studies of the development of smart ticketing schemes in Hong Kong (Poon and Chau, 2001) or in Seoul and Bogota (Audouin and Finger, 2018b). Again, there seems to be a research gap when it comes to the study of the processes having supported the birth of digital modal integration solutions. More specifically, there seems to be almost no studies focusing on the governance processes and policy development that have led to the implementation of smart cards in urban transportation systems. This critique is also valid for the last two digital integration schemes; that are MaaS and IMPs. The analysis of the role that public authorities played in the development of MaaS in Sweden and Finland by Smith et al. (2018a) may be an exception to that statement. However, given the potential social, economic, and environmental benefits that those solutions shall bring, if realized correctly, one might be interested in understanding the governing processes supporting the birth of those solutions, in order to potentially replicate those.

So first, it appears there is a need to conduct empirical research on the governance structures supporting the birth of ICT-supported integrated mobility schemes. Second, there is a need to look at other bodies of literature that might have looked at the development of ICT-supported integrated mobility schemes, unlike the transport integration literature. Given that what is really missing are studies looking at the role of the different stakeholders (and in particular of public authorities) into the development of digital integrated mobility schemes, it appears relevant to look at the transport governance literature. Thus, in the next subchapter (2.3) the transport governance literature is reviewed.

2.3 Transport governance literature

There is a consensus among academics that the organization of transport should fall under the responsibility of public authorities. However, the academic perspective on the role that public authorities should play in policy making and public service provision (including in transportation) has evolved greatly over the last few decades. Indeed, it is acknowledged for having shifted from a government to a governance perspective (Rhodes, 1996). Thus, is first reviewed the paradigm shift from government to governance before examining the literature on transport governance. This subchapter is divided into three main sections. It first looks at the evolution of the research perspectives on the role that public authorities should play (in general, not for transportation) in policy making and public service delivery. Secondly, it looks at the transport governance literature. Last but not least, it highlights the main research gap of the transport governance literature vis-à-vis this thesis' research question and introduces the last body of literature relevant to the present research endeavor.

2.3.1 From Government to governance

As briefly mentioned above, scholars generally agree that there has been a paradigm shift from government to governance when it comes to the perception of the role of governments in public policy making and service delivery. In order to better understand what this shift means, and the main differences between the two approaches, this section starts by looking at the "traditional" perspective of study of governments, before looking at the newer perspective, known as the governance perspective.

Looking specifically at what *"government can properly and successfully do"* (Wilson, 1887:197), public administration science has historically been the main perspective for looking at policy-making and public service delivery. Under this approach, organizations following heavy hierarchical structures and well-established bureaucracies were felt to be more efficient in their activities than organizations that did not (Ostrom and Ostrom, 1971; Simon, 1976). Traditional public administration understood public authorities as sole governing actors and, most of the time, as exclusive public service providers (Finer, 1941). However, this "traditional" approach to the study of government has faced major criticism. The politics-administration dichotomy paradigm, which lies at the core of public administration science, and for which policy formulation and its execution are thought to be independent tasks, suffered from a lot of skepticism among academics. For example, it has been described as untenable (Roberts, 1994), or "*naïve, at best*" (Henry, 1987: 41). For many scholars, this dichotomy had no reason to exist, as administrators and policy makers are basically in constant interaction (Svara, 2001; Peters, 1989). According to Simon (1998), although people are not always able to make the most rational decisions, they often seek to maximize their personal utility, which translates in the political domain as the maximization of power. So, regardless of whether they are policy makers or administrators, people working in the public sector are greatly interested in maximizing their utility, thus questioning the validity of the axiom along which administration and politics are dissociated. Consequently, it was quickly agreed among government scholars that the politics-administration dichotomy was no longer relevant and that new approaches were needed to look at the role of governments in policy making and public service delivery.

All of the criticisms of the traditional approach to the role of public authorities were summed up by Waldo (1984). By presenting public administration as facing a crisis of identity and arguing for a paradigm shift vis-à-vis the role of public authorities, Waldo (1984) proposed the New Public Administration (NPA) approach, which centered around the notions of social equity and gave less importance to bureaucracy. Although most scholars started to agree that public administration was going through an existentialist crisis, few of them embraced NPA. Many government scholars preferred another "new" approach.

Along with common problems that public administrations in developed countries started to face, such as the shortage of public funds and distrust of populations in government, and the new type of management techniques developed in the public sector in the 1980s, under the Thatcher administration in the United Kingdom, and the Reagan administration in the US, a new perspective to the study of the public sector emerged – commonly referred to as public management (Hughes, 2012). This new approach, which some defined as a new paradigm (Osborne and Gaebler, 1992), basically aimed to rethink the answers to the following questions: What should government do or not do? What should the public sector be responsible for? How can the public sector collaborate with the private sector in order to improve the quality of life of people and ease the public sector's economic burden?

The main idea behind this new approach, which Hood (1991) coined new public management (NPM), was that the public sector should no longer be the only actor involved in all aspects of public affairs, especially public service provision. According to Hood (1991), NPM relied on seven key principles: the disaggregation of units in the public sector; greater competition in the public sector; greater discipline and parsimony in resource use; the adoption of private-sector styles of management practices; hands-on professional management; the definition of explicit standards and measures of performance; and greater emphasis on output controls. The NPM approach has also been presented as the “steering not rowing” approach (Osborne, 1993), or as an answer to the “hollowing out of the state” (Rhodes, 1994). This new narrative highlighted the need for public authorities to “*do more with less without cutting [their] hands and feet*” (Osborne, 1993: 350). In particular, it promoted privatization and diminution of public intervention; the transfer of some central and local government functions to dedicated agencies; and the transfer of some central government functions to the EU level. The NPM approach is known to rely on three main pillars being liberalization, private sector participation (PSP), and regulation, all three of which are supposed to enable higher efficiencies in public service delivery, as well as cost reductions for the benefit of users and taxpayers.

Liberalization can be understood as the “*abolishment of reserved areas and the opening of markets for new operators*” (Finger and Jaag, 2016: 4). It is acknowledged to encompass a set of measures to enable competition in sectors that were once dominated by heavily regulated monopolies (mostly state-owned enterprises). Liberalization is often used interchangeably with the term deregulation (see, for example, Domberger and Piggott [1986]), but while the latter is industry-specific, the former deals with a general trend where the public sector tend to remove barriers across all economic sectors and adopt a more liberal approach.

PSP actually refers to means of involving the private sector in government activities (Kay and Thompson, 1986), which encompasses concepts of privatization, contracting out and public–private partnerships (PPPs). Privatization refers to “*the process of transferring ownership (…) from the public sector (government owned) to the private sector*” (Finger and Jaag, 2016: 4). According to Brada (1996), privatizations occur through three distinct processes. Firstly, privatizations of state-owned enterprises can happen through share issue privatizations (SIP); that is, via public share offerings made on capital markets. Secondly, privatization might occur through mass privatization, consisting, for example, of the free allocation of assets to the population through the distribution of vouchers. Thirdly, privatization can occur through asset sales, where government exchanges its owned asset for an explicit cash payment. Contracting refers to the outsourcing of public services provision, initially done by public service departments, to external contractors (Mulgan, 1997). The outsourcing is generally done through short-term contracts and is expected to produce efficiency gain thanks to induced economies of scale, increased competition among suppliers, and changes in labor practices (Ferris and Graddy, 1982). Finally, PPPs (sometimes referred to as P3s or 3Ps in the literature) refer to “*operation[s] of some sort of durability between public and private actors in which they jointly develop products and services and share risks, costs, and resources which are connected with these products*" (Van Ham and Koppenjan, 2007: 598).

Last but not least, regulation refers to the “*entirety of legal constraints on economic activity”* in a given economic sector (Finger and Jaag, 2015: 3). Regulation’s prime aim is to target and solve market failures, which are defined as “*failure of a more or less idealized system of price-market institutions to sustain desirable activities*” (Bator, 1958:351), and which might be caused by market power, externalities, information asymmetries, or consumption of public goods (Finger and Jaag, 2016; Keohane and Olmstead, 2016). Four kinds of regulatory instruments are usually used in the utilities sector (Albon, 2000). Rate of return regulation (also referred to as ROR, cost-plus or cost-based regulation) essentially aims to set the rate of return that the utility company can earn on its assets. Price caps aims to set the prices that a utility company can charge, which will be adjusted yearly based on the rate of inflation and other economic factors, in order to control prices. The purpose of revenue capping is to set a ceiling on overall revenue. Finally, yardstick regulation (also known as benchmarking regulation) aims to push utilities to reduce their costs by inducing them to compete with one another.

While research was conducted to emphasize the above-mentioned benefits of NPM (e.g. Savas, 1991; Megginson and Netter, 2001), many scholars have tried to demonstrate that the NPM approach was perhaps not the definitive answer to the public administration "crisis of identity", especially vis-à-vis policy-making and public service provision. For example, liberalization has been criticized for jeopardizing public values of utility sectors such as reliability, safety, and affordability of the service (Jørgensen and Bozeman, 2002). Liberalization was also shown to introduce important coordination problems between stakeholders and to potentially increase systemic risk (Laperrouza, 2009). In their book entitled *Privatization, how to avoid too much of a good thing*, Beisheim et al. (2005) warned about the dangers of privatization, which when conducted by weak public authorities could lead to corruption, lack of attention to the needs of the poor, increases in prices, and sometimes safety issues. Privatization was also said to favor business secrecy, the absence of participation or consultation of the stakeholders, and a lack of transparency in the decision-making process (Swyngedouw, 2005). Contracting was highly criticized, particularly by transaction cost economists (e.g. Williamson, 1985) for its cost for public authorities that could sometimes be so important that they would overwhelm the savings from contracting out (Prager, 1994). Contracting was also criticized for being more efficiency-oriented than service quality-oriented (Nalbandian, 2005), for ultimately being responsible for a vanishing of accountability of public authorities (Boston, 1995), and for favoring corruption (Albalate et al., 2017). In a similar fashion, PPPs were criticized for lacking clarity and flexibility (Bloomfield, 2006; Hart, 2003) and regulation was pointed out for increasing costs (Winston, 2000).

To sum up, the time during which NPM was seen as panacea did not last long. For example, Dunleavy et al. (2006) described NPM as no longer being anything "new" and for having led to increased complexity, fragmentation, and to the rise of populist parties. NPM was also criticized for having reduced the consumer-citizen/government relationship to a simple buyer/seller interaction, and thus for not being able to grasp the complexity of policy making and public service delivery (Pollitt, 1993). For De Vries and Nemec (2013), NPM should be considered *passé* and not well suited to tackling modern problems such as sustainable growth. Overall, NPM was, like traditional public administration, criticized for not being capable of addressing wicked problems (Head and Alford, 2008). In his article "*The Rise and Demise of New Public Management*", Drechsler (2005) presented NPM as an ideology that it was possible to believe in in 1995, hard to agree with in 2000, and that no one should adhere to since 2005. Consequently, new approaches to look at the role of the public sector in policy making and public service provision developed, to answer the crisis of identity that the public management approach was also going through. Denhardt and Denhardt (2000), for example, proposed the theory of new public services (NPS), which promoted, among other things, the need for governments to serve rather than control, referred to as the "*serving not steering*" approach, in reference to Osborne's "*steering not rowing*" term. Pollitt and Bouckaert (2004) proposed the Neo-Weberian State (NWS) approach, which promoted a more citizen-centered organization of policy-making and public service delivery. McGuire proposed the Collaborative Public Management (CPM) theory, which aimed at "*facilitating and operating in multi-organizational arrangements in order to remedy problems that cannot be solved – or solved easily – by single organizations*" (2006: 33). All of those new approaches to the study of government might actually be bundled under the emerging governance paradigm.

The word governance originates from the Greek verb *κυβερνειν* (kybernein), which was used to describe the skippering of a ship or the driving of a vehicle (Campbell and Carayannis, 2012) and gained visibility in the 1980s when used to depict the politics of international organizations such as the World Bank or the IMF (Bottici, 2014). In that context, the term was mainly used to describe the dynamics of the new globalized world, and the role that international organizations would play in it (Weiss, 2000). As used at that time to basically describe the kind of order orchestrating decisions at the supra-national level, the term progressively gained interest among scholars interested in the study of government and of the public sector. Since the beginning of the 1990s, the term has been used widely, and not always with the same meaning (Stoker, 1997). It is possible to distinguish two perspectives bundled in the governance approach.

On one hand, governance is related to policy development by governments and public service delivery (Mayntz, 2003). Friedmann (2012: 4) assessed that "*governance refers to the social processes by which binding decisions for cities and city regions are taken and carried out*". Similarly, Wangel (2011: 881) stated that "*Governance as structure concerns which actors are included and how these are organized, e.g. if the steering is done through hierarchical or horizontal organizations*". Under that first perspective, the state is acknowledged for losing its capacity for direct control and replacing it with a capacity for influence (Peters and Pierre, 1998). In other words, public authorities are not considered impotent, but rather as actors constantly bargaining with other actors of the governance system (private or third sector). Under that perspective, governance is believed to happen in the "shadow of hierarchy" (Scharpf, 1994); that is, with public authorities always present and influential and no longer as sole governing actors. In order not to choose between governance and government, and avoid "Governance without government" polemic, Bulkeley and Kern (2006) suggested focusing on the type of governing approach adopted by public authorities. Towards the same goal, Hooghe and Marks (2003) proposed the multi-level governance framework (MLG), which aimed to specifically analyze governance structures and governing mechanisms. The MLG is acknowledged for having provided researchers with a robust analytical tool to look at *"'arrangement' of policy-making activity performed within and across politico-administrative institutions located at different territorial levels*" (Stephenson, 2013: 817). According to their framework, governance is known to either happen under type I or type II. Type I governance follows a hierarchical structure and is composed of a limited number of general-purpose jurisdictions, on a limited number of levels, that usually have clearly delimited boundaries, and whose actions are not intersecting with one another. Type II governance is characterized by a higher number of task-specific jurisdictions, operating across different levels, sometimes overlapping but benefiting from an important degree of flexibility and adaptability. While type I MLG is sometimes referred to as a Russian-doll (or "Matryoshka") decision making process, supported by a limited number of authorities at each level, type II is presented as "*a puzzle made up of many functionally specific pieces, each providing services or solving problems*" (Stephenson, 2013: 821).

On the other hand, the term governance has been used to cover a much broader concept that not only relates to the reform of the public sector and the idea of governing of the state. For example, Williamson (2005: 43) used the term to define "*the means by which to infuse order, thereby to mitigate conflict and realize mutual gain*". According to Kickert, governance defines "*the achievement of a balance between governing actors*" (Kickert, 1993: 195). For Ostrom (1996: 1073), governance refers to the concept of co-production, which she defined as being "*the process through which inputs used to produce a good or service are contributed by individuals who are not in the same organization.*"

Adopting either of those two perspectives induces adopting a systemic approach and looking at actors, their interactions, and institutions influencing how actors interact with one another (Stoker, 1997). Concerned with better defining governance, Ansell and Gash (2008) proposed the idea of collaborative governance, which they defined as a "*governing arrangement where one or more public agencies directly engage non-state stakeholders in a collective decision-making process that is formal, consensus-oriented, and deliberative and that aims to make or implement public policy or manage public programs or assets*" (p. 554). From that school of thought, public authorities are known for initiating the dialogue with non-state actors, and for involving non-state actors in policymaking and implementation. Particular emphasis is placed on the history of public–private collaboration, incentives developed by the public sector to get non-state actors involved, and leadership of the initiating actors.

As seen above, there has been a shift regarding the understanding of the role that public authorities should play in policy making and implementation. This shift from government to governance is synonymous with a whole new understanding of what public authorities should and should not do. This shift has had a massive impact on academic understanding of the role that public authorities should play in the transport sector. Consequently the following subsection looks at the transport governance literature, before summarizing its main shortcoming vis-à-vis the present research endeavor.

2.3.2 Transport governance

Transport is acknowledged to have been historically dependent on governments (Docherty and Shaw, 2012). As the understanding about the role of public authorities has evolved from a government to a governance perspective, the understanding of how transport should be organized has also evolved. Hence, an increasing number of studies have acknowledged the importance of governance in the organization of transportation systems (Banister, 2008; Hull, 2008; Schiller et al., 2010). For example, according to Tsay and Herrmann: "*cities cannot construct sustainable transport systems alone. Creating these systems requires the simultaneous cooperation, construction, and funds of multiple actors, including the national government*" (2013: 10). Consequently, transport governance research has developed to understand the role of the different actors involved in the organization of transport activities, as well as the impact of governance mechanisms on transport system performance. Those studies can be categorized into two different groups: transport governance studies looking at the link between governance and performance, and transport governance studies concerned with politics and political aspects of transport policy and transportation service provision.

- Governance and performance

Given that liberalization, PSP, or regulation are often presented in the literature as governance tools (Brudney et al., 2005; Hodge and Greve, 2010; Braithwaite et al., 2007), scholars have been interested in assessing their impact on transportation system performance. Ultimately, those studies aim to better assess whether public authorities should collaborate with the private sector when it comes to transport service delivery and transport infrastructure development, and if so, how.

For example, scholars have been interested in understanding the impacts of liberalization on the performance of specific liberalized utility sectors formerly organized as regulated monopolies. Empirical research, mostly quantitative, has been conducted in many countries that have gone down this path. For example Alamdari and Morrell (1997) studied the liberalization of airline markets in Europe and the US and found that liberalization led to productivity increase, resulting in labor cost reduction. Finger (2014) looked at the liberalization of rail in five European countries and concluded that liberalization had different impacts depending on the governance and institutional context of each country. For example, while rail liberalization led to increased patronage in UK, it also became synonymous with decreased safety and cost increases. Finger argued that there was insufficient scientific evidence to assess systematically the impacts of liberalization on the performance of the system. Academics have also sought to understand the pace of liberalization of certain transportation sectors. For example, according to Boskovic and Bugarinovic's (2015) study of the development of liberalization of the railway system in Southeast Europe, no country will be able to grasp the full potential of liberalization if no dynamics are coordinated among different states that are part of the same geographical region. Similar research was conducted to evaluate the results of transport privatization. Using social cost-benefit analysis (SCBA), Pollitt and Smith (2002) assessed that the privatization of British

Rail actually led to increased efficiencies and increased output quality. Using data envelopment analysis (DEA), Cullinane et al. (2005) showed that the privatization of the container port industry on a global scale did not lead to the increased efficiency of the sector.

Research has also assessed the results of PSP in the transport sector, particularly for contracting and PPPs. Analyzing a mixed delivery system of bus service in Barcelona, Bel and Rosell (2016) found that, taking transaction costs into account, public firms had lower delivery costs than private companies. Looking at bus services delivery in Catalonia, Pina and Torres (2001) concluded that private management was no more efficient than public management. Examining the impact of specific contracts on the cost of subsidies for bus contracts, Hensher and Wallis (2005) used data over 20 years and from several different countries and found that competitive tendering, unlike its underlying assumption, was not systematically linked with reduced costs of subsidies, which might be more the case under negotiated performance-based contracts (PCB). According to them, PCBs are a better match to deliver value for money and maximize the benefits of subsidies to society as a whole than traditional contracting. According to Hensher and Stanley (2010), most contracting of urban bus services during the past 20 years have not fulfilled their objectives, often due to their lack of transparency and accountability. The two Australian academics recommended the development of trust between the purchaser and contractor in order to ensure greater efficiency of contracting, highlighting the need for contracts to include new clauses to enable changes and variations to happen. Looking at the Netherlands, Koppenjan (2005) emphasized the subdued results of using PPPs in transportation infrastructure development. The author also underlined the importance of having the public and private parties interact in the different stages of a PPP, in order to develop trust and facilitate joint image building as well as enrich the project content. The failure of PPPs to be economically efficient in transportation infrastructure development was also highlighted by Monteiro for the case of Portugal (2005).

Last but not least, studies of the economic dimensions of transport governance have also been interested in looking at the impact of regulation on transportation systems efficiency. Many studies have examined the impact of economic regulations on performance of transport systems. Looking at Madrid and Emilia-Romagna, Button (1999: 436) concluded that "*regulations can influence the economic efficiency of urban public transport*". Focusing on long-distance transport services in Norway and Sweden, Alexandersson et al. (2010) highlighted the potential of regulatory measures to have an impact on patronage or efficiency. In the context of the Norwegian bus industry, Dalen and Gomez-Lobo (2003) showed that the adoption of a yardstick type regulation was synonymous with reduced operating costs. Research has also looked at the impact of regulatory measures in developing countries. For Brazil, Golub (2009) found that regulating informal transport was not going to have an important welfare impact. This was supported by Sohail et al. (2016), who stated that self-regulation, through the formation of dedicated associations, encompassing transport users as well as transport providers, might be a better way to reach efficiency than traditional regulatory mechanisms in emerging economies.

- Politics and political aspects of transport governance

Transport governance studies have also focused on the politics of transport policy and planning. From that perspective, scholars have been interested in discovering how the distribution of power and legitimacy among different stakeholders affects the development of transport policies and ultimately their successful implementation. For example, Aldred (2012) showed that cycling in the UK suffered from the hollowing of the state, which was synonymous with cycling policy being made by either private or voluntary organizations. Burnham (2006) looked at the evolution of transport governance in London and concluded that having transport strategy and delivery falling under the responsibility of the mayor was the most effective and most suitable way to answer citizens priorities and needs, but not really efficient in monetary terms. Scholars have also been interested in understanding the role of specific mechanisms and tools into transport governance. For example, the development of trust, the involvement of all concerned stakeholders, as well as the development of partnerships between public bodies at the local and national levels have been acknowledged as key for the successful development and implementation of transport policies (Hansen, 2006). The adoption of collaborative stakeholders' dialogue (CSD) and participatory processes has also been acknowledged for being an effective governance tool for the successful implementation of transport policies (Baumann and White; 2012; Kim and Dickey, 2006) and for making it possible to depoliticize discussions between stakeholders and widen perspectives. Citizen participation has also been highlighted as an effective tool to produce more inclusive and satisfactory transport policies (Gil et al., 2011; Matthews, 2001), but has been criticized for being grounded in political expediency (Bickerstaff and Walker, 2001). Both public and political support have also been emphasized as critical factors in the success of certain transport policies, such as congestion charge development (Börjesson and Kristoffersson, 2015).

Most of the studies looking at transport governance from a political perspective have focused on the governance of sustainable transport policy. For example, looking at the translation of climate change targets into action in the transport sector in the UK, Bache et al. (2015) highlighted the importance of not relying on meta-policies only, and on developing policies at lower territorial levels. Some scholars have also used the MLG framework[11] to look at the governance of sustainable transport policy making. According to Bulkeley and Betsill (2005), for example, sustainable transport policies are more likely to be designed under type II than type I MLG, highlighting the need for public authorities to develop new governance structures, surpassing traditional governance schemes, in order to face contemporary societal challenges. While Marsden and Rye (2010) agreed that type I institutions might not be able to lead the definition of sustainable transport policies, they questioned the likeliness of type II institutions to do so, given their lack of power.

Some studies have looked at the governance of integrated transport and land use. For example, in the context of Chicago, Merk (2014) highlighted that institutional fragmentation was a major challenge to go towards an integrated transport and land use system. Using Melbourne and Perth as case studies, Legacy et al. (2012) highlighted that having an agency in charge of both transport and land use did not always lead to integration of transport and land use, but that developing networked governance and strong regulations was sometimes more effective. Lindseth and Reitan (2007) took the case of the land use and transport forum, developed in Kristiansand, Norway, to demonstrate the power of horizontal governance structures in producing transport policy discourse change.

2.3.3 Critiques and research gap

As seen above, many publications focusing on transport governance are concerned with analyzing the impact of some governance mechanisms on the transport system efficiency. Most of those studies are quantitative in nature. Few studies have been concerned with analyzing governance mechanisms from a political perspective, adopting a qualitative approach and paying particular attention to the historical processes that led to changes. The few studies that match that description are mainly concerned with looking at sustainable transport policy making. Very few studies have looked at governance of integrated transport systems. Exceptions include studies focusing on the governance of integrated transport and land use, cited above, or integrated transport policy; see, for example, Preston (2010). It seems that virtually no studies have looked at the governance of modal (transport) integration.

In the same vein, apart from the ones mentioned below, very few studies have looked at the governance of ICT-supported (smart) mobility solutions. Exceptions include Dowling and Kent (2015), who did so to analyze

[11] Presented in part 2.3.1.

the development of carsharing in Sydney. According to them, the willingness and openness of public actors to converse with private transport providers can be understood as an important success factor for the development of shared mobility. Similarly, Audouin and Neves (2017), Harding et al. (2016), and Edelman and Geradin (2015) have been interested in looking at how regulation could be used by public authorities to embrace ride-booking services in existing urban transportation systems. Docherty et al. (2017) looked at how governance structures would need to change in order for smart mobility solutions developed by the private sector to deliver as much public value as possible. They emphasized the need for public authorities to adopt long-term thinking in order to develop the right governance structures. Apart from those studies, there seems to be a profound research gap when it comes to the study of the governance of digital transportation systems, and in particular to the study of the governance of smart cards, IMPs and MaaS development.

One of the possible main reasons for the existing research gap could be the fact that governance literature is mainly static and adopts a rather top-down perspective. Indeed, while governance literature is interested in looking at the complex network of relationships between actors for the development and implementation of policies and for public service delivery, it seems to fail to look at bottom-up processes. Given the very low number of publications looking at the governance of new mobility modes, it seems the governance literature might need to be combined with another body of literature to fully understand the governance of new mobility.

Taking into account the environmental, social, and economic benefits they might bring, ICT-supported integrated mobility schemes can well be seen as innovations. But the governance literature has been rather weak on looking at innovation development. While the above-mentioned literatures have been effective for examining the role of public actors in policy making or public service provision, they have barely looked at the impact of governance mechanisms on innovation development (Halvorsen et al., 2005). Exceptions include studies of the link between liberalization and innovation (Jamasb and Pollitt, 2011), economic regulation and innovation (Winston, 2000; Ross and Yan, 2015; Bauknecht, 2011; Stefanadis, 2003), as well as PSP and innovation (Beisheim et al., 2005). Otherwise, the governance literature has not paid a lot of attention to the processes supporting the birth of innovations.

In order to tackle this research gap, there seems to be a need to combine the governance literature with another, yet to be defined, stream of literature. For that matter, the socio-technical transition literature might be a good candidate. Indeed, this literature is focused on the governance of transition of socio-technical systems, and transport can be understood as a socio-technical system. Furthermore, there are two additional reasons why the transition literature might be a good fit. Firstly, the transition literature (also called governance of transition) brings a dynamic perspective to governance studies by looking at the governance of socio-technical transitions. Secondly, the transition literature pays attention to bottom-up processes; that is, to transitions that are the result of innovations. Thus, transition studies, that are presented in the following sub-chapter (2.4), might tackle the critiques of the governance literature that is overly static and top-down-oriented.

2.4 Transition studies

As mentioned above, transport can be understood as a socio-technical system that is constantly evolving (Auvinen and Tuominen, 2014). Therefore, by looking at the literature specifically focusing on transitions of socio-technical systems (more often referred to as the transition literature), one might find studies that have focused on similar topics to the one explored in the present thesis. The following subchapter is divided into three sections. First, it seeks to review the transition literature and present the five main transition frameworks that are used by transition scholars. Then, it reviews studies that have applied transition frameworks to transportation. Finally, it highlights the main shortcomings of the transition literature vis-à-vis this thesis' research question.

2.4.1 Transition frameworks

The transition literature builds on evolutionary economics and science and technology studies. Scholars from that branch have been interested in looking at technological transitions (TT), or systems innovations; that is, "*major technological transformations in the way societal functions such as transportation, communication, housing, feeding, are fulfilled*" (Geels, 2002: 1257). Those societal functions are organized as socio-technical systems, which originates from the concept of large technical system (see Hughes, 1983). In a general sense, socio-technical systems are defined as consisting of "*(networks of) actors (individuals, firms, and other organizations, collective actors) and institutions (societal and technical norms, regulations, standards of good practice), as well as material artifacts and knowledge*" (Markard et al., 2012: 956). The concept builds on systems theory, which sees "*systems as composed of autonomous yet interdependent parts that mutually interact as part of a purposeful whole*" (Whitworth, 2009: 394). Ultimately, so-called transition scholars have been concerned with the study of the governance of transition; that is, with the governance structures that support the shift from one socio-technical system to another. In particular, most of the attention in transition research has been given to the transitions towards sustainable socio-technical systems, more commonly referred to as sustainability transitions (Ulli-Beer, 2013). According to Markard et al. (2012), four different frameworks, or approaches, have been developed in transition research to look at socio-technical transitions. These are strategic niche management, transition management, technological innovation systems, and the multilevel perspective. The coherence framework is added to this list as it can also be used as a lens to study system innovations development.

- Strategic Niche Management (SNM)

In broad terms, SNM is defined as "*the creation, development and controlled break-down of test-beds for promising new technologies and concepts with the aim of learning about the desirability, and enhancing the rate of diffusion of the new technology*" (Weber et al., 1999). It can be used either as a research model or a policy tool (Loorbach and Van Raak, 2006) for the management of technological innovations in their early days. Advocates of the SNM approach highlight the importance of creating technological niches for the incubation of new technologies for sustainable development in order to enable, in a protected environment, the co-evolution of the technology with user practices and regulatory structures (Schot and Geels, 2008), and to then use the result of the experiments for policy making. Interactions between stakeholders happening in technological niches are described as happening in the context of a socio-technical regime (or under a meta-production function), defined as "*the whole complex of scientific knowledge, engineering practices, production process technologies, product characteristics, skills and procedures, established user needs, regulatory requirements, institutions and infrastructures*'' (Hoogma et al., 2002: 19). The regime itself is known to be included in a "landscape" comprised of material and immaterial societal factors (van Eijck and Romijn, 2008). From the SNM perspective, technological innovations are known to go through a journey from technological niches to market niches, ultimately leading to a regime shift (Schot and Geels, 2008). Ultimately, the SNM approach can be understood as a bottom-up framework, focusing on the development of innovations in niches, and their progressive diffusion in the existing socio-technical regime in order to make it more sustainable. It is ultimately described as a necessary strategy for public authorities to manage the transition process to more sustainable socio-technical regimes (Kemp et al., 1998).

- Transition Management (TM)

Transition management (TM) can also be used either as a research model or a policy tool (Loorbach and Van Raak, 2006). It is defined as a "*form of process management against a set of goals set by society whose problem solving capabilities are mobilized and translated into a transition programme, which is legitimized through the political process*" (Loorbach and van Raak, 2006: 5). TM implies the definition of interim objectives based on a long-term vision shared by the actors involved in the process, sometimes referred to as "back-casting". TM scholars have highlighted the usefulness of this incremental approach to ensure a socio-technical transition is done "right"; that is, that it offers as much collective benefit as possible (Rotmans et al., 2001). In other words, TM aims to influence "*the direction and speed of transitions by coordinating and enabling the processes that occur at different levels in a more systemic and evolutionary way*" (Kemp and Loorbach 2006: 109). Particular importance in TM is given to the concept of transition arenas, defined as the institutional *setting that offers an informal space to a small group of change-agents from diverse backgrounds (businesses, government, research institutes, citizens)*, known to be visionaries or forerunners (Kemp and Loorbach, 2006; Roorda et al., 2012). TM is organized in a four-step process (Voß and Bornemann, 2011). The first step of the process deals with the creation of the transition arena. The second step refers to the development of the arena's vision and transition agenda. During the third step, experiments and projects aimed at fostering how new technologies might be used in society are conducted in order to better understand the benefits and drawbacks of available options. In the last step, the three first steps are evaluated. Throughout the process, learning mechanisms are acknowledged to be of significant importance (Loorbach and van Raak, 2006).

- Technological Innovation Systems (TIS)

The third transition framework, referred to as technological innovation systems (TIS), looks at the determinants of technological innovations. This approach builds on the systems of innovation (SI) literature, which emerged in the 1980s as a new school of thought to look at the underlying processes that determine innovation, rather than at their consequences. In broad terms, SI are defined as "*all important economic, social, political, organizational and other factors that influence the development diffusion and use of innovations*" (Edquist and Johnson, 1997: 14). The SI approach pays particular attention in its analysis to organizations (the players or the actors) and institutions (the rules of the game), and more specifically to the interactions between organizations, between institutions and organizations, and between institutions (Edquist, 2001). The SI approach has been developed at different levels. It was first developed at the national level with national systems of innovation (Lundvall, 1992; Nelson, 1993), before the development of regional systems of innovation (Doloreux, 2002; Iammarino, 2005) and sectoral systems of innovation (Malerba, 2002). Ultimately, the notion of technological innovation systems (TIS) emerged, which is known to differ from NSI, RSI, and SSI by the fact that instead of being bundled to a geographic region or a specific industry, they are defined around a particular technology or set of technologies (Carlsson, 2003). TIS builds on the concept of a technological system defined as "*a dynamic network of agents interacting in a specific economic/industrial area under a particular institutional infrastructure and involved in the generation, diffusion, and utilization of technology*" (Carlsson and Stankiewicz, 1991: 94). Particular interest in TIS analysis is given to actors, networks, and institutions. The performance of a TIS – that is, its ability to support the emergence and diffusion of technological innovation – depends on seven so-called "abilities"; namely: the ability to develop and diffuse knowledge, to incentivize actors to join it, to enhance entrepreneurial experimentation, to support market formation, to mobilize resource, to acquire legitimacy, and to develop positive externalities (Bergek et al., 2008). In the TIS literature, public authorities are known to be involved in knowledge exchange with companies during knowledge diffusion processes, in the development of niches through procurement policies for market formation, and ultimately in the creation of regulatory frameworks for the new technology in order to support new business models (Planko et al., 2017).

- Multilevel Perspective (MLP)

The fourth transition framework, is the multi-level perspective (MLP), which aims to provide an analytical tool to the study of socio-technical transitions. Under the MLP perspective, which builds on SNM, socio-technical transitions are thought to occur through an interplay of three key layers (Geels, 2002). At the bottom lies the niche level, in which radical (often technological) innovations are created, and where socio-technical transition processes are known to start. Those niches, which represent the micro-level of the framework, are protected from normal market selection processes and act as technological innovations incubation rooms (Schot, 1998). Three processes are acknowledged to be determinant in the success of niches: the alignment of actors' expectations, network formation, and learning processes (Schot and Geels, 2008). In the middle lies the socio-technical regime level, in which organizations (actors) interact under a set of rules (institutions). Several regimes interact in this layer, also called patchwork of regimes, where incremental innovations usually emerge (Geels, 2002). The top level is the socio-technical landscape level, which includes the environment, and its related variables, that might impact the regime and the niches. Technological trajectories, defined as "*the pattern of 'normal' problem solving activity (i.e. of 'progress') on the ground of a technological paradigm*" (Dosi, 1982: 152), are also known to be embedded in the landscape layer. According to Geels (2002), landscapes change much slower than regimes. Those three key layers are organized under a certain hierarchy. But this hierarchy is not static and might actually be perceived as heterarchy. According to Peter and Swilling (2014), heterarchies are flexible "flat" hierarchies that accommodate hierarchical shifts, such as a niche becoming part of a regime or hierarchical changes within one of the three conceptual levels. The main difference between the MLP and SNM approaches is that, for the latter, the success of a technological innovation depends not only on processes within its technological niche, but also on the alignment of processes within the niche, regime, and landscape layers, and the related presence or absence of a "window of opportunity".

- Coherence/Alignment framework

The last framework reviewed here is entitled coherence framework, which aims to evaluate the performance of network industries (such as transportation) as a function of the alignment between technology and institutions (Finger et al., 2015). The framework acknowledges that infrastructure systems are "co-evolving" as a result of evolution in technologies on one hand and institutions on the other (Finger et al., 2010). In particular, while the theory stipulates that technologies evolve from a centralized to decentralized state, institutions are acknowledged to evolve from "government to governance". For the proponents of that framework, innovations are known to occur as a result of the misalignment of technology and institutions (Crettenand and Finger, 2013). Thus, technological innovations might emerge as a result of institutional changes and, similarly, institutional innovations might emerge in reaction to technological changes. Three kinds of actors are defined under this approach (Finger et al., 2010). First, there are institutional actors, capable of defining institutional conditions that will influence the behaviors of other actors. Second are technological actors, which are able to foster technological innovations. Finally, there are market actors that emerge as the institutional context evolves towards a governance state. For Finger et al. (2010), the combination of all the above-mentioned actors ultimately creates the dynamics that lead to technological or institutional changes.

Due to the multiplicity of transition frameworks and their related focuses, various attempts have been made to compare the different approaches; see, for example, Coenen and Diaz-Lopez (2010) or Ulli-Beer (2013). While the MLP and TM seem to have a broader perspective on socio-technical regime shift, TIS and SNM are more concerned with what is happening at a more micro level (niches), or around a specific technological innovation. Attempts have also been conducted to link the existing different conceptual frameworks. For example, Geels (2004) has tried to do this for SSI and MLP. Markard and Truffer (2008) proposed a framework linking TIS with MLP. Schot and Geels (2008) highlighted the usefulness of the MLP to complement the SNM approach. Hekkert et al. (2007) proposed a representation of how the different systems of innovation relate to one another. Weber and Rohracher (2012) highlighted the need to incorporate transition studies insights into policy frameworks that rely heavily on innovation systems approaches, to be better suited to deal with long-term societal challenges. Last but not least, Bauwens (2015) combined the coherence framework with the MLP perspective. Although the MLP framework has not been the oldest transition framework in use, it is currently the most widely used one for looking at sustainability transitions. As described below, transition frameworks have been used extensively to look at the transition towards a sustainable socio-technical transport system.

2.4.2 Application to transport studies : the mobility transition

While transition frameworks have been used in energy studies to examine the transition from the current fossil-based energy system to renewable energy systems (usually referred to as energy transition), they have also been used a lot in transportation studies,[12] which has paved the way for a considerable amount of empirical research. Mobility transition has been defined within the field of sustainability transition as potentially the hardest case because of the "*many stabilizing mechanisms and secular trends that point in the direction of more, not less, mobility*" (Geels et al., 2012: xiii).

As mentioned in the introductory chapter, transportation is a socio-technical system that is currently organized under the *automobilit*y regime, synonymous with single-occupant fossil-fuel powered private cars, supported by a range of institutions and infrastructures, dominating space, and responsible for massive environmental resource consumption (Sheller and Urry, 2000). Conscious of the need to break away from the (unsustainable) automobility regime, research has been conducted to look at how to enhance the transition from the automobility regime towards a "post-car" regime. In other words, research has been undertaken to look at the development and diffusion of system innovations in the transport sector, defined as "*novel forms of providing transport services that are innovative in terms of technology, organisation and user behaviour, and require both new components and system architecture*" (Weber et al., 2014: 540). For that matter, sustainability transition scholars have been using transition frameworks to understand the dynamics of the so-called "mobility transition". Many academics have highlighted the break away from automobiles as the major challenge in moving towards sustainable transport systems. As detailled below, research has been conducted to look at the mobility transition as a whole, but also to look at the development of particular components of the mobility transition such as alternative propulsion engines, alternative fuels, dedicated sustainable mobility solutions, and finally non-technological innovations.

Some studies have examined mobility transitions in general. For example, Geels (2005) used the MLP to look at the transition from horse-drawn carriages to automobiles in the USA. For Geels, the success of internal combustion engine automobiles in evolving from technological niches to market niches and finally to regimes (unlike electric or steam-powered cars) can be understood as the result of changes at the landscape

[12] The link between transition frameworks and transportation studies is actually stronger. It is acknowledged that some transition frameworks have actually been developed to look at transport. For example, according to Ieromonachou (2004: 78) "*Strategic Niche Management has been developed in the context of transport technology projects*".

level (inclusion of entertainment, excitement, and fun values in popular culture), and the development and competition with the electric tramway regimes. Research was later undertaken to look at the on-going transition towards low-carbon transport systems. Using MLP, Geels (2012) investigated the mobility transition in UK and the Netherlands and concluded that although the automobility regime is still dominant, some technological niches (green propulsion technologies and ITS) are gaining momentum, which might lead to a shift towards a low-carbon regime. According to Wells and Nieuwenhuis (2012), the stability of the automobility regime is heavily dependent upon car manufacturers. Looking at the UK and Sweden, and using MLP, Nykvist and Whitmarsh (2008) showed the importance of hybridisation mechanisms between areas of innovation to generate a regime shift. According to Moradi and Vagnoni (2018), a shift from the current regime might be possible if non-dominant sub-regimes (public transport and human powered transport sub-regimes) reach a stable state, which might be possible if they gain more support from regime actors.

Although most of the research on the whole mobility transition has been conducted with the MLP, some scholars have also used transition management. Looking at policy development for sustainable transport through the lens of the transition management framework, Kemp et al. (2011) criticized Dutch authorities for being overly focused on short-term technological fixes and not developing a coherent future vision for transport, thus raising serious doubts about their ability to steer the mobility transition. Some scholars have also been interested in using transition frameworks to propose scenarios of evolution for mobility. In their book entitled *Automobility in Transition? A Socio technical analysis of sustainable transport*, Geels et al. (2012) presented the automobility regime as relatively stable but not as strong as it used to be. From the three scenarios they highlighted for the future of transportation, the one proposing the greening of cars (but not a redefinition of the role of the car) is presented as the most likely to happen. The scenario entitled *Intermodal urban transport* (relying on the development of intermodal journeys) is presented as less likely because of its higher dependence on government willingness to support it. Köhler et al. (2009) developed a simulation model, building on system dynamics and agent-based modelling, and using MLP as a theoretical framework, to assess transitions to sustainable mobility. Using UK data, the authors foresaw a shift towards ICE and hybrid vehicles in the next 10 to 30 years, and finally a dominance of hydrogen fuel cell vehicles after 2030. According to them, the product-service shift (shift from ownership to usership) is unlikely to happen, indicating that the demise of the private car might take a very long time to happen. Marletto (2014) suggested the use of a socio-technical map to propose transition pathway for mobility. For the author, three pathways exist: the AUTO-city (individual cars are still dominant, but are getting more electric), the ECO-city (increased reliance on non-car modes of transport), and the ELECTRI-city (new electric vehicles and smart grids). However, it is likely that the former will prevail if no clear-cut policies are developed in favour of the second one. Schwannen (2015) looked at the development of low-energy mobility modes in Oxford and Brighton. He concluded that although such solutions are being developed in both cities, they are not (yet) producing a regime shift due to their categorization as incremental (and not radical) innovations.

Given the importance of the fuel system in the automobility regime (Urry, 2008), studies have sought to understand how to enhance the transition towards non-fossil fuel system. Suurs and Hekkert (2009) used a TIS approach to look at the dynamics of the biofuels innovation system in the Netherlands. They concluded that the Dutch biofuels innovation system has not been successful mainly because most of the TIS functions were not fulfilled. Looking at the development of alternative transport fuels in Sweden and also using a TIS approach, Hillman and Sanden (2008) concluded that in order to be effective, policies must take into account and somehow balance all the dynamic forces within the TIS. Using a SNM approach, Ulmanen et al. (2009) concluded that Sweden developed biofuels more successfully than the Netherlands mainly due to a better niche management strategy, protection measures (tax reduction), as well as the institutionalization of a pro-biofuel discourse.

As ICE cars lie at the heart of the automobility regime, research has been conducted to look at the development and diffusion of non-ICE cars. For example, Schot et al. (1994), using SNM and looking at the Netherlands and California, proposed three strategies for the development and diffusion of Electric Vehicles. According to the authors, experiments in Niches and technology nexus development might help prevent the drawbacks of a technology forcing strategy. Looking at Europe and using MLP, Berkeley et al. (2017) stated that although EV development has been pushed by a landscape influenced by environmental and energy security pressures, their wider take up was actually dependent on the development of dedicated policies by governments. Using MLP, Ryghaugh and Skjølsvold (2018) showed that the on-going successful transition towards electric mobility in Norway was actually the result of incentives introduced to nurture what many hoped would be the next Norwegian industrial adventure and not, at that time, to stimulate mass market demand. Looking at Sweden, Nilsson et al. (2012) showed that different patterns of governance, which could be motivated by the position of the technology within or outside the socio-technical regime, led to different sustainable transport innovation development. For example, according to those authors, international levels and market-based governance are more likely to support the development of biofuels, whereas the development of hybrid vehicles is more likely to be supported by industry-led and cognitive governance. Using an MLP-based approach, Van Bree et al. (2010) derived different scenarios for the replacement of ICE by battery electric vehicles (BEV) or fuel-cell vehicles (FCV), from two different transition seeds, being either the increase of environmental stresses, or the increase in (conventional) fuel prices. Looking at the evolution of electric mobility from a socio-technical transition perspective, Dijk et al. (2013) concluded that electric vehicles have crossed a threshold in 2005 and that their share in personal mobility is very likely to increase in the coming years. Along with high oil prices and stronger carbon constraints, Dijk et al. presented the development of mobility operators and car sharing as factors that have supported the growth of electric mobility in the past and will potentially continue to do so in the future. Focusing on Stockholm, Nykvist and Nilsson (2015) used the MLP to analyze why EVs, despite a favorable environment, did not take off. They concluded that EVs could not develop mainly because of the lack of niche experiments, which was caused by the behavior of certain regime actors, such as the Swedish automotive industry, who supported the development of hybrids over EVs, and of public authorities being supportive of ethanol and not EVs.

Transition frameworks were also used to look at the development of human-powered mobility solutions as part of transition towards sustainable mobility systems. For example, as the bicycle has been presented as "*intermediate technology, between the horse and car*" (Genus and Coles, 2008: 1440), research has been conducted to look at its impact on the evolution of transportation. Using MLP, de Boer and Caprotti (2017) showed that while cycling was fully integrated in the transport regime in Amsterdam, it was still lying at the niche level in London. The authors argued that to make cycling part of London's socio-technical transport regime, effective policy-making and successful advocacy were to be developed at the regime level, and the niche needed to open up to a wider demographic. Using MLP and focusing on Johannesburg, Morgan (2017) showed that the materialization of a bicycle culture never happened, because no windows of opportunity were created during the process of development of dedicated bike lanes. Birtchnell et al. (2017) also used MLP to explain how the development of electric scooters in Australia was inhibited by the incumbent automobility regime, and how electric scooters, in the socio-technical transition jargon, could contribute to the process of niche development. Research using transition frameworks was also carried out to understand the process of development of dedicated sustainable transport solutions. For example, using the MLP framework, Tuama (2015) showed that the success of the public bike-sharing scheme in Dublin could be seen as the result of successive positive feedback loops having happened in the regime layer. Hynes (2016) used the MLP to show that the failure of telework to take off and become more than a niche in Ireland was due to several factors. Among them, he listed the inability to enroll additional actors in the telework niche, and the resistance of the incumbent regimes, being the traditional work regime and automobility, as well as the absence of policies from regime actors supporting the development of telework. Some more recent MLP-based works have examined the development of new innovative mobility solutions. For example, Reichenbach and Puhe (2017) used MLP to analyze the take-off of ropeways as a new travel mode in Germany and came to the conclusion that their development was mainly hindered by routines part of the incumbent public transport regime. Other studies have also investigated the development of car-pooling (Pekarskaya, 2015), car-sharing (Bloome, 2016; Noll, 2017), or even automated vehicles (Clark et al., 2016; Fraedrich et al., 2015).

Although developed to look at technological innovations development, SNM has also been used to look at non-technological innovation development. One of its uses has been to investigate transport policy development. For example, Ieromonachou et al. (2004) used SNM to look at the development of travel demand management policy. Coming up with the concept of strategic policy niche management (SPNM), they argued that introducing policies and supporting technologies simultaneously might pave the way for a regime shift towards more sustainable transport system. In a similar fashion, Shove and Walker (2010) used transition frameworks to look at the successful implementation of the congestion charge in London.

2.4.3 Critiques and research gap

As seen above, transition frameworks have been widely used in transportation studies to look at the development of technological innovations and their impact on the transition towards sustainable transport systems. From the above review of the literature on socio-technical transitions, it appears that most of the research making use of transition frameworks in transportation studies has indeed investigated the overall mobility transition, or the paths of development of specific technological innovations (non-ICE vehicles, alternative fuels). To date, very little research has used transition frameworks to look at the development of the intermodality regime. In the few studies that have done so, intermodality is described as being a "*niche caught between two regimes*", where no organizations (yet) assumes responsibility for seamless door-to-door travel (Parkhurst et al., 2012; Kemp et al., 2011). Similarly, almost no research has examined the development of ICT-supported mobility schemes. Exceptions include Audouin and Finger (2019b), who used a framework combining the coherence framework and the system of innovation approach to look at the development of smart ticketing schemes in London, and Smith et al. (2018a), who looked at the governance of MaaS using transition management and the MLP.

Therefore, it seems there is an urgent need for more empirical research into the development of technological innovations aimed at intermodality, such as ICT-supported integrated mobility schemes. The following sub-chapter (2.5) sums up the existing lack of research vis-à-vis this thesis' research question in the three above-reviewed bodies of literature, before finally presenting how the present research endeavor might contribute to each of those streams of literature.

2.5 Conclusion and summary of potential contributions

This chapter has highlighted that this thesis's research question has so far been under-researched in three bodies of literature: transport integration, transport governance, and mobility transition. Below, I explain how I believe that the present thesis can contribute to those three bodies of literature.

As explained earlier, most of the research conducted on transport integration has been concerned with the understanding of the impact of transport integration on existing transport systems, in economic, social, or environmental terms. However, very little research has been conducted to understand the processes leading to the development of integrated transport schemes, and even less has sought to understand the role that public authorities played in it. Given that this thesis specifically aims at examining the processes of development of ICT-supported integrated mobility schemes, I believe it will empirically contribute to the literature on transport integration/Mobility-as-a-Service.

Similarly, it appears there is an extensive body of literature focusing on transport governance. Unfortunately, most of this literature has focused on analyzing the impact of some governance mechanisms on transportation systems performance. A smaller body of literature, within the transport governance literature, has been interested in looking at transport governance from a political perspective; that is, the role of different stakeholders in the development of transport projects or transport policy. However, it appeared that no studies focused on the governance of transport integration. More importantly, very few studies have investigated the governance structures that have supported the birth of ICT-supported integrated mobility schemes, and even fewer have been concerned with looking particularly at the role of public authorities in the process of development of smart cards, IMP and MaaS. Thus, again, I believe the present study should contribute to the growing literature focusing on the politics of transport governance.

Last but not least, it seems the literature focusing on the mobility transition; that is, with understanding how some technological innovations might enhance the transition towards a more sustainable transport system, is important. However, most of this research has focused either on the overall mobility transition or on the development of some specific technologies, such as non-ICE engines, alternative fuels, non-car mobility solutions, or shared mobility modes. It appears that almost no research within the field of transition studies has concentrated on intermodal transport or on the development of technologies supporting transport integration. Thus, I believe that by answering my research question, I might also be able to bridge this existing gap and contribute to the literature on socio-technical transitions.

It is pertinent now to ask how I aim to do this, which I will explain in detail in the following methodology chapter (chapter 3).

Chapter 3 Methodology

In this chapter, I present the research strategy I have been using in this doctoral dissertation and provide some justifications about the methodological choices made to answer my original research question. I begin by presenting the epistemologies/ontologies under which I set myself, as well as the theoretical perspective I have adopted in this research project, and explain why I have taken such a position. I then present the research methodology that I have been using in this dissertation. In the third part, I justify my decision to adopt a case study approach as research strategy, before going into more detail regarding the case selection, data gathering and data analysis and case analysis processes. The fourth part explains my understanding of my role as researcher in this research project and how I have addressed ethical issues in this thesis. The fifth part explains how I have tried to ensure research quality, before the sixth and final part sums up the overall research design of the thesis.

3.1 Epistemology, ontology and theoretical perspective

According to Crotty (1998), the design of a research project actually depends on the researcher's worldview. More specifically, it depends on the researcher's epistemological and ontological positions, which influence the choice of methodology; this, in turn, has an impact on the research methods chosen to conduct the research project. Thus, this chapter starts by presenting my epistemological/ontological stances, before detailing the theoretical perspective that was adopted for this research project.

Epistemology is know as "*the nature of the relationship between the knower or would-be knower and what can be known*" (Guba and Lincoln, 1998: 108). In other words, epistemology is concerned with how knowledge is acquired. According to Crotty (1998), there are three main epistemological positions a researcher can adopt: an objectivist, subjectivist and constructionist one. Under the first approach (objectivist epistemological position), the researcher believes that knowledge exists "out there", under the form of a single and objective truth, independent from human consciousness, and that it is his/her role to discover it. Under the subjectivist epistemological position, the scientist believes that the meaning of objects does not emanate from objects themselves, but only from the researcher's own understanding. Under the constructionist perspective, knowledge is believed not to be discovered (as in objectivism) but constructed as a result of the interaction between the researcher and the object. The truth, which is not thought of as being an "objective truth", actually depends on the engagement of the researcher and his/her world realities. In my case, I believe that our understanding of the reality is constructed through human interaction and depends on the different contexts in which the research is undertaken. For example there is no single and universal understanding of people's mobility. People might move for various reasons that are affected by societies, social milieus, and the researcher's point of view. Similarly, there is no single understanding of what public authorities should be doing vis-à-vis transport digitalization. It might depend on the context we look at, the time period and many other factors. In the present research project, I set myself under the constructionist epistemological position.

Contrary to Crotty, many researchers emphasize the need to clearly differentiate ontology from epistemology. According to Gray (2009), while epistemology can be seen as focusing on the question of *what it means to know* (the nature of knowledge), ontology can be viewed as concerned with understanding *what things are* (the nature of existence). While there are multiple ontological positions, they are acknowledged to be organized on a continuum ranging from a realist to a relativist pole (Moon and Blackman, 2014). While the realists stipulates that only one reality exists, relativists believe that reality is constructed within the human mind, and that reality is therefore relative to each individual experiencing it. Perhaps due to my background education in science and engineering, I consider myself closer to the realists than the relativist pole. To sum up, I believe there is a single reality out there (realist) but that knowledge about it is constructed through human interaction (constructivist) and is not only "discovered". According to Crotty (1998), adopting a realist ontology and a constructivist epistemology turns out to be quite compatible.

There are various theoretical perspectives that the researcher can adopt, which have developed through time. Reviewing all the existing theoretical perspectives would go beyond the scope of this chapter, so only the most widespread theoretical perspectives, which can be categorized in five broad categories (Moon and Blackman, 2014), are presented. The first category of theoretical perspectives is concerned with undertaking research in order to *predict* things. It has been historically dominated by the theoretical perspective known as positivism, which builds on an objectivist epistemology and realist ontology. From that perspective, researchers think that the human and natural worlds are operated within a strict set of rules, which they must discover through empirical enquiry and through observations (Gray, 2009). Other theoretical perspectives that fall into this first category are post-positivism and structuralism. The second category of theoretical perspectives is concerned with *understanding* things. It is dominated by the interpretivism perspective (sometimes referred to as antipositivism), which lays on a constructionist epistemology. Within this category are comprised several theoretical perspectives, known as hermeneutics, phenomenology, and symbolic interactionism. From the interpretivism perspective, researchers believe that interpretations of reality should be made from culture and history. In more detail, interpretivists see "*the world as too complex to be reduced to a set of observable laws"* and believe that *"generalizability is less important than understanding the real workings behind reality*" (Gray, 2009: 33). The third category of theoretical perspectives, which is concerned in *criticizing and changing* things, falls under the umbrella of critical theory (sometimes referred to as participatory perspective). Under that perspective, researchers usually select their theoretical framework out of an ideology of which they become advocates. Critical theory encompasses theoretical perspectives such as feminism or queer theory. The fourth category of theoretical perspectives basically aims to *deconstruct* reality as it is known; for example, by using discourse analysis. The last theoretical perspective is known as pragmatism and does not give as much importance to ontology and epistemology as the other theoretical perspectives (Wahyuni, 2012). Specifically, pragmatism is concerned *"with applications and solutions to a problem. Instead of focusing on methods, researchers emphasize the research problem and use all approaches available to understand the problem*" (Creswell, 2009: 10). In other words, this last theoretical perspective seems to be more concerned with *solving* real-life problems than anything else.

I proceed by deduction to explain my choice of theoretical perspective. As explained in the introduction, this thesis did not aim to make any predictions. Nor did it aim to forecast the role that public authorities will play in the development of ICT-supported integrated mobility schemes in the future. While this might help public authorities to change their future behavior, I did not aim to predict that behavior. Therefore, the positivist perspective could be removed from my options. Also, given that I had adopted a rather constructionist epistemology, adopting a positivist perspective could not be a good match, as it lays on an objectivist epistemology. Similarly, the present research did not aim to change how things are or to empower a particular subject or group of subjects. Therefore, the critical theory perspective could also be removed from my available options. Last but not least, this research project did not aim to deconstruct a specific reality. ICT-supported integrated mobility schemes are just coming to life, so one might say that there is nothing to deconstruct as things are only being constructed. Thus, it seems I only had the choice between the pragmatic and interpretative theoretical perspectives for the present research project. However, although I was interested in solving an issue (potentially inappropriate behavior of public authorities in the development of ICT-supported integrated mobility schemes), I was more interested in understanding a particular phenomenon (the role of public authorities in the development of those schemes). Therefore, it seemed natural to go for the interpretivism perspective rather than the pragmatic one. By paying particular attention to "*contexts (…) in order to understand the historical and cultural settings*" (Creswell, 2009: 8) of the phenomenon, interpretivism seemed to be more appropriate for the present research project. Furthermore, the choice of the interpretivism approach was also a good match to my ontologies (realist) and epistemologies (constructionist). To conclude, the interpretivism perspective seemed to be the best fit to answer this thesis' research question.

3.2 Research methodology and research method

I must now detail the selection of methodology before presenting the research strategy that was adopted in this thesis. According to Gray (2009), the choice of research methodology actually depends on the researcher's epistemology, ontology, and theoretical perspective. Many research methodologies exist, but reviewing them all will again go beyond the scope of this chapter. In particular, it would not be interesting to look at research methodologies associated with theoretical perspectives, ontologies, and epistemologies that have not been chosen, such as econometric studies, usually used by positivist researchers. Given the nature of the present research inquiry, I have adopted a qualitative methodology. Within qualitative methodologies, I did not choose action research as being mainly used by pragmatism and critical theory researchers, and not fitting this thesis' research question. From the remaining qualitative research methodologies, I decided to set myself under the phenomenological research tradition, for its ability to generate "*thick descriptions*" of phenomena (Gray, 2009). According to Husserl (1970), who is considered by many to be the father of the phenomenological tradition, phenomenology aims to describe rather than explain, and usually starts free of hypothesis or preconceptions.

The main research methods used (to gather data) were document analysis and interviews. Documentation evidence is described as being relatively stable, unobtrusive, accurate, and as being broad in its coverage, while interview data are described as being targeted and insightful (Yin, 2009). Depending on what the researcher aims to retrieve from the interview, researchers can choose between different ways of interviewing (Gray, 2009). A first type is referred to as structured interview, where the researcher basically asks pre-established questions to the respondents and does not allow for important variations, or follow-up questions. A second type of interviews is so-called semi-structured interviews. Under that scheme, the researcher usually prepares a pre-established list of questions, defining the main topics to be examined, but is also ready to ask follow-up questions in order to pursue an idea or dig deeper into one of the answers of the interviewee. One of the advantages of semi-structured interviews pertains to its flexibility, and its ability to explore areas during the interview that have not been thought of in the interview preparation phase. Falling under semi-structured interviews are so-called focused interviews (Merton et al., 1990), the main aim of which is simply to verify certain facts that have been established by the researcher beforehand. In that setting, the researcher usually appears "*genuinely naïve about the topic and allow the interviewee to provide a fresh commentary about it*" (Yin, 2009: 107). The third and final type of interviews is defined as unstructured interviews (sometimes called non-directive interviews), where the researcher usually has an open conversation with the respondent that is not supposed to reflect on any preconceived theories. As the main reason for using interviews was to find missing information, and corroborate facts, I opted for semi-structured interviews. Having now detailed my choices of epistemological and ontological positions, as well as the theoretical perspective, research methodology and research methods adopted, I now detail the research strategy that has been used, which was the case study research strategy. An overall representation of my methodological stream is represented in Figure 3.2.1.

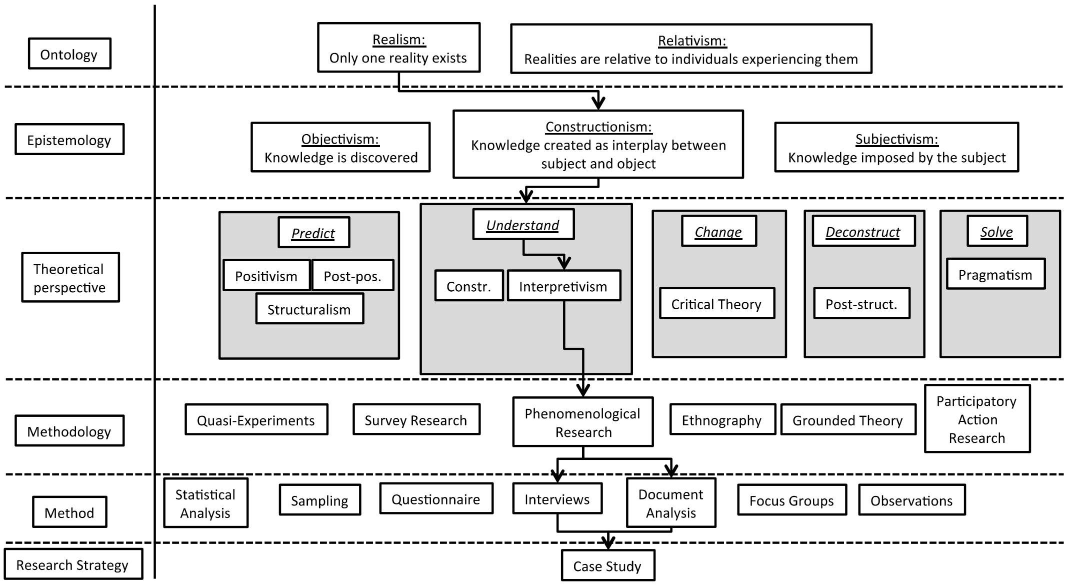

Figure 3.2-1: Research stream employed in this thesis (inspired from Moon and Blackman [2014] and Gray [2009])

3.3 Research strategy

Here is presented the overall research strategy adopted for the present research project, which was a case study research strategy. The case study approach should indeed not be considered as research method, nor research methodology, but rather as a research strategy (Yin, 1981) or research approach (Chadderton and Torrance, 2005). In this sub-chapter, I explain why I have chosen this particular research strategy, before going into more details and explaining my case design, case selection, data gathering, and data analysis processes.

3.3.1 The case study as a research strategy

A case study strategy was used, because of its usefulness to look at complex processes, and its suitability to look at phenomenon that cannot be clearly separated from their contexts (Yin, 2009). In particular, the case study approach was adopted because of its practicality to obtain a holistic understanding of a particular phenomenon (Gummesson, 1991). According to Meredith (1998), there are three valuable outputs of selecting a case study approach. First, it allows the researcher to study a particular phenomenon in depth, in its natural setting and context, and to generate theory from its understanding. Second, it allows the researcher to answer why-, what-, and how-types of research questions. Last but not least, it makes it possible to conduct investigations where the dependent and independent variables are still not known, and where there is very limited knowledge about the phenomenon studied. Yin (2014) added that selecting a case study approach is relevant when the researcher has no control over the behavioral elements and events studied, and that the phenomenon being looked at is contemporary and happening in a real-life context.

All the above-mentioned criterions led me to choose the case study as research strategy to conduct the present study. First, it appeared clear that I did not have any control over the behavior that public authorities adopted in the development of ICT-supported integrated mobility schemes. Second, the development of ICT-supported integrated mobility schemes is happening now and can thus be classified as a contemporary phenomenon happening in a real-life context. Third, the phenomenon of interest and the context were hard to dissociate in the present study. It seemed almost impossible to separate the behavior of public authorities in the development of ICT-supported integrated mobility schemes (phenomenon of interest) from the context of the study (political and economic context, transport digitalization trend). Fourth, I had formulated my research question as a how-research question, for which case studies are a relevant research strategy to adopt. Finally, transport digitalization is just beginning. There is really not a lot of research focusing on this issue, and even less focusing on the governance of transport digitalization. As seen in the literature review (Chapter 2), the novelty of the phenomenon meant that there is very limited evidence about the role that public authorities are playing in transport digitalization. Hence, one might not even be sure what to consider as dependent or independent variables. Therefore, the case study approach again seemed to be the best research strategy to answer this thesis' research question.

One might be tempted to ask why other research strategies would not have matched the present research project. To answer this question, the classification established by Yin (1984) to determine the type of research to endorse for a research project is used. It would have made no sense to go for an experiment research strategy, as that requires having control over behavioral events. Similarly, adopting an archival analysis or history research strategy would not have been useful given the contemporary characteristic of the phenomenon studied. There were some question marks about adopting a survey research strategy, but given the importance of the context in the present study, and the fact that interviews appeared to be a most efficient way to collect in-depth data, I ultimately opted for the case study research strategy.

It is worth emphasizing that the case study strategy is a well-used approach in the three streams of literature where this thesis aims to contribute. Given that the transportation sector is deeply linked with its environment (political, social, economic, geographical), it is not always easy to clearly separate between the phenomenon of interest and its overall context. Therefore, transport research has an existing history of using case studies as research strategy. In the transport governance literature, the case study strategy has also been used, for example, to look at citizen participation in transport policy development (Gil et al., 2011), or at the diffusion of new mobility modes in particular contexts (Shaheen et al., 2010). Finally, it is perhaps in the transition literature that the case study has been used most. It has been widely used to gain knowledge about the complexities of how transport-related system innovations develop (see, for example, Geels, 2005). Thus, my decision to opt for the case study strategy, while not highly innovative, is in line with the research strategies employed in the three above-mentioned literatures.

3.3.2 Case design

Different types of case studies exist, and one might wonder which one was used for the present study. Yin (1984) differentiated between three types of case study. First, researchers might decide to undertake exploratory case studies if the purpose is to better understand a new phenomenon and generate new theories (Baskarada, 2014). In particular, exploratory cases are used when existing theories are not able to provide a satisfactory explanation of a particular phenomenon. Secondly, researchers might decide to undertake explanatory case studies. Under that approach, the main goal is to explain a particular phenomenon, and more particularly to highlight a causal relationship that it might not be possible to emphasize with other research strategies. Explanatory case studies are used to test pre-established theories; that is, for theory testing (Baskarada, 2014). Finally, researchers might decide to undertake descriptive case studies if their goal is to portray a precise phenomenon, describe a sequence of events, and emphasize the underlying mechanisms of the studied phenomenon. Given that the aim of this study was not to test theory, doing explanatory case studies did not seem to be the right approach to adopt. As exploratory research is usually employed in order to generate propositions (and in certain cases theories) to be tested at a later stage, I also thought it would not be the best approach to answer this thesis' research question. Consequently, it appeared the present study should instead fall under the descriptive approach, as I knew from the beginning that I was interested in studying the role of public authorities in the development of ICT-supported integrated mobility schemes, and not explaining in great detail the reason for their behaviors. Hence, by deduction a descriptive case study approach was selected.

Having explained the type of case study selected, it is now important to present the choice of case study design. Different case study designs have been proposed by Yin (2003). In total, there are four possible designs, depending on what is being analyzed (number of units of analysis), and to what extent (number of cases undertaken by the researcher). The design is defined as holistic when there is a single unit of analysis, and embedded when there are several. Respectively, the design is defined as multiple when several cases are investigated and single when the investigation is only focused on one case. Consequently, four case study designs are available to researchers (Gray, 2009). The first is the single embedded case design, where only one case is investigated but through different units of analysis. The second one is the single holistic case design, where only one case is investigated in a holistic manner, which is mainly used in theory testing. The third is the multiple embedded design, where the same different units are analyzed across different cases. The final one is referred to as the multiple holistic case design, where multiple cases are analyzed in their whole, in order to replicate the findings from one case to another and potentially generalize to a theory. A summary of the different case study design available to researchers is given in Figure 3.3.1.

In the present research project, I was interested in understanding the role of public authorities in the overall process of development of ICT-supported integrated mobility schemes. I was not interested in looking at the different perspectives existing (such as from private, citizens, or public sector) about the role that public authorities should play from different perspectives, and thus had no reason to have different units of analysis; that is, opt for an embedded case design. What was of interest for me was the case in its entire form, which is why I selected a holistic design. Then, given that I wanted to reach some degree of generalizability, I felt it was important to compare the findings from different cases, and thus opted for multiple cases. Looking at multiple cases was indeed important for me, as the way transportation activities are organized is highly dependent on the surrounding context. Looking at just one case would not have allowed me to generalize and develop propositions and recommendations. Thus, the case study design adopted can be resumed as multiple holistic, or as collective case design (Stake, 1995).

According to Miles and Huberman (1994: 25), in a holistic design, the case actually is "*the unit of analysis*". Therefore, since my cases depict the processes of development of ICT-supported integrated mobility schemes in different contexts, I believe the unit of analysis in each case is the process of development of ICT-supported integrated mobility schemes. Given that technological development processes (for the development of ICT-supported integrated mobility schemes) ultimately rely on actors (Geels, 2005), particular attention was given, to the different actors involved, their actions and interactions with one another.

Stake (1995) provides another categorization for case studies that might be relevant to mention. According to him, a researcher can decide to conduct either intrinsic or instrumental cases. The choice to undertake intrinsic case is basically driven by the desire to learn about this specific case, and not by the desire to use the case to answer a research question. On the contrary, the choice to undertake instrumental cases is driven by the belief that this case will provide the researcher with elements that might potentially enable him/her to answer a previously established research question. Although the three cases were selected because of their uniqueness (there are not that many other cases of ICT-supported integrated mobility schemes development), the motivation to select them was rooted in a greater desire to gain understanding about a particular problem; that is, about the role that public authorities play in their development. Thus, the three case studies presented in this thesis should be categorized as instrumental rather than intrinsic.

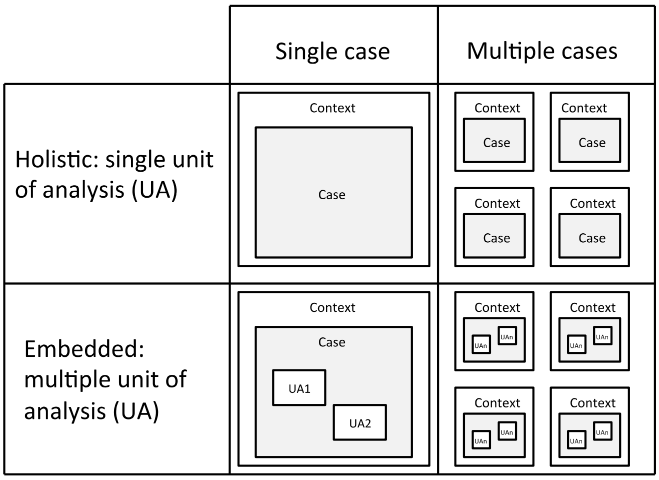

Figure 3.3-1: Types of case-study design (adapted from Gray [2009])

3.3.3 Case selection

While quantitative approaches usually rely on the high number of cases, selected randomly to allow generalization to a larger population, case selection in qualitative research requires more attention. Due to the low number of cases investigated in qualitative inquiries, cases need to be selected "*purposefully*" (Patton, 2002: 230), in order to reduce selection bias as much as possible. From all the different case selection techniques proposed by Patton, I opted for the *theory-based sampling*; that is, for a case sampling that is based on theoretical constructs. As mentioned in the literature review chapter, ICT-supported integrated mobility schemes can take various forms. Given that I was interested in understanding the role that public authorities played in it, I had to develop a framework allowing us to differentiate between different forms of ICT-supported integrated mobility schemes. Therefore, I developed a case-selection theoretical framework that was named the "new transport integration ladder", and that is presented below. The framework builds on theory but also on logic, and on my personal experience. Once again it is important to shed light on the experience I obtained when managing the IGLUS Executive Master at EPFL. As mentioned in the introductory chapter, I could see, in my capacity as manager of the program, good (and bad) examples of transport integration from around the world (Seoul, New York, Dubai, Detroit, Istanbul, Barcelona, Dortmund, Mexico City, Guadalajara), which ultimately helped us establish the present framework.

As seen in the literature review chapter, transport integration can actually be understood as a ladder, ranging from modal integration all the way up to integrated transport and land use, as well as integrated transport policy. The first step of this framework basically deals with physical integration (Hull, 2005), as it would not make sense to have timetable, fare, or network integration if people were not able to physically transfer from one mode to another. A transport system might be completely integrated in terms of fare, network and ticket; if people are not able to physically transfer between vehicles of different modes or operators, it does not make any sense. The second step deals with network integration. It comes second as physical integration is a pre-requisite for it, even though it is itself a pre-requisite for other integration steps. For example, what would be the point of coordinating timetables if modes were physically connecting but were not planned to accommodate the transport demand and offer (no capacity coordination). After timetable integration, which is the third step, comes fare integration (Preston, 2010), which comes on top of the three previous integration steps mentioned. The same approach is adopted to conceptualize ICT-integrated mobility schemes. On top of those three modal integration steps, logically, come ICT-supported integrated mobility schemes. It would not make sense to have such schemes if the previous steps were not in place already (Li and Voege, 2017). The first of those ICT-supported integrated mobility schemes, and thus the fourth of the transport integration ladder, can actually be understood as smart ticketing, which should be followed by integrated mobility platforms (fifth step), and ultimately MaaS (sixth step) (Kamargianni and Matyas, 2016; Sochor et al., 2017). The main difference made between IMP and MaaS relies on the fact that IMP are just the integration of multi-modal information and ticketing systems, whereas MaaS is a more advanced step aimed at providing its users with a mobility solution for whatever they intend on doing. Unlike IMP providers, MaaS providers make the promise to their users that their car will become useless by bundling into packages mobility solutions and a service promise, in exchange for a monthly fee.

After the ICT-supported integrated mobility schemes come, logically, the more advanced integration steps. As smart cards, IMPs and MaaS might also provide public authorities with data about what is happening in their transport systems (Pelletier et al., 2011), they should be seen as a pre-requisite, or enablers, for the definition of integrated transport and land use models, as well as integrated transport policies. From experience through the IGLUS master, many public authorities were complaining about not being able to define effective integrated transport policies due to their lack of data. ICT-supported integrated schemes might be a way to tackle the issue, which is why those should come between traditional modal integration steps and the more advanced stages of transport integration (integrated transport and land use and integrated transport policy). Figure 3.3.2 provides a graphical representation of the "new" transport integration ladder framework.

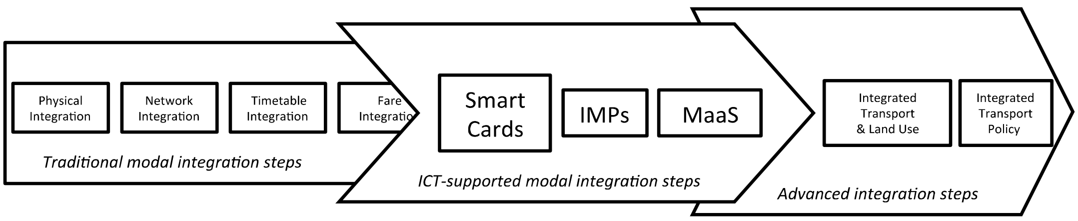

Figure 3.3-2: The "new" transport integration ladder (author's elaboration)

Based on that framework, the three case studies, that are basically processes of development of the three steps of the ICT-supported transportation integration ladder, were selected. The first case focused on a process of development and implementation of smart cards, the second case on the development of IMPs, and the third one on the deployment of MaaS schemes.

Cases are also known to have boundaries that help the researchers define what should and should not be studied (Patton, 2002). Although Miles and Huberman (1994: 27) argued that a case boundary is never "*as solid as a rationalist might hope*", they proposed several kind of boundaries, such as its physical location or temporal extent. It was therefore important in this research project to set the boundaries in order to select the cases. The first boundary set was a geographical one at the city/metropolitan level. Thus, I was only interested in ICT-supported integrated mobility schemes that developed on the city scale, not on other scales (regional or national scales). The second boundary set dealt with the time period studied. Given that the development of ICT-supported integrated mobility schemes is rather recent, I decided to consider a 10 to 15-year time period to select the cases to be explored. Thus, one could view the three cases studies as processes of development of the three steps of the ICT-supported transport integration ladder in specific cities. Having done this, I decided on other criteria that would help to select the cases. The first criterion was to select cases that had similar contexts, in order to compare them with one another, following Miles and Huberman's "comparable cases" strategy (1994: 176). I was first tempted to look at Seoul for the case on smart cards, given that their smart card solution is seen by many as a best practice, and that I had studied the case in depth for my master's thesis at Sungkyunkwan University in Seoul. However, South Korea's political, economic and social context is very particular, and I would have had difficulties comparing it with contexts from other cases. I would also have faced data gathering issues as I did not speak Korean and would have needed a translator, which was not materially possible because of the associated costs. Therefore, I decided to take three case of studies in Europe, and more specifically, located in countries member of the European Union, so they would all share the same (or at least comparable) economic, social, and institutional contexts.

Looking at Europe, the number of cases that I could have undertaken for the smart card case was still important. Indeed, many cities at that time already had a smart ticketing system in place. However, I wanted to take the most innovative case for smart card development in order to gain more insights on the role that public authorities played in it. I chose London as it was regarded as a highly successful smart ticketing system in Europe (Mayes, 2017). London's smart card, which is known as the Oyster, is regarded globally as a pioneer in smart ticketing. However, my choice to look at London was also motivated by the fact that a new smart ticketing system was being developed from 2012, to complement the Oyster one. Named CPC (standing for contactless payment card), the system aimed to enable all contactless payment bankcard holders to use their CPC as a payment method for public transport in London, even removing the need for Londoners to use an Oyster card in order to use public transport. This innovation appeared as something worth looking at, and fitting with the smart card step of the transport integration ladder. Given that CPCs had only been implemented at that time in London, I decided to undertake some preliminary research to ensure sufficient data was available. It is recommended that the researcher makes sure that the case will allow him to have sufficient access to data before deciding to undertake it (Gray, 2009; Crowe et al., 2011). Being satisfied with the amount of data I could find online about the development of the Oyster and CPCs in London, I decided to select the London case for the smart card development case.

For the IMP and MaaS case studies, unfortunately, I did not have many options to choose from. At the time this study was undertaken (summer of 2015), there seemed to be only two cases available to look at the development of IMP in Europe: one in Lyon and one in Vienna. However, after undertaking some preliminary search and encountering some difficulties in gathering data for the Lyon case (Optymod), I thought I would have less trouble exploring the Vienna case, and thus decided to definitively select Vienna as my IMP case. In particular, the availability of data about the SMILE project, which is considered as the major IMP developed in Vienna, motivated me to choose the Austrian capital city. A similar situation occurred for the selection of the MaaS case. When I started this study, there seemed to be only two cases available to look at the development of MaaS in European cities: Helsinki and Gothenburg. However, after making a preliminary check on the amount of data available to explore both cases, I decided to focus on the Helsinki case. This choice was also made after I realized that a lot of research was being conducted on the UBIGO project that happened in Gothenburg (by a research group at Chalmers University), which meant that I would potentially have more difficulty accessing the data than I would with a "virgin" (that is, un-researched) case. My decision to opt for Helsinki and Vienna was also motivated by the fact that already knew that public authorities had adopted different approaches in both projects. From preliminary searches, it appeared that the SMILE project was indeed initiated by the public sector while the development of MaaS in Helsinki was (apparently) being pushed by non-state actors. Being concerned with finding cases where public authorities would have different behavior – that is, heterogeneous cases (Patton, 2002) – this comforted me in my choice. Thus, I had my three case of studies: London for the smart card case, with a focus on the development of the Oyster and CPC; Vienna for the IMP case, with a focus on the development of the SMILE project and IMP projects having followed it; and Helsinki for the development of the MaaS case. A graphical representation of my case selection process is available in Figure 3.3.4.

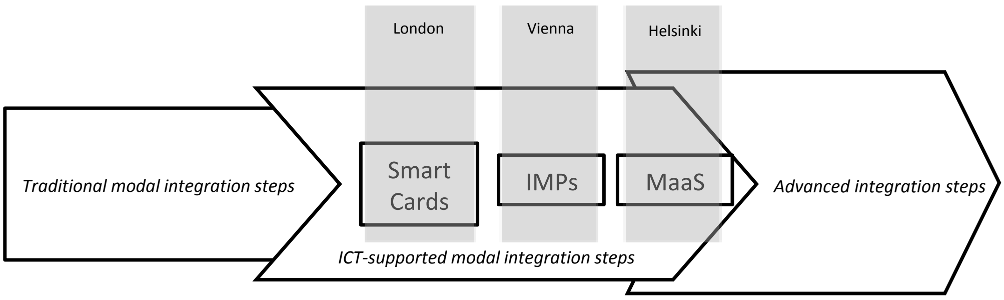

Figure 3.3-3: Case selection (author's elaboration)

Having now explained how we selected our case studies[13], we will now detail our data gathering process, as well as emphasize the way we constructed our case studies.

3.3.4 Data gathering process

The choice of the case study research strategy allows the researcher to use a wide combination of data sources, such as documentation, archival records, interviews, physical artifacts, direct observations, and participant-observation (Baxter and Jack, 2008). To build the case studies I have mainly used qualitative data, from two main sources being documentation and interviews. More precisely, I have first gathered documentation data to constitute a data basis for my cases, which I then complemented, when necessary, with interview data, depending on the information that was missing. Along the document analysis process, I prepared an interview questionnaire, the final version of which is available as Appendix 2. The definition of the interview grid followed the case protocol and original research question.[14] Squires (2009) argued that qualitative researchers might employ interpreters or translators in cases where the interviewees' first language is not English or where their level of English is so low that it might negatively impact data retrieval. However, given that all interviewees spoke good English (which I was able to assess when conversing with them in English via email to set the interview date), and due to logistical issues (insufficient time and funding to hire a Finnish and German interpreters and translators), I chose to conduct all of my interviews in English, which is believed to allow information retrieval in a more effective way than translation (Grabe, 1988).

The interview grid, which was the same for all interviewees, was divided into two main parts. The first part focused on the role of the interviewee's organization in the development of the ICT-supported integrated mobility scheme studied. Interviewees were invited to talk about how their organization was involved in the early days of development of the solution and on their perceptions of how the studied innovation had developed over time. The second part of the interview was reflective and aimed to discuss with interviewees how the studied innovation could have developed differently. I first used the interview grid for the Helsinki case, which proved successful, and then decided to re-use it by slightly improving it for the Vienna case. In particular, the interview grid for the Vienna case interviewees had fewer contextual questions and was more "straight to the point" with interviewees. Despite allowing me to gather data that I could not find online, I

13 Another approach could have been to only treat one case and do it much more in depth, by analysing it from various perspectives. In other words I could also have gone for a single embedded case, where I would certainly have explored the case of Helsinki, as it was this case that motivated this whole research project. However I decided not to engage down this path as it was my opinion too much risky from a research point of view. When I started this research project, the Helsinki case was not doing so well, and could have « collapsed » before the end of my PhD thesis. I therefore took the decision to look for other cases to derive insights from different contexts and avoid relying on a single case for which the outcome was very uncertain. This is why i developped the « new transport integration ladder » as case selection framework. Still, the Helsinki case was explored in more details in Audouin and Finger (2018a).

14 I could improve the interview grid thanks to the feedback received along my participation to the methodological seminar "The Research Interviews in Political Science" offered by the Doctoral Program in Political Science at UNIL (December 2016).

found that conducting interviews was also a way for me to validate some data I could find online (triangulation). Below, I explain the data collection and case construction process for the three case studies in more details.

- Helsinki case study

For the Helsinki case, I started by gathering documentation data from the summer of 2016 to December 2016, mainly through the use of online search engines. Multiple kinds of documentation data were used to constitute the basis of the Helsinki case study: written reports, newspaper articles, scientific publications, and press releases. I should also mention that the use of social media was very helpful in gathering documentation data. From the beginning of the PhD journey, I had subscribed to several involved stakeholders' webpages on LinkedIn and Facebook in order to monitor their activities regarding the development of MaaS in Helsinki. This was for me a way to get the latest published reports on the subject and gather thoughts from involved stakeholders and potentially learn about decisions made by important actors. I then decided to put all the historical events (extracted from documentation thanks to document analysis) that I believed were important on a time scale. Given that I was interested in understanding the role of public authorities in the development of ICT-supported integrated mobility schemes, I decided to classify the different actions of public authorities based on their level of decision-making (supra-national, national, regional/local). When this time scale of events was ready, I was then able to assess what information I was missing, and the list of organizations involved in the development of the ICT-supported integrated mobility scheme, from whom I could potentially get additional information. Based on the preliminary case report, I thus established a list of organizations to get in touch with, in order to set a date for an interview, and potentially gather the information I was missing.

The contacts for the interviews were initiated through two distinct channels. In August 2016, I had the chance to participate to a Summer School organized by Aalto University (in Espoo, in the Helsinki Metropolitan Area) about the management of complexity in transportation systems. During the summer school, I had the opportunity to discuss with the different participants about my research. Luckily, one of the participants, who was a PhD student at Aalto University, was also a full-time employee of the Helsinki Metropolitan Transport Authority (HSL), who later introduced me to a relevant contact to conduct an interview with. People at HSL also kindly introduced me to another company involved in the development of MaaS in the Helsinki Metropolitan Area called SITO (consulting company). During my first stay in Finland I also met a representative of a leading transport consultancy companies (Ramboll) who was delivering a lecture in the summer school. I was able to briefly present my research topic and have the representative agree to an interview by the end of the year. I also took advantage of my participation in the Aalto Summer School to conduct my first interview with a member of Maas Global, a leading company developing a MaaS service in Helsinki, thanks to a formal introduction to its CEO by my supervisor, Prof. Matthias Finger.

In October 2016, I reached out to the chairman of the board of MaaS Global via LinkedIn, requesting an interview, to which he kindly agreed. I conducted a Skype interview in October 2016 and I submitted to him a list of actors I was planning to get in touch with, which I thought would cover the stakeholders involved in the development of MaaS in Helsinki. The list included public authorities, transport authorities, transport operators, technology companies, consulting companies, and taxi dispatch centers, lying at different spatial governance scales. Once he agreed to my list, I reached out to all these people through email. When I did not have the appropriate email addresses I reached out to people on LinkedIn, sending them a short message (200 words) regarding my intentions to get in touch with them regarding my research. I was pleased to receive a high percentage of positive answers to my LinkedIn requests, allowing me to get in touch with the interviewees via email, sending them a one-page summary of my research and asking if they would be willing to be interviewed by December 2016. Out of the 12 organizations I had reached out to in October, I received nine positive answers for an interview and two negative answers. Only one of the organizations did not answer my request. Apart from one interview carried out during the Aalto Summer school, as mentioned above, and one Skype interview carried out in October, nine interviews were conducted in person between December 12th and December 15th 2016 in Helsinki. One interviewee also decided to answer the questions by email, and one additional interview was carried out on via Skype in January 2017, accounting for a total of 13 interviews. Interviews lasted from 45 to 90 minutes and were all audio-recorded. Given the highly dynamic nature of MaaS in Helsinki, I continued following its development closely, mainly using social media and newsletters to which I had subscribed. As the project took a new turn in the beginning of 2018, I decided to conduct three additional interviews, which took place via Skype in March and April 2018. Those interviews lasted from 35 to 60 minutes and were also all audio-recorded and transcribed. In total, 16 interviews were carried out for data gathering for the Helsinki case from August 2016 to April 2018, which lasted from 35 to 90 minutes. The list of interviewed organizations, and their related codes used in this thesis, is available in Appendix 1.

- Vienna case study

From September to December 2016, we (with Prof. Finger) hosted a master's student from the Management of Energy and Sustainability Master program at EPFL (MES) who completed a semester project within our lab. As part of his coursework, the student had to validate a 10 ECTS research project for which I was assigned as supervisor Thanks to the flexibility of Prof. Finger, I was able to choose the topic of this master student semester project and proposed him to work on the case of an integrated mobility platform development and implementation. Soon after the beginning of the semester, the student and I agreed to realize a study of the development and implementation of the SMILE project in Vienna. The student was expected to answer the following research question: *What are the main challenges related to the development of an integrated mobility platform?* I had deliberately given him a rather "broad" research question, as my main interest in his work was to have an overview of the case study and stakeholders in order to already gather as much data as possible about the Vienna case study. The master's student used data from multiple sources, such as written reports, policy documents, newspaper articles, and press releases gathered from the Internet. He finally received the grade of 5 out of 6 for his report. However, given that I could not use the report as it was for the present thesis, I started myself to gather reports, newspaper articles, scientific publications, and press releases from online sources in January 2017, in order to triangulate and to obtain new data. I also used social media to monitor the activities of particular stakeholders in the development of integrated mobility platforms in Vienna Metropolitan Area. Similarly to the Helsinki case, I established a timescale to look at the development of IMPs in Vienna in order to establish which organizations were involved in the development of the ICT-supported integrated mobility scheme, so that I could establish a contact list and contact them to conduct interviews.

The contacts for the interviews were initiated in late March 2017, based on the result from the documentation data collection and analysis, and the master's student's report. Furthermore, as I had conducted the Helsinki interviews beforehand, I was aware of the kind of interviewees I wanted to have for the Vienna case. Thus I started to look for relevant contacts in each of the organization I had selected. One difficulty I confronted was that some of the people involved at the time of development of the SMILE project had changed positions since then (the project stopped in 2014). I reached out to all these actors through email or LinkedIn (as for the Helsinki case) about my intention to get in touch with them regarding my research. Again, I was quite happy to receive a high percentage of positive answers to my LinkedIn requests, allowing me to get in touch with everybody via email, sending them a one-page summary of my research project (the same sent to Helsinki interviewees) and asking if they would be willing to be interviewed in May 2017. Of the 19 organizations I reached out to in March 2017, I received 12 positive responses for an interview, one negative answer, and did not hear from the remaining six organizations, although I did send a follow-up email. Twelve in-person interviews were conducted in Vienna from May 15–20, 2017. Two interviews were then carried out by Skype and telephone in late May 2017. Interviews lasted from 45 to 75 minutes and were all audio-recorded. In total, 14 interviews were carried out for the Vienna case. The list of interviewed organizations and the related codes used in this thesis is available in Appendix 1.

- London case study

For the London case study, the data gathering process was slightly different from the two other case studies as I did not conduct interviews and used only documentation data. In Fall 2015, I had the opportunity to supervise four master's students from the Management of Energy and Sustainability Master program at EPFL (MES) for a semester project with us, within the IGLUS (Innovative Governance for Large Urban Systems) initiative. Similarly to the Vienna case, I was able to choose the topic of their semester project and proposed them to work on a case of integrated transport system development and implementation. Soon after the beginning of their semester, we agreed to realize an in-depth study of the unfolding of contactless payment cards in London. The research question the students had to answer for their project was the following: *How did London integrate EMV contactless payment cards into the transportation network and what were the results?* As with the Vienna project, I had deliberately given them a rather "broad" research question, as my main interest in their work was to have an initial overview of this case study and to gather as much data as possible about the development of the solution studied. The four master's students used data from multiple sources, such as written reports, policy documents, newspaper articles and press releases gathered from the internet and from contacts they initiated with involved stakeholders. They received the grade of 5.5 out of 6 for their report.

After building the Helsinki and Vienna case studies, I came back to the London case study in Spring 2017 and, using the report of the four master's students, continued to "nurture" the London case study. I first had to double-check and triangulate all the information displayed in the students' report before starting to gather complementary information by myself, from reports, newspaper articles, and press releases as well as social media. As most of the data was available through the public authorities' websites and a lot of research had been conducted on the London Transportation System, the raw data we (with the students) could gather for the London case appeared to be particularly rich compared to the cases of Helsinki and Vienna, which relied on a combination of documentation and interview data. Consequently, given the richness of the London case, which relied only on documentation data, I decided not to conduct any in-person interviews as I felt I already had enough information to answer the thesis' research question at a future stage.

3.3.5 Data analysis, case construction and case structure

For all three case studies I applied document analysis (Bowen, 2009) to documentation data to retrieve the main key events having impacted the development of the three ICT-supported integrated mobility schemes. This allowed me to build a comprehensive basis that I later complemented with data extracted from the conducted semi-structured interviews for the Vienna and Helsinki cases. As mentioned, all interviews were audio-recorded and transcribed and analyzed using a qualitative data analysis software (MaxQDA). Here, codes related to particular events were developed on the interviewee's answers. Using open and then axial coding (Saldaña, 2009), I initially retrieved 152 quotes that I coded and then cross-checked, to finally come up with a reduced list of event-related codes for each case study. These were then placed on a timeline, which helped us complement the comprehensive case basis that I had established earlier with grey literature. Having created those timelines, I directly started to develop the case study narrative. I did not go through the intermediary case record stage, as it is often presented as an optional step in case study research. Overall, I followed the case construction process proposed by Patton (2002: 450), who stated that, in "*many studies, the analyst will work directly and selectively from raw data to write the final case study*".

I must now justify my decision to adopt a historical structure in the narrative of the cases and explain how I then constructed the three case studies. According to Baxter and Jack (2008), the presentation of the case study – that is, the case study report – is of high importance and it should enable the reader to have a full understanding of the phenomenon presented. Although the literature has suggested various methods for reporting a case study, scholars usually refer to the six categories proposed by Yin (1994). Case study reports can first adopt a linear structure that actually follows the traditional structure of scientific writing (introduction, methods, results, discussion). Researchers can decide to structure their case study reports following a comparative design, where the same issue is looked at from different points of view. Case study reports can also present the evidence in chronological order. One might decide to follow a theory building structure for its case report, where each new section of the report corresponds to a new part of the theory being developed. Case study reports might also follow a "suspense" structure, where the conclusion is presented at the start and the explanation is then developed during the rest of the case. Last but not least, researchers might decide to adopt an unsequenced structure for their case reports, where the order in which the evidence is presented does not really matter.

However, not all structures work with all kind of cases. According to Yin (2003), the type of case chosen (explanatory, exploratory, descriptive) might determine the case report structure. For example, explanatory cases are associated with linear-analytic, comparative, chronological, theory building, and suspense case structures. Exploratory cases are associated with linear-analytic, comparative, chronological, and theory building case study structures. Descriptive cases are associated with linear-analytic, comparative, chronological, and unsequenced structures. Given that a descriptive approach was selected, I could narrow down my choice to four case structures. As I was interested in understanding the role of the public authorities in the overall process of ICT-supported integrated mobility schemes development, I thought that the chronological approach was the best fit. The chronological case structure is acknowledged for not only being descriptive but also implicitly providing readers with insights into linkages and causes (Gray, 2009), which was quite a good match, as the purpose of the project was to understand how exactly public authorities behaved in the development of ICT-supported integrated mobility schemes, and implicitly why they behaved as such. Below is presented the literature that was used for the case analysis.

3.3.6 Case analysis

As stated by Tellis (1997: 15), "*the analysis of case study is one of the least developed aspects"* of the case study approach. However, it is a crucial step into the research process, as it enables the researcher to ultimately provide answers to the original research question. Conducting an analysis on a case provides an opportunity for the researcher to make it richer. More especially, it gives the researcher the ability to make its case a "*thick description*" of the phenomenon studied (Geertz, 1973). According to Yin (2003), three strategies exist to analyze case studies. First researchers might decide to analyze their cases by "*relying on theoretical propositions"*, which is the most common case study analytical strategy. Under that strategy, researchers are known to analyze their case study along specific propositions (that together constitute a conceptual framework) having been withdrawn from the scientific literature. Secondly, researchers might decide to analyze their case studies by "*thinking about rival explanations*". Under that setting, researchers develop rival explanations from the propositions withdrawn from the literature or based on their observation conducted in the data collection process to analyze the case(s). Finally, researchers might decide to develop a case study description to analyze their cases. However, this last strategy is mainly used when the researcher has difficulty identifying the relevant literature, which did not apply to this research project. Similarly, analyzing by developing rival explanations is mainly used for case study evaluation, which was not the purpose of the present research endeavor. As I already had in mind the literatures to use for the analysis, it appeared normal to opt for a case analysis strategy framed by theoretical propositions. This decision is in synch with Tellis (1997), for whom the selection of the descriptive case study as a research strategy must go hand in hand with the selection of some theory to compare the case to in the analytical phase. Thus, the streams of literature used in the analysis are presented below.

From the literature review chapter, it appeared two streams of literature could be used to analyse the case studies. On one hand, one could use the socio-technical transitions literature to look at the role of public authorities in the development of ICT-supported integrated mobility schemes. On the other hand, one might view it through the lens of the (urban) governance literature. While both approaches seemed to be legitimate to answer this thesis' research question, I explain why I have decided to finally use both and not select one or the other.[15]

As mentioned in Chapter 2, transportation can be understood as a socio-technical system, grounded into the damaging automobility regime, in need of a transition towards a more sustainable state. With new vehicle technologies and travel demand management schemes, solutions enabling "*shift from products to services*" are presented as potentially contributing to this socio-technical transition (Nykvist and Whitmarsh, 2008). Falling directly under this category, ICT-supported integrated mobility schemes (such as smart cards, IMPs and MaaS) might therefore be well understood as potential system innovations that have the ability to enhance the mobility transition. In particular, looking at the development of such schemes through the multi-level perspective on sustainability transition approach (MLP) appeared to be one of the most systematic ways to do this. By structuring socio-technical transition as the result of interaction between three structural layers (niche, regime, landscape), by proposing success factors for the uptake of technological innovations, and by suggesting different transition pathways, the MLP does provide the researcher with a systematic way of looking at socio-technical transitions.

Similarly, one could argue that the best option would have been to use the governance literature to look at the development of ICT-supported integrated mobility schemes. By looking at "*the system through which a kind of order is achieved among several actors who are interacting with each other about a common issue*" (Razaghi and Finger, 2013: 7), the governance approach seemed to offer a valid approach to answer this thesis' research question. However, instead of choosing one or the other approach, I decided to use both. I argue that combining both literatures was also a way to tackle some of their shortcomings and answer the recent calls of academics to do this, especially to look at the on-going evolution of the transport sector (Berkeley et al., 2017; Hoffmann et al., 2017).

While transition studies (and the MLP) place a lot of importance on the interactions of the niche, regime, and landscape layer, they have been criticized for not sufficiently looking at the roles and strategies of the actors involved, the interactions between actors and institutions, and to power and politics (Geels, 2011; Farla et al., 2012). Although transition frameworks acknowledge that different actors are involved in socio-technical transitions, and that transitions actually happen through the interaction of social groups (Geels, 2011), they often fail to distinguish between the levels at which they are operating (Avelino and Wittmayer, 2016). Although there have been some attempts to remedy to this shortcoming, those have remained marginal and incomplete to specifically focus on the role of public authorities in a particular phase of the transition process. By specifically differentiating between different levels of decision-making (national, regional,

[15] The conceptual frameworks used to structure the analysis are presented at the beginning of the analytical chapter (Chapter 5)

local), and paying attention to actor's engagement and influence (Stephenson, 2013), the governance literature seemed to be able to tackle the above-mentioned shortcomings of the transition literature. Another point where the MLP has received criticism is for favoring bottom-up more than top-down changes (Temenos et al., 2017). According to Berkhout et al. (2004: 62), the MLP approach tends to "*emphasize processes of regime change which begin within niches and work up, at the expense of those which directly address the various dimensions of the sociotechnical regime or those which operate 'downwards' from general features of the sociotechnical landscape*". However, this "weakness" could also be tackled using the governance literature, as it has been acknowledged for favoring horizontal analysis of interactions between actors (Stephenson, 2013). Finally, transition frameworks have been criticized for lacking a geographical dimension (Hodson and Marvin, 2010; Coenen et al., 2012; Whitmarsh, 2012). On the contrary, the governance literature is clearly rooted in a geographical context, which is why combining it with the MLP could potentially make the best of both worlds.

In sum, it seems that one might withdraw some synergies from the combination of both approaches. On one hand, the governance literature might bring some insights to understand the role of public authorities (and actors' agency) into technological innovation developments and socio-technical transitions. On the other hand, the transition literature might provide the researcher with tools to look at technological innovation development and diffusion with its structuration into layers and its "bottom-up" system innovation journey. Finally, the governance literature might also provide a geographical dimension to the study of technological innovation development. This is why it was ultimately decided to use both perspectives, as they seemed to be complementary. Hence, a "governance analysis" and a "transition analysis" were conducted on the three case of studies in parallel, to have different insights withdrawn and ultimately combine both in some recommendations geared at policy makers.[16]

Having presented the case analysis strategy (relying on theoretical propositions from the governance and transition literatures), it seems worth presenting the analytical technique used to analyze the case studies. According to Yin (2003), five different analytical techniques exist to analyze case studies. First, cases can be analyzed through pattern matching. This approach basically consists of comparing the observed pattern (described in the case) with a predicted pattern, emerging from the theory, and consequently validating or refining the theory accordingly. Secondly, researchers might decide to analyze cases with an explanation building technique. In such cases, researchers analyze the case by building plausible explanations about the case. Third, a case might be analyzed through time series analysis. Under that approach, data are traced over time in order to ultimately compare predicted patterns with actual patterns. Fourth, one might decide to follow a logic model for the analysis, which actually combines the pattern matching and time series analytical techniques (Gray, 2009). Fifth, cases might be analyzed with a cross-case synthesis, which is particularly relevant for the analysis of multiple case studies as it makes it possible to "*draw cross-case conclusions about the objects of interests and their outcomes*" (Stjelja, 2013: 10). Given that I selected a multiple holistic case design, I naturally decided to select the cross-case synthesis to analyze the three different case studies.[17] For the case analysis, I went back to the interview data and retrieved, using selective coding (Saldaña, 2009) some 830 quotes (397 quotes for the governance analysis and 433 quotes for the transition analysis), from which I selected a few quotes to ultimately illustrate the findings in the analytical chapter (Chapter 5).

Below, I now explain my understanding of my role as researcher and the way I have handled ethical issues in this research project, as both are important elements to consider in a qualitative study.

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[16] The governance and the transition conceptual frameworks are presented in the analytical chapter of the thesis (Chapter 5)

[17] The case analysis process per se (and the supporting conceptual framework) is presented in great detail at the begining of the analytical chapter (Chapter 5).

3.4 Role of the researcher and ethical considerations

I now shed light on my understanding of my role as researcher in the current research endeavor. While the role of the researcher in quantitative studies is known to be quasi inexistent, things are acknowledged to be quite different in qualitative studies. Unlike quantitative research, where the researcher is described as being external to the data studied, and as having (theoretically) limited impact on them, data in qualitative research are known to be mediated through the human brain, and the result of a joint construction between the researcher and research participants (Guba and Lincoln, 1989). Given this fact, it appears important for researchers using qualitative approach to clarify their roles in order to make their research credible (Unluer, 2012). Researchers can usually categorize themselves as insider or outsider researchers (Bonner and Tolhurst, 2002). In the latter case, the researcher is known to belong to the group that is the focus of the study, whereas in the former case, the researcher is described as not belonging and being external to the group under study. While I agree that such extreme categorizations might prove useful in theory, I join Breen (2007) in not clearly categorizing myself under one or the other category. Although I might think of myself as outsider researcher since I was not working in any of the organizations interviewed in this thesis and did not have any activity that would concretely contribute to the development of ICT-supported integrated mobility schemes, it is hard to say that I did not have any insider role. I believe that by interviewing some of the actors I also somehow contributed to the development of the projects. As several interviewees acknowledged it, the very act of answering my questions was also a way for them to take a step back and perhaps see the "big picture", which might potentially have contributed to making things move forward. Therefore, although I did not have an active role in the development of ICT-supported integrated mobility schemes, I believe I still had a somehow passive role, which is why I might also potentially think of myself as insider researcher. According to Ellis and Bochner (2000: 743), as qualitative researchers "*we are inside what we are studying*". To conclude, I therefore agree with Breen (2007) that the role of the researcher should be conceptualized on a continuum where I would set myself closer to the outsider than the insider pole.

Having emphasized the understanding of my role as researcher, I turn to the ethical positions I adopted in this research project. According to Gray (2009), ethical principles are acknowledged to fall under four main categories: the need to avoid harm to participants, to ensure informed consent of participants, to respect the privacy of participants, and to avoid the use of deception. In this thesis I have tried as much as possible to address those four categories, all along the different phases of the research, as detailled below.

The word "harm" can be understood in various ways, but in research ethics it is generally linked to physical, mental or emotional harm (Gray, 2009). Given that I did not conduct any physical experiment, as it was not needed for the present research, I do not believe I have caused any physical or mental harm to participants (interviewees). As most of my questions focused on the organization level, rather than on their personal experience, I also believe to have avoided any emotional and mental harm. According to Sundman (1998), harm can also be caused when the participants are disturbed because of the research. This could be the case, for example, when interviews are rescheduled multiple times because of the lack of organization of the researcher, creating a disturbance in the interviewee calendar and personal life. However, I tried to remain as flexible as possible when scheduling interviews. During the data collection phase, I always tried to accommodate the interviewee's needs over my own. However, I must mention one case where I might have caused some disturbance to one of my interviewees in Vienna. In this case, I became confused between two different interviewee's addresses, leading to me going to one address when I was supposed to be at another. As I was leaving Vienna on the same day, I had to reschedule the interview, which fortunately was not a problem for the interviewee. In some cases, I also had to do numerous follow-ups, either by email or over the phone, to set an interview date. While my follow-ups may have caused minor stress for the interviewees, those should not be considered as having caused major harm.

Ensuring informed consent of research participants is often referred to as an important ethical aspect when conducting a research study and refers to the provision to research participants of all necessary information about the research project, so that they have all the information they require to decide whether they want to be part of the study (Gray, 2009) or potentially withdraw from it. Although there is a discussion about what should constitute informed consent, especially when research participants are from 'vulnerable' groups (e.g. Crow et al., 2006), ensuring informed consent in its traditional form is usually synonymous, for the researchers, with letting research participants know about the purpose of the research, about who will be conducting it and who else is participating in it, about the kind of information being sought, about the time required and the identity of the people who will have access to the data, and ultimately about the anonymity of participants (Gray, 2009). I believe I have addressed most of the above-mentioned requirements with my research participants. Before the interviews, all interviewees were emailed a one-page summary about the research project, which clearly stated its goals and my motivations. At the beginning of each interview, I again explained the purpose of my research and motivations in case people had not read the one-pager. Before starting the interview, I also explained the interview was entirely anonymous, and that I was the only one involved in the project – that is, that this project was my PhD dissertation and that I was working alone on it – and that it was not embedded in any bigger research project. By saying that I was the only one involved, I was also implicitly saying that I was the only person who had access to the data. Given that I was not asked about who else was going to have access to the data, I never thought usefull to specify to the research participants that no one else would have access to the data. Regarding the information about who were the other research participants, I informed the participants that other stakeholders of the transport sector of the city I was in were also going to be interviewed, but without giving the names of those people, as interviews were anonymous. If the research participants insisted on knowing the identity of other interviewees, I usually gave them the name of some interviewee's organizations, but never revealed the name of the other interviewees. Participants were also aware of the time required to conduct the interview, as I had informed them of this by email upfront.

By preserving the anonymity of the participants (for example, by using codes for quotes used in this thesis), I believe I have addressed the issues about the respect of privacy of my research participants. None of the questions I asked could be considered "personal". Indeed, I always sought to learn about the organization's role or actions, rather than the participants' experiences. However, as Gray stated (2009: 74), "*even though attempts might be made to preserve the anonymity of individuals, it is by no means always impossible for people to be identified*". For example, I have spoken to people from very small organizations, and given the number of employees in those organizations, expert readers might have guessed whom it was I talked to. For most of my interviews, I made research participants aware that they might be "discovered" by readers who looked closely at the quotes and were familiar with the context of the study (such as colleagues or collaborators); fortunately, this did not discourage them from answering my questions.

Finally, researchers must avoid the use of deception when conducting their study. Deception can be described as "*the transmission of information that implicitly encourages another party to make incorrect conclusions*" (Boles et al., 2000) and might include misrepresentation, lying, or bluffing. In my case, deception could include presenting a false statement from another interviewee in order to make the research participant react in a specific way, and then using his or her reaction as if it was something that naturally occurred. While I sometimes used quotes from other interviews to generate interview reactions, I never used false quotes or any unethical method that would generate a biased interviewee reaction.

3.5 Ensuring research quality

According to Morse et al. (2002), criteria used to ensure rigor depend on the different theoretical perspectives adopted by the researcher. While the notions of internal validity, external validity, reliability, and objectivity have usually been associated with the positivistic paradigm, Guba (1981) proposed four new criteria to ensure rigor of qualitative inquiries: credibility, transferability, dependability, and conformability. Having myself undertaken a qualitative inquiry, I follow Guba's categories to assess the rigor of the present work and ultimately the research quality of this thesis.

By assessing the *credibility* criteria (which corresponds to internal validity criterion for positivists), researchers seek to address the following question: "*How congruent are the findings with reality*?" (Merriam, 2009: 213). To address that question I have used several techniques that are acknowledged for contributing to the credibility of a research project. For a full referencing of those techniques, see Shenton (2004). For example, I have used triangulation, when possible, between multiple sources of information (documentation, interviews) to corroborate the veracity of some facts. The fact that the information was first found for the London and Vienna case by master's students and that I had to double-check the validity of that information by finding other sources can also be seen as having contributed to the validity of the study (involvement of several researchers). I also submitted the present research project to peer scrutiny, through presentations at brownbag seminars, conferences, practitioners' forums, or summer schools or journals. I also had multiple debriefing sessions with my research supervisor. Last but not least, I provided thick descriptions of the phenomenon of interest, with many details, which should also have helped improve the credibility of the present research endeavor. The credibility of a research project is also linked with the researchers' ability to reach data saturation, which is attained when it is no longer possible to obtain additional new information (Guest et al., 2006). It is acknowledged that researchers might face an issue in knowing if they have reached a saturation phase because no practical guidelines for data saturation exist, and data saturation basically differs from one research design to another (Guest et al., 2006). Having been able to interview the main stakeholders involved in the development of ICT-based integrated mobility schemes in Vienna and Helsinki, I believe I did everything I could to gather all possible information available. According to Bernard (2012), data saturation might be reached by interviewing additional people that would not be normally considered. Given that I conducted such interviews for the Vienna and Helsinki cases, I also believe I have taken the point of data saturation into consideration in this study.

The *transferability* (which corresponds to external validity/generalizability for positivists) of a research project is itself assessed on the ability that one might have to transfer the result of the study to other situations. However, it is acknowledged that the transferability of findings in qualitative study is often hard to obtain (Shenton, 2004). The present study is no exception to that statement and also has limited transferability[18]. It would be presumptuous to say that this thesis' findings would be accurate for all cities around the world. The lack of transferability of this thesis' findings is highly dependent on the importance that the context plays in each of the case studies. Consequently, I have made a lot of effort to depict with as many details as possible the context of each of the cases, as recommended by Guba (1981).

When similar results are obtained when running the project in the same conditions, with the same methods, and same participants, the research is acknowledged to have a high *dependability*. In order to ensure this, researchers are required to carefully describe their research design and implementation, the operational

[18] The transferability of the present research endeavour is further discussed in the Conclusion chapter (chapter 6).

details of data gathering, and assess the effectiveness of the methods used in their inquiry. Having done this in the present chapter, I believe I have done everything in my power to guarantee my project's dependability. The final criterion used to evaluate the trustworthiness of a research project is *confirmability*. A project has high confirmability when the work's findings are basically "*the result of the experiences and ideas of the informants, rather than the characteristics and preferences of the researcher*" (Shenton, 2004: 72). Again, confirmability can be ensured by using triangulation to reduce the investigator bias, which I have done, as previously explained. Shenton (2004) also preconized researchers to recognize the shortcomings of the research methods used in the inquiry to increase confirmability, which will be done with greater details in the conclusive chapter of this thesis (Chapter 6).

3.6 Overview of research design

Here I sum up the overall research design adopted in this thesis (see Figure 3.6.1). Before doing so, it might be tempting to apply another categorization to the present research. According to Saunders (2009), every research project can be located on a continuum ranging from basic to applied research. While basic research aims to develop universal principles and expand knowledge, applied research seems more concerned with proposing solutions to existing organizational problems and improving understanding of specific organizational issues. While I hope that this thesis' findings contribute to expanding knowledge, I believe that the key aim of the research undertaken in the present thesis is to get a better understanding of a specific organizational problem. As explained in the introduction, public authorities around the world nowadays are unsure about the role they should play in the development of ICT-supported integrated mobility schemes. Therefore, they need solutions to decide, which is what the present thesis aims to propose. Hence, I believe this research should be considered as being applied research more than basic research.

This research project started with a broad research question in mind (Chapter 1). From the very beginning, and perhaps also motivated by my experience as IGLUS project manager and my research interests in governance (also shared by my supervisor), I was interested in exploring the governance of ICT-supported integrated mobility schemes. Having looked at this potential subject from different angles, I finally decided to focus specifically on the role of public authorities in the development of ICT-supported integrated mobility schemes. This perspective was welcomed by experts of the transportation sector when discussing it at various events such as forums, brownbag seminars or conferences. Transport practitioners have often highlighted the need to have a study focusing on the role of public authorities in the development of MaaS schemes, which is probably why they were supportive of the idea. However, to convince myself that this subject was worth studying for my PhD, I needed to be sure that it would also contribute to the scientific literature. Consequently, I conducted a literature review of the literatures potentially associated with this thesis' research question (Chapter two). I then decided on the methodology and research strategy to be used to answer my research question (Chapter 3).

A deeper analysis of the (transport integration) literature allowed me to establish my case selection framework that I used to select the London, Vienna, and Helsinki case studies. I then ran the three cases in parallel (Chapter 4), which are structured as follows. As Baxter and Jack (2008: 555) stated: "*it is important that the researcher describes the context within which the phenomenon is occurring as well as the phenomenon itself*". Consequently, I have given particular importance to the context of the three different cases, which is visible in the way they are organized. I started by describing in as much detail as possible the political, economic, and transport context of the three cases, before presenting chronologically in detail the development of transport systems and of the ICT-supported integrated mobility schemes studied. I then conducted two parallel cross-case analyses (Chapter 5), through two theoretical frameworks (governance and transition) emerging from my review of the literature on transport governance and system innovations. By combining both analyses, I was then able to draw up a list of recommendations for public authorities interested to see ICT-supported integrated mobility schemes emerge, which are summed up in the conclusion (Chapter 6). In the conclusion I also shed light on the limitation of this thesis and propose new leads for research to be conducted on ICT-supported integrated mobility schemes.

In the next chapter (Chapter 4), the three cases of studies will be presented. The order in which they are presented – London, Vienna, and Helsinki – follows the case-selection framework[19].

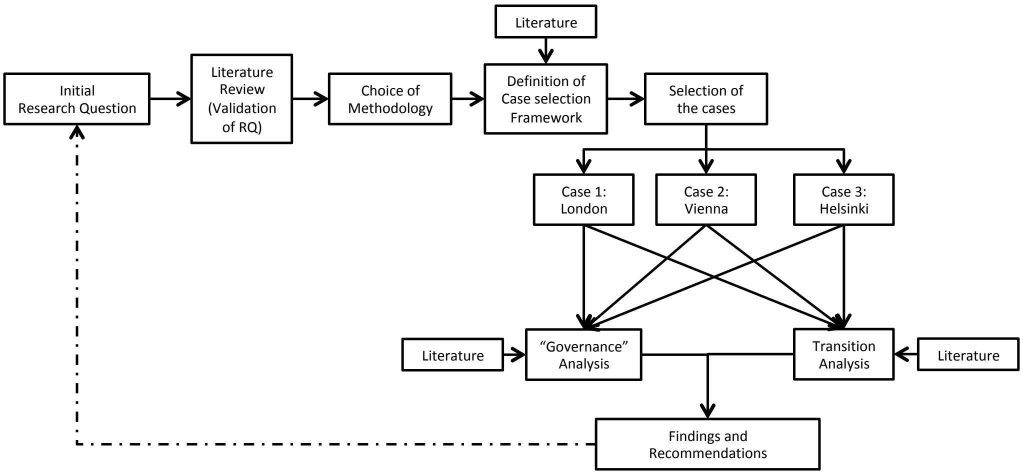


Figure 3.6-1: Overall research design (author's elaboration)

19 i.e. the "new transport integration ladder", presented in subchapter 3.3.3

Chapter 4 Case studies

In this chapter, the three case studies selected along the so-called “new” transport integration ladder, are presented. To begin, I describe the case of the Oyster and contactless payment card development in London from 2002 to 2018. In a second time, I present the development of integrated mobility platform in Vienna with through the SMILE and follow-up projects from 2007 to 2018. Finally, I conclude this chapter by depicting the unfolding of MaaS in Helsinki from 2009 to 2018, with a focus on MaaS Global’ solution, Whim. The three case studies follow the same structure. Firstly, a thorough description of the case context is given. Particular attention is given to the politico-economic context at the national and local level, the transport governance context, as well as about the technical and institutional developments of the urban transport system. Then a historical and chronological description of the development of the studied solution is provided. At the end of each case, a graphical representation of the main events that led to the development of the studied innovation is given in order to summarize the case studies. The supporting technology of the studied innovation is also described in dedicated text boxes at the end of each case.

4.1 London case study

In order to fully understand the context in which the development of Oyster and contactless payment cards has occurred in London, this subchapter starts by providing the reader with the political and administrative organization of the United Kingdom at the national level, before deep-diving into the local level. Then, the historical development of London’s transportation system from the beginning of the 20^{th} century to today is presented. In a last time, the reader is walked through the key events that led to the development of innovative ticketing systems in London, namely the Oyster cards and contactless payment cards.

4.1.1 Context

4.1.1.1 National level

- Current situation

In 2015 the United Kingdom had a population of 65.11 million people (ONS, 2016a). With 17.7 percent of the population being aged between 0 and 14, 64.6 percent between 15 and 64, and 17.7 percent being older than 65, ageing population is an actual phenomenon in the UK (Eurostat, 2015). It is estimated that the UK population will increase by 9.7 million inhabitants over the next 25 years, reaching 74.3 million in mid-2039, making it the fourth-fastest-growing population in Europe (ONS, 2015a), and the most populated European country by 2050 (Eurostat, 2017). It is also estimated that 41 percent of the projected increase over the next 25 years will come from net migration, while 49 percent will come from natural increase (ONS, 2015a). With 83 percent of its population living in urban areas, the UK is one of the most urbanized countries in Europe, and above the OECD average of 80 percent. The country has long been more urbanized than the European average, as can be seen in Figure 4.1.1.

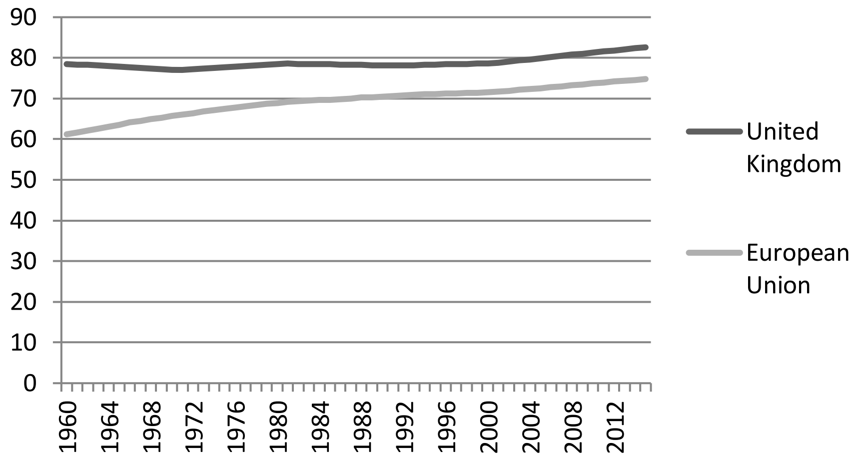


Figure 4.1-1: Urbanization evolution in UK compared to EU (author's elaboration based on WB data)

In 2015, the UK's GDP per capita was US$41,779, just over the OECD average of $40,791 and the EU average of $38,621 (OECD, 2016). Although the UK was hit hard by the 2008 financial crisis through a long recession, it has recovered well since 2013. According to the OECD, "*structural reforms have strengthened work incentives and supported a business-friendly environment, thus sustaining one of the most flexible economies in the OECD"* (OECD, 2015: 8). Regarding mobile penetration, it is estimated that there were some 91.7 mobile broadband subscriptions per 100 inhabitants in the UK, slightly lower than the OECD average of 95.1 (OECD, 2016c). The UK was ranked 19th in the 2016 Human Capital index ranking (WEF, 2016) and 20th in the 2016 Global Gender Gap index (WEF, 2016). In 2014, the UK was presented as having good social indicators overall. Indeed, the UK scored better than the G7 country average regarding subjective well-being, personal security, environmental quality, civic engagement and governance, social connections, health status, jobs, and earnings. However, the UK was ranked below the OECD average regarding relative poverty. It also performed worse than the G7 average regarding education and skills, work and life balance, housing and income, and wealth (OECD, 2015). Furthermore, the UK ranked second worst among OECD countries, just after the US, regarding income inequalities. It is also expected that the UK economy will most probably suffer from its withdrawal from the European Union (OECD, 2016a), directly following the referendum of June 2016 in which 52 percent of the British population voted in favor of the "Leave" solution, paving the way for the so-called "Brexit".

Below, the administrative structure of UK is presented, in order to better understand how public authorities are embedded into the local urban governance system.

- The English administrative system

The United Kingdom is a constitutional monarchy with a parliamentary system. It comprises four countries: Wales, Scotland, Northern Ireland, and England. The UK does not have a single document framing the structure of the state. In other words, it does not have a codified constitution, but rather various texts, judicial decisions, and practices that are understood as constitutional documents (Cabinet Office, 2011). The state is headed by a hereditary monarch, currently Queen Elizabeth II (since 1952), while the prime minister heads the UK government.

The Parliament is comprised of two entities: the House of Commons, with 650 democratically elected members of parliament, and the house of Lords, composed of 629 life peers, 91 hereditary peers and 24 clergy (Boyle, 2011). Since 2011, House of Commons members have been elected for a maximum period of five years, which can be shortened if a motion for general election is decided by two-thirds of the seats of the Commons or if a motion of no confidence passed by the government goes through. The monarch usually appoints the leader of the winning political party as prime minister. Ministers are then appointed by the monarch, upon the recommendations of the prime minister, given that they are members of either house of Parliament (House of Commons, 2015). The government is accountable to the monarch as well as the Parliament.

The main functions of the UK parliament are to carefully check and challenge the work of the government, to make laws, to control national expenditures, as well as to debate the important issues of the day (Cabinet Office, 2011). All parliamentary acts go through parliamentary procedure often referred to as "ping-pong". Both chambers must agree on a bill in order for it to succeed and changes proposed in any of the chamber must be accepted by the other chamber in order for the bill to pass. When agreement cannot be found, the House of Commons may be able to have the "last word" and pass the bill. All the bills that are passed must then receive royal assent to become law.

The local government structure in England is quite complex. England is divided between 228 two-tier local authorities and 125 single-tier authorities. The 228 two-tier local authorities are made of 27 county councils, encompassing 201 district councils that have distinct functions. The 125 single-tier authorities are made up of unitary authorities, 32 London boroughs and 36 metropolitan boroughs, which handle all local government functions (Sandford, 2017). All these entities are divided into wards from which councilors are elected. London has a status that does not fit the traditional English administrative decoupage. The British capital city, usually referred to as Greater London, is made up of 32 London boroughs as well as the county of the City of London. The Greater London Authority (GLA), constituted of the democratically elected Mayor of London and 25 members of the London Assembly, governs Greater London. As the metropolitan level is quite important for the organization of transport in London, particular attention will be given later, regarding how metropolitan governance has evolved in London over the last decades.

- British politics at the national level

Here is described how political life is organized in the UK. The first two presented political parties have historically dominated the British political landscape, but smaller and more "local" political parties have been gaining momentum on the political chessboard.

- The Conservative Party (also referred to as the Tories) sits at the center-right of the political spectrum. It defines itself as supporting "*policies that grow the economy as a whole, generating new jobs and higher wages for everybody*" (Conservatives, 2015: 13).
- The Labour Party sits at the center-left of the political ladder and aims to create a country that "*works again for working people*" (Labour Party, 2015: 6).
- The Liberal Democrat Party lays at the center of the political spectrum and aims to build a fair, free, and open society for the UK.
- The Scottish National Party is perhaps one of the strongest of the local political parties. Sitting at the left of the spectrum, the SNP aims to secure Scotland's interests in Parliament.
- The Democrat Unionist Party represents Northern Ireland's interests in Parliament. It lays on the right of the political ladder
- The Green Party of England and Wales sits at the left of the political spectrum and puts environmental protection as one of its core values.

- The United Kingdom Independent Party (UKIP) sits on the far right of the political spectrum and is known for defending values such as border control, self-governance, and patriotism. It is perhaps the most euro-skeptical of the UK political parties.

Many other smaller local political parties are trying to be represented at the national level. These include Plaid Cymru (Wales), the Ulster Unionist Party, the Alliance Party of Northern Ireland, the Scottish Green Party, and the Green Party in Northern Ireland. Although British politics have been considered as polarized between the Tories and the Labour Party for a long time, scholars have observed a depolarization in the last 20 years and a convergence between the elites of the two dominant political parties (Adams et al., 2012). Still, it seened important to briefly summarize the results of the general elections and successive national governments from the beginning of the 21st century.

Following 18 years of domination of the Conservative party, under Prime Minister Margaret Thatcher from 1979 to 1990 and then John Major from 1990 to 1997, the general election of 1997 marked the return of the Labour Party in the British government. Indeed, the progressive evolution of the Labour into "New Labour" after the accession of Tony Blair as party leader in 1994 helped the Labour Party increase its popularity. The Labour party defeated the Tories in the 1997 General Election, with an outstanding 165 seats majority in the House of Commons (Margetts, 1997). The Labour Party won 419 of the 659 available seats, compared to 165 for the Conservatives and 46 for the Liberal Democrats. Following that election, the Queen appointed Tony Blair as chief of the government and he formed his Labour government. During Blair's first term as Prime Minister (1997–2001), John Prescott, the deputy prime minister, occupied the position of secretary of state for transport in the newly created Department of the Environment, Transport and the Regions (DETR). Under Prescott's secretariat, four different politicians occupied the position of minister of state for transport. They were: Gavin Strang from May 1997 to June 1998, John Reid from July 1998 to May 1999, Helen Liddell from May 1999 to July 1999, and Gus Macdonald from July 1999 to June 2001.

In 2001, the UK General Election saw Labour keep its net majority in the House of Commons with 414 seats, despite losing five seats to the Liberal Democrats (52 seats), while the Conservatives won the remaining 166 seats. Norris (2001) described this victory as an apathetic political landslide and the second historic victory of the Labour Party in general elections. Blair remained prime minister and formed a new government, appointing Stephen Byers as the secretary for the newly created Department of the Environment, Local Government and the Regions (DLTR). During that time, John Spellar served as minister of state for transport. In 2002 the Department for Transport (DfT) was created, for which Alistair Darling took the lead until 2006. Under Darling's secretary, Stephen Ladyman, Tony McNulty, and Kim Howells successfully served as ministers of state for transport.

The 2005 General Election was won for a third time by the Labour Party, but this time by a slight majority. The Labour majority that had stood at 160 seats from 2001 to 2005 fell to 66 seats in this election (Labour held 355 seats, the Tories 198, and the Liberal Democrats 62). Darling continued to head the DfT until May 2006, when he was replaced by Douglas Alexander. In June 2007, Prime Minister Tony Blair resigned and Labour Party elections were organized, finally won by Mr. Gordon Brown, who became prime minister. Under Brown's leadership, Ruth Kelly held the position of secretary of state for transport from July 2007 to October 2008, with Rosie Winterton as minister of state for transport. Geoff Hoon held the position of secretary of state for transport from October 2008 to June 2009, with Lord Adonis as minister of state for transport, and later becoming secretary of state for transport from June 2009 to May 2010. Under Lord Adonis' tenure, Sadiq Khan served as the minister of state for transport.

The 2010 General Election witnessed the defeat of Labour by the Tories after 12 years in government. Compared with the 2005 elections, the Conservatives realized a net gain of 96 seats, while Labour lost 90 seats and the Liberal Democrats lost five seats (Cracknell et al., 2011). The new House of Commons was constituted of 306 Conservative seats, 258 Labour seats, and 57 Liberal Democrat seats. Conservative Party Leader David Cameron became prime minister and then formed a coalition government with the Liberal Democrats. The secretary for transport position was held by Conservatives Philipp Hammond from May 2010 to October 2011, Justine Greening from October 2011 to September 2012, and then Patrick McLoughlin.

In 2015 the UK General Election confirmed the domination of the Tories over the other political parties. The new house was comprised of 330 Conservative seats, 232 Labour seats, 56 Scottish National Party seats, and eight Liberal Democrat party seats. For the first time in history, the Scottish National Party became the third most important political party in the House of Commons. Cameron remained as prime minister and formed a Conservative Government, ending the coalition with the Liberal Democrats. In 2013, in order to gain more votes from the Eurosceptics, Cameron had promised that if its party had a majority in the 2015 general elections, a referendum would be organized about the future of the UK in the European Union. Following the Conservative victory in 2015, David Cameron kept his promise, organizing a referendum, held in June 2016, on whether the UK would stay in the EU or leave. Contrary to most predictions, 52 percent of voters chose the "Leave" option. Consequently, Cameron, who was in favor of staying in the EU, resigned. Theresa May was appointed by the Queen as prime minister and formed a Conservative government, with the difficult task of organizing the post-Brexit vote era; that is, the progressive exit of the United Kingdom from the EU. Chris Grayling replaced McLoughlin as secretary of state for transport. Figure 4.1.2 summarizes the political turnover of UK over the last 15 years.

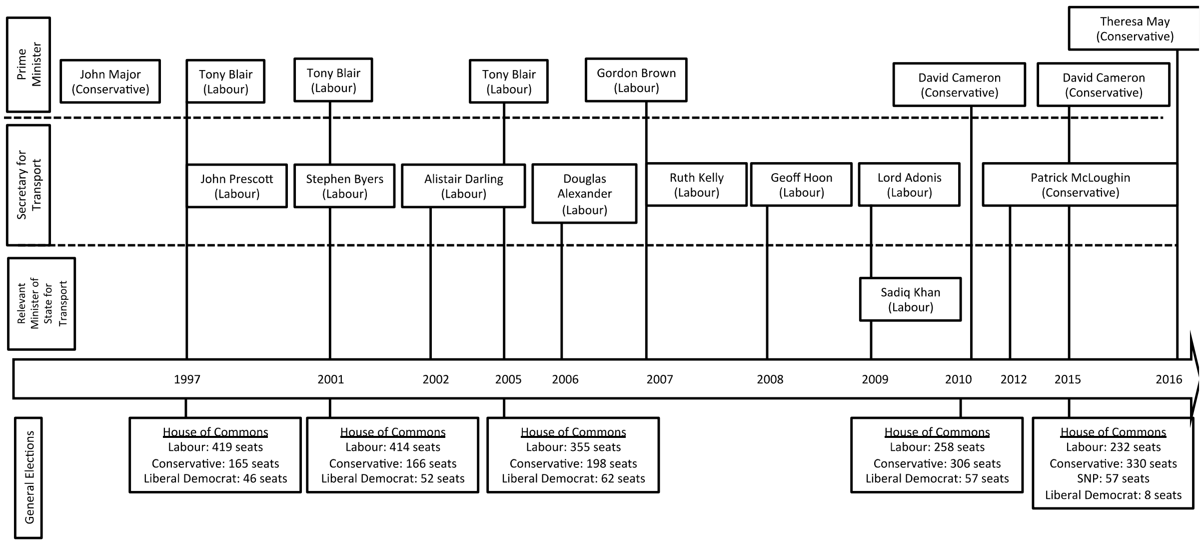


Figure 4.1-2: Political turnover in UK from 1997 to present (author's elaboration)

- NPM and decentralization

To Groot and Budding (2008), NPM came to life in the UK under Margaret Thatcher's leadership. From 1987 to 2004, it is estimated that about £40 billion of private capital was invested in 626 projects in 20 different public sectors departments across the UK. Roughly half of this expenditure is known to have actually happened in the UK transportation sector (Gannon, 2005). As it will be detailed later, the transportation sector in the UK, and particularly in London has been an ever-evolving playground for the collaboration – not always successful – of the private and public sectors, resulting in an extremely complex institutional setting.

Other UK public sectors have also been impacted by NPM. For example, the UK water and sewage industry was entirely privatized in 1999, which resulted in a 46 percent rise in water prices in the same year (Dore et al., 2004). The electricity supply industry was also privatized in England and Wales, which Green described as the "*most complex* [privatization operation] *that a government has undertaken*" (Green, 1991: 245).

The following subsection starts by presenting some context elements for London, before focusing on the historical development of London's transportation network, both from institutional and infrastructural points of view. All the relevant actors involved in the development of smart integrated ticketing solutions in London are then presented, before some words are said about the evolution of metropolitan governance in the English capital.

4.1.1.2 Local level: London

- Current situation

London is the capital city of the UK. In the 2016 Mercer Quality of Life Index, London was ranked 39th position, and 11th in the 2009 Green Cities Index by Siemens. London is composed of 32 boroughs plus the county of the City of London, which together form the Greater London Territory, as can be seen in Figure 4.1.3.

Figure 4.1-3: Boroughs of Greater London (author's elaboration based on ONS [2013])

Politically, London (or Greater London) is represented by the Greater London Authority (GLA), formed by the democratically elected London Assembly and the Mayor of London, whose mandates are detailed below. The current Mayor of London is Sadiq Khan (Labour), who was elected in May 2016. Prior to being elected mayor, Khan was an MP in the House of Commons from 2009, as well as minister of state for transport from 2009 to 2010 under Prime Minister Gordon Brown.

Economically, London is considered, along with Tokyo and New York, to be a so-called Global City (Sassen, 1991). In 2014, London's GDP per capita was €59,700, and had a Power Purchasing Standard of 186, while the EU28 average GDP per capita in PPS was 100. Greater London is the largest financial center in Europe. In December 2016, it had an unemployment rate of 5.5 percent, above the 4.8 percent UK average (ONS, 2017). It is relevant to assess the environmental footprint of the Greater London. In 2014, a total of 35,103 $mtCO_2eq$ (metric tons of CO2 equivalent) were emitted within Greater London, with 7304 $mtCO_2eq$ (20.8 percent) coming from transport (including private transportation), 12,556 $mtCO_2eq$ coming from domestic use, and 15241 $mtCO_2eq$ coming from industrial activities. In 2014, each Londoner emitted some 4.2t of tCO_2eq (ONS, 2016b).

The population of London has grown rapidly since the end of the 1980s. Following, a 22 percent decrease between 1939 and 1988, London population grew from 6.7 million inhabitants in 1988 to 8.4 million in 2011, reaching 8.63 million in 2015, its highest number ever. Since 1939, most of the growth has occurred in outer London. It is estimated that in 2039, London will have approximately 10.2 million people (GLA, 2015), which will account for about 13 percent of the total British population. Figure 4.1.4 shows the population evolution in London, Inner-London and Outer London from 1970 to 2015.

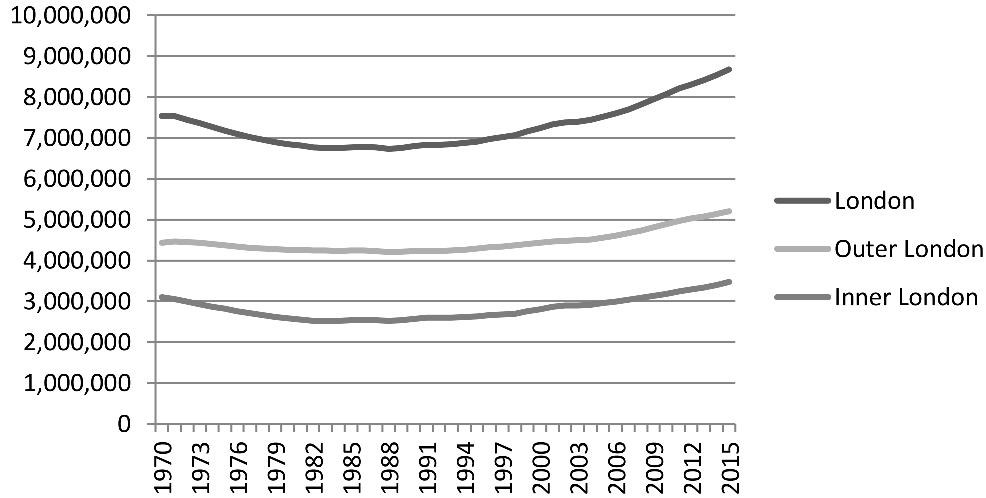


Figure 4.1-4: Population evoution for Greater London since 1970 to 2015 (adapted from ONS [2013])

In the following part, all the relevant actors linked with the development of intelligent integrated ticketing schemes in London are presented, to better understand how they are related to each other and who (when applicable) they are accountable to.

- Actors

    - The Greater London Authority (GLA) is composed of the Mayor of London and the London Assembly, both democratically elected for four years. While the GLA is often described as having important powers like other local parliaments (Scottish Parliament, National Assembly for Wales, and Northern Ireland Assembly), this is not the case in reality. The GLA is not defined as other county councils, which have service delivery responsibilities. Indeed, this applies to the 32 London boroughs, which are unitary local authorities that together form the GLA (Sandford, 2017). The GLA's budget is set by the Mayor of London and accepted by the London Assembly. It is funded by government grants, business rates, transportation fares, and council tax.

    - The London Assembly is constituted of 25 members and composed of several committees. Its role is to monitor the actions of the mayor and examine its different strategies in the field of transport, housing, energy and so on. The London Assembly may amend the mayor's annual budget or a specific mayoral decision, should it obtain a two-thirds majority among its 25 members.

- The Mayor of London holds the executive power of the Greater London Authority. In particular, the mayor is responsible for setting the strategy and vision for London in terms of arts and culture, business and economy, environment, fire, health, housing and land, planning, police and crime, regeneration, sport, transport, and higher education. He is also expected to attract foreign investment as well as international events and conferences to London. He is responsible for setting up the budget for the Greater London (including the Mayor of London, The London Assembly, the Mayor's Office for Policing and Crime, the London Fire and Emergency Planning Authority, TfL, the London Legacy Development Corporation and Old Oak and Part Royal Development Corporation), which for 2017–2018 was approximately £16 billion (Mayor of London, 2016b).

- The Department for Transport (DfT) is the UK government department (ministry) responsible for organizing transport in England and part of the transport network in Wales, Scotland, and Northern Island. It is responsible for policy, strategy, and guidance for roads, rail, buses, shipping, and aviation. The DfT also invests in roads and rail network expansion, manages rail franchises, and partly funds local public transport authorities (such as TfL). For example, in 2014–2015 the DfT spent some £20 billion: 52 percent for rail, 22 percent for local transport, 22 percent for motorways and trunk roads, and 3 percent for other projects (NAO, 2015).

- Transport for London (TfL) is a functional body of the Greater London Authority responsible for organizing most dimensions of London's Transport system and implementing the Mayor's Transport Strategy. TfL was created in 2000 following the creation of the Greater London Authority (GLA). TfL's 2016–2017 total budget was of £10.4 billion, 46 percent (£4.8 billion) of which came from fare revenue, 23 percent (£2.4 billion) from grants, 20 percent (£2.1 billion) from borrowing and cash reserves, 8 percent (£878 million) from other sources of cash, and 3 percent (£138 million) from Crossrail funding. The main grant (subsidy) contributors are the DfT and the Greater London Authority (TfL, 2016d). Two-thirds of the budget (£6.8 billion) is spent on running the network (that is, operational costs) and the remainder on investment (£3.5 billion) (TfL, 2016e). TfL's board is appointed by the Mayor of London. For most of the services proposed, TfL owns and manages the infrastructure, through various subsidiaries, while it outsources some of the service through competitive tendering processes (bus services in particular). TfL is divided into three units being Surface Transport, Underground and Crossrail. The Underground is operated and owned by London Underground Limited (LUL), while Crossrail is jointly owned between TfL and the DfT and will be operated by a private operator (MTR) when completed. Surface transport encompasses the following departments:
    - London Bus Services, which is TfL subsidiary managing bus services for Greater London. London Bus Services manages contracts awarded to private bus operators through a competitive tendering process. TfL owns the bus stops but the private contractors own the bus fleets. London's bus network is one of the largest in the world, comprising approximately 9300 vehicles operating 675 different routes. The largest bus operating companies are Go Ahead London, Arriva (Deutsch Bahn), Metroline, and London United Busways (RATP).
    - Overground is a suburban rail network managed and owned by TfL. It is operated by Arriva (DB).

- ❖ Dockland Light Railway is a light metro that is owned and managed by TfL and operated by Keolis.
- ❖ London River services are managed by TfL and operated by Thames River Services (TRS).
- ❖ TramLink is a tram network owned by TfL and operated by FirstGroup.
- ❖ TfL is also responsible for licensing taxicabs, private hire, and minicab services in Greater London through its Taxi & Private Hire department

Surface transport also encompasses the Emirates Air Line (Cable car), Dial-a-ride (transport for disabled people), Victoria Coach Station (medium- to long-distance coach terminal), and Walking departments. Finally, TfL owns the ticketing infrastructure across the entire transportation system (at metro stations, overground stations, buses, etc.).

- Cubic Transportation Systems is a subsidiary of Cubic corporation, which specializes in integrated payment systems for transport. Cubic Transportation Systems holds the TfL-awarded Electra contract, and thus handles fare collection operations for London Transportation system, through the Oyster and contactless payment cards. It has won several international awards for its development of contactless payment cards as a means of transportation payment. Cubic Transportation Systems operates fare collection systems in cities such as London, San Francisco, New York, Chicago, Brisbane, Sydney, and Vancouver.

To fully understand the relationship between public authorities in London, the evolution of metropolitan governance within the Greater London Area is given below.

- Metropolitan governance in London

As the largest and most prosperous city in the United Kingdom, relationships between the central government and London's government, as well as between territorial entities within the Greater London area, have not always been peaceful and steady. London is described as having suffered from confused (Travers, 2005) and instable government (Thornley, 2003) for the last decades.

The first institutional body set up for the Greater London was the London County Council (LCC) in 1888, which covered all built-up area at that time, except a famous and prosperous tiny territory, located in the heart of the urban area, which was already home to financial and international activities and is today known as the City of London, which was (and still is) managed by the City Corporation (Thornley, 2003). In 1963, under Prime Minister Harold Wilson's Labour administration, the *London Government Act 1963* established the Greater London Council (GLC) and redefined the structure of local governments in the capital city. The GLC's main duties were to manage traffic, waste, fire, and ambulance brigades and to maintain roads, within the 32 newly established London Boroughs and to coordinate actions with the City of London (Porter, 1998). After having been controlled by a succession of Labour and Conservative leaders, the GLC became Labour-controlled for one last time in 1981, led by Ken Livingstone, who quickly used the GLC as a stage for opposition and confrontation to UK's central government, led at that time by the Tory Prime Minister Thatcher (White, 2008). The Thatcher government proposed the *Local Government Act in 1985*, which ultimately abolished the Greater London Council and gave power back to the London Boroughs.

The victory of Tony Blair (Labour) in the 1997 UK general elections sealed the return of a metropolitan government for the Greater London. Following the publication of a green paper about the restoration of a potential metropolitan authority, Blair's government organized a referendum in 1998 on the proposal to create a "Greater London Authority" (GLA) for the capital (Travers, 2008), which was accepted by 72 percent of the voters. Hence, the GLA, along three statutory organizations (Transport for London, the London Fire and Emergency Planning Authority, and the London Development Agency), was created to establish policies that aimed to impact London as a whole. The first elected mayor of Greater London (referred to as the Mayor of London) was Ken Livingstone (Labour) in 2000, who was re-elected for a second term in 2004. Boris Johnson (Tories) was then elected for two consecutive terms, before seeing Sadiq Khan become the newly elected Mayor of London in June 2016.

In the following part the development of London's transportation system, from an institutional and infrastructural point of view, is provided. As it will be shown, many of the institutional changes regarding transportation were linked with institutional changes related to metropolitan governance. London's transportation system is one of the most complex and developed in the world, which is why its historical development has been divided into as many different time periods as possible. It seemed important to deep-dive into the evolution of London's transportation system in order to fully understand the evolution of the associated ticketing system, which ultimately evolved into the development of smart ticketing schemes.

4.1.2 Historical development of London transportation system

4.1.2.1 From the 1860s to 1933: From fragmentation to unification

In conjunction with the Industrial Revolution, many railways were built in the UK during the first half of the 19th century, a phenomenon sometimes referred to as "Railway Mania" (Glover, 2011). The first local railways established in London were the steam powered London & Greenwich railway in 1836 and the London & Blackwall railway in 1840 (Glover, 2011). As with many cities, transport in the first half of the 19th century mainly relied on horse-powered carriages, also referred to as omnibuses. From 1855, the London General Omnibus Company started buying omnibuses operating in London, and established agreements with the remaining ones (Costa and Fernandes, 2011), gradually establishing a monopoly on bus operations in London. At that time, bus carriage companies had to request a license from the Metropolitan Police under the *1869 Metropolitan Public Carriage Act*, after which they were free to operate (Hey, 2009).

To prevent the capital city being over-run with railways, a Royal Commission set up in 1846 recommended that the main railway lines would end up at the periphery of central London. With the exception of Charing Cross station, this recommendation was respected and enabled the subsequent development of the metro network (Glover, 2011). The first metro line construction began in 1860, commonly known as the Metropolitan Railway, which aimed to connect the different peripheral main-line train stations together to decrease congestion in Central London (Glover, 2011). The steam-powered Metropolitan Railway opened in 1863 between Paddington and Farringdon, connecting the surface rail stations of Euston, St. Pancras, and King's Cross (Levinson, 2007).

At the same time, the first horse-powered tramway lines were inaugurated. However, those did not last long as no regulations existed for them. Although the *1870 Tramway Act* was supposed to pave the way for the rolling out of tramways in London, it never gained attention as it was mainly considered as a solution that was more suited for the suburbs than for London's city center (Wilson, 2013). From the 1870s, several tramway lines were privately developed for London suburbs, which were progressively electrified from the late 1890s (Wilson, 2013). As of 1911, it is estimated that the London City Council was the owner of an electrified tram network of about 123 miles, bought from numerous commercial companies (Inwood, 2005).

However, due to the high cost of infrastructure maintenance and the affordable cost of bus carriage, most tram operators stopped operating.

The second section of the Metropolitan Railway was opened in 1868 from Paddington to South Kensington (Porter, 1998). It is estimated that between 1860 and 1869, 219 railway bills were submitted to the Parliament, only a few of which were approved (Simmons, 1978). The development of the Metropolitan Railway was accompanied by the development of the Hammersmith and City Railways. In 1884, by linking the Metropolitan and newly developed district railways, the (soon-to-be) Inner-Circle Line was created (Levinson, 2007).

However, because of the cut-and-cover method being used to build the different metro lines, the center of London quickly became impracticable, due to construction work. This motivated developers to go towards the deep-hole boring method, which had the advantage of carving out routes without disturbing the town landscape (Porter, 1998). Because steam engines were not going to be accepted in deep holes tunnels, electric traction was finally introduced and the "Tube" (as it is commonly referred to nowadays) was born. The first tube line to be built was the City and South London Railway, inaugurated in 1890 (Levinson, 2007). This was followed by the building of the Central London Railway, which was financially supported by international investments (Porter, 1998). The beginning of the 20th century was marked by the arrival in London of the American investor Charles Tyson Yerkes, who saw in London rapidly growing population and the need for mass transit a "*Gold mine*" (Franch, 2006: 285). Yerkes is known to be responsible for having built the Bakerloo, Piccadilly, and Hampstead tube lines, as well as participating in the electrification of London Underground (Franch, 2006).

Although 1902 marked the beginning of the first motorized buses operations in London by the LGOC (Inwood, 2005), it also represented an important institutional change. After acquiring London United Tramways (LUT), Yerkes created the Underground Electric Railway Company of London (UERL) in 1902, of which he became chairman. After some difficult years, the UERL acquired London's largest bus operators at that time, the London General Omnibus company (LGOC), as well as the Metropolitan Electric Tramways and the Central and the City & South London Lines (Daniel, 2004). In 1910, all lines owned and operated by the UERL were merged and almost all companies started a joint marketing policy under the name "Underground". In order to avoid ruinous competition, companies of the "Underground" also decided jointly on fare levels (Glover, 2011). In 1912, the "Underground" bundled all London metro lines together, except the Waterloo & City line and the Great Northern line, which were owned by the Metropolitan (Glover, 2011). It was only a matter of time before all London Metro lines were unified and integrated under a single brand.

In 1919, under Prime Minister Lloyd George, the Ministry of Transport was created, which oversaw transport as part of the First World War reconstruction efforts. The first minister in charge, Mr. Geddes, who was already aware of the high fragmentation state of transportation systems nationwide and in favor of nationalization, commissioned the creation of the Advisory Committee on London Traffic, which proposed the creation of the London Traffic Authority. Because of a lack of funding, the authority never eventuated, but did pave the way for the *1924 London Traffic Act*, which aimed to regulate bus traffic, as some unregulated operations were taking place (Hey, 2009).

Since 1863, the London Underground system had been developed exclusively by the private sector; this changed in 1933 with the creation of the London Passenger Transport Board, when the London Underground network came under public ownership. In 1933, the London metro system counted eight different lines: the District Railway, the Bakerloo Line, the Piccadilly Line, the Central London Railway, the Edgware Highgate and Morden Line, the Metropolitan Railway North and South, and the East London Railway.

4.1.2.2 From 1933 to 1948: Municipalization and London Passenger Transport Board (LPTB)

In April of 1933 the *1933 London Passenger Transport Act* was published, which aimed at the "*establishment of a Passenger Transport board for an area to be known as the London Passenger Transport Area, which shall comprise certain portions of the London Traffic Area and of the districts adjacent thereto, and for the transfer to that Board of various transport undertakings and interests; to make other provisions with respect to traffic in the said area; and for purposes connected with the maters aforesaid*" (1933: 1). Following this Act, the newly created LPTB absorbed the London Underground Group (UERL), the Metropolitan Railway (UERL's main competitor) and remaining tramway companies, including London United, which had started introducing trolleybuses to replace electric trams. All the undertakings were bought up with interest-bearing stock (Harris, 2011). For the first time, London's transportation system was unified under a single body and regulated under the *1924 London Traffic Act*.

In 1935, The LPTB announced the progressive replacement of the trams by trolley buses, mainly for economic reasons, which was completed in 1952. The same year the LPTB announced the planning of the Underground network extension (Harris, 2011). In 1939, the famous RT I double-decker buses, manufactured by the Associated Equipment Company (AEC), a subsidiary of LGOC, were introduced (Taylor and Green, 2011). However, the underground network extension was stopped because of the start of the Second World War in 1939. London's transportation system was not used much during the war as authorities were trying to save as much energy as possible. Due to air raids and the depth at which some of London's Tubes tunnels had been dug, some tube stations were used by civilians as shelters. For example, on September 27, 1940, 177,000 people spent the night in London Underground stations to be protected from the bombings (Glover, 2011).

Figure 4.1.5 summarizes the main institutional and infrastructural developments that occurred in London Transportation Systems from 1836 to 1940.

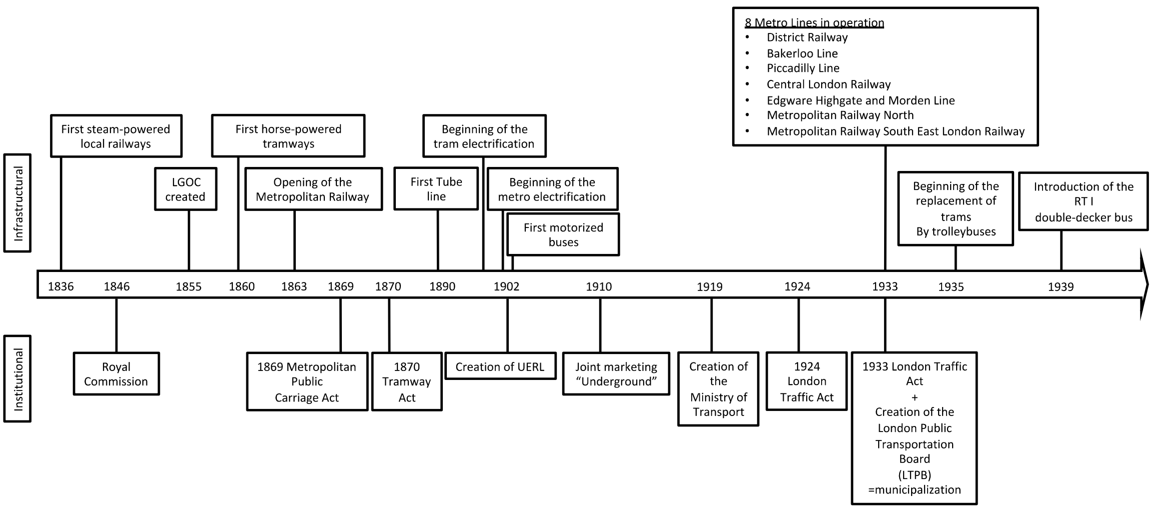


Figure 4.1-5: Institutional and infrastructural evolution of London's transportation system from 1836 to 1940 (author's elaboration)

4.1.2.3 From 1948 to 1962: Nationalization and London Transport Executive (LTE)

The war was followed by a period of nationalization. In November 1946, a transport Bill was published under Clement Attlee's Labour Government, which led to the creation of the British Transport Commission (BTC), taking over all the canal and railway undertakings, including the LPTB (Day, 1972). To assist the BTC, five executives were formed (Millward, 1997), including the London Transport Executive (LTE), whose aim was to provide, jointly with the Railway Executive, an "*efficient, adequate, economical and properly integrated system of passenger transport, by rail and by road, in the London Transport Area*" (Glover, 2011: 49). During these years, most efforts were put into fixing the damages caused by the war and electrifying the remaining steam-powered lines, the electrification of which had been postponed because of the war (Day, 1972). The central line was extended to the east and the west, and some of the pre-war projects were re-evaluated to be finally abandoned, due to the establishment at that time of the Green Belt surrounding London (Harris, 2011), based on the *1947 Town and Country Planning Act*. The year 1962 marked the end of operations for trolleybuses that had been replaced by diesel buses, as well as the end of the LTE (Harris, 2011).

4.1.2.4 From 1962 to 1969: London Transport Board

The *1962 Transport Act* resulted in the establishment of dedicated public authorities to replace the BTC. In particular, it enabled the creation of the London Transport Board (LTB), the British Transport Docks Board, the British Railways Board, and the British Waterways Board, all with directed chairmen appointed by the transport minister (Transport Act, 1962). The LTB's mission was to "*provide or secure the provision of an adequate and properly co-ordinated system of passenger transport for the London Passenger Transport Area and to have due regard to efficiency, economy and safety of operation as respects the services and facilities provided by them*" (Transport Act, 1962: 7). The Act also specified that the LTB would have to cooperate with the Railways Board to coordinate services. Not much happened during the LTB era apart from the construction of the Victoria Line, for which early planning started back in 1943 (Day, 1972). The government gave the green light to LTB to start the construction of the Victoria Line (also called Route C) because the tunneling would provide many jobs for Londoners (Harris, 2011). The first section of the Victoria Line opened in September 1968, the first new tube route to open since 1907.

4.1.2.5 From 1969 to 1984: London Transport Executive / LTE (re-municipalization)

Following the constitution of the Greater London Council (GLC) in 1963, and the LTB's increasing deficit and staff shortages, the central Labour government agreed to pass all transport undertakings to the GLC through the newly created London Transport Executive (Glover, 2011). According to the *1969 London Transport Act*, "*it shall be the general duty of the Greater London Council (…) to develop policies, and to encourage, organize and, where appropriate, carry out measures, which will promote the provision of integrated efficient and economic transport facilities and services for Greater London*" (London Transport Act, 1969: 1). In 1971, the green light was given to extend the Piccadilly line towards Heathrow Airport, which was hosting more and more passengers. The line extension was finally inaugurated in December 1977 (Glover, 2011).

The second major underground project that happened during the LTE era was the opening of the first part of the Jubilee line in 1979, planned to run from north to south east London, through its center (Taylor and Green, 2001). Instead of extending the Jubilee line to the east, a cheaper option was found with the development of the Docklands Light Railway (DLR).

The transportation system was not at its best at that time. Total bus ridership for Central Area routes decreased from 1.9 billion passengers in 1965 to 1.4 billion in 1972. In 1974, only two out of five buses were driver-only operated, although all were supposed to be (Harris, 2011). From 1963 to 1979, it is estimated that costs per bus mile in London rose by a factor of 2.3, while from 1970 to 1982 they rose by more than 68 percent. In the same period, from 1970 to 1982, it is estimated that the annual grant paid to LTE from central government increased from £6.5 million to nearly £85 million – a thirteen-fold increase (Kennedy, 1996b). At the beginning of the 1980s, friction started to appear between the Labour-led GLC (the LTE) and the Tory-led central government.

The *1980 Transport Act* introduced the possibility for county councils to set up trial areas to test bus deregulation. Although it was concluded at the end of the trials that deregulated bus services were not perfect, all the trials demonstrated lower fare, better levels of service, and reductions in revenue support (Poole, 1999). In 1983, as political fights were occurring between GLC and the government, and the performance of London public transportation system was still low, the central government suggested major changes for the organization of London's public transportation system (Hensher, 1991). Figure 4.1.6 shows the institutional and infrastructural evolution of London transportation system from 1946 to 1983.

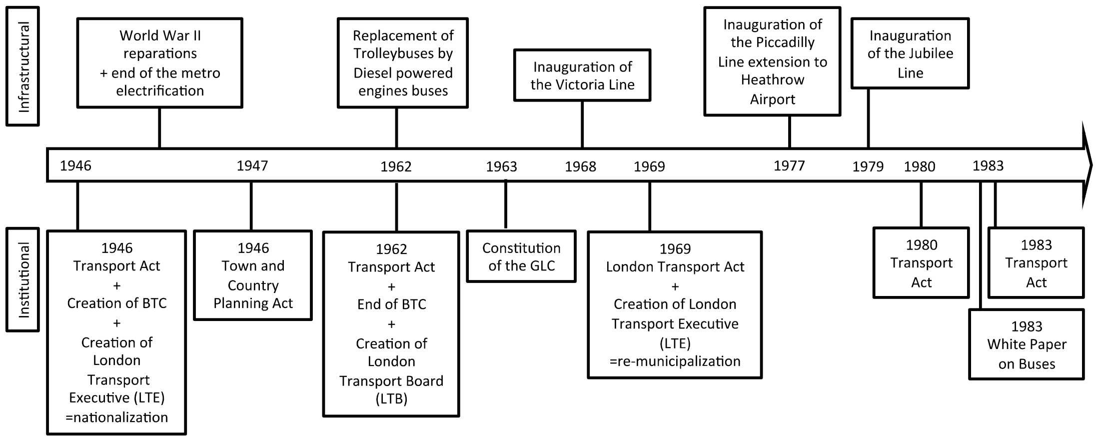


Figure 4.1-6: The institutional and infrastructural evolution of London Transportation system from 1946 to 1983 (author's elaboration)

The *1983 Transport Act* obliged Metropolitan Counties and their passenger transport executives to submit three-year Public Transport Plans in which they would estimate the costs of providing transport services and the anticipated levels of demand (Dodgson and Topham, 1986). Ultimately, the central government, still led by conservatives, proposed a *White Paper* in 1983 (Kennedy, 1996b), which paved the way for nation-wide bus deregulation.

4.1.2.6 From 1984 to 2000: London Regional Transport (LRT) and privatization

In 1984, the conservative government, led by Mrs. Thatcher at that time, decided to remove the transport competency from the GLC's authority, which eventually announced the abolishment of the GLC that happened in 1986 (Taylor and Green, 2001). The *1984 London Regional Transport Act* constituted London Regional Transport (LRT), whose duty was "*to provide or secure the provision of public passenger transport services for Greater London*" (London Regional Transport Act, 1984: 2) and was to report directly to the secretary of state for transport. The Act also forced the newly created LRT to establish companies to run London bus and underground services. Thus, London Buses Ltd. (LBL) and London Underground Ltd. (LUL) were created as fully-owned subsidiaries of LRT (Kennedy, 1996a). The 1984 London Regional Transport Act also introduced a system of tendering for bus operations in London. The first tenders, which concerned 13 self-contained routes in outer London, were set up in 1985, representing 1.2 percent of the LRT bus network (Kennedy, 1995).

This was followed by the *1985 Transport Act*, which aimed to amend "*the law relating to road passenger transport; to make provision or the transfer of the operations of the National Bus Company to the private sector; to provide for the reorganization of passenger transport in the public sector; to provide for local and central government financial support for certain passenger transport services and travel concessions; to make further provision with respect to the powers of London Regional Transport*" (Transport Act, 1985). This act is acknowledged to have enhanced the deregulation of bus services throughout the UK, but exempted London from doing so. However, still following the *1984 London Regional Transport Act* that stipulated moving towards competitive tendering when possible and relevant, more bus routes were put to tender and awarded to the bidding operator that was capable of providing the best service quality at the most cost-effective price (TfL, 2016c).

As mentioned earlier, the Docklands Light Railway (DLR) was proposed as an alternative to the completion of the eastward section of the Jubilee line, which opened in August 1987, but was insufficient to meet the increasing transport needs to and from the Docklands neighborhood. Thus, the Jubilee line was finally extended and opened in 1999 (Taylor and Green, 2001). The extension of the Jubilee line was made possible thanks to a PPP including central government, LRT, land developers Olympic and Warf, and British Gas (UCL, 2009)

It is estimated that by 1993, approximately half of London's bus miles had been awarded through gross cost contracts to private operators following competitive tendering process. The other half was operated as a monopoly by LBL (Kennedy, 1996). In 1992, LBL divided its operations within 13 subsidiary companies that started competing with one another. Fifty percent of LBL's bus routes were gradually put to tender (TfL, 2015). In 1994, following a decision from the central government, the 13 LBL subsidiaries were finally sold, either through management buyouts or sales to other bus operating companies from outside London or abroad (TfL, 2015). Three distinct types of contract have been tendered since 1985: gross cost contracts, net cost contracts, and, since 2000, quality incentive contracts (TfL, 2016i). According to White (1990), the London bus reform has led to a welfare gain of £42 million per year, and London has been doing especially well compared to the full deregulation that occurred in the other British provinces following the *1993 Transport Act*.

The rail sector was also significantly impacted during the Thatcher years. In 1992, the DfT released a white paper entitled "*New opportunities for railways*", which aimed to introduce competition and vertical separation, and involve the private sector. In the following year the *1993 Railway Act* was published, which led to privatization of British railways, owned and operated at that time by the public entity British Rail. The rail infrastructure was taken over by Railtrack, which was then sold to the private sector. In 1996, the first franchises of passenger train operation were sold to private train operating companies (Finger, 2014). The British Rail privatization case is known to be a unique and extreme case of privatization that has benefited patronage growth, but also suffered from increased costs and decreased levels of safety (Finger, 2014).

Considering London Underground Limited's significant assets and costs compared to its revenue, LUL underwent a wide array of funding initiatives, including private sector participation (Gannon, 2005). In March of 1998, following a decision from the UK prime minister, London Underground Limited was split into four parts: one operating company (Opsco) and three infrastructure companies – BCV Infraco (standing for the Bakerloo, Central and Victoria lines), JNP Infraco (standing for the Jubilee, Northern, and Piccadilly lines), and SSL Infraco (standing for the sub-surface lines; that is, the Circle, District, East London, Hammersmith and City, and Metropolitan Lines). While Opsco was responsible for operating the trains and running the stations and safety, the three Infracos were responsible for funding, renewing, and maintaining LUL's assets.

London's transportation system has gone through various forms of ownership and governance over the last century (municipalization, nationalization, re-municipalization, privatization) to finally go under re-municipalization in 2000 as detailed below.

4.1.2.7 From 2000 onwards: the TfL era

The end of the 1990s marked an important turn in the governance of London's transportation system. Following 14 years without a democratically elected government for the whole London area, the *1999 Greater London Authority Act* established the Greater London Authority and Mayor of London, as well as Transport for London (TfL) and other administrative bodies. It gave the mayor the rights to "*develop and implement policies for the promotion and encouragement of safe, integrated, efficient and economic transport facilities and services to, from and within Greater London*" (Greater London Authority Act, 1999: 89), through the development of the Mayor Transport Strategy. Transport for London was officially established in July 2000, few months after Ken Livingston was elected as the first Mayor of London, and as a combination of five TfL sub-departments: buses, underground, Victoria Coach Station, DLR, and London River services (Glover, 2011). LUL continued to exist after the birth of TfL. The overall institutional evolution of transport in London since 1933 is summarized in figure 4.1.7.

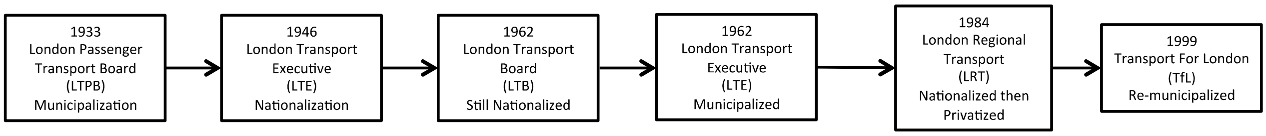


Figure 4.1-7: Institutional evolution of London Transportation system from 1933 to nowadays (author's elaboration)

One of the main problems that London Underground faced at the start of the 21st century was securing funds in order to maintain and update the gigantic underground infrastructure. Thus, London Underground undertook a series of public–private partnerships (PPPs) to secure funding. In 2003, CV and SSL Infraco were acquired by Metronet, and JNP Infraco acquired by Tubelines (Gannon, 2005). Under their respective contracts, Metronet and TubeLines were to provide London Underground with trains, stations, and related infrastructure according to a set of performance criteria, in exchange for a monthly payment based on their performance, which is also known as an infrastructure service charge (ISC). After these PPPs were signed, the whole Underground undertaking finally passed to TfL in July 2003 (Glover, 2011). However, based on the poor performances of the Infracos, Metronet Rail transferred its assets to TfL in 2008 after going into administration (TfL, 2008), which was also the case for TubeLines in 2011. To sum up, from 2003 to 2011, the whole London underground network went under PPPs, where infrastructure assets were maintained by private companies (Metronet and Tubelines), but still owned and operated by London Underground, to finally come back under public ownership as TfL assets.

In February 2003, the Mayor of London and TfL launched the Congestion Charge Scheme, which aimed to decrease congestion in and around central London. It was accompanied by the launch of several methods to pay for the charge, such as SMS payment or online payments (TfL, 2004b). In 2007, the congestion charge scheme was extended to the west to cover most of Kensington and Chelsea plus Westminster (TfL, 2006b). Conservative Mayor of London Boris Johnson finally decided to remove the Congestion Charge Scheme over the extended zone in 2011.

In 2007 the London Overground was launched, which is considered as a successful transformation of unutilized and over-fragmented railway infrastructures (Badstuber and Smales, 2013). This transformation actually began in early 2004, after the DfT released its white paper entitled "*the Future of Rail*", aimed at presenting the organizational and structural changes needed to make the British rail industry better at serving its customers as well as improving performance, safety, and controlling costs (DfT, 2004b). This white paper also led to TfL gaining responsibilities vis-à-vis rail services in the Greater London area by proposing that the Mayor of London become responsible for rail services within the GLA area. Following this white paper, TfL took over the Silverlink metro network located in Northern London and invested in new rolling stock, infrastructure upgrades, and station refurbishments to increase customer services standards. TfL renamed this part of the network Overground, which went live in late 2007. In 2011, TfL then added to the Overground network the East London Line and created four additional stations, ultimately forming an orbital rail network around London. The development of the overground accounted for £1.5 billion for TfL (Badstuber and Smales, 2013).

Following its 2004 bid, London was selected to host the 2012 Olympic Games. To cope with the growing demand that was going to be brought during the Olympics, and the obsolete state of the transportation system, the Olympic Delivery Authority created the Olympic Transport plan, which resulted in a £6.5 billion investment by TfL around the Olympic Park and across London (Butcher, 2012a).

In 2007 the DfT released a white paper entitled "*Delivering a Sustainable Railway*", which planned to invest £5.5 billion in the Thameslink project (Butcher, 2010), with the aim of transforming north–south travel through central London by increasing capacity and reducing journey times through the refurbishment and expansion of the current Thameslink route through central London (Butcher, 2012b). The project is expected to be completed by 2018. On May 15, 2009, Labour Prime Minister Gordon Brown and Conservative Mayor of London Boris Johnson inaugurated the beginning of the construction of the Isle of Dogs soon-to-be Crossrail station (The Economist, 2009). This project, which is supposed to create a 118 kilometer east–west rail corridor running through central London, had been on the table since 1989. After being rejected by Parliament in 1994 and having faced severe opposition, the project received Royal Assent in July 2008. With an estimated cost of about £16 billion, the Crossrail mega-project is the UK's largest investment ever (Hebbert, 2012), funded for £7.7 billion by GLA and TfL, including £3.5 from a special tax on London businesses, £5.6 billion from the DfT, £2.3 billion from Network Rail (formerly known as Railtrack), and the rest from Corporation of London, Canary Wharf property developer and BAA, which runs most of London airports (The Economist, 2009). Crossrail is supposed to be completed entirely by 2019 and to deliver a 10 percent increase in rail-based network capacity in London. It should be opened as the "Elizabeth Line" in honor of Queen Elizabeth. A Crossrail 2 project, also originating from the 1989 Central London Rail study, that would come across London from south west to north east, is also in the pipeline (TfL, 2014b).

In 2010, building on work from the previous mayor, Ken Livingston, newly elected mayor Boris Johnson proposed, as part of the Cycling Revolution project, the establishment of a Cycle Hire Scheme, soon to be referred to as "Boris's Bikes", planned to be functional by summer 2010. It is estimated that the whole cycle hire scheme cost was approximately £140 million, over £25 million of which was financed by Barclays Bank through sponsorship (CNN, 2010). Santander Bank took over the bike sharing scheme sponsorship in 2015 for £43.75 million over seven years, which was then composed of 11,500 bikes and 748 docking stations (TfL, 2015a). As part of the Cycling Revolution project, cycle superhighways were also to be developed in the capital (TfL, 2010b), at a cost of approximately £400 million (The Guardian, 2008). Figure 4.1.8 shows the use of "Boris's Bikes" since its launch in 2012.

In 2012, Uber began its operations in London. It is estimated that two years after the launch of the TNC, there were 26 percent more licensed cabs in London (The Telegraph, 2015). Taxi drivers have been protesting and striking (The Telegraph, 2015b) since Uber began operating, accusing TfL of being "in bed" with Uber (The Telegraph, 2015c). Thus, at the end of 2015 TfL proposed a regulation including a clause to force customers to have to wait five minutes between ordering and delivery time (FT, 2016). These proposals were finally dropped by TfL, which in 2016 proposed new regulations, including the need for Uber drivers to pass a special English test and to have special insurance. Uber has since sued TfL. To fight against Uber and help the black cab industry, newly elected Mayor of London Sadiq Khan presented measures that will allow black cabs to use some priority lanes used for buses and grant money for replacement of old cabs (The Telegraph, 2016a). However, against all odds, TfL decided in September 2017 not to renew Uber's operating license, citing a lack of corporate responsibility of the e-hailing service in London. Uber decided to appeal that decision and is still allowed to operate until any appeal processes have been exhausted (TfL, 2017a). In June 2018, Uber finally regained its operating license.

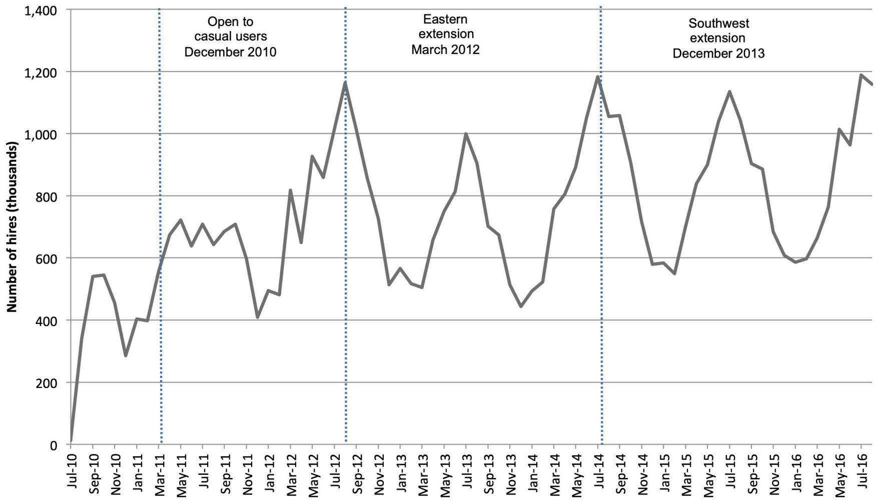


Figure 4.1-8: Evolution of cycle hires in London from 2010 to 2016

In 2014, the Car Club Coalition was created in London, constituted of car sharing schemes (Bolloré, car2Go, City Car Club, DriveNow, E-Car Club, Europcar, Hertz and Zipcar), London Councils, GLA, TfL and other important stakeholders, aimed at setting a collaborative strategy among car clubs to accelerate the growth of the car sharing market in London (TfL, 2014a). Car sharing is presented in the paper as a real alternative for private car use in London and as being able to bring environmental, economic, and social benefits. In January 2015 London's Car Clubs had about 135,000 members and is expected to have about 264,000 by 2020 (Frost and Sullivan, 2015).

In November 2015, following a statement from the Chancellor of the Exchequer (equivalent of the minister of finance) George Osborne, the DfT announced that its resource budget will be decreased by 37 percent by 2020. In other words, the DfT's operational budget is expected to fall from £2.6 bn in 2015 to £1.8 bn in 2019–20 (*The Guardian*, 2015). Because of these cuts, TfL's budget originating from the DfT is to be reduced to zero, leaving TfL to fund itself entirely through commercial investment, cuts, and restructuring (*FT*, 2015).

In February 2016, during the mayoral campaign, the Labour party candidate, Sadiq Khan, stated that it would not allow transportation strikes to happen during his mandate, recalling the 16 strikes that happened during mayor Livingstone's mandate and the 35 strikes that happened during mayor Johnson's mandate (*Daily Telegraph*, 2016b).

> *"As Mayor what I'd do is roll up my sleeves and make sure that I'm talking to everyone who runs public transport to make sure there are zero days of strikes. Sixteen was too many and 35 is a disgrace."*

In late 2016 and early 2017, after Khan's election, London's underground metro system was animated by a series of strikes initiated by the Rail, Maritime and Transport (RMT) Union in protest against the suppression of nearly 900 jobs and the closure of ticket offices (Labourlist, 2017), directly resulting from subsidiaries cuts from the DfT. The RMT Union was officially protesting about a "wholesale breakdown" of industrial relations, as well as the closure of ticket offices (Telegraph, 2016). The deletion of 900 staff positions was also presented as a threat to the tube security since it made the whole metro system under-staffed. Khan was heavily criticized as he had promised that there would not be any strikes of the transportation system under his mandate (CityAM, 2016).

In December 2016, TfL published a business plan for 2017/2018 to 2021/2022. The plan stated that fares will indeed become the primary source of income for TfL, growing from 70 percent of its budget in 2016/17 to 76 percent by 2021/22. The plan also stated that fares would not rise and that everything would be done in order to protect core investment, modernize the network, and increase its capacity. According to the plan, new transport developments such as the Elizabeth line, planned to break ground in 2019/20, will help increase the number of customers, but also that more has to be done to get some of the customers back onto the network, particularly regarding bus services (TfL, 2016b). The year 2016 was also marked by the beginning of the night tube service in August, with services all night long on the Central, Jubilee, Northern, Piccadilly, and Victoria Metro Lines (TfL, 2016c). Thus, London joined the very small list of cities with an all-night metro system, including New York, Chicago, Copenhagen, Melbourne, and Mumbai. Figure 4.1.9 summarizes the main institutional and infrastructural developments that occurred in the London Transportation Systems from 1984 to the present.

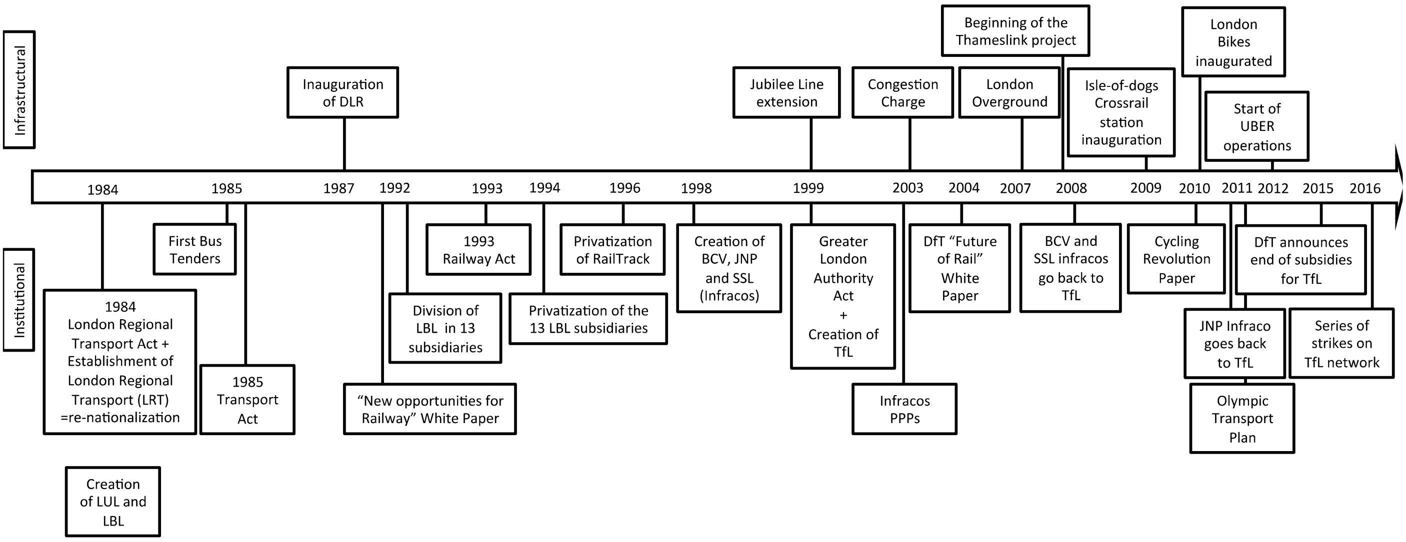


Figure 4.1-9: Institutional and infrastructura evolution of London Transportation system from 1984 to nowadays (author's elaboation)

4.1.2.8 *Transport in London nowadays*

From 2000 to 2015, 10.4 percent of trips shifted from private transport towards public transport, walking, and cycling, which together accounted for 63.8 percent of all trips taken in London (TfL, 2016f). Authorities acknowledged a 5 percent shift away from car travel in inner London between 2005/06 and 2015/16, from 26 percent to 21 percent, benefiting mostly human-powered modes (3 percent) and public transport (2 percent). In outer London, it is estimated that a 3 percent shift away happened from car use, from 50 to 47 percent, benefiting public transport and cycling, while also reducing walking modal share (TfL, 2016a). In general, road traffic has decreased by 10 percent from 2000 to 2015, which accounted for a 21 percent reduction in inner London. This is acknowledged to be mostly the impact of the congestion charge launched in 2003 (TfL, 2016a). In 2015, London's population was 8.6 million inhabitants, which is 19 percent higher than in 2000 and 10.3 percent higher than in 2008. Figure 4.1.10 represents the evolution of modal share in Greater London from 1995 to 2015.

In 2014, 26.6 million trips were made on an average day in London, which was 2 percent higher than in 2013 and 8.2 percent higher than in 2008 (TfL, 2015c). In 2014, 9.5 million trips (36 percent) were made on an average day using public transportation, 9.8 million (37 percent) using private motorized vehicles and 7 million (27 percent) using human-powered mobility modes (walking or cycling). Among the 9.5 million daily trips made by public transport in 2014, 4.1 million (43 percent) were made by bus and trams, 2.6 million (27 percent) using underground and overground and 2.8 million (30 percent) using rail. The modal share is summed up in Figure 4.1.11 (TfL, 2015c).

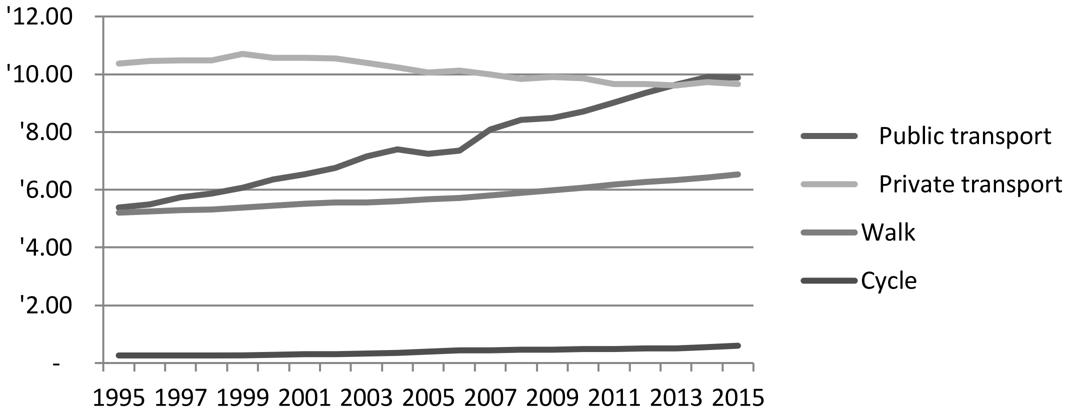


Figure 4.1-10: evolution of daily average number of trips by main mode of travel from 1995 to 2015

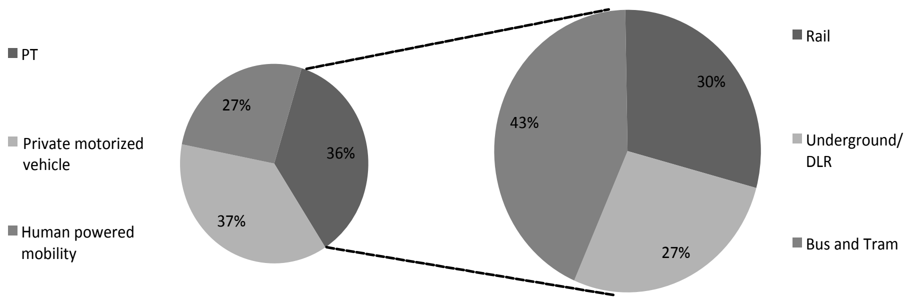


Figure 4.1-11: modal share in Greater London in 2014

As shown in Figure 4.1.12, public transport has been growing at a much faster pace than London population for the last 25 years. It is also interesting to compare the growth in journey stages on selected modes to the population growth in London. In 2012, there were 2.56 million cars registered in London, which is approximately 300 cars for every 1000 inhabitants. Forty-six percent of households did not own a car, 40 percent had one car, 12 percent had two cars and fewer than 2 percent had more than two cars (TfL, 2012c). According to TfL (2015c), the situation regarding per capita car travel follows the peak car use proposed by Newman and Kenworthy (2011) and has been decreasing recent years, although it has reached a peak in the last decade. According to the BBC, there were 309 cars per thousand people in 2015, compared to 325 in 2011 (BBC, 2016).

Although the number of cars per inhabitant has been decreasing, congestion is still a big issue in London. Congestion costs in London are estimated to be approximately £4 billion a year (Frost and Sullivan, 2015). In Q2 of 2016, it is estimated that 85% of riders were satisfied with Metro services (TfL, 2016g) as well as with bus services (TfL, 2016h), which was the target set out by TfL. Customer satisfaction regarding reliability was 85/100, while staff behavior ranked 88/100 and value for money ranked 74/100 (TfL, 2016c).

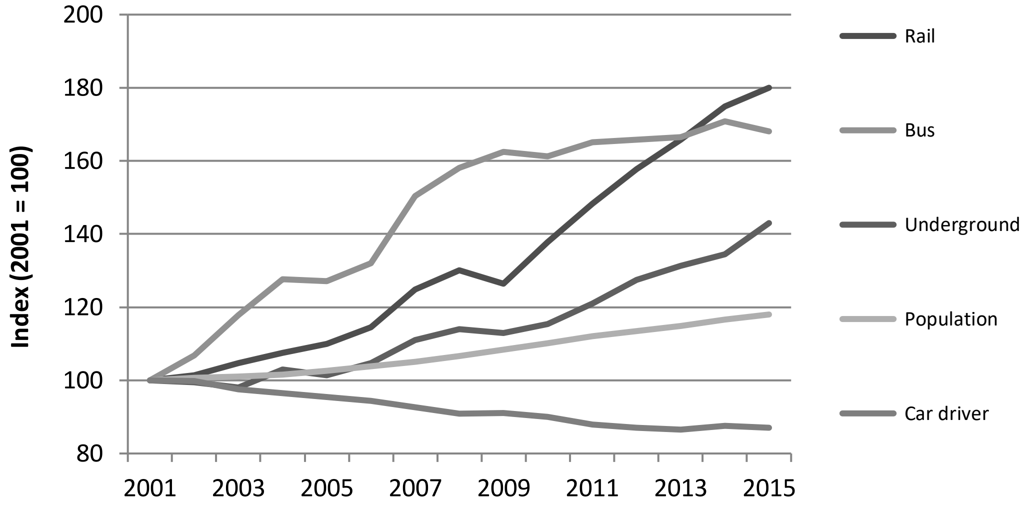


Figure 4.1-12: growth in journey stages in Greater London on selected modes from 2001 to 2015

4.1.3 Evolution of Climate Policies

In order to have a better understanding of what was planned regarding transportation in UK to reduce carbon dioxide emissions, the main policies at the national, and local levels regarding climate change are summarized. For a full review of UK climate change policies, see Bowen and Rydge (2011).

In 2000, the Department for Environment Transport and Regions released the *Climate Change Program,* which sought to go further than the Kyoto Protocol. That report set a goal of reducing carbon dioxide by 20 percent below 1990 levels by 2010 (DETR, 2000). In 2002 the *UK Emission Trading Scheme* was released, following by the EU ETS, developed in 2005, which integrated the former (Sustainable Prosperity, 2012). In 2003, the Blair government published an *Energy White Paper*, which presented how the UK planned to redefine itself as a low-carbon economy. In particular, the White Paper set a target of reducing carbon dioxide emissions by 60 percent by 2050 (DTI, 2003). In 2004 the *London Plan* was released, which aimed to reduce carbon dioxide emissions by 23 percent compared to 1990 levels by 2016 (Mayor of London, 2004).

In 2005, Blair used the UK's presidency of the EU and the G8 to boost multilateral efforts on climate change (Sustainable Prosperity, 2012). The *2006 Climate Change Program* set the target of reducing UK greenhouse gas emissions by 23–25 percent against 1990 levels by 2010; that is, only half the reduction formulated in the Kyoto protocol (Defra, 2006). Regarding the transport sector, the Government acknowledged in the report that it was supportive of "*a range of measures, called 'smarter choices' which are aimed at helping people choose sustainable travel options*" (2006: 69).

Following the 3*20 package set by EU leaders in 2007, the *Climate Change Act* (first introduced in 2005) came into effect in 2008, instituting binding reduction targets for carbon emissions of 34 percent by 2020 and 80 percent by 2050, compared to 1990 levels (DECC, 2008). This is known to be the first binding reduction target published by any country (Sustainable Prosperity, 2012). This was followed by the release of a white paper in 2009 that planned to cut greenhouse gas emissions by 18 percent by 2020 compared to 2008 levels, and getting 40 percent of the electricity from renewables by 2020 (DECC, 2009a). During the same year, the 2008 revision of the London Plan was published, which presented less ambitious targets than the 2004 London Plan. Through Policy 4A.2 on reducing carbon dioxide emissions, it planned a 15 percent reduction compared to 1990 levels by 2010, 20 percent by 2015, 25 percent by 2020, and 30 percent by 2025 (Mayor of London, 2008).

In 2009, the *Carbon Budget Order* was accepted, which planned different emission reduction packages towards the 2050 goal. It proposed three carbon budgets, as follows: the first carbon budget aimed at a 23 percent carbon reduction in the 2008–2012 period; the second carbon budget aimed at 29 percent carbon reduction in 2013–2017; and the third carbon budget aimed at 35 percent for 2018–2022 (DECC, 2009b), all compared to 1990 levels. In 2011 was voted the fourth carbon budget, which aimed at a carbon reduction of 50 percent by 2025 (Garton-Grimwood, 2016). In 2011 mayor Boris Johnson announced, in his *Climate Change Mitigation and Energy Strategy*, targets to reduce CO_2 emissions drastically in the following decades. The policy aimed to reduce CO_2 emissions by 20 percent compared to 1990 levels by 2015, 40 percent by 2020, 60 percent by 2025, and at least 80 percent by 2050 (Mayor of London, 2011). This objective was also written down in the 2011 London Plan.

In 2015 at COP21 in Paris, 195 countries, including the UK, adopted the so-called "Paris Agreement", which aimed at "*Holding the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels*" (UNFCCC, 2015: 3). In line with the Paris Agreement, the Committee on Climate Change proposed the fifth carbon budget (Garton-Grimwood, 2016), which was voted for during the summer 2016.

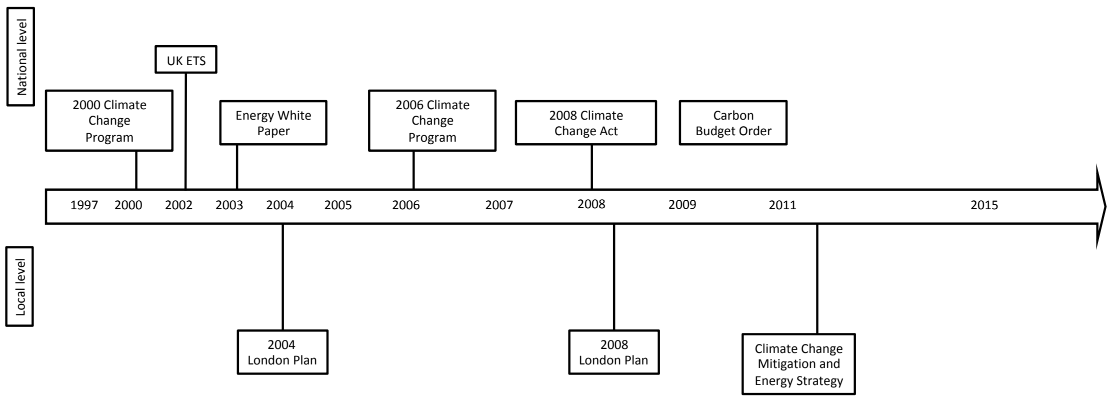


Figure 4.1-13: evolution of climate change policies at national and local levels from 1997 to nowadays

4.1.4 The development of Smart Transportation Cards in the London Metropolitan Area

Here, the main actions at the national, national and local level that have potentially played a role in the development of the Oyster card and of the contactless payment cards (CPCs) in London are summarized. The time period covered is from the mid-1980s to nowaday.

In 1981, led by Ken Livingstone, the Labour party won the Greater London Council elections, overturning the Conservative Party administration in place at that time. One of the key transport policies developed by the Labour administration in 1981 was the "Fair Fares" policy, which introduced a system of zonal charging aiming at reducing public transportation fares substantially for users (Harris, 2011). However, as fares were only artificially reduced, one of London's boroughs filed a high court auction to see the policy declared unlawful, and finally won, which created a 92 percent fare increase that negatively impacted all users and, consequently, patronage on London public transport (Glover, 2011).

In 1983, the London Travelcard was launched, which allowed users to have unlimited access to public transport, for a given daily, monthly or yearly fee, and unlimited free transfer from one mode to another, and between routes of the same mode (Booze&Co, 2009). According to White, the introduction of the Travelcard redefined the product: *"The public transport user perceives a payment for the use of the system as a whole, with individual journeys at zero marginal cost (…)* [With the Travelcard] *Perception of cost is placed on* *a similar footing to that of the private car*" (1984: 134–135). This first Travelcard was being supported by a concentric ring fare structure into six different zones. It re-introduced a 25 percent fare decrease, putting the fare half-way between pre and post the unsuccessful "Fair Fares" episode (Glover, 2011). Depending on the zonal coverage of the Travelcard, users could also travel from one zone to the other. The Travelcard was the first integrated fare system implemented in London. The fare system was changed again in 2000, when a flat fare for buses was implemented across the entire London bus network.

In 2000, the DfT released the *2000 Transport Act* which made the first steps in the development of a legal framework towards the development of integrated ticketing schemes. For example, it urged each local transport authority to "*develop policies for the promotion and encouragement of safe, integrated, efficient and economic transport facilities and services*" (DfT, 2000: 66). This paper came along with the 10 years plan, aiming to invest over £180 billion over the next 10 years in projects to reduce congestion and pollution, which foresaw the spread of smart cards across the country.

In 2001 the first *Mayor Transport Strategy* (MTS) was released, the key proposals of which were to freeze bus fares, limit underground fares, introduce smart cards, and simplify ticketing across all transportation modes in London, including national rail (GLA, 2001). At the end of 2001, TfL presented its 2002/2003 business plan (TfL, 2002a), which aimed at:

1. Improving the system safety and customer security
2. Improving the financial efficiency
3. Reducing traffic congestion and increasing public transport usage and network capacity
4. Improving network reliability and service delivery quality
5. Improving network integration and support of local authority initiatives
6. Improving access to the transport system.

In 2002, to help achieve initiatives 3, 5, and 6, TfL presented its 2003–2004 business plan that included a ticketing and boarding strategy to "*achieve faster boarding, passenger convenience, and efficiency savings consisting of three elements: introduction of cashless operation in Central London, expansion of cashless operation across the whole bus network by 2008 and, in parallel, the progressive introduction of articulated buses with open boarding*" (TfL, 2002b).

4.1.4.1 The Oyster era

> *"No other change or innovation so dramatically changed passengers' lives or willingness to use the system. Oyster had a bigger impact on bus usage than the frequency improvements, in my opinion. Given the complexity of the Tube fare structure, the development of Oyster on the Tube was a world best management change." Tim O'Toole* – Chief Executive at firstGroup (Begg, 2013)

As seen above, the London Underground has gone through a range of financing schemes involving the private sector to find ways of funding its system, given the substantial size of its network and value of its assets. Among the wave of privatization that happened in the 1990s, the RFID supported Oyster card stands as one of the private finance initiatives (PFIs) done at that time. For a full list of PFIs that happened at that time, see Gannon (2005). Thus, in August 1998, following two smart card trials having happened in 1992 and 1994 (Taylor and Green, 2001), a £1.1 billion, 17-year PFI contract was signed between London Transport Executive and Transys (Gannon, 2005), a consortium made up of several technological providers whose main actors were Cubic and HP Enterprise Services (TfL, 2010a). The card was supposed to support flat fares of the bus system and zonal fares used on the underground system. It aimed to make the overall system more efficient by reducing queues at metro station gates as well as cutting fare collection costs for TfL.

While the ticket barriers, machines, validators, and the like were being installed during 2002 by Transys, TfL staff were already able to use Oyster cards at that time. In 2003, as part of a new system, the Oyster card was launched for annual and monthly tickets. At that time, it relied on the NXP/Philips' MIFARE Classic microchip and could store 1024 bytes of data, using NXP's own proprietary 48-bit encryption technology (Muller, 2016). In 2004, TfL launched the Oyster Pay-As-You-Go (PAYG) system (TfL, 2009b), which was initially named "pre-pay". The idea behind the card was to offer an alternative to season tickets for who would pay for their journeys at the point of use. Users could top up money on their card (up to £90) whenever needed. In 2005, daily capping was introduced on the Oyster (TfL, 2005).

The *2004 London Plan*, prepared by the Mayor of London, encouraged a modal shift and proposed the development of a "*well-integrated public transport"* to offer *"alternatives to car use*" (Mayor of London, 2004 :19). During the same year, the DfT presented its *Future of Transport Strategy*, where it promoted integrated ticketing as a means of attracting more people into public transportation (DfT, 2004a). In 2005, TfL announced its plan to enable the use of Oysters as an e-wallet, enabling users to pay for low-value items in shops with their oyster (Smart Card News, 2005), as was already the case with smart transportation cards in Hong Kong or Seoul. Unfortunately, this idea was finally dropped and Oysters could never be used as e-wallets. In 2006, TfL again announced new fare packages in order to boost Oyster usage (TfL, 2006a). The PAYG system was progressively extended to National Rail in the Greater London area during 2007 and 2010. In April 2007, the Mayor of London launched a massive diffusion campaign, giving out 100,000 free Oyster cards so that vulnerable groups of people could start using the service (TfL, 2007).

In 2008 there were three major incidents involving the Oyster card. Following a long period of criticism related to the security of the Oyster card, computer scientists from Germany and the US managed to break the Oyster card encryption and gain access to all Oyster cards' data (Muller, 2006). This was followed by the hack of Mifare Classic by Dutch scientists, who managed to clone oyster cards and travel freely on London Transportation System (Sparkes, 2008). Then, in 2008, some 78,000 Oyster smart cards became dysfunctional, which forced TfL to issue more than 40,000 new ones with the same balances. Later, approximately 200,000 PAYG cards became corrupted. The two shutdowns cost TfL about £1 million in lost fares (*FT*, 2008). After these two events, TfL gave notice to terminate the current contract with the TranSys consortium (TfL, 2010a). The same year, TfL hired the consulting company Deloitte to migrate the Oyster system to Linux to prevent future hacks (ZDNet, 2008). Following a long period of negotiations between TfL and train operating companies (TOCs) between 2006 and 2009, an agreement was finally reached on 16 October 2009 between TfL and the TOCs to allow Oyster PAYG readers to be installed at all National Rail stations in London (TfL, 2011). In response to criticism regarding the security of the first Oyster cards, TfL decided to change the supporting technology behind Oyster cards, choosing the MiFARE DESFire EV1 technology, which was supposed to be more robust than its predecessor (Muller, 2016).

Zoom on the Oyster

Technology: The Oyster card is a pocket-sized integrated circuit with a memory chip and a microprocessor chip. It works with radio-frequency identification (RFID) technology, which provides the energy needed to run the microprocessor from the electromagnetic field created between the reader and the chip. Oyster can be used in two ways. It can contain a travel card, for which customers pay a fixed fare per month and then have unlimited travel or it can be used as pay-as-you-go (PAYG). For the PAYG, customers must top up money on their cards (online or with cash at charging stations). This money is then stored on a dedicated bank account. Oyster users must tap in and out when using rail service. When tapping in, data is first transferred from the card to the reader, so the reader can verify whether the oyster card contains a valid Travelcard or enough

PAYG balance (credit). Data indicating that the customer is starting his/her journey is then transmitted from the reader to the card and stored in the card. When tapping out, data indicating where the customer started his/her journey is transferred from the card to the reader. Thus, readers have data about the start and end of the journey that will be used to calculate the total length of the journey and the respective exact fare. The data are then stored in the readers and sent to TfL central servers by batches, which is responsible for a roughly 24 hours delay in TfL being able to exploit the data. Computation on travel length and exact fare is made by the central servers. TfL's acquiring bank then requires the transaction to be made from the bank associated with Oyster, and individuals' Oyster cards data (transaction and time) are retained by TfL for eight weeks (Muller, 2016). When using bus services, users are only asked to tap-in, as the fares are flat. In this case, the Oyster card sends information to the reader to let it know whether it contains enough credit or a travel card, as well as the time of boarding. Based on this data, TfL's acquiring bank then requires the transaction to be made from Oyster's bank.

Functionality: The main functionality of the Oyster Card is to enable through-ticketing. The system does not integrate any transport planning functionality or booking service; it is just a card to be used for ticketing.

Transport modes integrated: CPCs are accepted as a ticketing means for all transport modes provided by TfL (bus, metro, overground, DLR), as well as for commuting trains within Greater London.

4.1.4.2 The contactless payment card (CPC) era

> *"I travel a lot to London and* [CPCs] *have been one of the best implementation and progresses …that is a very small thing (…) but really, that makes all the difference. That is so much easy to use."* (IH11)

In 2006, TfL launched the Future Ticketing Project (FTP). It aimed at making TfL gain a deeper understanding of the costs of fare collection associated with the Oyster card, and learn about other emerging payment technologies, to ultimately assess the likelihood of them reducing costs borne by the Oyster system. It is estimated that, in 2005/2006, revenue collection costs for TfL accounted for 14 pence out of every pound collected (TfL, 2016j). During this period, TfL closely worked with the Massachusetts Institute of Technology (MIT) to assess different scenarios of payment and event implemented a mobile phone pilot payment system (London Assembly, 2011).

In September 2007, Barclaycard issued a credit card named OnePulse, which was a Visa contactless credit card embedded with the functionality of TfL's Oyster card (TfL, 2007b). Since that date, Barclaycard, a subsidiary of Barclay, one of UK's leading Banking group, has been TfL's acquiring bank. In 2009, the DfT published its *Smart and Integrated Ticketing Strategy,* which aimed to have all of the UK's main urban centers equipped with smart ticketing schemes by 2015, and along with the ITSO specification, create a standardized nationwide smart ticketing network. CPCs and other technologies were already mentioned in the document as a way to "*remove the need to queue to buy a ticket ever again*" (DfT, 2009:1).

In 2009, the mayor delegated to TfL the responsibility of drafting the MTS (TfL, 2009a). After public consultation and few modifications made by the London Assembly, in particular by the Transport Committee, the mayor approved the MTS in May 2010 and set the strategy for transports in London up to 2031 (Mayor of London, 2010). The MTS comprised of three different parts: the first part set the context and made an introduction to the challenges London transport system would soon have to face. The second part set out the different policies and the proposals in order to apply the latter, and the third part stated how the strategy would be delivered. Through MTS Policy Number 10 (Mayor of London, 2010), TfL, with the help of the DfT and other stakeholders, was asked to improve the efficiency of the transport system. One of the proposals (Proposal 123) for the application of this policy is the use of new technologies to improve the cost and efficiency of fare collection (Mayor of London, 2010).

In 2009, a business case was presented to the board of TfL, proposing a five-step development process for the implementation of CPCs. While the two first phases dealt with the introduction of CPCs in buses in 2012, and underground in 2012–2013, weekly capping was to be introduced in 2013 and the Oyster card of the time was to be decommissioned by 2015 (London Assembly, 2011). On January 2, 2010, the Oyster PAYG was extended to all 350 National Rail stations in London. This constituted the largest expansion of the Oyster network since its launch in 2003 (TfL, 2010a). In 2010, the contract between Transys and TfL officially came to an end. TfL terminated the PFI contract by exercising a break option in the contract (TfL, 2010a). TranSys took on £190 million of debt from a consortium of lenders, which was scheduled to be paid off over the term of the 17-year Contract; that is, by 2015. TfL then paid off the PFI debt on February 26, 2010 to finally deliver £4 million debt interest savings for TfL (TfL, 2010a). Transport Trading Limited (TTL), a subsidiary of TfL, entered into a new contract with Cubic, namely the Future Ticketing Agreement (FTA). The FTA aimed at (TfL, 2014c):

- Giving TfL full access to all intellectual property rights needed to operate the system and to run a competitive procurement
- Allowing TfL to use third parties or in-house teams to provide services where this provided value for money
- Providing for flexible hand-back arrangements to allow for another party to take over the services
- Providing for TTL ownership of the system assets and control of the money spent on refreshing these assets

The FTA contract also established that Cubic would be fully responsible for TfL's fare collection services from August 2010 to August 2013. Part of Cubic's responsibility under this new contract was to design and supply a new card reader that could support both the old model of Oyster transactions and the new EMV contactless payment system.

In order to find the technological solutions that would fit best this system, TfL hired three consulting companies: Storm Consulting, Hyperion, and NCC Group. Storm Consulting helped TfL develop a new reader architecture that would allow the system to be transferred to a back office so that neither the card nor the reader had to hold fare information. Within six months, the consultants developed a proof of concept and prototype. Using those, TfL made the business case for the £75 million project, which was later approved by TfL's board and the Mayor of London. This modular proof of concept was later adopted and adapted by Cubic when it designed the final version of the reader. Hyperion Consulting worked on developing a new reader prototype that could work in this new system. Finally, NCC Group was hired to ensure the reader complied with PCI DSS standards (NCC Group, 2015). In 2011, the London Assembly Transport Committee launched an investigation into the benefits of implementing CPCs in London transportation system. The Transport Committee reached out to a series of stakeholder to comment on the matter. The text was commented by, for example, Visa and the consumer association *Which?* (Mayor of London, 2011). Based on its investigation, the Transport Committee edited in 2011 a set of non-binding recommendations to TfL for the implementation of CPCs (London Assembly, 2011).

By 2012, TfL had issued more than 43 million Oyster cards since its introduction. Oyster also accounted for more than 80 percent of all journeys on public transport in London (TfL, 2012a). In September 2012, the OnePulse card was discontinued to new users. Barclaycard announced in February 2014 that all OnePulse functionality would cease after June 30, 2014. In 2012, TfL invested £12.8 million in launching the first phase of the Future of Ticketing Project; this consisted of enabling the acceptance of CPCs on buses, which went live on December 2012 (TfL, 2012b). In 2012, the DfT released a follow-up report restating its willingness to move towards smart ticketing, particularly by working closely with ITSO to have transport ticketing schemes compatible over the country, and potentially with other cities worldwide (DfT, 2012b). In a policy paper entitled "*2010 to 2015 government policy: local transport*", the DfT also confirmed the provision of £15 million for the development of smart ticketing schemes across the UK, as well as a £45 million investment to extend smart ticketing across London and the south-east of England through the South East Flexible Ticketing (SEFT) program (DfT, 2012a).

In 2013 the DfT released the *Door-to-Door Strategy*, in which it stated its previous and future actions to improve the efficiency of the UK transport system. The plan was divided into four chapters, including a dedicated part on smart ticketing (DfT, 2013). More precisely, in this chapter the DfT promoted its ITSO on Prestige (IoP) project, the goal of which was to make CPCs developed by Cubic for London compatible with ITSO standards. The IoP project, which was worth £70 million and funded by the UK government, was finally completed in the autumn of 2014 (DfT, 2014).

In 2014, after a competitive bidding process, TfL awarded the "Electra Contract" – the new contract for managing and maintaining TfL ticketing system (Oyster and CPCs) – to Cubic Transportation Systems Ltd. TfL thus renewed the partnership with Cubic for an additional seven years. The contract is worth around £660 million and is expected to bring savings (mainly from fare collection) of £11 million per year compared to the previous FTA contract (TfL, 2014f). The Electra contract aimed to move from a closed (Oyster) to an open-loop system, enabling Oyster to continue functioning, while other devices could also be accepted for payment (CPCs). In 2013/14 TfL invested another £56.8 million to extend the integration of CPCs to TfL's other transport services and introduce daily and weekly capping, which went live in September 2014 (TfL Database). In October 2014, mayor Boris Johnson launched a new scheme, called "A Penny for London", to collect charitable donation from contactless card payments on the tube to raise money for disadvantaged young people in London. Each time a CPC of the scheme would be used, one penny would be deducted and transferred to the Mayor's Fund for London and other charities, whose focus was on helping disadvantaged people (*The Guardian*, 2014). For the mayor at that time (*The Telegraph*, 2016d):

> "*Penny for London is a big, bold idea that will revolutionize the way we give to charity (…) The latest contactless technology is going to help transform the lives of thousands of young people across the capital (…) Enabling people travelling around the city to pool their pennies could potentially add up to hundreds of thousands of pounds. And the best thing about it is just how simple it is. Just sign up and swipe."*

In 2014, the mayor released the 2050 London infrastructure plan and its supporting transport paper. Once again, integrated ticketing was presented as a key innovation to help developing the transport system of tomorrow. The plan stated the mayor's willingness to also provide "*seamless information and integrated systems for users*" (Mayor of London, 2014: 203). In 2015 Boris Johnson continued promoting the CPCs. He said: "*It's been an astonishing 12 months with so many Londoners embracing contactless technology on our transport network. It is clear passengers love using the payments to travel, and why on earth not – it's quick, it's easy and ensures you get the best fare. It's yet another example of how we continue to invest in the latest technology to make getting around the capital as easy as possible"* (TfL, 2015b). Last but not least, 2014 marked the year when it became no longer possible to pay with cash on London Buses. Through ethnographics and interviews, Pritchard et al. (2015) studied the impact of this decision on populations and concluded that even if there was much to gain from cashless payments, the complete withdrawal of cash could have social impacts, such as increased fear from citizens regarding surveillance or vulnerability of citizens from hacks.

In summer 2015, CPCs and Oyster became accepted on Southeastern's high-speed service between St. Pancras International and Stratford International. At the end of 2015, WiFi was installed on 100 additional metro stations in London, bringing the total to 250 stations equipped with Wi-Fi, provided by private companies (TfL, 2016). In late 2015, TfL commissioned the travel company 2CV to research the business opportunities to develop the very first TfL ticketing app. The app, developed by Cubic, was finally released in September 2017 and allowed Oyster users to get information about current balance on their oyster cards as well as top-up their oysters virtually using their credit cards online (CBR, 2017). Through the app users were also able to check their travel history for the past eight weeks. In December 2016, it is estimated that there were 102.7 million CPCs in use in the UK, of which 70.1 million were debit cards and 32.6 million were credit cards. This represented a 25.8 percent yearly increase (UK Card Association, 2017). In February 2017, Barclaycard retained its contract as TfL acquiring bank for another seven years (with possibility of a three-year extension) (Peyton, 2017). The contract accounts for approximately £380 million.

Smart cards (Oyster and CPCs) are currently the only accepted means of payment for public transportation in London. Figure 4.1.14 represents the evolution of the number of journeys on the TfL network for which users used CPCs.

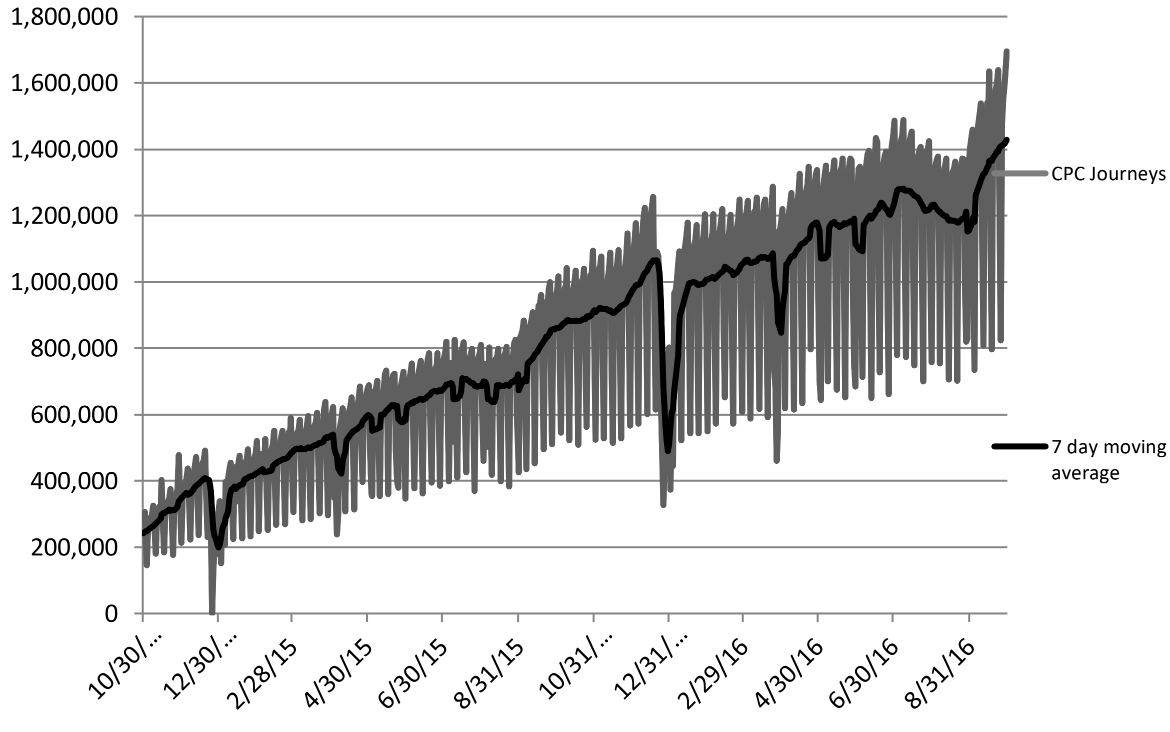


Figure 4.1-14: evolution of the number of journeys processed by TfL using CPC (based on data from TfL)

In 2015/106, CPCs accounted for 26 percent of all PAYG tube and rail journeys, while accounting for 23 percent of all bus trips (TfL, 2016). The Oyster card accounted for the remaining percentage. It is estimated that TfL's cost of fare collection dropped from 14 percent to 9 percent after the introduction of CPCs, moving towards the objective of limiting them to around 6 percent (L.E.K, 2016).

In 2016, TfL and Cubic agreed to develop a license, worth £15 million, for the use of London's contactless ticketing system technology by other cities worldwide, and have already made a proposal to implement the technology to Metropolitan Transit Authority (MTA) in New York (UITP, 2016). In late October 2016, TfL announced that credit cards, and more specifically contactless payment would be allowed on all London black cabs, ending a long period in which the only way to pay for a taxi in London was with cash (TfL, 2016a).

Zoom on CPCs

Technology: Contactless payment cards are credit cards that have been equipped with a microprocessor and internal memory in order to be able to communicate with smart card readers through RFID technology. CPC chips are able to handle, store, and grant access to data on the device in which they are embedded through the interaction with the card readers, as well as perform internal functions such as encryption (Smart Card Alliance, 2006). The reader used by TfL is the Tri-Reader 3, which was developed in conjunction with Cubic Transportation Systems Ltd. and ViVOtech. It is a retrofitted version of the previous TfL readers used for Oyster Cards. It enables the use of the Oyster cards as well as CPCs issued by banks. These operate in an "open-loop" system, meaning it accepts payment devices that are not issued specifically by TfL. As a result, the readers do not need to hold information about fares, as these are calculated in a central location to which the information is sent (back office). Whenever a contactless bankcard is used, the reader authenticates the card and generates a simple zero-value transaction, which is sent to the back office. This allows the readers to be very simple as they do not need to perform the computations.

When a CPC is used, the reader sends the data to the Payment Gateway (1), which in turn encrypts and sends it to the acquiring bank (TfL's bank) for authorization (2). The data is then sent (3) by the acquiring bank to the card-issuing bank (customers bank) through the card payment network. After having checked the availability of balance or credit limit, the issuing bank either authorizes the transaction or declines and notifies the acquiring bank (4), still through the card payment network, which then sends the data back to the payment gateway (5). The card scheme (Visa, MasterCard, American Express) receives a fee from the merchant for utilizing its network. If authorized by the bank, the data is then tokenized and sent to the Business Logic Processing center of the back office (6), which then determines, based on previously established standards, whether that card can be used to pay for TfL services. If it determines that it cannot, the card is added to the Deny List (7a). This list is fed to all readers every 10 minutes, so that the next time this card is used it will automatically be rejected. If a credit card is eligible to be used at TfL, the zero-value transaction is stored (7b). Since the bus fares are flat, there is no need to tap out on the buses. When tapping out on rail, the location, date and time data are stored so the distance traveled and resulting exact fare can be calculated. At the end of the day, all these transactions are retrieved and the appropriate fare is calculated. The system then generates a one-time fare for all the trips made during the day (8), which is then charged to the customer bank once the acquiring bank request the funds from the issuing bank (9). The issuing bank receives a fee (transaction fee) from the acquiring bank when the former realizes the transaction. This fare is calculated using similar fares than those used for Oyster journeys, with some additional capping (TfL, 2014e). The process is summed up in Figure 4.1.16.

Functionality: The main functionality of a CPC is to enable through-ticketing. The system does not integrate any trip planning functionality or booking service.

Transport modes integrated: CPCs are accepted as a ticketing means for all transport modes provided by TfL (bus, metro, overground, DLR), as well as for commuting trains within Greater London. Since January 2017, CPCs have also been accepted as a means of payment in black cabs.

Figure 4.1 15: Data and monetary flows (author's elaboration based on TfL (2014e))

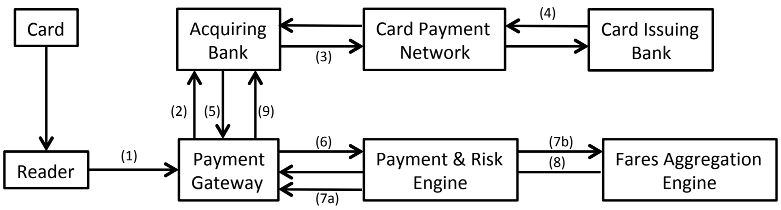


Figure 4.1.16 summarizes the overall development of Oyster and CPCs in London. The following sub-section presents the development of IMPs in Vienna, which is the second case study at the center of this thesis.

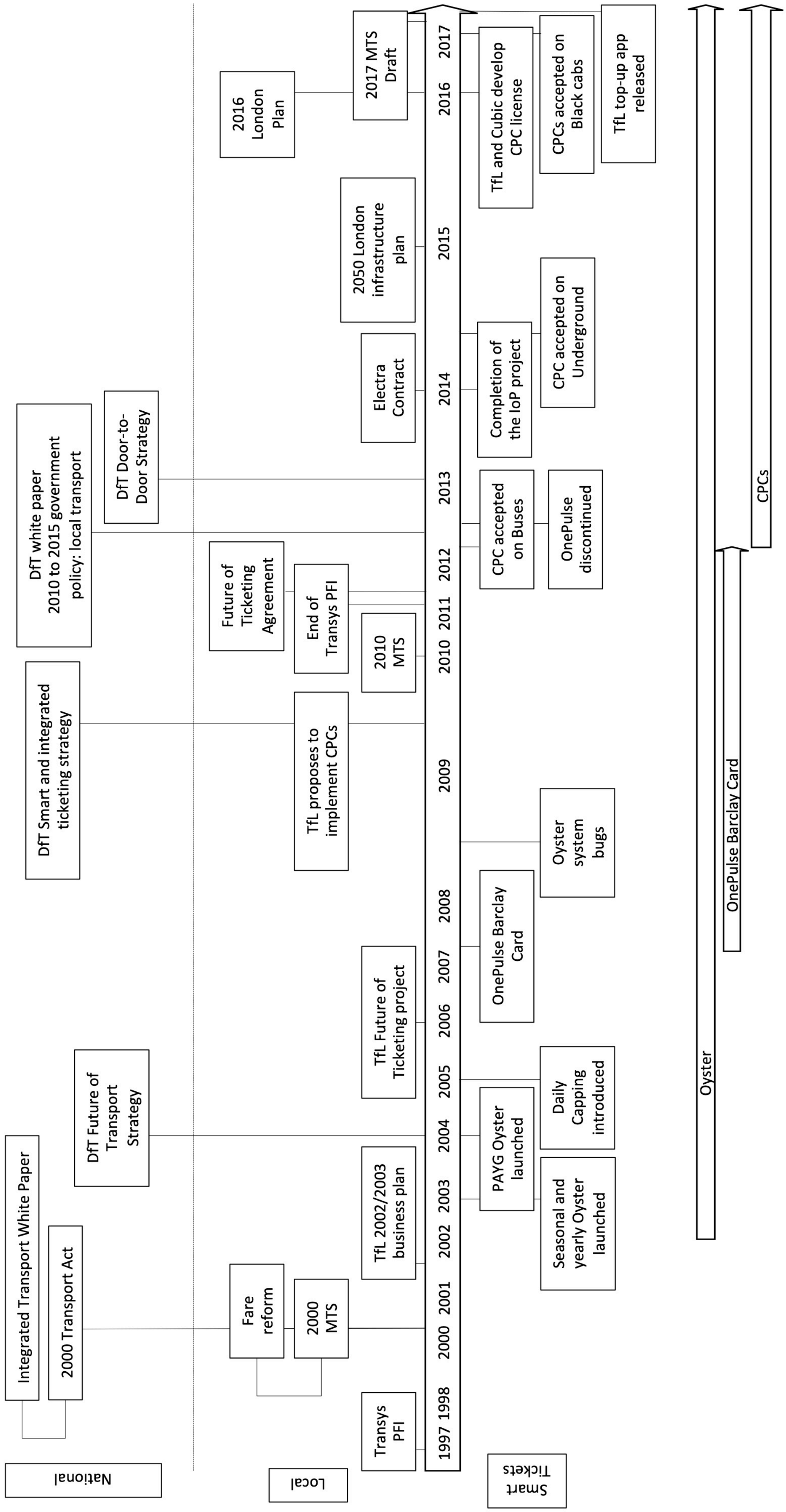


Figure 4.1-16: development and implementation of digital ticketing systems in London (author's elaboration)

4.2 Vienna case study

Vienna is the capital of Austria. In order to fully understand the context in which the development of integrated mobility platforms has occurred, this subchapter starts by detailing the political and administrative organization of the country at the national level, before the same is done for the local level. Then the historical development of Vienna's transportation system (from the beginning of the 20th century to the present) is reviewed. Finally the key events that led to the development of integrated mobility platforms in Vienna (from the mid-2000s to 2017) are reviewed.

4.2.1 Context

4.2.1.1 National level

- Current Situation

In 2016, Austria had a population of 8.68 million people (WKO, 2016) and it is estimated that the country will have 9.6 million inhabitants by 2040 (EC, 2014). With approximately two-thirds of its population living in urban areas in 2015, Austria is not the most urbanized state within the EU. The percentage of the Austrian urban population has actually been steady over the last few decades, as it was of 64.7 percent in 1960 and of 65.9 percent in 2015. The average percentage of EU citizens living in cities actually overtook the Austrian average in the late 1960s, which is quite unusual. Figure 4.2.1 shows the evolution of the urban population in the EU and in Austria from 1960 to the present.

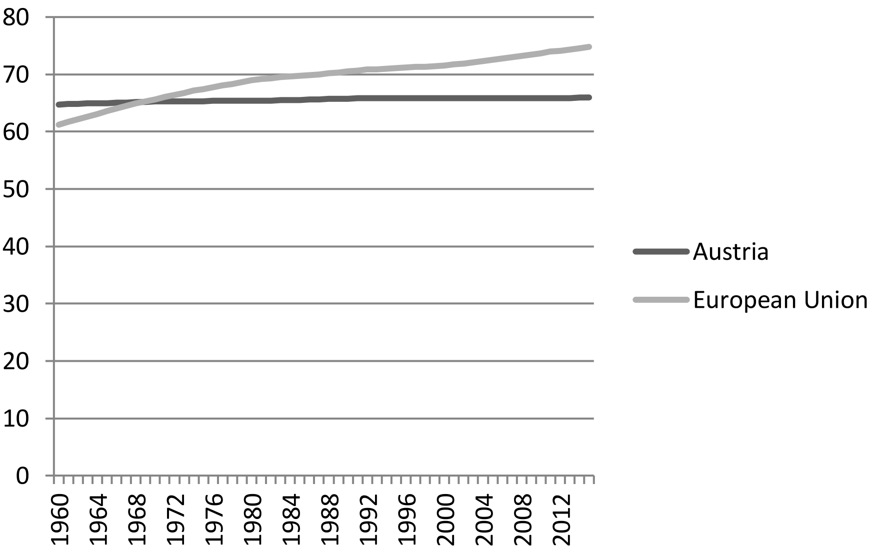


Figure 4.2-1: Urbanization evolution in Austria compared to EU (based on WB data)

In 2016, Austria's GDP per capita was €36,608, which is above the EU average of €30,815. Although Austria has suffered from the 2009 financial crisis, it has never fallen into recession. In 2016, Austria averaged 1.6 percent growth, and it is estimated that growth will be 1.7 percent for 2017 (WKO, 2016). In 2016, Austria had an unemployment rate of 5.9 percent, slightly higher than that of the UK (5.0 percent). Austria's GDP comes mainly from the tertiary sector (70.7 percent), followed by the secondary sector (28 percent) and the primary sector (1.3 percent) (WKO, 2016).

Regarding connectivity of the population, in 2015 there were 78.2 mobile broadband subscriptions per 100 inhabitants in Austria, lower than the OECD average of 91.7 per 100 inhabitants (OECD, 2016c), and lower than the UK average. Austria ranked 53rd in the 2016 Global Gender Gap index (WEF, 2016) and 12th in the Human Capital index (WEF, 2016). Compared to other OECD countries in 2015, Austria is located in the middle third for jobs and earnings, housing conditions, environmental quality, health status, education and skills, and subjective well-being; in the top third when it comes to social and family environment as well as income and wealth; and in the bottom third regarding child well-being (OECD, 2015).

- The Austrian administrative system

Austria is a federal country made up of nine different states, referred to as "*Länder*". The head of the state is the federal president, who is elected every six years and cannot be elected more than twice. According to the Austrian Constitution, the federal president is able to dissolve the National Assembly and state parliaments, and appoints the federal chancellor, who is the head of the Federal Cabinet; that is, the chief of the federal government, which is composed of 12 federal ministers.

At the federal level, the Parliament consists of two chambers: the National Council, also called Lower House, and the Federal Council, called the Upper House. The National Council is directly elected every five years and made up of 183 members. The Federal Council is composed of 61 members representing the Austrian states on a federal level and is elected every five to six years, according to proportional representation. Ultimately, the Federal Council is known to have much less power than the National Council. Following National Council elections, the federal president usually appoints the leader of the victorious political party as the federal chancellor, who does not have any term limit per se, but must resign if the Parliament passes a vote of no-confidence. Each of the nine Austrian states also has a parliament, called the *Landtag*, which is elected every five to six years depending on the Lander Constitution, which legislates on non-federal matters. The party that wins the most votes at the Landtag elections is then in charge of appointing the state governor, who is sworn in by the federal president.

At the lower level are municipalities, which are independent administrative bodies in charge of issuing general regulations and provide public services to their citizens at the city level. Municipalities are organized as follows. The main decision-making body of Austrian municipalities is the Municipal Council, which is elected by the citizens of a municipality every five years. It is responsible for adopting the municipality budget and handling finances. The members of the Municipal Council elect from their peers the Municipal Board (also called City Council or City Senate), commonly referred to as Municipal Government. The Municipal Board is then chaired by the mayor, who is either elected by direct suffrage, or elected by the Municipal Council.

- Austrian politics at the national level

Although Austria has been known to be one of the most stable and robust European party systems for many years (Müller 2006), things have evolved quite a lot in the last decade, especially with the rise of far-right political parties (Aichholzer et al., 2014) and the entry of new parties in the national Parliament. Below the main political parties in the Austrian political landscape are presented:

    - The Austrian People's Party (ÖVP), which might be considered conservative, emerged in 1945 from the former Christian Social Party and lies at the center-right of the political spectrum.
    - The Austrian Social Democrats (SPÖ), which originates from the Social Democratic Worker's Party of Austria, lies at the center-left and has dominated the Austrian political landscape, together with the SPÖ, since the end of the Second World War.

- The Austrian Freedom Party (FPÖ) is a populist right-wing party that originated from the League of Independents in 1949 to gather former Nazis and war returnees. It is often cited as a threat to Austrian democracy (Luther, 2000).
- The Green Alternative, also referred to as “The Greens”, is the Austrian green party. Created in 1986, it has not been heavily represented at the federal level, but has been gaining momentum in local and European elections.
- The Alliance for the Future of Austria (BZÖ), created in 2005 and originating from the FPÖ, sits at the far-right of the political spectrum.
- The New Austria and Liberal Forum (NEOS), created in 2014, is a merger of the Liberal Forum, which itself originated from FPÖ, and of the Young Liberals, a liberal party in Austria. One might consider it as a liberal party.

To better understand Austrian politics, it seemed important to summarize the evolution of the presidential and parliamentary elections at the national level for the last decade. It is important to note that until the 1990s, the FPÖ (far right) never really appeared as an important party. Since then the populist Austrian party has gained momentum and must now be considered as important as the two other historically dominant parties (ÖVP and SPÖ).

The rise of the FPÖ started in 1990, when the FPÖ, led by Jorg Haider, almost doubled its number of seats in the National Council, gaining most of them from the ÖVP. The increase of the FPÖ at the expense of the ÖVP continued until the 1999 parliamentary elections, when the FPÖ finished second and the ÖVP third. The 1999 parliamentary election marked the end of an era. From 1986 to 1999, federal chancellors had always come from the SPÖ, but this changed in 2000, when for the first time in a long time, Mr. Schussel (ÖVP) was appointed federal chancellor, despite the previous parliamentary elections having been won by the SPÖ. To be able to govern, Schussel formed a coalition government with the FPÖ.

In 2006, general elections were held for the National Council and the SÖP beat the ÖVP by a narrow margin of 1 percent. Without a majority, however, both parties decided to form a coalition government, bringing an end to almost six years of ÖVP/FPÖ coalitions and recalling the SPÖ/ÖVP coalitions used in the past, from 1947 to 1966 and from 1987 until 2000 (Fallend, 2009). After a long period of negotiations, a new chancellor from the SÖP was finally sworn in, in January 2007. However, this coalition broke down in 2008 following disagreements between SPÖ and ÖVP leaders about European policy. As a result, anticipated elections were organized. The SPÖ and ÖVP came out victorious again, although witnessing a net progression from the FPÖ, picking from their electorates. Werner Faymann (SPÖ), the former federal minister of transport, was sworn in as federal chancellor and a coalition government with the ÖVP was proposed.

Five years later, in 2013, National Council elections were held that were later described as a political earthquake (Dolezal and Zeglovits, 2015). The two major political parties (SPÖ and ÖVP) had never scored as low, while the FPÖ realized a net increase again. Two new parties, the liberal NEOS and the populist “Team Stronach”, also entered the Austrian parliament. Because SPO and ÖVP still had a parliamentary majority by collaborating, they kept the coalition in place and Faymann remained federal chancellor.

In 2016, Faymann stepped down as the SPÖ party leader, leading to the nomination of Mr. Haupl, then Mayor of Vienna, as new party leader. However, given the preference of Haupl to continue being the Mayor of Vienna, the president ended up swearing in Christian Kern (SPÖ), at that time CEO of the Austrian Federal Railways (ÖBB), as new federal chancellor, and he also became new SÖP party leader. Figure 4.2.2 shows a graphical representation of the last parliamentary elections in Austria.

As the federal president does not have much power in reality, and the position is often described as "ceremonial", the history of past presidents is not given here, as not really relevant. However, it is important to recall the 2016 presidential election to understand the rise of the FPÖ as a political party, and the fact that more and more Austrian voters seem to be tempted by the far right. In the second round of the Austrian presidential election, held in April 16, Mr. Van der Bellen ran as an independent, but member of the Green party, against Mr. Hofer from the FPÖ. The results of the second round were extremely tight, with Van der Bellen receiving 50.3 percent of the votes, compared to 49.7 percent for Hofer. The election was finally annulled by the Austrian Constitutional Court as there had been irregularities in the count of the vote for several constituencies (Oltermann, 2016) and rescheduled for December 2016. In the new election, Van der Bellen received 53 percent of the votes compared to 47 percent for his rival. The election of Hofer would have been the first election of a far-right candidate as the head of a Western European state.

In May 2017, the stability of the coalition in place (ÖVP-SPÖ) was questioned after the resignation of Vice Chancellor Mitterlehner (ÖVP), which occurred following disputes within the coalition government (FT, 2017). Ultimately, a new National Council election was held in October 2017. The ÖVP finished first with 62 seats, followed by the SPÖ (52 seats) and FPÖ (51 seats), demonstrating again the rise of the populist party. ÖVP leader Sebastian Kurz was ultimately sworn in as Federal Chancellor by December 2017 and proposed a coalition government with the FPÖ.

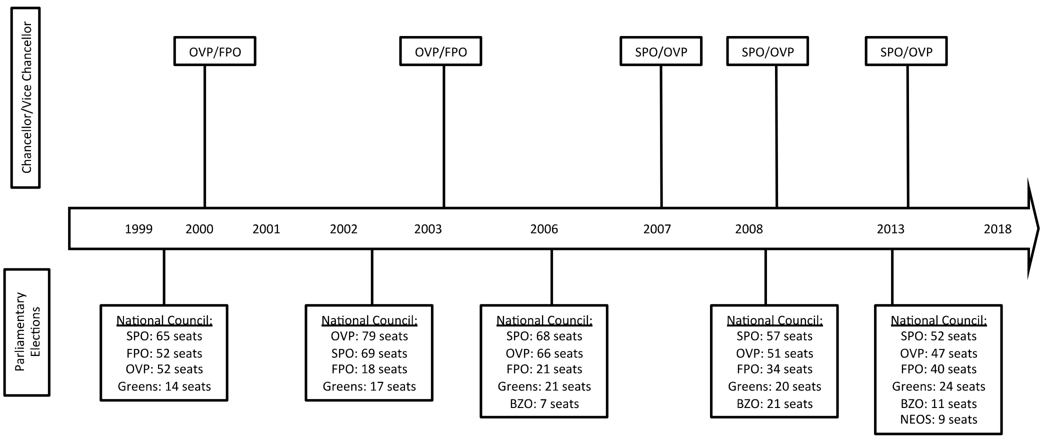


Figure 4.2-2: Austrian parliamentary elections from 1999 to nowadays

- NPM and decentralization

Compared to other European economies, Austria is located in the lower bound of utilities and state-owned enterprises privatization (Belke and Schneider, 2003). Sectors that are usually organized in natural monopolies were slow to liberalization before the 2000s, but this finally started due to EU pressure (Aiginger, 1999). The most prominent example of liberalization and deregulation of Austrian network industries can be observed in the electricity sector, which was pushed by the right-wing government (ÖVP-FPÖ coalition) at that time and resulted in the development of regional monopolies (Hofbauer, 2006). The rail sector was officially liberalized in 1998 but is still known to be heavily dominated by incumbent actors (OECD, 2013).

4.2.1.2 Local level: Vienna

- Current Situation

With 1.8 million of inhabitants as 2015, spread over 23 districts, the City of Vienna is Austria's largest and capital city, accounting in 2016 for 21.2 percent of the total Austrian population (WKO, 2016). The population of Vienna has evolved significantly over the last century. In 1910 the city was home to about 2.1 million people (Bohm, 1998), making it one of the most populated cities in Europe at that time. However, the population shrank importantly because of the First and Second World Wars and its population dipped to 1.6 million people as of 1945 (Bohm, 1998). The population continued to shrink till the 1990s, when it reached 1.49 million inhabitants (Buehler et al., 2017a) and has increased again since then.

Vienna is part of what is often referred to as the Viennese Metropolitan Area, which constitutes surrounding municipalities from neighboring states of Lower Austria and Burgenland. The Vienna Metropolitan area was home to 2.4 million people as of 2013 (City of Vienna, 2015e). The increase in Viennese population, as well as the Viennese metropolitan population is mainly due to migration from newly integrated countries in the European Union (Cox, 2009).

Politically, Vienna holds both status of city and Lander, which is unique in Austria. Like all Landers, it functions with a unicameral parliament (the Vienna Landtag), composed of 100 members, that in this case serves both as Municipal Council and State Legislature (Buehler et al., 2017a). Due to the double status of the city of Vienna, as Lander and state, the city's mayor is also the state governor and *de facto* is not directly elected by the Viennese citizens in municipal elections. He is chosen from the Viennese Landtag majority and sworn in by the federal president. Vienna's highest executive body is the Vienna Provincial Government, which is headed by the governor/mayor and formed by 12 city councilors.

Vienna is a socialist city. From 1945 till 2010, Vienna always had SÖP mayors as well as SÖP transport ministers. The current SÖP mayor, Mr. Haupl has been in office since 1994. Since 2010, however, the SÖP has entered a coalition with the Green Party, putting an end to its historical coalition with the ÖVP. As a result, Ms. Vasilikou from the Green Party has held the vice-mayor chair in charge of transport since 2010 (Buehler et al., 2017a). Figure 4.2.3 maps the different jurisdictions within the city of Vienna.

Figure 4.2-3: map of Vienna and its 23 districts (adapted from Viennamap360.com)

Vienna is often noted as having the top ranking on the well-known Mercer index for quality of life (Buehler et al., 2017a). It also ranked well on the Siemens Green City Index, achieving fourth position in 2009. Economically, Vienna has a GDP of €47,300 per capita, which has remained stable from 2014. In comparison, the GDP per capita of surrounding landers, part of the Viennese Metropolitan Area, in 2013 were €31,100 for Lower Austria and €26,100 for Burgenland. The Viennese economy is mainly dominated by Services (85.5 percent of the 2014 gross value added) and industry (15 percent) (City of Vienna, 2016). The unemployment rate in 2015 was 13.5 percent, which is higher than the national average of 9.1 percent (WKO, 2016).

From an environmental point of view, in 2013 (latest data available) each Viennese citizens emitted 2.8 tCO2eq (City of Vienna, 2016e). Motorized traffic was estimated to have caused about 40 percent of Viennese $C0_2$ emissions (City of Vienna, 2015a).

- Actors

Local public transport in Vienna has long been characterized by public ownership and political responsibility, and there is no sign that this will change in the near future (Kostal et al., 2014). Below are presented all the actors having been involved in the development of IMPs:

- The Ministry for Transport, Innovation and Technology (BMVIT) is the federal ministry responsible for transport policy, applied research and technology development. In terms of transportation, the BMVIT is in charge of policy, as well as planning, organizing and providing a financial base for railway and urban public transport services (ICF, 2016). In Austria, transport services are contracted out based on the federal law on tendering (Bundesvergabegesetz), the federal law on licenses for operators of bus services (Kraftfahrlinien Gesetz), and the general law on the organization of local public transport (ÖPNRV law). The BMVIT also owns the Austrian Federal Railways (ÖBB).

- The Austrian Research Promotion Agency (FFG) is the national funding agency for industrial research and development in Austria and was founded on September 1, 2004. It is owned by the Ministry of Transportation (BMVIT) as well as the ministry of Science, Research and Economy (BMWFW). Through tenders, it grants donation to applied research projects, up to 80 percent of the project costs, that fit the focus areas and strategic goals preliminary established by the BMVIT and the BMWFW. In the field of mobility, the FFG usually releases two to three call for proposals a year, with a budget of €12–15 million.

- The Climate and Energy Fund (Klima und Energi Fund) is the Austrian fund for climate and energy, founded in 2009 by law. It belongs to the Ministry of Transportation (BMVIT) and the Ministry of Environment (BMLFUW). Through tender, it administrates funding to projects that help reaching the short- and long-term goals of the federal government in terms of greenhouse gases emission reduction, energy consumption reduction, as well as diversion from fossil fuels and increase in renewable energy production. It has three focus areas: research and development, mobility, and market penetration of green technologies. Its total annual budget fluctuates from €100–150 million.

- Austria Tec is the technology agency of the Ministry of Transport Innovation and Technology (BMVIT), founded in 2005. Their activities range from policy advice to the operation of infrastructure or services and supervision of specific smart mobility projects.

- The City of Vienna oversees policy and planning and is composed of 70 municipal departments referred to as Magistrat (MA). Magistrats are bundled under the responsibility of one of the 12 City Councilors that sit in the Viennese Provincial Government (Landtag). Transport-related responsibilities are shared among three city councilors:

    - ❖ Ms. Vassilakou from the Green Party is the vice-mayor and executive city councilor for urban planning, traffic and transport, climate protection, energy and public participation, who entered the local government after the 2010 municipal elections. Under Vassilakou's watch lies the MA18, in charge of transport planning.

    - ❖ Ulli Sima, from the SÖP, executive city councilor for the environment and Vienna public utilities.

    - ❖ Renate Brauner, from SÖP, executive city councilor of finance, economic and international affairs.

- The Wiener Stadwerke (WS) is the City of Vienna public utility company. It is 100 percent owned by the City of Vienna and is one of Austria's largest companies. It has a turnover of about €2 billion. It is organized into different subsidiaries. The most important subsidiaries are Wien Enegie, in charge of supplying energy to Viennese citizens, Wiener Netz, an electricity and natural gas distribution operator, Wiener Linien in charge of providing public transport services, and WIPARK, in charge of operating car garages over Vienna.

- The transport authority of the city of Vienna is Wiener Linien (WL), which is 100 percent owned by Wiener Stadtwerke. It operates under a contract with the city of Vienna. The WL owns the tracks, stations and vehicles and its main tasks are to operate buses, trams, and underground railways, and to manage traffic (planning routes and timetables, coordinate activities, sales and marketing, quality management system, etc.). As part of its duty in managing the system, Wiener Linien operates the five metro lines, 29 lines of light rail/tram services, and approximately one-third of the 115 bus lines. Wiener Linien is responsible for setting fares, although those need to be harmonized within the regional transport association for East Austria (VÖR). Wiener Linien also puts part of the bus routes out for competitive tendering. Wiener Linien receives its income from transport fare revenue and from subsidies. All of the subsidies that WL receives come from the city of Vienna when it comes to operational expenses (fixed amount every year) and investment in infrastructure such as stations and vehicles (variable). For the construction of new underground tracks, WL receives half of the funding from the City of Vienna and the other half from the Austrian Federal Government.

- Upstream is a company founded in 2016 as an outcome of the SMILE project. It is 51 percent owned by the Wiener Linien, and 49 percent by the Wiener Stadtwerke. Its main purpose is to use previous experiences to build digital tools for mobility. Upstream currently receives most of its budget from the Wiener Stadtwerke and Wiener Linien and is expecting to be able to finance itself within the next 3–5 years.

- The ÖBB (Österreichische Budesbahnen) is the federal railway company and is fully owned by the federal government. ÖBB is organized in different subisidiaries. ÖBB Personenverkehrs, which is an ÖBB subsidiary, takes care of passenger transport, by operating about 4000 trains a day, 3600 of which are local transport (commuting trains). ÖBB, for example, operates the Vienna S-Bahn. ÖBB Infrastruktur operates and manages the train infrastructure over Austria, which is owned by the federal state. The ÖBB rail network length in 2013 was 4859 km, 72 percent of which was electrified (Emberger, 2017).

- iMobility was founded in 2015 as an outcome of the SMILE project. It is a joint venture between the ÖBB, and a famous Austrian Venture Capitalist Fund called Speedinvest.

- Fluidtime is one of Austria's leading suppliers of IT systems for integrated mobility, since 2004. The company develops and operates user-friendly software solutions and mobile services in the fields of integrated mobility and traffic data management. Fluidtime specializes in the development and design of information, ticketing, and booking systems. It is 75 percent owned by Kapsch, a leading Austrian company in the field of telematics.

- CityBike is the first bike-sharing scheme that was implemented in Vienna, back in 2003. It is provided by the advertising company Gewista and is the largest bike sharing system currently in place in Vienna, with 120 stations and some 1500 bikes. In 2016 it provided more than 1 million rides and had about 800,000 registered users.

- Car2go is a subsidiary of Daimer AG providing free-floating carsharing services in about 30 cities across Europe and North America, including Vienna, which regularly ranks in car2go's top five cities worldwide, in terms of number of rentals and average number of rentals per cars. Since 2013, it has provided 700 gasoline-powered cars over a business area of 101 km^2, covering all 23 districts of Vienna, at least partially. After having created a car2go account online, car2go customers are able to book shared-cars through a single click on the car2go app on their smartphones. They are also able to see on the app what cars are available around them and check the fuel gauge or battery state of charge of surrounding vehicles. There are approximately 125,000 registered car2go users in Vienna.

- ETA is a consulting company with approximately 10 staff, which was founded in 1994 in Vienna and historically specialized in environmental management. In recent years, ETA has been increasingly involved in the urban transportation sector, dealing with integration, shared, automated, and electric mobility projects.

- Taxi 31300 is one of the main Viennese taxi companies. Created in 1969, first as a family business, Taxi 31300 operates as a taxi dispatch center, bundling services from about 700 taxis and 2500 active drivers.

- Metropolitan governance in Vienna

As both a city and a lander, Vienna does not have any additional administrative layer to deal with the issues happening at the metropolitan level. Being surrounded by the Land of Lower Austria, and close to the Land of Burgenland, the PGÖ (PlanungsgemeinschaftOst) was created to coordinate and prepare regional plans as well as cross-border issues (Patti, 2017). In 2006, the Stadt Umland Management (SUM) was also created as an association between the City, the Land of Vienna and the Land of Lower Austria to ensure communication and co-ordination among different planning institutions (Patti, 2017).

Many European countries consider Austria to have best practice when it comes to metropolitan coordination for transportation systems, as regional transport associations, gathering the different involved stakeholders, have been created all over the country. In the case of the Viennese Metropolitan Region, the VÖR (Verkerhrsverbund Ostregion), established in 1974, deals with timetable and tariff coordination across the metropolitan region. The VÖR also orders public transport from the main railway, bus, and tramlines operating in Vienna (Jansen, 2017). VÖR also pays compensation to the operators for revenue losses due to integrated fares. It is 44 percent owned by the state of Vienna, 44 percent by the state of Lower Austria, and 12 percent by the state of Burgenland. The VÖR catchment area is approximately 3.6 million inhabitants. The VÖR chairman is a SPÖ member of the Vienna City Council, while the vice-chairman is an ÖVP member from Lower Austria Landtag. However, the VÖR is often described as ineffective at designing solutions for the entire metropolitan area, due to internal political conflicts.

Due to its proximity with the neighboring Slovak capital of Bratislava, Vienna has also been presented as being part of a wider Vienna–Bratislava metropolitan region, which is recognized as a functional entity by the European Union (Schremmer, 2003). Again, however, one can witness the lack of cross-border metropolitan governance institutions (Sohn and Giffinger, 2016), especially when it comes to transport. Below the historical development of the Viennese transportation system is presented to better understand the context in which integrated mobility platforms have developed in recent years.

4.2.2 Historical development of the Viennese Transportation System

Since its creation, the city of Vienna has developed as a compact monocentric city, using mixed land use, leaving little room for private cars (Buehler et al., 2017a). Urbanist Otto Wagner is acknowledged as having shaped Vienna as it is known today and using urban planning techniques to promote and facilitate movements of people on the streets. The Austrian capital city is often considered urban planning best practice. Paal (2003) argued that the city of Vienna had developed through five distinct phases, which are detailed below, along with key transport infrastructure development in each of those phases.

4.2.2.1 Founder's period (1857–1914)

Following the demolition of the historical city walls and moats by Austro-Hungarian Emperor Franz Joseph of Austria in 1850, and the establishment of the Bauzonenplan to frame the land development of Vienna, the late 1860s marked the beginning of the professional public transport era in Vienna. Indeed, it was during that time that the first horse-powered tramway was introduced, between Schottenring and Hernals Streets. This was followed in 1867 by the awarding of the first license by the City of Vienna to legally transport passengers. The tramway industry continued its growth, and the Neue Wiener Tramway-Gesellschaft (the New Vienna Tramway Corporation) was founded in 1872, which started to expand the tramway system into Vienna's suburbs (Kostal et al. 2014). The development of the tramway network underwent a major change in 1897, when the electrification of Vienna's tramways was commissioned; this was largely completed by 1903 (Wiener Stadtwerke, 2015). At that time, the entire tramway network, which had been privately owned and operated until then, came under public ownership after the takeover by Vienna Mayor Mr. Lueger, who established the Stadt Wien-Städtische Straßenbahnen in 1903 (City of Vienna-City Tramways) (Kostal et al. 2014).

1898 marked the opening of the Metropolitan Railway, which paved the way for the Viennese metro system as it is nowadays. The steam-powered metropolitan railway at that time was operated by the Federal Railways. Following what happened to trams, this Metropolitan Railway was electrified in the beginning of the 20th century. Following the establishment in 1881 of the precursor of bus services with the Erste Pferdestellwagen-Gesellschaft (First Horse-Drawn Bus Corporation), the bus network underwent further development at the beginning of the 20th century before being incorporated into the City Tramways company in 1922 (Frank, 1960).

4.2.2.2 *Intermediate war period (1918–1934)*

The inter-war period was marked by intensive communal housing development as well as the establishment of the land development plan. During those years, expropriation was established by law to facilitate urban development (Paal, 2003). 1922 marked the last year of operation of steam-powered tramways, which were all electrified after that date (Emberger et al., 2013).

4.2.2.3 *Post-war period (1945–1970)*

The city of Vienna was severely damaged during the Second World War, after which the city underwent a major phase of reconstruction. Many buildings were demolished and reconstructed and the city was considerably expanded (Paal, 2003). The Wiener Stadtwerke was founded in 1949 as a merger of different municipal companies, including the municipal transportation company (City Tramways). The city's tramway system, which was one of the largest in the world prior to the war, also went under major restoration projects and could only reach its pre-war level in 1950 (Kostal et al. 2014). As the city was experiencing important post-war growth, it was decided in 1954 to undertake the construction of the Vienna Metropolitan Railway (S-Bahn) as a part of reconstruction of the national railway network. Although already planned in 1955, the S-Bahn took quite some time to become a reality as a lack of funding caused delays (Kostal et al. 2014). The first junction of the Viennese S-Bahn was inaugurated in 1962 (Wiener Linien, 2014). In 1969 construction of the Vienna U-Bahn (underground) began, voted by the governing Social Democrats, which had been also supported by the Conservative Party (ÖVP) since the 1950s (Pirhofer and Stimmer, 2007).

4.2.2.4 *Consolidation (1971–1989)*

In 1974 the Verkehrsverbund Ost-Region (VÖR) was established, which is thought to have contributed in increasing PT ridership during a period of rising vehicle ownership (Pucher and Kurth, 1996). The 1970s were also marked by infrastructure projects that have contributed to lock private car use in the capital of Austria. In 1978 an urban motorway was opened, which at that time was intended to relieve the crowded city center. However, this motorway had the opposite effect as it worsened traffic conditions, air quality, the local economy and increased congestion in downtown districts (Knoflacher, 2007).

The 1970s and 1980s were marked by the development and implementation of the municipal plan for urban development (STEP84), which aimed to rediscover the inner city and implement urban renewal projects (Paal, 2003). It also marked the further development of the Viennese urban rail. The first U-Bahn line was inaugurated in 1978 and completed by 1982 by two other lines, forming at that time a 30km U-Bahn network (Hofling, 2010), which was expanded to 41 km during the 1980s to finally reach its current size of almost 80 km, along five lines and 101 stations, in 2015 (Prillinger, 2015).

In the 1980s, the *City of Vienna Transport Plan* set the groundwork for the development of the bike network. A dedicated position was then created by Mayor Helmut Zilk in 1990 to pursue the development of the bike network. In 1993, parking management was implemented in Vienna's First District (Buehler et al., 2017a) with the aim of better managing parking in the most central and crowded district in Vienna. The 1980s were also marked by the beginning of pedestrian-friendly policies to help reduce car use. Street calming strategies, such as limiting vehicle speed to 30 km/h and encouraging mixed usage of streets were implemented, but more at the district than the city level (Buehler et al., 2017a).

4.2.2.5 *Internationalization (1990–nowadays)*

The Austrian federal constitution does not require Austrian municipalities to develop urban mobility plans, so it is up to each municipality to deal with its traffic. The city of Vienna has understood this for a long time and has taken this issue seriously. To tackle car dependency, in 1994 the City of Vienna established an urban mobility plan entitled “*Wiener Verkehrskonzept 1994*” (STEP94), which included the extension of the U6 line, the construction of the U3 line, new parking charge schemes, as well as the development of the bicycle network (Emberger, 2006).

Since the beginning of the 1990s, the City of Vienna has adopted a new planning strategy aimed at positioning itself better on the international scene. From a transport point of view, the public transport system continued expanding, potentially thanks to the 1991 Austrian Master plan, which aimed to make public transport more attractive (Emberger, 2017). Major institutional changes also occurred. In 1999 Wien’s utility company, managing transport, energy and other services, Wiener Stadtwerke, was corporatized and transferred to a newly established joint-stock company, Wiener Stadtwerke Holding AG, which was fully owned by the City of Vienna. Wiener Linien GmbH and Wiener Linien GmbH & Co KG were specifically founded as Wiener Linien subsidiaries responsible for transport activities (Kostal et al. 2014). In the late 1990s Wiener Linien experienced NPM approaches when starting to put some of the Viennese bus network routes to competitive tendering (Hermann, 2006). Today it is estimated that at least a third of the bus routes in Vienna are still operated by Wiener Linien, and the other half by other bus operators, such as Postbus (a 100 percent owned subsidiary of ÖBB), Dr. Ricard, Blaguss or Zulkin.

In 2003 the first *Transport Master Plan for Vienna* (Jansen, 2017) was developed, which laid down transport and traffic development for the next 20 years. Among other measures, the 2003 Transport Master Plan, entitled *Smart Moves*, targeted, by 2020, to reduce motorized individual traffic to 25 percent of all trips, increase bicycle traffic share to 8 percent, increase public transport share from 34 percent to 40 percent, and invert the modal split for public transport vs. motorized individual traffic across municipal borders from the current 35/65 percent to 45/55 percent (City of Vienna, 2014b). It also planned the development of park-and-ride facilities at the city’s limits (City of Vienna, 2003), to encourage people to shift from personal cars to public transport when entering Vienna’s urban core.

Since 2005, the city of Vienna has also conducted a major transit-oriented development project with its Aspern Development project. Located on Vienna’s former airfield, the project connected to the city center via public transportation (U2) since 2013, is expected to host 26,000 new residents by 2030, as well as businesses and recreational services at a walking distance, in order to reduce the temptation of residents to use private motorized vehicles.

The biking culture dynamics continued in 2003, when the first bike-sharing system, called CityBike, was inaugurated (Buehler et al., 2017a). The advertising company Gewista, which had close ties with French Advertising company JCDecaux, was awarded by the City of Vienna a contract to build and operate a bike sharing system for the next 10 years. The first 60 stations were financed from advertising, while the next 60 stations were financed by the City of Vienna. The system currently accounts for 120 stations and approximately 1500 bikes. Vienna was the first large-scale bike-sharing system worldwide, which paved the way for the roll-out of renowned bike sharing schemes across Europe, such as Velib’ in Paris or Velov’ in Lyon. From 1990 to 2014, it is estimated that the size of the bike network was multiplied by a factor of six, from 190 to 1200 km. Also, 2003 saw the development of the first *Vienna Urban Mobility Plan*, which aimed to reduce the $C0_2$ emission per person originating from the transport sector by 5 percent, increase the security of the transportation network, increase the capacity of the tram network by expending it, increase the efficiency of the transport network by giving right of way to public transport, and replace the tram rolling stock with ultra-low floor trams (Emberger, 2006).

The year 2010 represented a turn in transport policy in Vienna. In that year, following the municipal elections, Maria Vassilakou became deputy mayor of Vienna in charge of planning, transport, climate change, energy and public participation. Since then, Vassilakou has attempted to develop more sustainable transport policies. For example, she proposed reducing the price of the annual public transport ticket to €100 before coming back on her proposition and finally setting the annual ticket price at €365, symbolically at €1 per day (Buehler et al., 2017a). Vassilakou has also pushed cycling higher on the Viennese political agenda.

In December 2011 the carsharing service car2go started in Vienna, which initially proposed 350 free-floating cars. The size of the fleet quickly increased to 500 by April 2012 and 700 by the end of 2013. The roll-out of car2go services has also been possible thanks to an agreement made with the city of Vienna along which car2go has to pay an annual fee of €2500 per car to the city to allow its cars to be parked anywhere in Vienna. This represents significant income for the city of Vienna as well as an interesting agreement for the carsharing operator. Following an inquiry from the ÖVP City Council members, a study was commissioned by the City of Vienna in 2012 to understand the impact and acceptance of carsharing services in Vienna. After two years of data collection, the results, released in 2015, showed that each carsharing vehicle was synonymous with a reduction of five private cars, and that carsharing did not take any customers away from public transport. In the meantime, DriveNow, a joint venture by BMW and car rental company Sixt, started providing free-floating car-sharing services in 2013 and nowadays provides some 500 vehicles to its users in Vienna.

In 2011, as part of the Model Regions of Electric Mobility program from the Climate and Energy Fund, Wiener Stadtwerke Holding AG was awarded a contract to develop the "e-mobility on demand" (eMoD) Model region for Vienna. Undertaken by a consortium led by NeuMo, a subsidiary of the Wiener Stadtwerke, the project resulted in the installation of 350 charging stations, the testing of electric buses on some public transport routes, as well as research about behavioral use of electric vehicles (Klima und Energiefonds, 2015). The project ran from 2012 to 2015.

Initiated in 2011, the *Smart City Vienna Framework Strategy* was presented to the public in 2014, aiming to guide Vienna through the 21st century and help the Austrian capital achieve growth while reducing resource consumption. The document proposed a list of rather broad objectives in terms of climate impact reduction, innovation development, and improvement of the quality of life. In terms of mobility, the strategy's objectives are the following (City of Vienna, 2014a):

- Increase human-powered mobility modal share; decrease the number of trips done by private motorized traffic to 20 percent by 2025 and less than 15 percent by 2050; maintain the percentage of trips realized by public transport.
- By 2050, all motorized individual traffic within the municipal boundaries is to make do without conventional propulsion technologies.
- By 2030, commercial traffic originating and terminating within the municipal boundaries is to be largely CO_2-free.
- Reduce energy consumption by passenger traffic across municipal boundaries by 10 percent in 2030.

Surprisingly no ICT-supported tools are promoted to reach those targets, and no mention is made of integration and/or intermodality.

Following the Smart City Vienna Framework Strategy, the City of Vienna proposed in December 2014 a new Sustainable Urban Mobility Plan (SUMP). The plan targeted to reduce by 2025 the use of individual motorized vehicles to 20 percent of all trips, and to reduce by 20 percent the energy consumption associated with transport activities. It also targeted a 30 percent increase in the share of citizens walking and cycling more than 30 minutes per day, for example by planning the development of more long-distance cycling routes

(City of Vienna, 2015d). Prepared as a response to the Smart City Framework Strategy, the new SUMP stressed the need to develop multi-modal transport from door-to-door as well as incentivize Viennese citizens to share rather than own:

> *"The citizens of Vienna do not need to own cars to be mobile. Cars can readily be hired if needed. Bicycle sharing systems supplement public transport." (City of Vienna, 2015b: 10)*

The plan also underlined the need for closer networking of mobility players, as well as joint marketing of various services. The Smart City Vienna Framework strategy was also followed in 2015 by the publication of the *E-mobility Strategy* of the City of Vienna, which proposed measures for the electrification of vehicle fleets as well as the installation of the required charging infrastructure. However, the strategy stayed vague on ways to get there, as it specifically underlined that EVs should neither benefit of any special parking rule, nor be able to use public transport lanes (City of Vienna, 2015a). Again, nothing is mentioned about integration of EVs to other transportation modes, or about intermodality.

In the last few years, the City of Vienna has been working on metro extension and modernization. While modernization of the U4 started in 2014, an extension of the line U1 to the south is to be completed by 2017, of U2 to the south by 2028, as well as of U5 (City of Vienna, 2016d).

Regarding non-conventional passenger transport, Uber started operations in Vienna in February 2014. While it has not yet been subject to any particular regulation, the City of Vienna voted in April 2017 for a new regulation aiming at regulating ride-booking services more heavily. The "*Wiener Landesbetriebsordnung für das Taxi und Mietwagen-Gewerbe*" (LBO), which came into effect in January 2018, requires ride-booking drivers to have a special license.

In 2016 the Smarter Together project was launched, an EU-funded project in collaboration with the cities of Lyon and Munich that aims to implement innovative smart city concepts combined with urban renewal strategies at the district level. Many partners from different horizons are collaborating under this project, such as Wiener Stadtwerke and its subsidiaries, several municipal departments, but also private companies such as Siemens, Sycube, and Caruso. In terms of mobility, Smarter Together proposes the construction of "mobility points," which are physical points that integrate different modes of transportation (such as public transport with e-bike sharing or car sharing), supposed to fit users' needs (City of Vienna, 2016a). A summary of the institutional and infrastructural evolution of transportation in Vienna can be seen in Figure 4.2.4.

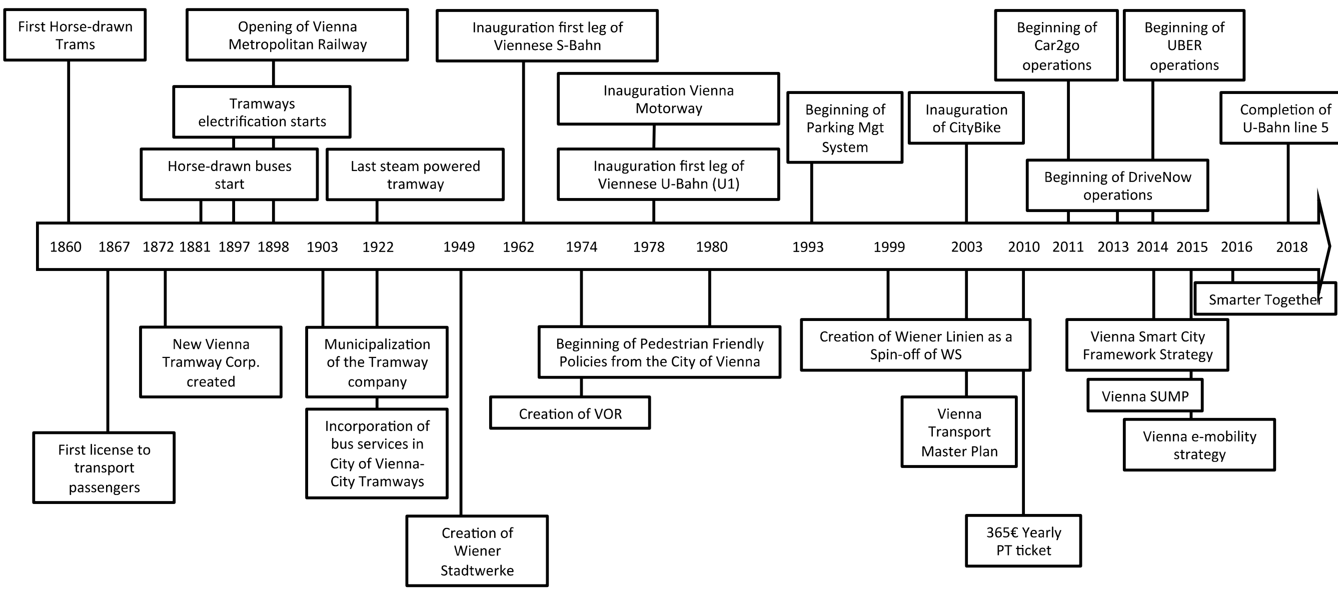


Figure 4.2-4: institutional and infrastructural evolution of the Viennese transportation system from 1860s to present (author's elaboration)

4.2.2.6 Transport in Vienna presently

Through various policies and measures, the City of Vienna has succeeded in reducing car use by 13 percent over the last 25 years. From 1990 to 2014, car use went from 40 percent to 27 percent of daily trips, public transport increased from 29 percent to 39 percent, and bike trips increased from 3 percent to 6 percent, while pedestrian trips held steady at 28 percent of daily trips (Buehler et al., 2017a). Figure 4.2.5 shows a summary of the evolution of modal shares (percent) for the Vienna Metropolitan Area.

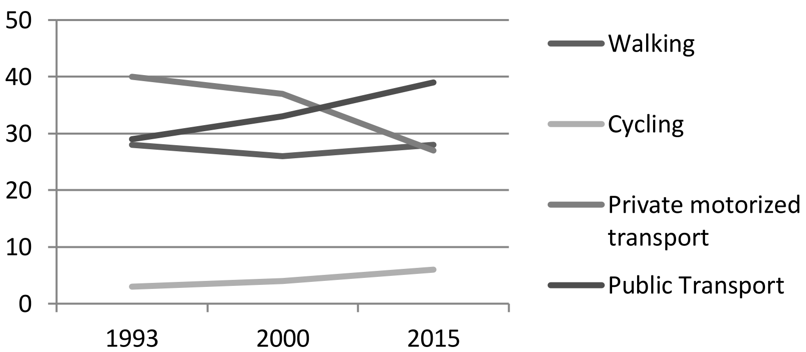


Figure 4.2-5: modal share evolution in Vienna metropolitan area from 1993 to 2012 (adapted from Buehler et al. 2017b)

Although private motorized transport constituted the first travel mode in the 1990s, it was overtaken by public transport in the early 2000s. Private motorized transport was even overtaken by walking in the 2010s. In 2015, 954 million people were transported by WL services (WL, 2016). SBahn, which is provided by the Austrian Federal Railways, also accounts for a significant share of trips within Vienna. Despite the absence of clear data, we learned from that SBahn represented about 20 percent of public transport ridership (IV7), as represented in Figure 4.2.6.

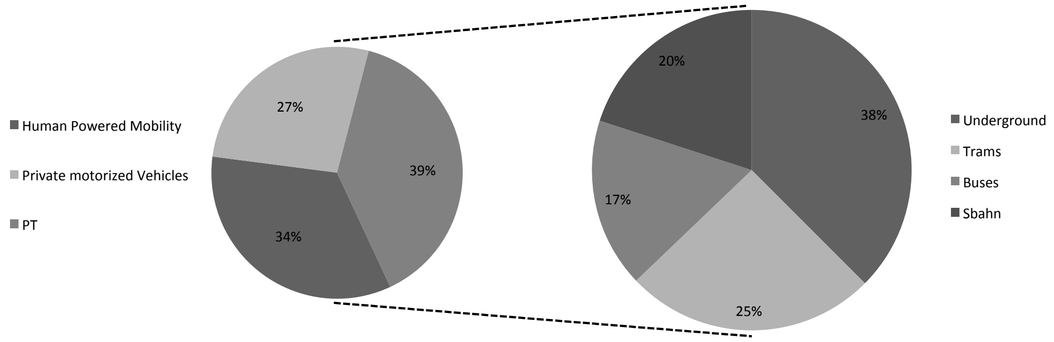


Figure 4.2-6: modal share in the city of Vienna in 2016 (author's elaboration, based on data from City of Vienna [2016])

Although private car ownership increased steadily from the 1960s to the 2000s, from about 90 cars to 395 cars per 1000 inhabitants (Buehler et al. 2017b), the rate of private motorization has been decreasing in recent years. As of December 31, 2016, there were 685,570 cars registered in Vienna and 698,968 annual public transport passes issued. Thus, for the first time in history, the number of public transport passes ex-ceeded the number of registered cars (City of Vienna, 2016c). The evolution of the number of annual season tickets holder is quite impressive, as Figure 4.2.7 below shows:

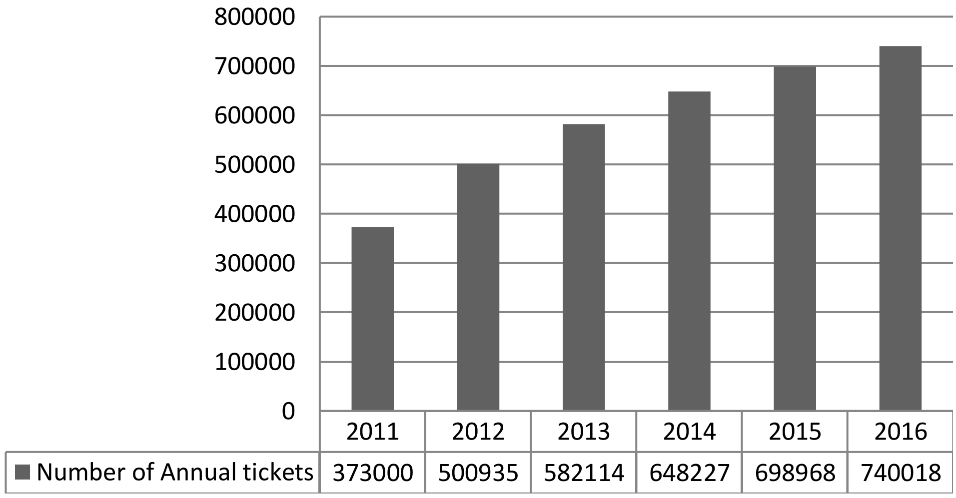


Figure 4.2-7: evolution of the number of public transport yearly passes in Vienna (author's elaboration, based on data from WL [2015; 2016])

Due to the wide penetration of seasonal tickets, single tickets only represent 11.6 percent of WL revenue (WL, 2016). In 2016, Vienna had the lowest car ownership rate among all Austrian provinces, with 372.5 cars per 1000 inhabitants (City of Vienna, 2016c). This is significantly lower than in the 2000s and approaching the 1990s level of 375 cars per 1000 inhabitants (Buehler et al. 2017a). Regarding the amount of space used by transport infrastructure, roads occupy 14.4 percent of Vienna's land surface (City of Vienna, 2016).

However, it is important to note that these data are related to the City of Vienna alone and do not take into account the whole Viennese Metropolitan Area. Although the transportation system in Vienna city center does not seem to rely any longer on the use of personal cars, it is not the case for citizens living in the outer Vienna, and not true at all for citizens living in the Viennese suburbs. Most people living in the suburbs still use their personal vehicles to commute to the city center.

Eurostat estimate that while there were some 381 cars per 1000 inhabitants in Vienna in 2014, there were 609 and 640 cars per 1000 inhabitants for Lower Austria and Burgenland, respectively. It was also estimated that there were 2.1 public transport vehicles per 1000 inhabitants in Vienna, compared to only 1.1 and 0.9 public transport vehicles per 1000 inhabitants for Burgenland and Lower Austria, respectively (Eurostat, 2016). Figure 4.2.8 below shows the evolution of private car ownership rate for the states of Vienna, Lower Austria, and Burgenland, and one can observe that the three states are not following the same path when it comes to reduction of the number of motorized vehicles per 1000 inhabitants. While the numbers are going down for Vienna, they are clearly increasing for the two other surrounding states that are part of the Viennese Metropolitan area.

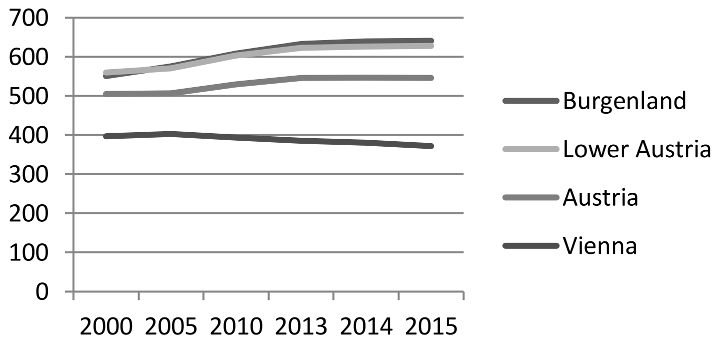


Figure 4.2-8: Evolution of the number of passenger cars per thousand inhabitants for Vienna, Lower AT and Burgenland (adapted from WKO [2016])

Thus, the situation seems to be very different considering the whole metropolitan area. This is also valid for modal share as can attest figure 4.2.9.

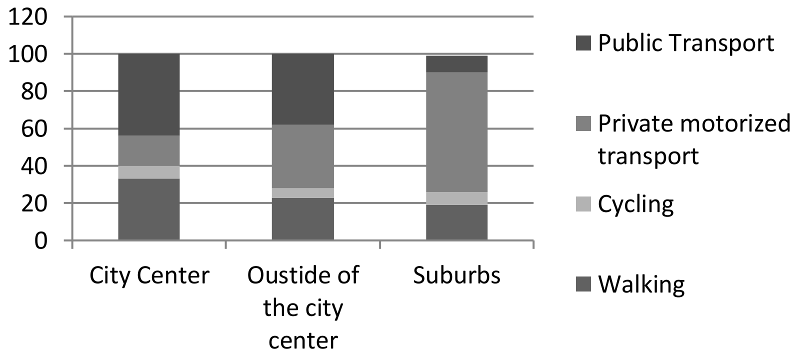


Figure 4.2-9: spatial variability of modal share between Vienna city center, periphery and suburbs (adapted from Buehler et al. 2017b)

However, there are very few recent available data that take into account commuters who come from the neighboring states of Lower Austria and Burgenland. It is estimated that up to 500,000 cars commute to Vienna from neighboring states on a daily basis.

> *"When I come to work, I can see that on the highway entering Vienna, two-thirds of the plates are not from [here] (…) People working here [in Vienna] and from the outer parts have company cars so they have a Vienna plate, but they are from Burgenland. There are even more people commuting by car than you think."* (IV10)

Thus, modal share figures are quite different for the Viennese Metropolitan Area than for Vienna itself. In 2010, approximately 80 percent of commuting trips (from Viennese suburbs to Vienna city center) were made by private motorized vehicle, compared 20 percent by public transport, mainly through the SBahn (Prenner, 2015). The traffic figures that are proudly announced by the City of Vienna do not take commuting into account, which is definitively part of the problem.

4.2.3 Evolution of climate policies

Here the evolution of climate change policies at the local and federal levels is given and summarized in figure 4.2.10. In comparison with other European countries (such as the Nordic countries), Austria has not been quick to define and implement Agenda 21 (ICLEI and difu, 1999). In Vienna, the Agenda 21 process only started in 1997 and faced important issues regarding its implementation at the whole city level. As a result, it was only implemented for some of the 23 Viennese districts.

One might consider the first national climate change policy to be the *2002 Austrian Strategy for Sustainable Development*, proposed by Austrian authorities to comply with UN requests. The strategy proposed to decrease energy intensity by 1 percent per year, increase the share of renewable energy by 1 percent per year, and decrease greenhouse gas (GHG) emissions by 13 percent until 2008–2012, following the Kyoto protocol (Martinuzzi and Steurer, 2003). However, the strategy was criticized for lacking a clear implementation plan (Martinuzzi and Steurer, 2003). Although the plan did include a dedicated part on transport, it did not set any specific targets for transport-related CO_2 emission reduction (BMLFUW, 2002).

In 1999, the City of Vienna started its climate action program, entitled *KLIP*. The first version of the KLIP, named KLIP I, aimed to limit transport-related CO_2 emissions to a 5 percent increase by 2010 compared to 1987 levels, as well as to increase human-powered mobility modal share and car-pooling activities (Magnin and Lacassagne, 2003). KLIP II was accepted in 2009 by the Vienna City Council and proposed a 21 percent reduction of GHG emission per capita by 2020 compared with the 1990s levels. In terms of transportation, KLIP II continued to promote human-powered mobility modes and public transport against private car use, but without setting new emission reduction targets for transport. It also emphasized the need to better combine mobility modes with one another in order to better fit Viennese citizens' mobility needs (City of Vienna, 2009).

In 2004, the Ministry of the Environment created the *Klimaaktiv initative,* which aimed to develop standards, train professionals, and create a network of professionals involved in sustainable development. In particular, the initiative planned to offer consultation and financial support to municipalities in different fields, including mobility management (Eltis, 2016). Following the definition of the 3*20 targets by EU leaders, the Climate and Energy Fund was founded, which aimed to fund initiatives that would help achieve national climate change targets. In 2011, the *Austrian Climate Protection Act* was passed, establishing the National Climate Protection Committee (NCPC) and a National Climate Protection Advisory Board (NCPAB). However, the Act failed to provide new GHG emission reduction targets. The Austrian Climate protection Act was amended in 2013, but again failed to adopt ambitious GHG reduction targets. According to Tobin (2015), the failure of the Austrian State to define bolder climate targets can be explained by its lack of alternative for energy production, direct consequence of the 1978 referendum, in which a majority of the population voted against nuclear power production.

In 2014 the *Smart City Wien Framework Strategy* was adopted, which sought a 35 percent CO_2 emission reduction by 2030, as well as an 80 percent CO_2 emission reduction by 2050, both compared to 1990 levels. The strategy also aimed to have between 20 percent of the energy consumed in Vienna come from renewables by 2030, and 50 percent by 2050. The strategy ultimately planned for all individual motorized traffic vehicles to be fossil-fuel free by 2050 (City of Vienna, 2014a).

In 2017 the new *Austrian Energy and Climate Strategy*, which aimed to propose new measures to fit EU targets and honor the Paris Agreement, was supposed to be released. However, the definition of this document was delayed due to the resignation of the vice chancellor, Mr Mitterlehner (ÖVP), in May 2017, as well as the victory of the ÖVP at the National Council elections in October 2017. Quite a few measures are expected to concern transport in the document, such as the promotion of shared and integrated mobility modes to help reach climate goals.

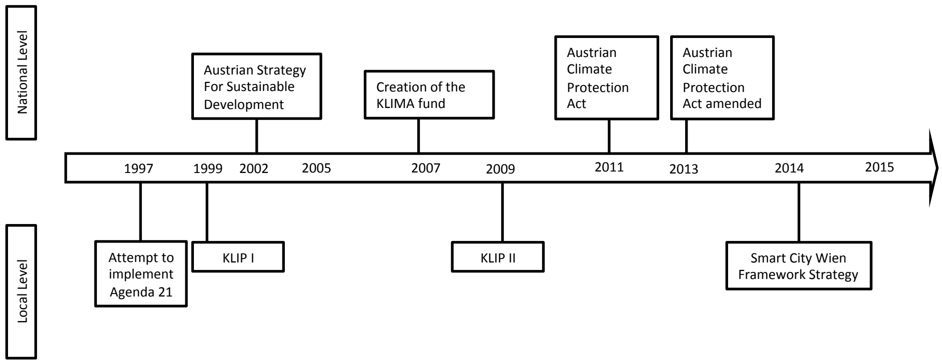


Figure 4.2-10: evolution of climate change related policies at the local and national levels (author's elaboration)

In the following part, we review the main events having had an impact in the development of Integrated mobility platforms in Vienna.

4.2.4 The development of integrated mobility platforms (IMPs) in the Vienna Metropolitan Area

In conjunction with the *Austrian General Transport Plan*, the Federal Ministry of Transport, Innovation, and Technology (BMVIT) published in 2002 the *Transport Telematics Offensive 2002+*, which aimed to promote telematics and integrated transport management to shape transport flows more efficiently as a whole and ultimately reduce congestion and travel times (BMLFUW, 2002). The early 2000s also saw the development of several federal research programs that aimed to support the development of intelligent mobility services, such as Move or IV2S (Intelligent Transport Systems and Services). Within the IV2S initiative, the Impulse program I2 focused specifically on the development of transport telematics and ITS, in order to create for example "*up-to-date traveller information systems*" or "*innovative mobility and transport concepts with modern approaches in regard to intermodality*" (BMVIT, 2006: 13). In total, about 95 projects focusing on ITS and intermodality were recommended for funding. For example, the I2 program funded the Con.takt project, aimed at securing bus and rail connections, by allowing time of arrival information to be exchanged between those two modes of transport and displayed to users. Also funded by the I2 program was the trip planner proposed by the Vienna Spirit project in 2003, which combined information for personal motorized transport and public transport (Bruntsch and Rehrl, 2005).

In 2004, the *Telematics Master Plan Austria – Telematics Applications for Traffic and Transport* was published, which sought to define a set of measures where telematics would be used to optimize, improve, and increase the safety of transportation networks. The Austrian ITS efforts were then concentrated into a single federal agency created for this purpose in 2005: AustriaTec (BMVIT, 2011). This was followed by the creation in 2006 of the ITS Vienna Region, as part of the VÖR, which gathered together the landers of Vienna, Lower Austria and Burgenland. The ITS Vienna Region covers an area of about 3.5 million people and can be understood as a collaborative body in charge of ITS for the entire Viennese Metropolitan Region. With an annual budget of about €1 million, ITS Vienna Region aims to promote a shift from private motorized travel towards more environmentally friendly and sustainable means of transport (City of Vienna, 2014b). The IV2S funding initiative was followed by the IV2SPlus funding initiative, which was intended to fund innovative transport and mobility solutions from 2008 to 2012 (BMVIT, 2009). This funding program was followed 2012 by the development of the *Mobility of the Future* program, which aimed at "*identifying and refining creative new ideas based on technological, social and organizational innovations*" (BMVIT, 2012: 7). The mobility of the future program benefited from an annual budget of about €15 million.

In 2011 the first Austrian ITS Action plan was presented. The plan stressed the need to define a single framework to guarantee the interoperability of ITS services, in terms of data collection, processing, maintenance, and service (BMVIT, 2011). The plan also identified six areas of actions for the implementation of the strategy, one of which was the "informed travellers" area that would comprise "*measures that supply traffic information to the individual travellers and offer booking and invoice services*" (BMVIT, 2011: 12). Ultimately, the Austrian ITS law, in compliance with the 2010 EU ITS directive, was adopted in 2013 (Aifadopoulou et al., 2014). In 2012 the BMVIT developed the "*ICT of the Future*", which sought to fund projects with ambitious use of ICTs. Although some of the projects focused on mobility, such as projects focusing on autonomous vehicles, none of the projects presented in the project reports focused on integrated mobility platforms (BMVIT, 2015).

As detailed below, the development of digital transport solutions has been pushed by three different actors (the ÖBB, the VÖR, and the Wiener Linien) for whom we detail the different actions below.

4.2.4.1 The Pre-SMILE era

- The ÖBB way

In 2007, the ÖBB launched "Scotty", which started as a web-based route planner delivering door-to-door information, based on timetable data from all public transport operators in Austria. This was followed in the summer by the launch of a pilot project called "platform stewards", which had dedicated trained ÖBB employees support travelers on-site, providing them with information on timetables and connections (ÖBB, 2007). A Scotty app was made and released to the public in 2011. It is still one of the most used apps for long distance travel in Austria (IV9).

In the late 2000s, the ÖBB also developed a web ticketing service, before launching in 2013 the ÖBB official ticketing app for smartphones. Surprisingly, the app was not merged with Scotty at that time and customers had to use separate apps for information and for ticketing.

> *"A few years ago, we started a ticketing app (...) It was first an on-line service and then they built an app. But they did not link that to the information app. They did not integrate it to Scotty which was strange. Looking back it was not a good idea, but it is how it developed."* (IV9)

In October 2010, initiated by the ÖBB, started the eMORAIL project, which explored new ways to integrate electric mobility services with public transport, especially for commuters. The project received funding from the Climate and Energy Fund as part of the electric mobility flagship project in 2011, and supported the development of electric vehicle charging points in selected railway stations, as well as the development of the eMORAIL app, that could be used to access information about availability, current battery status, and range of the electric cars, PT real-time timetable information, as well as to make vehicle bookings. The pilot project was conducted over three railway stations in the Vienna Metropolitan area, as well as two railway stations in the Graz Metropolitan area. Users had to pay a monthly fee including a commuter ticket, a public transport ticket at their destination, as well as the use of the electric vehicles (Klima und Energiefonds, 2016). The pilot project ended in December 2013 and paved the way for a concrete implementation in selected railway stations over Austria, but not in the Viennese Metropolitan area, in 2017. The ÖBB's interest in integrated mobility started thanks to the eMORAIL project.

> *"We started the whole idea of integrated mobility with the electric mobility hype. Thanks to eMORAIL, ÖBB realized that if you want to be part of the electric mobility bubble, you have to go for integrated mobility systems (…). It does not matter who does the first or last mile, so we started to say that we did not want to be the ones that are only doing the long distance, but wanted to be the mobility provider for the whole chain. That was the idea."* (IV9)

- GIP and VAÖ

From 2006 to 2009, largely funded by the Climate and Energy Fund, the GIP (Graph Integration Platform) was developed. This was a nation-wide platform that gathered databases and geographic information systems from various transportation infrastructure managers and operators. The GIP digital map of transport was supposed to gather all kind of information, including safety-relevant implementation, such as accident data, and be regularly updated by the different transport operators and infrastructure managers.

In May 2011 a cooperation agreement for the Verkehrauskunft Österreich (VAÖ) project was concluded to establish a uniform, non-discriminatory intermodal online traffic information platform across Austria (IV14). The project, funded by the Climate and Energy Fund, brought together the ASFINAG (a publically-owned company in charge of highways in Austria) with different regional transport authorities, broadcast systems, the Austrian Automobile touring club, as well as the ÖBB. All project partners signed a data exchange agreement in October 2010. However, the ÖBB then decided to stop its collaboration as it was finding it difficult to engage in the development of a non-discriminatory trip planner.

In September 2012, the Arbeitsgemeinschaft der österreichischen Verkehrsverbund-Organisationsgesellschaften (ARGE ÖVV) was founded by the different regional transport authorities of Austria, including the VÖR, to carry on the project of a nation-wide data platform for transportation (IV14). The ARGE ÖVV finally presented the VAÖ 1.0 (first nationwide data platform), which at that time was using static data and relied on the GIP, at the ITS World Congress in Vienna in October 2012. The project entered a second phase in May 2013, relying on real-time data. 2014 saw the release of VAÖ 2.0, which relied on real-time data. This platform laid the groundwork for the Austrian transport digital infrastructure, on which other services could develop, such as new routing apps and so on. The VAÖ platform is currently managed by VAÖ GmbH, a company created by ASFINAG, ARGE ÖVV, ÖAMTC (Austrian Automobile Touring Club), BMVIT, and the ÖBB.

In late 2012, based on VAÖ 1.0, the ITS Region Vienna released a first version of its trip planner for Vienna Metropolitan Region, called AnachB.at (Menzel and Bohm, 2014). Among other things, it encompassed information from Austrian Highways operator ASFINAG, the ÖBB, Wiener Linien, and traffic information from the City of Vienna and Austrian Police. In 2014, a more elaborate app, called the AnachB/VÖR app, was launched in collaboration with VÖR and supported by the VAÖ 2.0 platform.

- The Wiener Linien (WL) way

In September 2003, celebrating 100 years of its existence, WL implemented an SMS ticket on its network, called the Wiener Linien HANDY Fahrschein (IV1). It is acknowledged as one of the first public transport operators to have proposed such a service in Europe. Back then, the service offered customers the possibility to buy a day-ticket, allowing for unlimited use of public transport, for a fee of €4.20. The transaction was made through the electronic payment platform Paybox (now part of the ABN AMRO bank group) and paid by the customer at the end of the month via his/her monthly mobile phone bill.

In 2007, WL launched its online ticket shop (IV1) for a range of tickets including day-tickets, three-day tickets, weekly ticket, and special tourist tickets. Customers could pay for their tickets online and then print them at home. In the same year WL also conducted a pilot study to explore the possibilities of NFC technologies for ticketing. In 2009, WL launched its trip-planner app entitled Qando, which it had developed jointly with VÖR and the technology company Fluidtime (IV1). Qando encountered a lot of success and hence received a best practice award from UITP. The app is still being widely used in Vienna, as it processes an average of about 2.5 million route requests a day.

In 2011, WL released its *Strategy 2020* (IV1). In the document, the WL stated its willingness to become a central point of contact in the context of mobility inquiries in order to strengthen its market position. The same year WL launched its ticketing app, which first allowed users to display tickets preliminarily bought online, and then allowed users to directly buy tickets from the app. Surprisingly, when the ticketing app was released it was not integrated to the existing routing information app Qando, apparently for organizational reasons:

> *"We got two apps, one for routing and one for ticketing, and the main reason for that [was] organizational. We have one CEO in charge of finance, market and IT, and one CEO in charge of operations and infrastructure. Thus, the routing information app is coming from one, whereas and the ticketing app from another." (WL)*

In late 2011, as part of the Open-Government initiative from the City of Vienna, WL decided to progressively open some of its data. In June 2013, geographic data of public transport stops (buses, tramways, underground) were released, followed by the opening of real-time departure data, as well as bus route data (Interview WL). To access those data, which are published online under the CC BY license, interested developers need to register to the Open Data Portal of the City of Vienna. It is estimated that dozens of apps have since been developed by third-party developers.[20]

4.2.4.2 The SMILE era

- Development process

In June 2011, the Climate and Energy Fund released its call for the third *Austrian Electric Mobility Flagship project*, which aimed to fund projects that would contribute to the roll-out of electric mobility in Austria (IV11). More specifically, the call looked at projects that would enhance the "*development of interoperable mobility information, electric mobility offers and electric mobility billing by public transport service providers and operators and their integration in a functioning system environment by using linked ICT systems*" (Klima und Energiefonds, 2011: 11).

At that time, the Wiener Stadtwerke approached the ÖBB to create a consortium to respond to the Climate and Energy Fund's call (IV9). The Wiener Stadtwerke had long had this idea of developing an integrated mobility scheme, but decided to join forces with the ÖBB in order to develop a nation-wide integrated mobility

[20] In Spring 2017, WL had still not provided Google with the required APIs to have public transport information available on Google Maps. People who are used to finding their way around in foreign cities using Google Maps might thus be forced to download Austrian apps to have access to public transport information in Vienna.

platform, and not only something for the City of Vienna (IV9). The idea was to develop an integrated mobility platform as a research project in order to determine what was doable and achievable. The ÖBB quickly agreed to pursue this path.

> *"Wiener Stadtwerke came to us. They were thinking about creating a card that could be used for all PT in Vienna, but then thought it should not only be for Vienna and considered approaching ÖBB. So they wanted to make a joint project with the two biggest Austrian mobility providers, which was a good approach to make this project a success. This is how it started."* (IV9)

ETA and IC Consulenten, two Viennese consulting firms, were quickly hired to help put together a consortium, which was ultimately constituted of Wiener Stadtwerke, Wiener Linien, Wien Energie, WienIT, ÖBB Holding, ÖBB Infra, ÖBB Personenverkher, iC consulenten, Fluidtime, NTT Data, TU Wien, Quitessenz, tbw research, ETA, and NeuMo. The consortium started to get in touch with other mobility providers to integrate them into the platform. Car2go, Taxi 31300, and CityBike quickly joined the project (IV6, 13), as did other public transport authorities from other Austrian cities such as Graz Linien or Linz Linien. Most mobility partners were enthusiastic about participating in the SMILE project, as it was a way for them to learn about IMPs as well as maintain a good relationship with the Viennese Public Transport company.

> *"I think it is for us absolutely an interesting thing. Every presentation of our cars, in every possible environment is interesting, especially combined with public transport. We want to be in there. We want to be seen there. That is for sure (…). We are doing it because we want to have a good relationship with the city and the public transport companies."* (IV13)

> *"We said yes because it was interesting for us. Such things can really have an added value (…) The idea for ordering to paying with one fingerprint, is a really 'sexy' thing (…) We were very enthusiastic from the beginning."* (IV6)

> *"We are not to be used alone, as citybike, but you always use citybike in some kind of combinations or together with other needs, which is why it made sense for us to join the SMILE project."* (IV10)

Having partnered with other mobility providers, the consortium applied to the electric mobility flagship program, with the SMILE project. Because it was proposing a solution that would better integrate electric mobility to the existing transportation system, the consortium was ultimately awarded a grant of €2.9 million in December 2011.

> *"There are three basic components in electric mobility, which are the vehicle, the infrastructure and the user. We [The Climate and Energy Fund] wanted to fund projects that had this holistic understanding of electric mobility (…) [The SMILE consortium] came up with this ICT/app approach that would enable people to plan their trips and have access to different transport solutions. And we wanted something that supported electric mobility (…) so it went through."* (IV11)

The consortium later responded to a call for funding from the FFG, for which it was also awarded funding (IV12). While the strategy was implemented from early 2012, the system and app were built in 2013. A pilot phase eventually took place from January to December 2014 and involved 1000 test users. The estimated total cost of the project was approximately €6.7 million (Wiener Stadtwerke, 2013). Throughout the project, the operative project management team, comprised of Wiener Stadtwerke, Wiener Linien, and the ÖBB, met on a monthly basis. The strategic project management team, comprised of Wiener Stadtwerke, Wiener Linien, the ÖBB, ETA, and ICconsulenten, also met monthly. The steering committee, which was made up of Wiener Stadtwerke and all consortium partners, met twice a year. The Climate and Energy Fund and the steering committee met every six months and reported every 9–13 months.

While the SMILE project is acknowledged for having developed quite smoothly in general, there has been some areas that have posed problems among stakeholders. The different expectations from the involved stakeholders, as well as the great variety of employees working on the SMILE project, coming from different professional backgrounds, is acknowledged to have slowed the project:

> *"It was a lot of coordination. A you can assume, those people did not only have SMILE on their plates, so they had their usual jobs and SMILE on top of it, which was a little bit conflicting sometimes. In SMILE we had to think big, look forward on how to reach our goals. It was a lot of different languages. There were lawyers, IT, consultants, designers … So different kind of people, with different mindsets. They all had to be focusing on the same goal to finish the project and have a final product that the people would like."* (IV3)

Legal difficulties of setting up the SMILE project, particularly in terms of liabilities in cases of use of non-public transport mobility services was also mentioned as something difficult.

> *"If you clicked on our general terms and conditions in their app, we needed to be sure that, in case of trouble, we had a legal connection. If the customer, for example, said, '*no I have never accepted those terms and conditions, and the bike is gone and it is not my problem'*, we needed to be able to do something. If the liability was not clearly given to this person from a legal standpoint, it was not OK."* (IV10)

The availability of proper dedicated funds for every stakeholder involved in the project was also mentioned as a barrier. Only the organizations that were part of the consortium received financial compensation. All other partners that joined the project and were not part of the original consortium had to pay for their own costs and could not benefit of any subsidy.

> *"We did not receive any money for this project. Every step, every minute our staff was working on this project, we had to pay from our pocket. The interface work for example was done by our software company, so we had to pay for them."* (IV6)

Although the technicality of the SMILE solution is not cited as the main bottleneck for the development of the project, it is acknowledged as having raised some issues:

> *"A bigger challenge was the technological one (…) Ticketing, for example, is not only based on one system, but on four of five systems, and getting all them work together on this common goal was quite challenging. So the only real tough challenge was I would say technological. So far it was quite easy for the rest."* (IV3)

It was also mentioned that the SMILE engine, as it was during the project, was not financially sustainable; that is, it was not making enough profits to cover its costs. However, this was not seen as a difficulty because the project was a research project and did not intend to find a profitable business case. Nevertheless, the business model played a role in deciding what would be the outcome of the project.

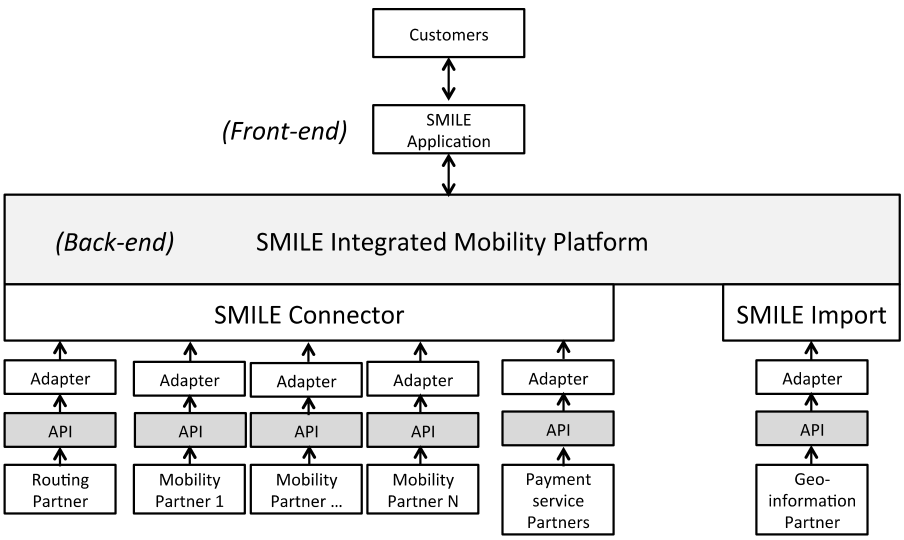
Zoom on the SMILE product

Technology: From a technological point of view, the SMILE product integrated four types of APIs (application programming interfaces), provided by the partners of the project. It integrated the APIs of the routing partner VAÖ, for routing services; the mobility providers, for real-time timetable and location information, and for some of the mobility providers' payment, booking or pre-registration services; the service partners for payment services; and the geo-information partner for mapping services. In addition to this back-end (constituted of the integration of the four above-mentioned types of APIs), a front-end was also integrated, which was actually an app, being the only contact point with users. Figure 4.2.11 represents the technical architecture of the SMILE Integrated mobility platform.

Functionality: The SMILE product had four main functionalities: (i) It enabled users to plan their trips (trip-planning function) by proposing all possible transport options imaginable to travel from one point to another; (ii) It enabled users to book mobility services in advance (booking function); (iii) It provided users with electronic tickets (ticketing function); (iv) it proposed a monthly billing service.

Transport modes integrated: The SMILE product integrated a wide array of transportation solutions including public transport (bus, trams, metro), national rail services, commuting rail services, car sharing, bike sharing, taxis, parking services, and electric car charging services. However, not all transport solutions had the same level of integration. Although public transport and rail services were fully integrated, users could not access car sharing and bike sharing services directly (only with the SMILE app), as those services required the users to go partially through their channel.

Figure 4.2 11: Technical architecture of the SMILE IMP (Author's elaboration)



- Results from the pilot phase

The pilot phase of SMILE began on May 8, 2014, when all project members were invited to download and test the app on their personal smart-phones for their journeys. The test-user base was then expanded in July 2014 when employees from the different partners of the project were also invited to test the app. The external pilot operation started in November 2014. People who registered as pilot users were then able to download the app from the Google Play Store and use it freely on their smartphones. Seventy-eight percent of the test users were males, 81 percent lived in Vienna, and 53 percent were between 20 and 40 years old and held a higher education degree, which is known to more or less correspond to the category of Viennese early adopters (SMILE, 2015).[21] Through the three different pilot phases, it is estimated that over 1000 different people tested the app. In total, pilot users spent over €4200 on approximately 40 taxi rides, 434 Wie-

[21] http://smile-einfachmobil.at/pilotbetrieb_en.html, accessed 8 June 2017.

ner tickets, 261 ÖBB tickets, and 80 car2go rides. It is also estimated that citybike benefited from about 100 new registrations from the SMILE app during this year of pilot tests. For many of its stakeholders, the SMILE project showed that a cooperation among so many stakeholders, each of whom had their own interest in joining the project, could be successful.

However, the SMILE project raised a series of questions that have been responsible for the non-continuation of the project and more importantly, the end of the cooperation between the two companies (the ÖBB and the Wiener Stadtwerke) that had been leading the project.

4.2.4.3 Post-SMILE era

The end of the SMILE project was followed by a short period of uncertainty on how the project would move on and how the main stakeholders would decide to pursue their cooperation. Ultimately, two main IMP projects emerged from the SMILE pilot, each led by the SMILE project leading organizations, being the Wiener Stadtwerke and the ÖBB. The "divorce" between those two public companies, which provide by far most of the public transport rides in Austria, has been seen as a lost chance.

> *"WL and the ÖBB wanted to do their own things. Now we have two solutions. That was not the best way to do it from my perspective. It would have been better if they had stick together (…) I think in my opinion it would make more sense to have one."* (IV13)

> *"Unfortunately, it broke up as the two main project leaders decided to have different strategies, which I think was worse for end users. It would have been better to have it sustain. (…) It was ready for a full success story. It could have been much more successful, if the partnership was extended."* (IV2)

While the Wiener Stadtwerke decided to focus more on the back-end and to invest into the development of an IMP as a digital and public infrastructure, the ÖBB adopted a more commercial approach that would avoid them losing a direct link with their customers, as it will be shown below.

> *"We (ÖBB) first talked to Wiener Stadtwerke to make a joint venture, but it did not work out, because our strategic positions were quite different. We thought it had to be commercially sustainable, whereas the WS was thinking they were building a digital infrastructure for mobility, which should be funded with public money. And for us we though a startup should do it, that would have commercial vision and interests. This is why we have not pursued things together."* (IV9)

- The Wiener Stadtwerke way

In March 2015 the Wiener Linien released the WienMobil Card, a mobility card that added to the annual transport ticket possibilities for users to access bike (citybike) and car sharing (Drivenow) schemes, to pay in taxis from the 31300, 40100, and 60160 companies, as well as for parking or for electric charging services (IV1). When registering the WienMobil card (which cost €377, or one euro per month more than the annual public transport ticket implemented by vice-mayor Vassilakou), users needed to enter their banking details, so mobility service fees (such as car sharing, bike sharing, taxis, parking, or charging) could directly be deducted from their bank accounts at the end of each month. However, due to a low number of cards sold in the first years of the project, the Wiener Linien decided to stop the operation of the WienMobil Card in 2017 (IV1).

Soon after the end of the SMILE project, in May 2015, the Wiener Stadtwerke, through its subsidiary Neue Urbane Mobilitat Wien (NeuMo), announced the development of an integrated mobility solution, without the ÖBB, with the Beambeta project, still in collaboration with Fluidtime and other mobility providers (IV2). This was a continuation of the SMILE app that used a large part of the original code and back-end and had many of the same mobility providers on board (Wiener Linien, car2go, Taxi 31300, CityBike, Wipark, Graz Bike, Nextbike, Linz Linien) but from which the ÖBB functionalities were deleted (IV2).

> *"The Wiener Stadtwerke wanted to use the outcome of SMILE, so created the Beambeta, which was a re-branding, which was basically SMILE but getting rid of the functionalities of the Austrian Railways."* (IV2)

The app went live for Android OS in July 2015 and, like SMILE, enabled users to have information about different mobility solutions to get from one point to another, as well as to book and pay directly on the app for some mobility services. In early 2016, Upstream Gmbh was created as a subsidiary, for which Wiener Linien would hold 51 percent of the shares and Wiener Stadtwerke 49 percent. The leader of the SMILE project for WS was ultimately appointed CEO of Upstream.

Upstream's approach is slightly different from that of the SMILE operating unit. While SMILE's operating unit was in charge of providing the back and front ends, Upstream's primary focus was on creating the digital infrastructure (back-end) that would enable the integration of information, routing, booking, and payment from different mobility providers, on top of which applications can be created (IV1, 3).

> *"The core competence of Wiener Stadtwerke is infrastructure, also in the physical aspect. So the decision was to go in the infrastructure layer even from the digital side (…) The platform was ready in September 2016, and in parallel we started for searching for different ways to use the platform, so let's call it business models."* (IV3)

Upstream is also developing apps (front-end) on top of their digital infrastructure (back-end), when mandated to, for which they also receive revenues. One of them is the WienMobil app, ordered by the Wiener Linien, which presents the same functionalities as the SMILE app but is organized slightly differently. Indeed, in the WienMobil app, the operating actor (Upstream) acts as a broker and not as an agency like the SMILE operating unit used to do. Thus, Upstream is no longer in charge of the clearing and hence does not have to bear financial risk. A pilot for the WienMobil app was released in November 2016 and the full app was released on June 8, 2017. A web-service for WienMobil is also planned for 2018. As of May 2017, this app could not allow its users to book ÖBB tickets and therefore had a lower geographic coverage than the SMILE app.

In parallel, Upstream also launched an IMP for the city of Graz, which uses the same data infrastructure (back-end). In 2017, Upstream also released the application "*JO Bin Schon da!*", which targets companies interested in changing the mobility behavior of their employees by awarding them mobility points in function of the travel mode they use for their business-related trips. Mobility partners for this B2B solution (for Upstream) are the Wiener Linien, Taxi 40100, Taxi 31300, car2go, DriveNow, and Ibiola.

Upstream has been supported by some actors, who consider it a good way to create the data infrastructure and keep it into public hands, while not being part of the public administration and thus being able to move quickly and adapt to markets.

> *"This digital platform in the background is new, and it is in public hands with Upstream. I think it is a good approach. It may be a problem with all the data going around to have the platform in the hands of a private company, and better to have it in public hands, close to the authority and not somewhere in California. (…) Maybe some other services provided by private companies can come on top of it, but the platform should be publicly owned."* (IV7)

"I think it is good to have the public authority being the aggregator and being in the middle of the thing (…) The city of Vienna is interested in increasing the quality of life of its citizens. They are not focused on making profit, but are focused on the people." (IV6)

"I think the idea of setting up Upstream as an own company is the right way to do it. Companies outside the public administration scheme are easier and faster to adapt to new situations and react on new developments." (IV13)

Some other actors have raised concerns regarding the sustainability of the Upstream solution, not so much in terms of income as in terms of scaling their solution up, and have a nation-wide solution for Austria, rather than a solution focusing only on Vienna, let alone the Viennese Metropolitan area.

"How can it scale up? This will be a question. If Upstream focuses on transferring or selling the technology to other cities, and if it works better over there than in Vienna, they will have serious issues. On the other hand, if the service in Salzburg for example is not as good as the service in Vienna, they will also have issues. So it is good to start and for this pilot phase. But you need to have another concept for the next scale-up phase." (IV4)

- The ÖBB way

In May 2015, the ÖBB partnered with an Austrian Venture Capitalist fund specialized in tech start-up, called Speedinvest, to fund iMobility, which is 49 percent owned by the Austrian railways and 51 percent by Speedinvest (IV9). The idea behind this partnership was to benefit from Speedinvest's experience in the tech scene, as well as from the ÖBB's experience with the SMILE project. To avoid starting from scratch, in the second half of 2015, iMobility bought a start-up that was developing a routing information app called Next-stop. The Nextstop app was then rebranded "WegFinder" and launched in April 2017. In the summer of 2017, the app provided users with routing and intermodal information, but did not yet allow them to buy tickets through the app, although partnerships were established with ÖBB, Westbahn, Citybike, car2go, the City Airport Train, and Uber. Having partnered up with the VAÖ, iMobility also had access to information of the Wiener Linien for local public transport. Furthermore, as the ÖBB is affiliated to sell local public transport tickets, users should be able to buy public transport tickets once the ÖBB is integrated within Wegfinder.

iMobility has adopted a different business model than Upstream as it has opted for a B2C approach, rather than B2B, thus aiming to get most of its incomes from commissions taken on each sold tickets; that is, following an affiliation model.

"There are big differences between the two approaches. The Wiener Stadtwerke approach is more an '"enabling approach', driving more some indirect revenue streams, and fulfilling a service, while we are more a kind of 'over the top' provider, which has a kind of affiliation model in behind. That is a completely different model. We are more on the consumer side, but building our own back end, while they are more coming from the back-end perspective. It is currently the overlap we have in those two activities." (IV9)

iMobility would be interested in having ÖBB shut down the Scotty app and ÖBB ticketing app, to transfer those customers onto Wegfinder and achieve a critical mass, so that iMobility would become financially sustainable. Overall, iMobility has been more criticized than the Wiener Stadtwerke app, for being less dynamic, lacking support from its own investor (the ÖBB), and for the rather risky business model it has adopted:

"Upstream came up rather quickly, whereas iMobility slept for quite a while. They bought this Nextstop app, which already existed on the market but they only launched it five weeks ago. Two years after the termination of SMILE they woke up. Before that I did not know what was happening. Now they have a private investor as well. From the functional point of view, it is basically an information app, nothing more. There are some ticketing functionalities, but even not the ÖBB tickets. You can buy Westbahn tickets, but not ÖBB tickets, which is a bit ironic and funny." (IV5)

"The ÖBB thinks it has to work on its own and finance itself. I am not sure if this is a good decision. They now have an app, Wegfinder. And this was interesting, because you were able to buy tickets from the WestBahn, which is a competitor of ÖBB, but not from ÖBB. It was interesting. It is a project on its own. We will see. One app will be much nicer than the other one. They wanted to collect everything, but now everybody is collecting everything." (IV10)

Figure 4.2.12 summarizes the main development related to IMP in Austria and Vienna from 2011 to the present.

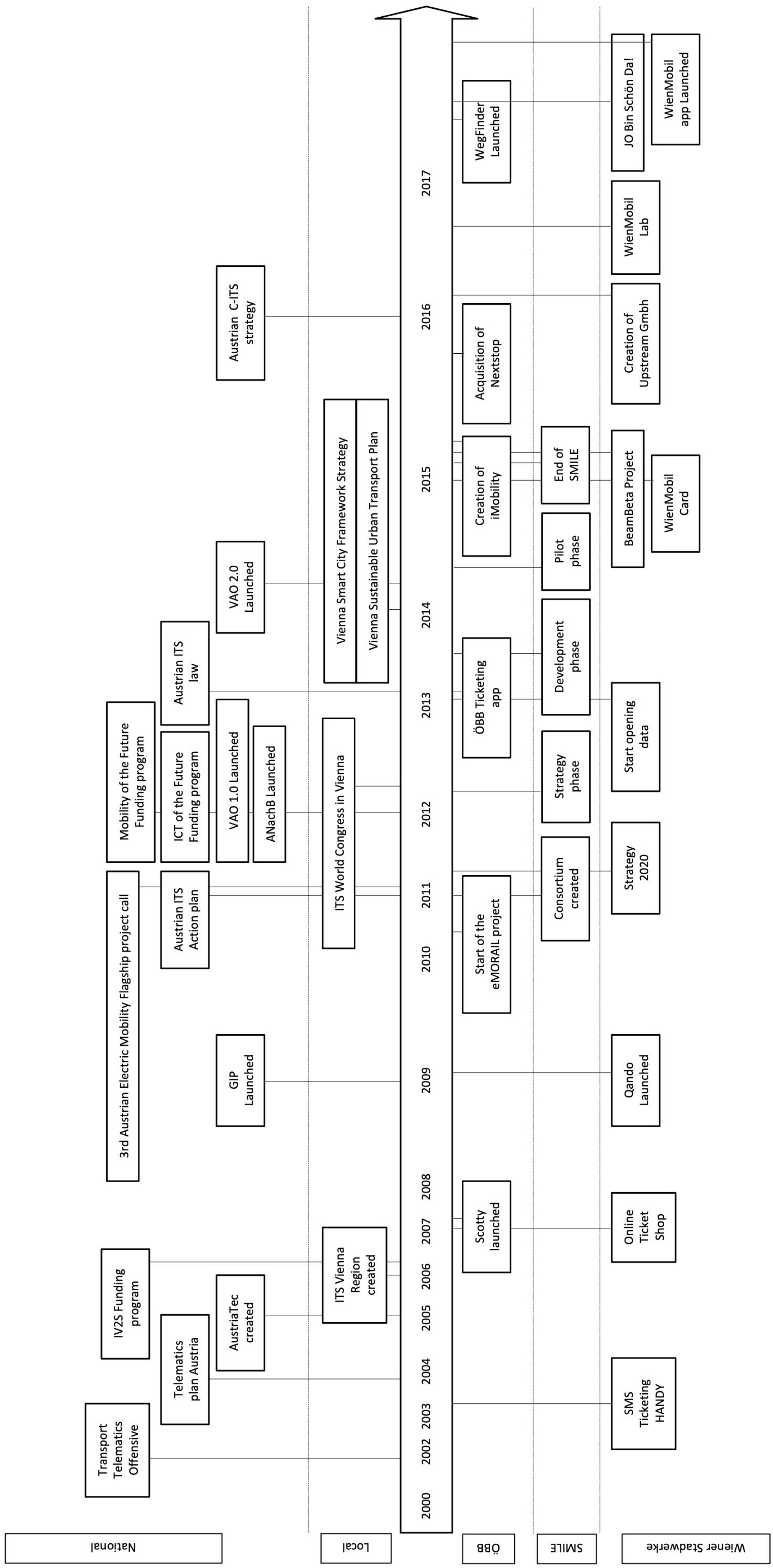


Figure 4.2-13: development of IMPs in Vienna from 2011 to nowadays (author’s elaboration)

4.3 Helsinki case study

In order to fully understand the context in which MaaS has developed this subchapter will detail the political and administrative organization of the country at the national level, before diving into the local level. Then, the institutional and infrastructural development of transportation in Helsinki from the beginning of the 20th century to the present will be presented, before the key events of the development of MaaS from 2009 to 2017 are highlighted.

4.3.1 Context

4.3.1.1 National level: Finland

- Current Situation

Finland is evolving as a parliamentary representative democratic republic and multi-party system. In 2015 the country had a population of 5.487 million people, making it the 23rd least populated country of the EU (Eurostat, 2016) and the one with the lowest population density, with an average density of about 18 people per km^2 (WB, 2015). Starting around the 1950s, Finland urbanized quite rapidly compared to many other European countries. From 1950 to 1995, the Finnish urban population grew from 2 million to 3.5 million people. It is estimated that, in 2015, 85.1 percent of the Finnish population was living in urban areas, accounting for 4,592 million people (World Bank, 2015), 40 percent of which lived in the six biggest urban agglomerations (Sjobolm, 2011). Ninety percent of the Finnish territory is considered to be an "out-migration" territory (Loikkanen et al., 1998). Figure 4.3.1 depicts the evolution of the urban population in Finland in comparison to the EU average.

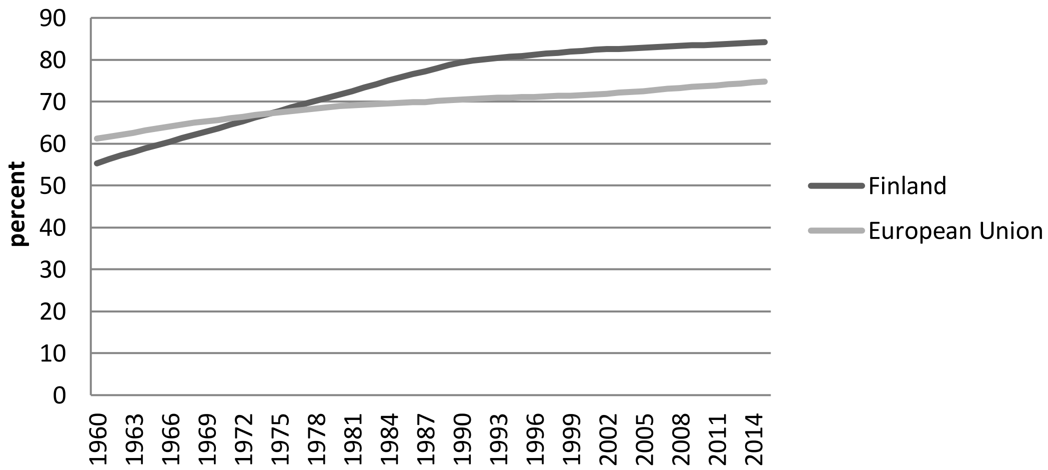


Figure 4.3-1: evolution of urban population in Finland compared to EU from 1960 to 2014 (author's elaboration from WB data)

With 16.3 percent of the population being aged between 0 and 14 years old, 63.2 percent being between 15 and 64 years old, and 20.5 percent older than 65 years old, the ageing population phenomenon is a rising concern in Finland. By 2050 it is estimated that 27.3 percent of the 5.9 million people living in Finland will be older than 64 (Statistics Finland, 2016). From an economic standpoint, the OECD sees Finland as having enjoyed important economic progress for the past decades, which has led to high quality of life, education, skills, environmental quality, and personal security (OECD, 2016). In 2015, Finland had the 17th highest GPD per capita in the OECD, at USD42,268, which is slightly higher than the OECD average of USD40,791 and the

EU average of USD38,621 (OECD, 2016). Despite a high level of well-being, the OECD describes the Finnish economy as “weak”, with a very few start-up being created and limited growth of young firms. Rising public debt is also considered as a threat to the Finnish economy. Finland is known to have suffered significantly from the 2008 Global Financial Crisis and is recovering from it slowly.

Finland generally ranks quite high on renowned international indexes. In 2015, Finland was ranked first in the Human Capital Index and described as “*the best-performing country in the world when it comes to building and leveraging its human capital potential, taking the top spot on the Under 15 and 25–54 Age Group pillars and scoring in the top 10 for the remaining age groups*” (WEF, 2015: 9). Finland was ranked second (behind Iceland) on the Global Gender Gap Index (WEF, 2016). Inequalities in Finland are among the lowest within the OECD (OECD, 2016). Housing conditions are better than the OECD average and health conditions are similar to OECD average. Finland is also known to have a well-connected population. In 2015, it is estimated that there were some 139.4 mobile broadband subscriptions per 100 inhabitants in Finland, which is much higher than the OECD average of 91.7 per 100 inhabitants (OECD, 2016c).

- History and evolution of the Finnish administrative system

Since its independence in 1918, Finland has been a constitutional republic, where the Parliament and the president of the republic are directly elected by the people. The president is elected every six years and has the mission of approving the laws passed by the Parliament and budget of the state. Furthermore, the president appoints the prime minister, as well as the ministers, themselves proposed by the prime minister. The Finnish Parliament is constituted of one chamber of 200 members elected for four years by direct, proportional, secret ballot. The Parliament’s mission is to enact laws and vote the State budget. According to the Finish constitution, local authorities can organize their municipal administrations freely. Their only requirement is that they must have a municipal council, a municipal executive board, an auditing committee, responsible for auditing finances and an election committee, responsible for organizing elections (Sjobolm, 2011).

Finish local government is known to be a one-tier system. Finnish municipalities are responsible for providing local services as well as welfare services to their residents. The most important statutory obligations for Finnish Municipalities are social welfare, health care, education, environmental protection and technical infrastructures (Sjobolm, 2011). Because local governments provide a wide range of services, Finland is often characterized as a decentralized unitary state (Loughlin, 2000). Although the membership of Finland to the EU in 1995 strengthened the role of meso-governments slightly, as part of EU requirements (Kettunen and Kingla, 2005), Finland still lacks an all-purpose organization and democratic representative entities at the regional level, which puts significant pressure on local authorities (Sjobolm, 2011). To tackle that issue, in 2005 the central government launched the Municipal and Service Structure Reform to ensure a higher quality of service provision by local governments. The reform promoted voluntary mergers between municipalities and, as a result, the number of municipalities was reduced to 384 at the end of 2008. Ultimately, 17 urban regions covering 102 Finnish municipalities were defined (Sjobolm, 2011). Finnish municipalities are organized under a council-manager government, where the highest decision-making body is the municipal council (elected every four years by the citizens), which then votes for a mayor every seven years. However, since 2017 the city mayor, directly elected by the citizens for a four-year term, has replaced the city manager.

- Finnish politics at the national level

Below is describd the organization of the political landscape in Finland. There are six main political parties involved in politics in Finland that evolve both at the local and national levels (Deloy, 2015):

- Founded in 1990, the Left Alliance is perhaps the party that lies the most to the left of all the political parties. It promotes greater job security for workers and environmental values.
- Created in 1899 as the Workers' Party of Finland, the Social Democratic Party (SDP) lies at the center-left of the political landscape and considers itself as in favor of a fair society, a supportive state, and a sustainable future.
- Created in 1987, the Green League lies on the left of the political continuum and most often puts the protection of the natural environment as a priority in its agenda.
- The National Coalition Party, (NCP) also called the Conservative Assembly (KOK), was founded in 1918 as is defined as a conservative and liberal and pro-European party; it lies at the center-right of the Finnish political spectrum.
- The Centre Party, founded in 1906 as the Agrarian Party, sits on the right of the political scale and focuses on the interests of the rural population, promoting decentralization.
- The True Finns Party is the populist and nationalist party, known to be Eurosceptic and lying to the far right. It was formed in 1995 from the ashes of the Rural Party, which was originally created in 1959.
- Directly originating from Finland's political history, the liberal Swedish People's Party (SFP), created in 1906, aims to represent the interests of the Swedish-speaking minority in Finland.

Due to the plurality of political parties, Finland's politics are known to be highly fragmented and the most polarized political system among Nordic Nations (Mattila and Raunio, 2002). Hence, Finland is often presented as a country of "*surprising political coalitions*" (Alho, 2011). Political coalitions, as much on the local as the national scale, are indeed very frequent in Finland. Below the results of the successive parliamentary elections for Finland since 2003, as well as the different people who have occupied the function of transport ministers are presented, to illustrate the high political turnover of governments.

Parliamentary elections were held in Finland in 2003. The Centre won the most votes (24.7 percent), followed by the SDP (24.5 percent), the NCP (18.6 percent), the Left Alliance (9.9 percent), the Green League (8.0 percent), the SFP (4.6 percent), and the True Finns (1.6 percent). The chief of the Centre Party at that time, Ms. Jäätteenmäki, was appointed as prime minister by the president and decided to form a coalition government with the SDP and SFP. Ms Luhtanen (SDP) was appointed transport minister. However, Jäätteenmäki had to resign from her political party shortly after her election due to a political scandal linked with the Iraq War, called at that time the Iraq-gate (Downs and Riutta, 2005). In October of the same year, Mr. Vanhanen became head of the Centre Party and was subsequently appointed as prime minister. Vanhanen kept the coalition government and Luhtanen in her position as minister of transportation and communications, but she was replaced in September 2005 by Susanna Huovinen (SDP).

In April 2007, parliamentary elections were held again. The Centre Party again finished first (23.11 percent), followed by the NCP (22.26 percent), the SDP (21.44 percent), the Left Alliance (8.82 percent), the Green League (8.46 percent), the SFP (4.61 percent), and the True Finns (4.05 percent). Vanhanen kept his position as prime minister but proposed a different coalition government, with members from the NCP, the Green League, and the SFP. In June 2010, Vanhanen step down as the head of the Centre Party and was replaced by Ms. Kiviniemi, minister for public administration and local government in Vanhanen's government, and freshly elected as president of the Centre Party.

New parliamentary elections were held again in April 2011. The NCP finished first (20.4 percent) for the first time in many years, followed by the SDP (19.1 percent), the True Finns (19.1 percent), the Centre (15.8 percent), the Left Alliance (8.82 percent), the Green League (7.3 percent), and the SFP (4.3 percent). Acknowledging the defeat, Vanhanen (Centre) stepped down and Mr. Katainen (NCP) was appointed as prime minister. He proposed a coalition government with the SDP, Left Alliance, Green League, and SFP. In 2012, Mr. Niinisto (NCP) was elected president, replacing Ms. Halonen (SDP), who had held the position since 2000. In 2014, Katainen stepped down, having been chosen to become European commissioner, and was ultimately replaced by Alexander Stubb (NCP).

However, the NCP did not succeed in maintaining its newly gained place. The 2015 parliamentary elections were won by the Centre Party (21.1 percent), followed by the NCP (18.2 percent), the True Finns (17.7 percent), the SDP (16.5 percent), the Green League (8.5 percent), the Left Alliance (7.1 percent), and the SFP (4.9 percent). Stubb subsequently resigned from his position and Sepia (Centre) was appointed prime minister. For the first time, a coalition government gathering political actors from the Centre, True Finns, and NCP was proposed (The Guardian, 2015). However, in June 2017, following the election of Jussi Halla-Aho as the head of the True Finns party, considered to lie at the right of the already far-right party, the Finnish prime minister announced the end of the coalition with the True Finns.

Figure 4.3.2 summarizes the evolution of the political landscape from 2003 to illustrate the important political turnover in Finland.

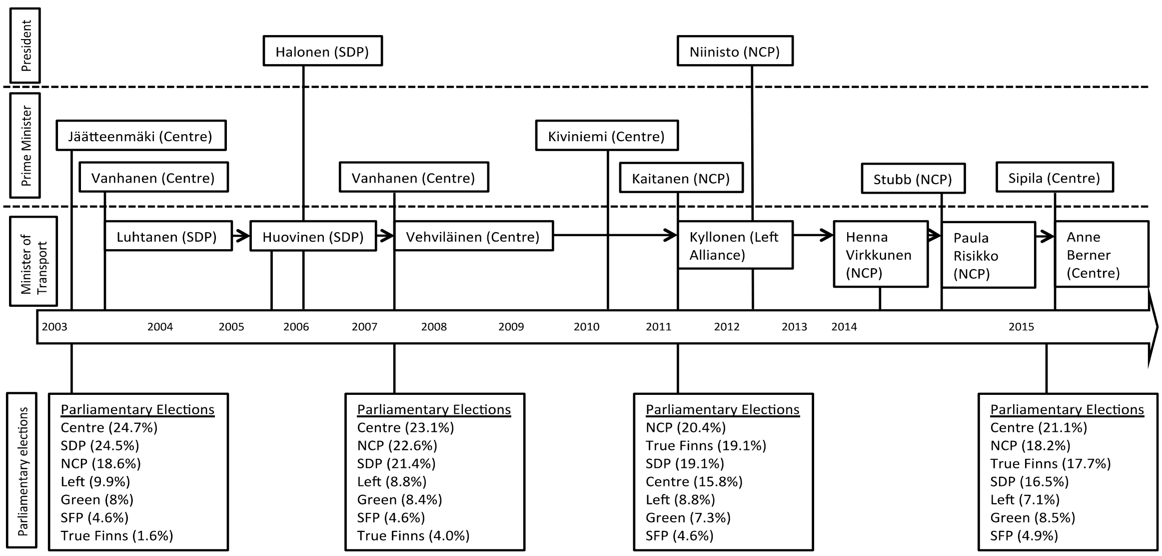


Figure 4.3-2: evolution of Finnish political landscape from 2003 to nowadays (author's elaboration)

- Decentralization and New Public Management

The Finish welfare state and its administrative institutions emerged from the 1940s to the 1990s, definitively taking shape in the 1960s and 1970s, slightly lagging behind the establishment of welfare states in the neighboring Nordic countries. Since its independence, Finland has followed the Nordic administrative tradition by being a unitary state with a strong local government (Sjobolm, 2011), providing a wide range of public services. Finnish public services follow a model based on corporatism, professionalism, Weberian public bureaucracy, and transparency based on the rule of law and political consensus (Valkama and Anttiroiko, 2014).

New public management, which was seen at that time as a solution to the economic challenges that Finland was facing, especially the so-called "Great Recession" of the early 1990s (Kuusi, 2015), as well as the heaviness of the Finish administrative system that accounted at that time for 60 percent of the GNP expenditures (Salminen, 2003), has had a clear influence on the evolution of public services provision in Finland. Decentralization, deregulation, outsourcing, and adoption of purchaser-provider models started to be used in Finland at that time (Rose and Stahlberg, 2005). Corporatization of Finish state agencies and enterprises started in the 1980s and was followed by privatization, which happened on a case-by-case basis; that is, not part of any national privatization program. As a result of privatization, the number of state employees decreased from 215,000 to 125,000 from 1988 to 2006 (Valkama and Anttiroiko, 2014). However, the number of municipal employees did not change a lot during this period. Privatization did not occur at the local level as much as it did at the national level, although corporatization of local public service provision was a popular method of reorganization at that time. From 1997 to 2004 the number of municipally owned companies in Finland grew by 40 percent (Valkama and Anttiroiko, 2014).

Given the great number of tasks that Finnish municipalities have to fulfill, and the fact that state grants allocated for municipal tasks declined following the economic recession (Haveri and Airaksinen, 2007), inter-municipal cooperation developed when looking at public services provision by local governments. Joint municipal boards and inter-municipal utility companies in water, electricity, transport, education, health, regional e-government, and culture emerged across the country (Haveri and Airaksinen, 2007).

4.3.1.2 Local Level: Helsinki

- Current Situation

Helsinki is the capital city of Finland, and its largest city, with a population in 2015 of 628,208 inhabitants, accounting for 11.5 percent of the total Finnish population. The city of Helsinki is surrounded by a first ring of municipalities, forming what is defined as the Helsinki Metropolitan Area (HMA) and comprised of the cities of Helsinki, Espoo (second most populated city of Finland with over 269,802), Vantaa (fourth most populated city of Finland, with a population of 214,605) and Kauniainen (9346) itself surrounded by Espoo (Statistics Finland, 2015). Although the population of Helsinki has been growing steadily since 1995, the population of the Helsinki Metropolitan Area has been growing at a higher pace; see Figure 4.3.3.

The HMA is surrounded by what is called the Outer-Helsinki Region, composed of 10 other municipalities and forming together what is called the Greater Helsinki, or Helsinki Region, accounting for 1,420,284 inhabitants in 2015; that is, 25.9 percent of the total Finnish population. The authorities expect the Helsinki Region population to be home to around 1,668,691 inhabitants by 2030 (Helsinki Region, 2015). The Greater Helsinki Region is also part of the Uusima Region, which is currently home to 1.6 million inhabitants and is composed of Greater Helsinki and 11 other municipalities (Helsinki-Uusimaa Regional Council, 2016). Helsinki was ranked 30th in the 2016 Mercer Quality of Life Index and 7th on the 2009 Green City Index by Siemens.

The municipality of Helsinki works as follows. A City Council, composed of 85 members is elected every four years by citizens and decides on the general strategy of the city. It is the highest decision-making body. City Council members then elect a City Board, composed of 15 members, for a two-year term. The City Board, directed by the chairman of the City Board, decides on everything that is not under the authority of any other city body or officer. It has a strong administrative function. The City Council also elects the mayor and deputy mayors that must be members or alternate members of the City Council. Prior to 2017, the Helsinki City mayor was elected for a period of seven years, but starting from the 2017 municipal council elections, the mayor will only be elected for one City Council term; that is, four years. This follows a governance reform introduced in June of 2016, which also includes the replacement of all the different city departments by four main units, in charge of education, environment, culture and leisure, and social services and health care. Under the new governance structure, the mayor also serves as the chair of the City Board, and deputy mayors chair the sector committees (City of Helsinki, 2016). This structure is expected to come into force by June 2017, when the next municipal elections are organized.

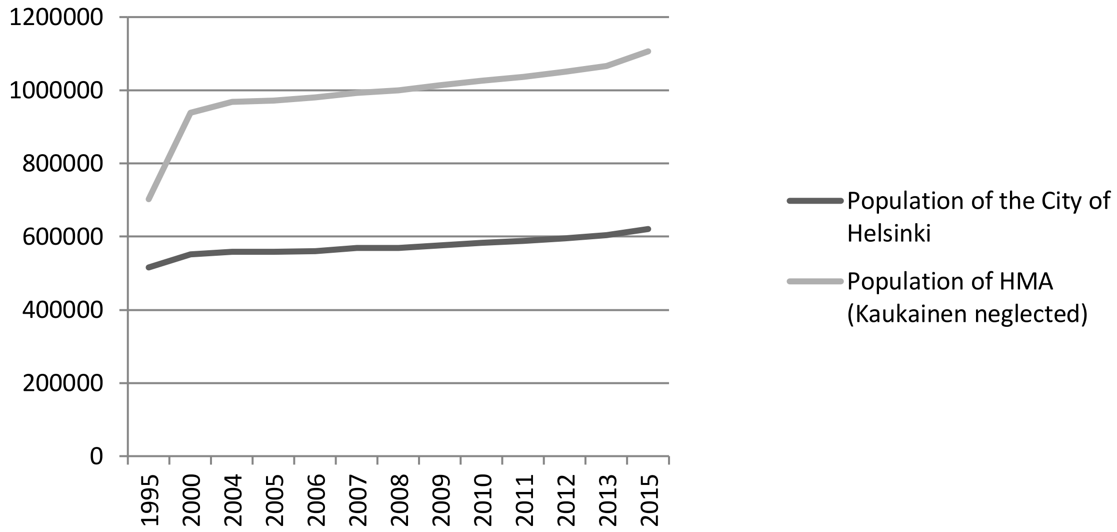


Figure 4.3-3: evolution of the population of the city of Helsinki and of the Helsinki Metropolitan Area (author's elaboration from data from the City of Helsinki, and Statistics Finland)

Since the 1970s, the NCP has been the dominant party in the Helsinki City council, always wining more than 25 percent of the seats in the elections. The second-most represented party is usually the SDP with generally around 20 percent of the City Council seats. Since the 1990s, the third-most represented party has been the Green League, even beating the SDP in the 2008 and 2012 elections. Although less represented than at the national scale, the True Finns have increased their share of seats in the municipal council, winning eight seats in the 2012 elections.

From 2005 to 2017, Jussi Pajunen (NCP) has occupied the position of City manager.[22] Following the 2017 City Council elections, and the introduction of the governance reform, Jan Vapaavuori (NCP) was elected as new mayor of Helsinki. Anni Sinnemäki, from the Green Party, who was previously in charge of the Public Works and Environmental Affairs municipal department and was appointed as deputy mayor in charge of the environment, for which she will also be in charge of everything related to transportation.

- Presentation of the Actors

Below the main actors that have been involved into the development of MaaS in the Helsinki Metropolitan Area are presented.

- The Ministry of Transport and Communications (LVM) is in charge of providing safe and secure transport and communications connections and services throughout the country. The LVM is responsible for legislation and law drafting in order to create the best operating environment for transport and communication services. In terms of size, the LVM is a rather small public entity, employing no more than 100 people.

[22] http://www.hel.fi/hel2/kanslia/guggenheim/pajunen_bio.pdf, accessed 5 January 5, 2017.

- TEKES is the Finnish Funding Agency for Technology and Innovation. It acts under the Ministry of Employment and the Economy. It was founded in 1983 and aims to fund "*industrial projects as well as projects in research organizations, and especially promotes innovative, risk-intensive projects*" (TEKES, 2012: 4). In 2010 it invested €633 million in R&D grants to companies, R&D loans to companies, research funding, and research programs for universities (TEKES, 2012).

- VR was created more than 150 years ago as the national train operator. It is a 100 percent state-owned enterprise and is currently the only passenger operator in Finland. Its main services are passenger services, which are divided into long-distance services, commuter services, and restaurant services. VR also owns a bus company that operates both local and long-distance services. The VR group also counts the freight operator VR Transpoint, which has competed with other smaller companies on the market since its liberalization, and VR track, which maintains the train tracks for the government. The train infrastructure is actually owned by the Finnish Government. VR operates approximately 300 long-distance trains on a daily basis and has almost 12 million passengers yearly. Commuter services (regional train) account for a total of approximately 60 million journeys yearly. The company's entire turnover is about €1.3 billion. VR also owns part of the newest fleet through an equipment company that has two other main stakeholders, being HSL and cities of HMA. VR gets most of its operating income in HMA from HSL, which buys routes and train departures from VR. Ticketing of VR-operated trains in HMA is done by HSL.

- At the time this study was undertaken (that is, prior to the governance reform), the City of Helsinki was composed of 33 different departments. The following were the two most relevant departments linked to the development of MaaS in HMA.

    - ❖ The Public Works Department of the City of Helsinki (HKR) is in charge of the development, design, and maintenance of Helsinki's streets and green areas (that are the property of the city). Maintenance and construction are usually contracted out by HKR to third-party companies or the city-owned company Stara. HKR is also responsible for organizing parking control in the city (Heikkila, 2014).
    - ❖ The City Planning Department of the City of Helsinki (KSV) is responsible for urban planning in Helsinki. It prepares plans for the City Planning Board to approve (Heikkila, 2014). The department encompasses the Strategic Urban Planning Division, the Town Planning Division, and the Transportation and Traffic Planning Division.

One of the key elements to remember is that the City of Helsinki (as well as other cities of the HMA) funds most of the transport infrastructure development (the other part being financed by the LVM). It also owns public transport infrastructures, either directly or through its transport municipal company (HKL).

- HKL was founded in 1944 and is 100 percent owned by the City of Helsinki. HKL's main task is to produce Helsinki's tram, metro, and ferry services. HKL owns all the public transport infrastructures in Helsinki; that is, tram and metro tracks, stations, stops, bus stops, and the largest terminals, except for a few stations that are owned by the City of Helsinki or the Finnish State. HKL is responsible for Helsinki's track infrastructure and most other public transport infrastructure like stations and terminals. HKL has approximately 1100 employees, who drive trams and metro trains, control traffic, maintain equipment, and plan and implement new projects. HKL's annual turnover is more than €140 million and its investment program for 2015–2024 is approximately €1.2 Billion. HKL's most important partner is Helsinki Region Transport (HSL), from which it receives nearly 100 percent of its operating income.

- HSL is the Helsinki Metropolitan Transport Authority and was formed in 2010. HSL plans and organizes public transport in seven municipalities of the Greater Helsinki: Helsinki, Espoo, Vantaa, Kauniainen, Kerava, Kirkkonummi, and Sipoo. The only thing HSL owns is the ticketing and information system of the transportation system. These seven municipalities own 100 percent of HSL. Half of HSL's income comes from ticket revenue, for which it is responsible in HMA, and the other half from municipal subsidies of the seven owning cities. As it works under the Public transport purchaser-provider model (HSL, 2016), HSL organizes public transport services in the seven cities by tendering bus services and procuring rail services from HKL for trams and metro, and VR for commuter train services (HSL, 2014a). In 2016, HSL's operating income was €647.2 million, 49.3 percent (€319 million) of which came from ticket revenue, 48 percent (€311 million) from municipal subsidies, 0.8 percent (€5 million) from central government subsidies, and 1.9 percent (€12.2 million) from other sources (HSL, 2016a). HSL's operating expenses in 2016 were €654.2 million, 75.3 percent of which (€493 million) came from operating costs, 15.2 percent (€99 million), and 9.6 percent (€63 million) from other sources. HSL has an executive board constituted of politicians from the seven member municipalities. For the last four years, the board has been formed of seven members from the Helsinki City Council (including the chair), three members from the Espoo City Council (including the vice chair), three members from Vantaa, and one from Kirkkonummi. HSL's executive board decides the fares and levels of service. Above the executive board is what is called the general meeting of HSL, where delegates from each city vote on the budget and make major decisions (IH10). HSL also proposes the Helsinki Region Transport Plan (HLJ), a strategic document prepared in close coordination with the Land Use and Building Act (HSL 2015), outlining short- and long-term transport development projects for the Greater Helsinki Area. HSL is responsible for the marketing of public transportation in the HMA, as well as passenger information (Ullah, 2016). According to its charter, HSL is supposed to cover all Greater Helsinki municipalities in the region in the future (HSL, 2014e). Finally, HSL pays compensation to cities (or their transport companies) for using their infrastructure. For example, in 2015, the infrastructure compensation paid by HSL to HMA municipalities amounted to €68.6 million; 85 percent of that amount went to the City of Helsinki, as the sole owner of the Metro and tramway system, while Vantaa received about 8 percent and Espoo about 2 percent (HSL, 2014a).

- Forum Virium is a non-profit company that was founded in 2006 and is fully owned by the City of Helsinki. It defines itself as an in-house innovation agency that aims to support the development of new initiatives in the city, taking care of European R&D projects. As a company Forum Virium receives its base funding from the City of Helsinki, which is slightly under €1 million, and receives a few million on top from other sources (Cities of HMA, European funding, corporate membership fees) (Forum Virium, 2015).

- City Car Club (CCC) was originally founded in 1999 and is presented as being one of the first world operators in the car sharing business; it was also a finalist in the World Technology Award in 2003. The company has also won environmental awards in Helsinki and in the HMA. In 2010, CCC merged with a media company called O2 media. CCC receives its income from advertisements it displays through its car-sharing network and from car-sharing fees. The company has

60–70 cars in the HMA and has a turnover of about €1 million. It recently invested in the development of its fleet by buying 20 GTE hybrid vehicles

- Lahitaksi is a company founded in 1965 that started in Vantaa (part of HMA). Gathering about 1250 taxi cars, it is the second–largest taxi company in Finland in terms of cars, providing in total over five million trips yearly. Lahitaksi's main activity is to make the taxi demand match the offer by dispatching taxi-ordering calls. Lahitaksi main income comes from the commission taken from customers ordering taxis by phone, as well as the membership paid by Lahitaksi taxi members (about €150 monthly) to benefit from the dispatching call service. Lahitaksi operates in 17 municipalities of the Uusima region as well as in the city of Helsinki. The company is 100 percent owned by Lahitaksi member companies (about 700 companies). The annual turnover of the company is approximately €6 million and the revenue of all Lahitaksi drivers combined is about €150 million (from which Lahitaksi does not take any fee). Lahitaksi is also part of Suomen Taksiliitto, the Finnish Taxi association, which includes roughly 80 percent of all taxis in Finland; that is, 9000 taxis. Suomen Taksiliitto (located in the same building as Lahitaksi) is in charge of defending the interests of taxi companies and taxi drivers and is known to be a powerful lobby.

- Ramboll is a private Danish consulting company that was established immediately after the end of the Second World War. It was originally involved in a Finnish company called Viatek. Ramboll is 100 percent owned by a Danish Foundation. Its core business is in infrastructure planning, plumbing, highways, and streets. Ramboll has a long history of planning for Finnish transport agencies and Finnish municipalities. ITS-related projects account for nearly 20 percent of Ramboll's revenue in Finland.

- Eera is a Finnish business and strategy management consulting company that specializes in building businesses ecosystems. The company split in January 2016 into an entity specialized in management consultancy (Eera) and Eera Industrial Development (EID). The management consultancy company employs about 40 people, 20 of whom are special advisors, mostly former Finnish executives and officials. Although Eera historically had public and private contractors, most of its contractors recently have been private. Eera's annual turnover is €2–3 million.

- SITO is a Finnish engineering company that was created in 1976 and now employs about 550 people. Quite heavily positioned in the planning sector, the company is trying to diversify itself and move into new traffic solutions. ITS-related projects account for about 10 percent of the company's revenue.

As seen above, the city of Helsinki is surrounded by populous municipalities, forming what is called the Helsinki Metropolitan Area, and the Greater Helsinki Region. It seems thus important to pay attention to how metropolitan governance is considered in the HMA to better understand the context in which MaaS has developed in recent years.

- Metropolitan Governance in Helsinki

Following the 2003 OECD Helsinki territorial review report, the Finish Ministry of the Interior appointed a civil servant to redefine metropolitan governance for the Finnish capital region (Ache, 2011). Among other recommendations, Mr. Alanen proposed the merger of the Uusima and East Uusima regions into a single administrative body that would be in charge of *"land use, housing, traffic and public transportation systems*"

(Ache, 2011: 162). Although the proposal was rejected quasi-unanimously by the different involved actors (the municipalities and the two targeted regions), it is acknowledged that the Alanen report paved the way for more cooperation between municipalities within the Helsinki Region, which ultimately motivated the birth of the Helsinki Metropolitan Area Advisory Board in 2004 and the Helsinki Region Cooperation Assembly in 2005. While the former has brought together the municipalities of Helsinki, Espoo, Vantaa, Kauniainen, Kirkkonummi, Vihti, Sipoo, Hyvinkaa, Nurmijarvi, Tuusula, Kerava, Jarvenpaa, Mantsala, and Pornainen to focus on land use, housing, and transport, the latter has brought together the four municipalities of the HMA to look at strategic issues (Ache, 2011). Another attempt towards metropolitan governance was made with the creation of the Helsinki Club, which included the four mayors of HMA, the director of the chamber of commerce, university rectors, Sitra, and some other key figures of Helsinki Metropolitan area, and aimed to a "vision" for the HMA. In 2011, the Uusimaa and East Uusimaa regions merged as initially proposed by Alanen into the Helsinki-Uusima Region.

However, until that point, no functional and holistic metropolitan governance body had been implemented for the HMA or the Helsinki Region, which suffers from clear institutional fragmentation (Ache, 2011). Figure 4.3.4 is a map of the different functionning entities of the Helsinki Region.

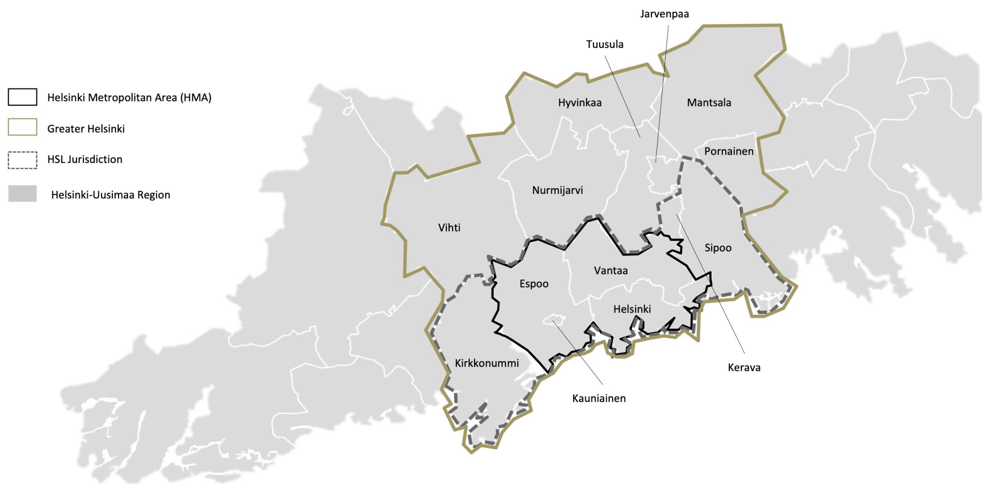


Figure 4.3-4: map of different jurisdictions within the Helsinki Metropolitan Area (author's elaboration, based on HSL [2015])

For example, seven different policy visions that have been designed for the Helsinki region since 2003, by Helsinki Metropolitan Area Advisory Board, the Helsinki Region Cooperation Assembly, YTV, the counties, or a combination of the above-mentioned actors, but none of these visions are supported by actors having coercive powers, and thus have low chances of being implemented. According to Haila and Le Galès (2009), possibilities of seeing a metropolitan body emerge from the four municipalities of the HMA are very low, as the four cities seem to be in constant competition and hence resist attempts to institutionalize metropolitan governance. The latest attempt to consolidate metropolitan governance – the constitution of two working groups in 2013 to prepare new legislation and municipal division arrangements for the HMA by the Finnish Ministry of Finance – has been poorly received by the concerned municipalities. The metropolitan administration, which would have been responsible for making decisions for the whole area for housing, land use, or transport, was originally supposed to start in 2017 but never came to life (Söderström et al., 2015). Thus HSL, as well as HSY in charge of providing water and waste management services, seem to be the only authorities operating at a metropolitan level in the HMA. In the next par, the historical development of the Helsinki Transport system, through its key infrastructural and institutional developments from the beginning of the 20th century until today, is presented.

4.3.2 Historical development of Helsinki transportation system

4.3.2.1 Development

In 1887 the Helsinki Omnibus Ltd (HRO) was founded, which provided transport services with horse-drawn omnibuses. In 1889, HRO received the right to build tramlines in Helsinki, which at that time had nearly 87,000 inhabitants (Weckstrom, 2016). The Helsinki tram system was one of the first functioning tram systems worldwide. However, due to the slowness of the HRO tram electrification process, which started in the late 1890s, some other electrified tramlines moving around the city were developed by competitors to be finally transferred to HRO in exchange for HRO stocks (Herranen, 1988). The electrification of the entire tram network was completed by 1901. In 1913, the City of Helsinki decided to buy the majority of HRO stocks (City of Helsinki, 2012), and the tram network reached its most advanced state in 1930, when there were 14 lines in operation, all operated by HRO (Alku, 2002), providing over 61 million tram journeys during 1939. In 1944, the City of Helsinki bought the remaining HRO shares and turned HRO into a municipal transport company, under the name HKL. The development of the tram network in the 1900s enhanced the expansion of the city towards the north, as well as the development of an industrial belt around the inner city, and along the orbital tramlines (Sundman, 1982). As a result, 100,000 people were estimated to live in the Finnish capital city in 1907 (City of Helsinki, 2012), which was still contained within the actual city of Helsinki's jurisdictional boundaries.

As the population of the city was increasing rapidly, the need to plan the Helsinki region as an entity, and not only the city of Helsinki, became real. The first plan was brought up in 1912 by famous Finnish architect Eliel Saarinen and his team, as the *Munkkiniemi–Haaga plan*, which proposed the development of two suburbs outside the official boundaries of Helsinki, offering options for the expansion of the city (Niemi, 2016). The city kept growing and, in the 1920s, the population of Helsinki reached 152,000 inhabitants (City of Helsinki, 2012). Following the Paris Peace treaties of 1947 that followed the end of the Second World War, Finland lost the region of Karelia to the Soviet Union. As a direct consequence, the Karelia-located city of Viborg, Finland's second-largest city at that time was "annexed" by the Soviet Union, which caused massive migration. This lead Helsinki to accommodate an influx of 30,000 people, which resulted in a significant increase in the number of inhabitants in Helsinki (Weckstrom, 2016).

The expansion out of the historical downtown area – that is, out of the peninsula – only happened in the 1960s once the first radial freeways were built (Leaks and Keinanen, 1995). Since then, urban sprawl of the Helsinki region has been quite rapid (Sundman, 1982). The planning of the city of Helsinki was facilitated by the fact that the City at that time owned almost two-thirds of the land within its own borders, which was not the case for the surrounding municipalities. In 1925, Finnish municipalities gained the legal right to embody surrounding suburbs and the Town Plan Code of 1931 gave municipalities the right to plan privately owned land (Bengs and Loikkanen, 1991). However, Helsinki continued its old practice of buying private land to be zoned for urban development, also increasing its role in the land market (Laakso and Keinanen, 1995). Urban sprawl was also facilitated by the development of the bus network in the capital region.

In 1973, the cities of Espoo, Helsinki, Vantaa and Kauniainen (which together form the HMA) decided to join forces under a joint municipal authority called YTV (standing for Helsinki Metropolitan Area Council) to handle waste management, regional and environmental services, and arrange regional transport between the member municipalities. Decisions within YTV were carried out by a Regional Assembly constituted of representatives from the four municipalities. Being proportional to the population of each municipality, 11 representatives from the City of Helsinki sat in the assembly: five from Espoo and five from Vantaa, as well as one from Kauniainen (YTV, 1996).

Regarding transportation, YTV was at that time responsible for arranging public transportation services across municipal boundaries of the HMA, leaving municipalities responsible for organizing bus services within their jurisdictions (Valkama and Anttiroiko, 2007). As local bus services were at that time contracted by municipalities with third-party operating companies, YTV continued to work under a contract based co-operation scheme. YTV's main responsibilities were to plan cross-municipalities bus routes and buy bus services from operating companies under a specific license scheme (Valkama and Anttiroiko, 2007). However, as a consequence of its EU membership, Finland had to embrace the single-market framework of the European Economic Community, which meant opening up its transport market to competition, as formulated in the European Commission's 1992 White Paper on Transport (Commission of the European Communities, 2001).

In March 1991 the new National Passenger Transport Act became operational in Finland, allowing municipal authorities (and thus YTV) to organize tenders for public transport provision. Consequently, YTV established a framework to guide tendering processes. In December 1992, YTV decided to put regional bus services to tender, planning to have the first tendered services running on January 1, 1995 (ICLEI, 2003). Although multiple tendering processes were considered, YTV chose to tender via the km cost so that it could still get all the ticket revenue (ICLEI, 2003). Under this mechanism, the planning of routes, time-tables, and fleet schedules is left to the organizing authority, while the winner of the tender is only responsible for providing the buses and crews as well as running the service (ICLEI, 2003). By the beginning of the 2000s, all bus lines of the Helsinki Region, including those within municipalities, were organized under competitive tendering procedure. In 2003, four operating companies were providing 81 percent of bus services in the Helsinki Region. Two of them were municipal companies and two of them were private, being Veolia Transport and Nobina (Valkama and Anttiroiko, 2007). The introduction of competitive tendering for bus services in Helsinki Region enabled savings of €21 million for YTV from 1995 to 2000 (Valkama and Anttiroiko, 2007) and also decreased the average age of the bus fleet by two years and increased overall customer satisfaction (ICLEI, 2003).

Within the City of Helsinki's jurisdictional boundaries, a metro system was also proposed several times between 1918 and 1955 (Weckstrom, 2016). In 1963, the first plan for a metro system was finally presented to the City Council, but was criticized for having too many stations and too many overlaps with the existing rail network. The system that was finally chosen for construction in 1969 was smaller, with a total length of 38 kilometers (Weckstrom, 2016). In 1982, the first section of the Helsinki metro, 10.7 km in length, opened between Roihupelto and Herttoniemi (Iltanen 2001) and later expanded towards the East and the West; that is, the center of Helsinki. The metro was financed by the municipalities of Helsinki and Espoo as well as by the state of Finland (HSL, 2014).

On January 26, 1969, the first electric commuting trains started to operate in the HMA, initially between Helsinki and Kirkkonummi (Alameri, 1979). The development of commuter train services also influenced the radial development of the metropolitan area. Hämekoski and Sihto (1996) argued that Helsinki city center's location on a peninsula has influenced land use and the development of transport networks, and made the city's spatial structure look like the fingers of a hand.

In 2006 the City of Espoo approved the construction of the western extension of the metro, construction of which began in 2009 and was finally inaugurated in November 2017. This eight-station extension, which cost €1.1 billion, was financed by the cities of Espoo (72 percent) and Helsinki (28 percent) thanks to loans from the European Investment Bank (EIB) and the Nordic Investment Bank (NIB). The new development, which is operated by HKL, is expected to cut transport-related emissions along this corridor by 40 percent, and will be used by an estimated 50,000 people each day. Another five-stop extension is planned for 2020 at the earliest

(Metro Report, 2017). In the meantime, the second line of the metro towards the airport and the north is currently being discussed and might start once the western expansion is completed.

Following the creation of HSL in 2010, a new transport plan called HLJ was developed in 2011, and for the first time took into account the 14 municipalities of the greater Helsinki (HSL, 2014c). The first plans for the Helsinki Metropolitan Area were set out by YTV in 1994 as the Transport System Plan (PLJ). The exercise was continued with the PLJ 1998, PLJ 2002, and PLJ 2007. These plans insisted on the need to link transport planning between the region and the state. HJL 2011 was followed by HJL 2015, which promoted four main directions. It planned the strengthening of transport system financing, the improvement of service level of sustainable modes of transport, an increased use of information and steering tools, as well as the improvement of logistic traffic flows. Under the second direction, the document planed to include a 60 percent increase in park-and-ride sites for cars and 80 percent for bikes by 2025, in order to promote intermodality and physical integration. To engage in the four above-mentioned directions, the plan also promoted the adoption of an integrated vision when it comes to public transport in the Helsinki Region, by developing an integrated ticketing system for the region.

In order to break with the radial structure of the HMA (Albacete et al., 2015), a ring rail line directly linking Vantaa Airport to Helsinki central station also opened in 2015 after six years of construction. This new line allowed about 200,000 people to shift from private car to rail. The project costs were estimated at approximately €675 million, supported by the Finnish Transport Agency, the City of Vantaa Finavia (Finish Civil Aviation Administration), and the EU, thanks to TENT-T funding (Finnish Transport Agency, 2013a). Trains running on the Ring Rail Line are operated by VR as all other commuter trains in Greater Helsinki.

In December 2015, HKL signed a 10-year contract with CityBikeFinland, a joint venture between the bike sharing services provider Smoove and the public transport specialist Moventia. The first 500 bikes of the bike sharing system were inaugurated in May 2016, and 1000 more bikes are expected to be added to the network by the summer of 2017 (CityBikeFinland, 2016). Figure 4.3.5 summarizes the key infrastructural and institutional developments of Helsinki's transport system.

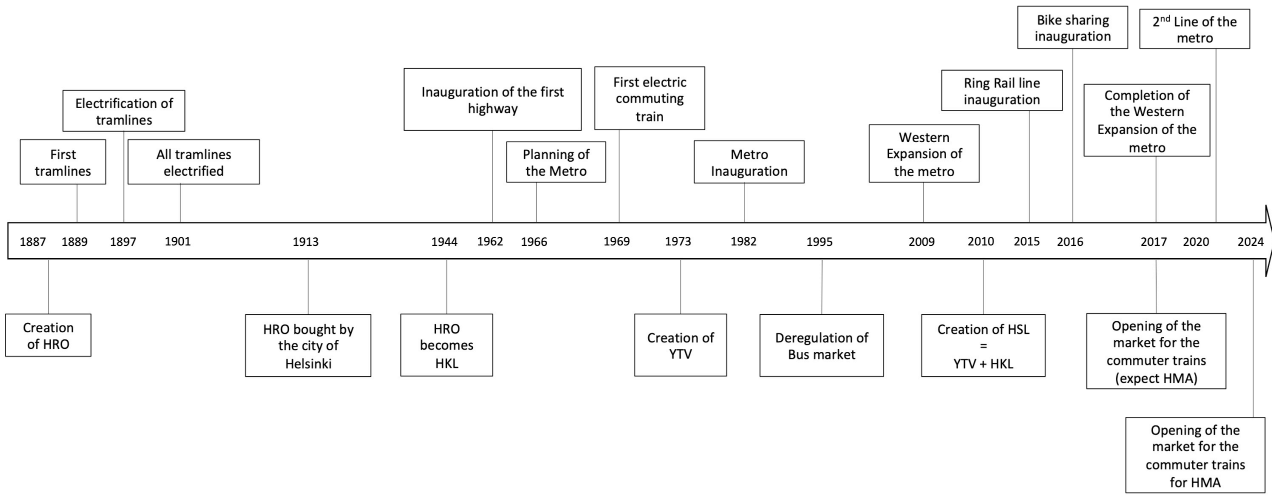


Figure 4.3-5: infrastructural developemnt of Helsinki's transportation system (author's elaboration)

Although VR has had the exclusive right to operate domestic passenger traffic Finland, as stated in the agreement on exclusive rights signed between VR and the LVM (Finish Transport Agency, 2013b), domestic passenger transport market is supposed, as part of EU requirements, to be liberalized and open to competition in 2017, to enable other actors to enter the market and provide services that better match the demand (Barrow, 2015; Heikkila, 2014). In 2016, HSL started an RFB process that aimed to open the commuter train markets of the HMA to other train operating companies. However, after having VR agree to a 15 percent decrease in prices, HSL finally decided to postpone the RFB until 2021. According to VR:

> *"(HSL) is satisfied with the quality and operations (…) And I guess that the whole Infra is not ready for competition yet (…)therefore that's maybe one reason that they started to negotiate with us, and they were saying that the only problem* [now] *is the price level. Quality is okay and fleet is okay and all these, but the price is too high. So we committed that if we decrease* [our] *price (…) they are ready to postpone the RFB process, because it is quite heavy for both sides and requires heavy organization and time to commit. We promised that we will start this kind of program in the company to cut our costs and that was the target. So we made quite huge savings, and this will take place year by year as we go."* (IH3)

Public authorities in Finland are also considering heavy deregulation in urban rail that have not been deregulated yet. It is estimated that the City of Helsinki, as well as HSL, will consider opening up urban rail by 2021, for a possible opening in 2024.

> *"When it comes to tram and metro,* [opening to competition] *is possible… it may happen but it will be analyzed whether it is good for the society and profitable or if HKL is the best solution. That analysis will be done by HSL and by the City Council of Helsinki and neighboring cities. It will be a political decision. Our present contract in metro and tram transportation are going until the mid of next decade; that is to say, until the end of 2024. And the decision about the possible opening for competition will be done in 2021 or so. HKL's aim is to enhance our both financial efficiency and quality, so we can show that we are the best solution. But it is also possible that we don't manage to do that and the competition will come."* (IH4)

A new region zone model is planned to be introduced in 2018, which will not follow municipal boundaries as is the case nowadays, but will be concentric and centered on the Helsinki city center, making it easier to extend to further municipalities that will be interested in falling under HSL jurisdiction in the future. Among the advantages brought by this new zoning system, pricing is expected to be based more on the distance travelled than it is today, potentially resulting in cheaper journeys for cross-municipality travel, and longer distances within the same travel zones (HSL, 2012).

4.3.2.2 Transport in Helsinki nowadays

The post-war era in Finland coincided with economic renewal and consequently rising car ownership. If the bus was the preferred way of travel in Finland in the 1950s, the private car became the preferred way to move in the 1960s (Meinander, 2011). In the mid-1960s, the number of registered cars in Finland grew significantly, from 258,000 to 602,000 private vehicles, which can be understood as a growing demand, but more precisely as a consequence of car importations deregulation by Finish authorities (Meinander, 2011). In the 1990s there were over 2.2 million private vehicles registered in Finland (Meinander, 2011), for a population of nearly 5 million people. In 2015, some 3,847,045 vehicles were registered in Finland, which represented 701 vehicles per 1000 habitants (Statistics Finland, 2016). Figure 4.3.6 shows the evolution of private car ownership for Helsinki, its surrounding municipalities, and the Helsinki Metropolitan Area. Although it seems that car ownership has not been increasing remarkably for the city of Helsinki, it has continued to increase for the HMA in general, mainly due to significant increases in the cities of Espoo and Vantaa. Even when considering the plateau reached by the city of Helsinki as coinciding with the Peak Car phenomenon, the argument is not valid to analyze the trend over the entire metropolitan area.

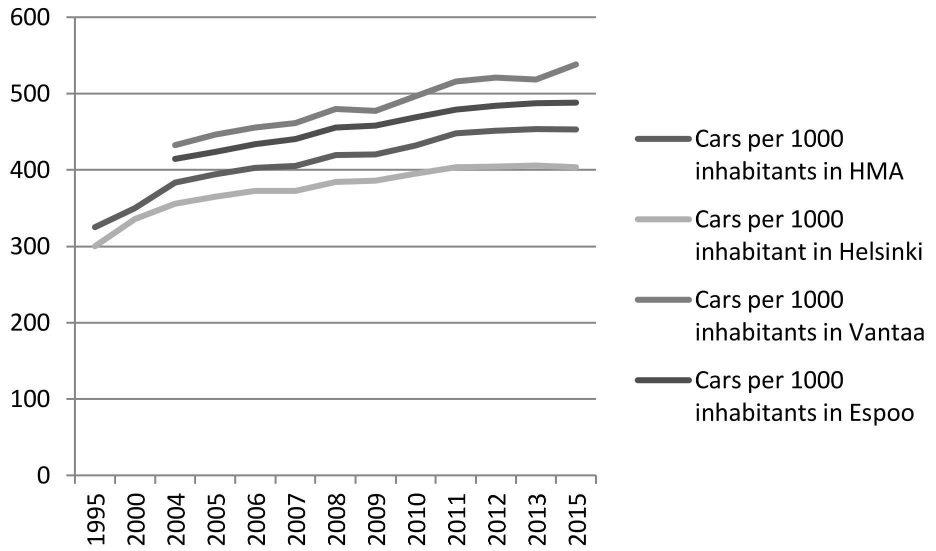


Figure 4.3-6: evolution of car ownership in HMA (adapted from Statistics Finland [2016)]

In 2015 there were 5158 road traffic accidents in Finland, involving 260 deaths and 6385 persons injured (Statistics Finland, 2016). It was estimated that transport induced 27 percent of Finland's greenhouse gases in 2012 (Heikkila, 2014). In 2015, within the HMA, 41 percent of trips were made by private vehicles, 33 percent by public transportation, and 26 percent by human-powered mobility (Rosello et al., 2016), as can attest Figure 4.3.7.

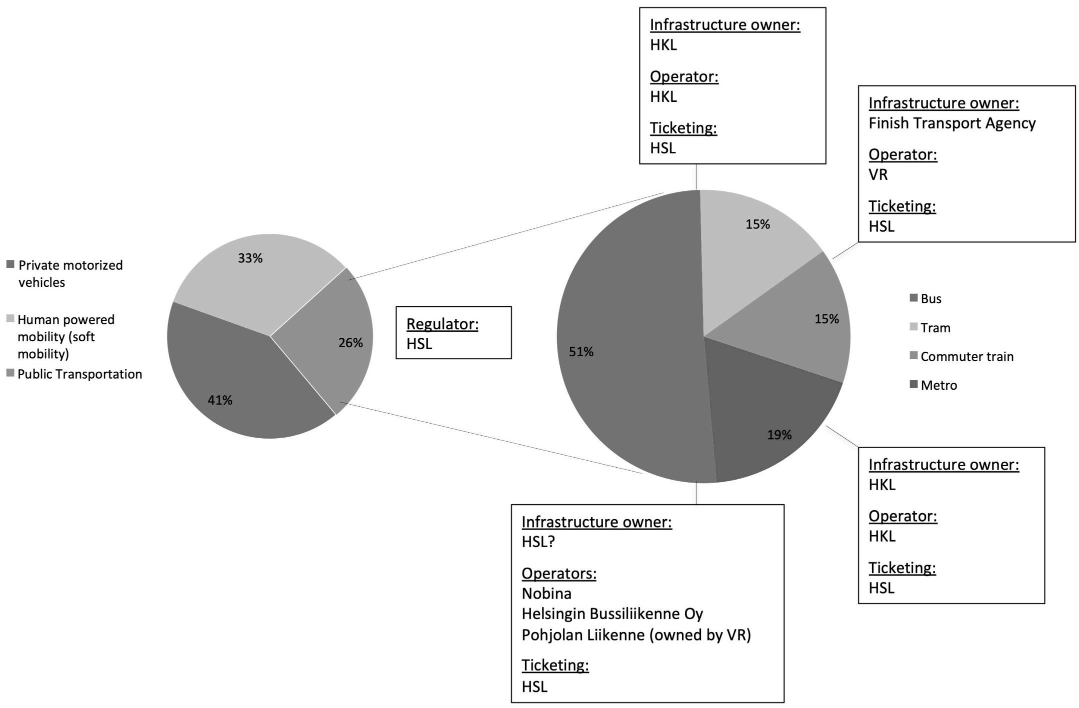


Figure 4.3-7: modal share in the HMA in 2015 (adapted from Rosello et al. [2016])

In 2014, 51 percent of the trips done by public transport within HMA were realized by bus, accounting in total for 182 million trips (Ullah, 2016). At that time, four different bus operating companies (Nobina, Helsingin Bussiliikenne Oy, Veolia Transport and VR-owned Pohjolan Liikenne) provided bus services for HSL within the HMA. Since then, Veolia Transdev has exited the Finnish bus market. In 2014, trams operated by HKL provided 55 million trips, accounting for about 15.5 percent of all public-transport-related trips; commuter trains, operated by VR, provided 52 million trips (15 percent of all public transport trips); and 62 million trips (19 percent of all public transport trips) were made by metro, operated by HKL.

From an environmental point of view, it is estimated that transport accounted in 2014 for 23.2 percent of the carbon emissions of the city of Helsinki and for 24.1 percent of the Helsinki Metropolitan Area (Dahal and Niemelä, 2016).

4.3.3 Evolution of Climate policies at the National and Local levels

Climate change has long been on the table for Finnish authorities, as one might already observe with the *2001 Finnish Climate Strategy*. However, in 2003, the Finnish government decided to work on a new strategy, in order to follow the EU Emission Trading System (ETS) developed to monitor the implementation of the Kyoto Protocol, which was published in November 2005. This new strategy emphasized the need to increase the efficiency of the Finnish transport system as well as to use less CO_2-emitting technologies in order to reduce GHG from traffic. In 2008 Finland edited its *National and Climate Strategy* to implement the 3*20 EU package (TEM, 2013). In 2009, Finland committed, through its *Long-Term Climate and Energy Policy*, to reducing its domestic traffic related emissions by at least 80 percent by 2050 compared to its 1990 levels (VNK, 2009).

In comparison with the neighboring municipalities, the climate mitigation targets set by the City of Helsinki are known to be more ambitious. Where Espoo and Kauniainen have not defined bold climatic targets, the City of Helsinki, in its *2013–2016 Strategic Plan*, has planned to have its carbon emissions reduced by 30 percent by 2020 compared to 2005 and to be carbon-neutral by 2050. The Strategic Plan also targeted improving energy efficiency by 20 percent by 2020 compared to 2005, and to have at least 20 percent of their energy consumed coming from renewables (Dahal and Niemelä, 2016).

In 2014, The Finnish Ministry of Employment and the Economy edited its *Energy and climate road map*, targeting an 80–95 percent CO_2 emission reduction by 2050 compared to 1990 levels. To do that, the report recommended moving towards fossil fuel-free fuel for vehicles and working on the efficiency of transportation systems, promoting public transport and other sustainable ways of transportation (TEM, 2014). In 2014, the Uusimaa Regional Council also fixed in its strategy document the aim of becoming carbon-neutral by 2040 (Uusimaa Regional Council, 2014).

In 2016, Climate Analytics released a report analyzing the Paris Agreement and explaining the consequences it would have on Finnish Energy and climate policies. The report stated that neither the 2030 nor 2050 targets for Finland were in line with levels consistent with the Paris Agreement, and that if Finland wanted to respect its engagements taken by supporting the Paris Agreement, It would have to adopt bolder climate and energy targets (Climate Analytics, 2016).

At the end of November 2016, the Finnish Government approved the *National Energy Strategy for 2030*, which has since that been submitted to the normal parliamentary procedure. According to the first version of the strategy, Finland aimed to increase the share of final energy consumption coming from renewables to over 50 per cent in the 2020s in order to move towards a carbon-neutral energy system. Regarding the transport sector, the strategy proposed the development of new transport services and intelligent transport methods (TEM, 2016). While the Finnish Government views transport as an important sector in moving towards a more sustainable society, climate change is also acknowledged to lie at the core of the LVM policies (IH11).

Figure 4.3.8 summarizes all the different climate related policies that have been put in place these last years, focusing on the supranational, national, and local levels.

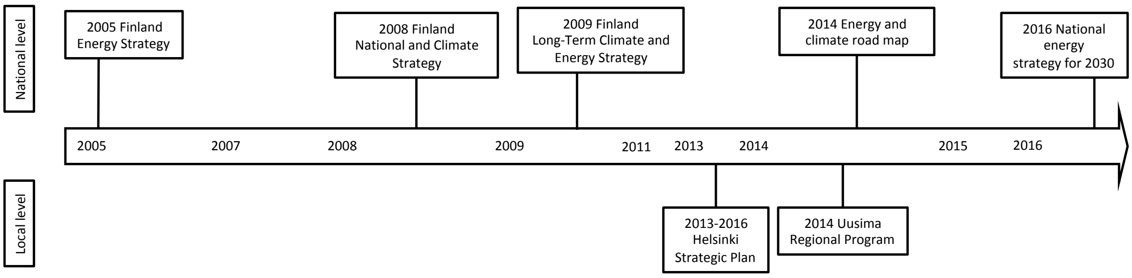


Figure 4.3-8: evolution of climate and energy policies at the local and national levels (author's elaboration)

Having looked at the historical development of the transportation system in the HMA and the evolution of climate-change-related policies in Finland and in Helsinki, the next subsection will present the different stages of development of MaaS in the HMA.

4.3.4 The development of MaaS in Helsinki Metropolitan Area

According to the father of the concept, MaaS would be, at least conceptually, over 15 years old:

> *"It started somewhere turn of millennium, I saw the development that happened in telecom (…) We had the infra layer, the transportation layer but we were lacking the last layer as in telecoms, where it is the operators. Once I got to that one, I thought it was obvious we were definitively going to have mobility operators at some point."* (IH1)

It is estimated that integrated ticketing has been on the table of Finnish Authorities prior to the 2000s. For the LVM, there are "*papers from 1989 talking about nationwide ticketing and payment systems, which is trying to push for what is best for the users*" (IH10). However it is really in the early 2000s that concrete developments happened vis-à-vis integrated ticketing systems. At that time, a project was developed by LVM to create physical centers where customers would be able to buy tickets from different transportation providers.

> *"The LVM wanted to put together bus operators, train operators and taxis, and at that time some type of park-and-ride system in the same building and then give funding to build these centers. It existed for five or six years, and then the program ended (…) They tried to look at one place where the people could buy tickets for the bus and the trains together."* (IH5)

In September 2006, on the basis of two early reports from Finnish Ministry of Finance from (*Finland – Towards an Information Society, A National Outline*) and the Finnish National Fund for Research and Development SITRA (*Quality of Life, Knowledge and Competitiveness*), the *National Information Society Strategy for 2007–2015* was published, presenting "*72 proposals for measures intended to ensure Finland's transformation from an industrial society to an internationally attractive, human-centric and competitive knowledge and service society*" (VNK, 2006: 5). Regarding transportation, the report foresaw that ICT-based transportation systems such as smart cards, route navigation, or electronic timetable information would be part of Finnish citizens' daily lives by 2015. In June 2007, the Finnish Government appointed the Information Society Advisory Board to oversee implementation of the National Information Society Strategy.

In the *2007 Finnish Transport Policy Report*, apart from some discussion of intelligent speed adaptation and intelligent road pricing, nothing was mentioned about ITS or digital transport (LVM, 2007). As a direct consequence of the *National Information Strategy*, the government encouraged the introduction of transport services, which "*make use of information technology*" in the *2008 Transport Policy Guidelines report* (LVM, 2008: 24). In 2009, the Finnish Ministry of Transportation and Telecommunication released the first *National Strategy for ITS*, which aimed to make Finland one of the five most advanced nations in the world when it comes to the use of ITS by 2020 (LVM, 2009). The strategy also targeted a 20 percent increase in non-private vehicles modal share and a 20 percent decrease in traffic delays caused by congestion in large urban areas.

In the early 2000s, a web-based journey planner was released in HMA, which is believed to be one of the first publicly available journey planners in the world (IH6). In the same year, YTV implemented an electronic travel card system (Matkakortti) in the Helsinki Metropolitan Area for all transport modes – buses, commuter trains, trams, metro, and Suomenlinna ferry (Mezghani, 2008). In 2002, HKL proposed the first SMS ticketing system, in collaboration with PlusDial MTSP. The system was quite successful, as in January and February 2002 alone, over 100,000 SMS single tickets were purchased.

Regarding national transport policy, 2010 saw some significant developments. The organization of the transport sector at the ministerial level changed from having different modal agencies to having two holistic and transversal agencies. At that time were created the Transport Safety Agency (Trafi) and the Finnish Transport Agency (FTA), which both looked at all transportation modes.

> *"[From 2010] In the ministry there was no longer several transport modes department. That is one of the ground lane things about MaaS as well. We blurred the lines between the different modal silos."* (IH10)

That was followed by the release of a report entitled *Digital Finland, New Transport Policy*. This report aimed to inform the different Finnish political parties about possible future developments in the transport sector thanks to digitalization (LVM, 2010). In December 2010, *the Finnish Digital Agenda for 2011–2020* was submitted to the Finnish Parliament and eventually published. It promoted the change in customer paradigm enabled by the ICTs. In particular, the Digital Agenda set out the vision of having customers at the center of the mobility system, and the possibility of customers becoming actors who were potentially able to provide services (LVM, 2011a).

In September 2011, the LVM released the *Transport Revolution Report,* which aimed to offer a new dimension and a new momentum to transport, based on the assumption that "*The roles of the private and public sectors are changing; the role of the private sector is increasing*" (LVM, 2011b: 11). Among other things, the report proposed the improvement of information management and traffic flow management through 'smart traffic' means to leverage transport systems more efficiently, as well as to move towards more integrated urban transport (LVM, 2011). It is estimated that the Transport Revolution Report paved the way for more MaaS-oriented policies.

> *"In 2010 began the Transport Revolution policy. Once again, it did not include the term MaaS, but it was there. And then I joined the ministry in 2011. It [MaaS] has been at the heart of our transport policy ever since."* (IH10)

Along the definition of the *Transport Revolution Report*, a think tank was put together in 2011, under the direction of Finnish Minister for Transport Merja Kyllönen, to carry out innovative ideas related to the development of intelligent transport solutions (IH1, 4, 9, 10, 13). Headed by the LVM, the think tank put together local Finnish transport authorities, and cities, including HSL and the City of Helsinki, and non-profit, such as ITS Finland. The purpose of the think tank was to make the perception of the transportation sector evolve and stop organizing it around the private car.

> *"Six or seven years ago [in 2010] we have been (…) looking at apps ecosystem for cars. The focus there was cars. At that time we discussed that some of the services you used in the car, such as parking the*

car and hopping off on a bus, they follow you on your mobile phone anyway ... So we thought, 'should we re-check the focus?'" (IH13)

The same year, 2011, represented a shifting point for the national train operator VR, which decided, shortly after having started to install Wi-Fi on its trains, to renew its sales channel and establish a customer loyalty program. Hence, VR created a digital platform for customers to choose from among all kind of services it was providing, and also started to gather data about its customers. Regarding the ticketing, VR decided to have all its tickets equipped with bar codes, allowing it to see whether the tickets had been validated or not, and also to cancel tickets bought from the webstore.

In June 2012, the LVM released its report on transport policy, which framed the future of transport towards 2022. Although almost nothing is mentioned on ITS, the report stated the creation of a working group to propose a new ITS strategy by 2013 (LVM, 2012c). In the same year, the Helsinki City Planning Department commissioned a report on the development and exploitation of intelligent transport systems (ITS), released in May 2013 (KSV, 2013). The report promoted the use of ITS to reduce congestion and improve the efficiency of transportation systems. With the goal of fulfilling the 2011 EU White Paper on transport and the 2010 EU ITS directive, the second Finnish ITS strategy was released in April 2013. It aimed to improve the level of services for mobility, transport, and information services for the customers, enhance the development of a new transport policy, and exploit the potential brought by the rapid development of the ICTs (LVM, 2013). This new ITS strategy, developed by a working group composed of FTA, Traffi, the Finnish Meteorological Institute, the City of Helsinki, ITS Finland and Nokia, particularly emphasized the need to develop integrated public transport systems and smarter and more eco-friendly mobility, through the use of ITS. The document also stated that approximately €300 million would be needed to develop projects in these areas, approximately 71 percent (€215 million) of which would from the Finnish central government, 7 percent (€20 million) from municipalities, 10 percent (€30 million) from businesses, and 12 percent (€35 million) from end users (LVM, 2013). The second ITS strategy in particular insisted on the need to develop information provision through multiple channels, and seamless ICT-facilitated door-to-door trip chains, in order to have a transportation system that achieved a level of flexibility and functionally close to that of the private car (LVM, 2013). According to the strategy, seamless mobility would only be possible if substantial investments were made in feeder traffic, park-and-ride payments, information services, and new mobility modes such as car sharing or pooling development.

In 2012, Gemalto won the tender to develop a new SMS ticketing system for the inner Helsinki area (Gemalto, 2016), taking over the service that had previously been provided by Plus Dial. In the same year, the Kutsuplus service was launched in Helsinki by HSL, after five years of research and trials, jointly done with Aalto University. Kutsuplus was an on-demand transportation mode (VTT, 2016), similar to a DRT solution, that connected passengers flexibly to the nearest viable vehicle, relying on an algorithm using real-time data being collected by ICTs. Although the system was not integrated to HSL ticketing system, it was a real success. Due to the fact that the service was highly subsidized and consequently required investments from the partner municipalities to sustain, Kutsuplus was finally abandoned in December 2015 (Ullah, 2016) but gained international recognition. By the time it stopped, more than 31,000 people had subscribed, and over 100 vehicles were being used.

In 2012, Sampo Hietanen, by many referred to be the father of the Maas concept, resigned from his job in the civil engineering sector to start preaching his MaaS idea. He joined ITS Finland in 2012, a non-profit organization that aims to create a network of professionals related to ITS. As the chairman of ITS Finland, he was invited to join the Transport Revolution think tank.

> *"Sampo is the one who kind of described* [MaaS]*, and said, 'this is what we should be doing'. In that think tank they really picked that up, especially our transport minister."* (IH13)

Another integrated travel card, supported by the Finnish Transport Agency, was also to be developed for the 22 remaining main Finnish urban centers in 2013 by the company TVV Lippuja maksujärjestelmä Oy, founded by the Finnish Government and other Finnish municipalities (Tieto, 2013), but never came through. In 2013, VR also established a mobile application to enable customers to buy long-distance tickets, connected with their loyalty program database.

In 2013, discussions were ongoing in the transport revolution think tank and the transport director of the City of Helsinki became interested in MaaS (IH13). Given his willingness to know more about the subject, and better understand what would be the role of the city as well as the one of public authorities to make MaaS happen, he commissioned a master's thesis to Aalto University in the summer of 2013 (IH4, 6, 9, 8, 13). The thesis was to be jointly supervised by himself and Hietanen. Sonja Heikkila, a master's student from Aalto University, was selected from among various candidates to undertake this job, which she finally delivered in Spring 2014. It is acknowledged that the main building blocks of MaaS were defined in the working meetings between the transport department of the City of Helsinki, Hietanen, and Heikkila:

> *"We designed the criteria of MaaS during those meetings when we were supervising Sonja. Everything, including the name MaaS, came up in one of those meetings. I still have some mails calling MaaS 'transport-as-a-service'."* (IH13)

In 2013 the *Helsinki City Plan Vision 2050* was released, where the transport system was described more efficiently and as being composed of an integrated system of various modes of transport. In its *2013–2016 Strategy*, the City of Helsinki targeted being a city with good services, transparent decision-making processes, and a hub for the science, art, and creativity scenes, as well as a world-class business and innovation center. The strategy also noted that the HMA will be developed as a uniformly operating area, respectful of its environment and neighboring nature. The strategy also targeted the improvement of public data openness. In terms of transport, the strategic plan proposed prioritizing projects focusing on the development of public transport, walking and cycling, improving the current park-and-ride system, and developing a network of electric car charging stations (City of Helsinki, 2013b). The report did not make any reference to MaaS.

In February 2014, a report from the LVM proposing the replacement of the in-place fixed tax system by the kilometer tax acknowledged that ITS should allow the development of "Traffic-as-a-Service", defined as "*effective and user-friendly coordination and integration of intelligent transport infrastructure, transport services and transport-related information and other services*" (LVM, 2014a: 8), and used interchangeably with MaaS. According to the report, reaching Traffic-as-a-Service would require the lowering of boundaries between transportation modes and the re-design of transport pricing. However, the kilometer-based tax was not implemented at that time and postponed.

In March 2014, discussions about the future of transport were undertaken at the LVM. Merja Kyllösen, who was still minister of transport, highlighted the opportunity to use the ICTs to make the Finnish transport sector a potential sector of growth and employment (LVM, 2014b). This was followed by the organization in spring of 2014 of workshops focusing on Mobility-as-a-Service (MaaS) by TEKES (IH3, 13), where the city and ministry officials, public transportation authorities, transportation providers, and technological providers discussed solutions and ways forward (TEKES, 2016).

In preparation for the European ITS congress of June 2014, to be held in Helsinki, the LVM commissioned the consulting company Eera to coordinate the development of the Traffic Lab (IH6), which aimed to gather private and public actors to put together data from different traffic services, sell them, and use them to develop innovative digital services. As a member of the Traffic Lab, ITS Finland took part in the discussion and managed to position MaaS as a subject of interest for the Traffic Lab (IH6). In her opening speech of the ITS congress, the Finnish Minister of Transport and Local Governments, Henna Virkkunen, announced the opening of the Traffic Lab (LVM, 2014c), a trial of electronic transport services, supposed to make travel easier through more intelligent choices in traffic. However, the Traffic Lab experiment ended in December 2015 (LVM, 2014d).

MaaS was officially presented to the public at the 2014 European ITS congress (IH6, 10, 13). Subsequently, a lot of media articles came out in Finland and internationally about MaaS. Most of the articles stated that according to the City of Helsinki, the city would be car-free by 2025 thanks to the development of innovative mobility packages (Helsinki Time, 2014). However, there was never a real policy from the City of Helsinki targeting a car-free city within a 10-year timeline (IH13). At the beginning of December 2014, HSL announced the development of a National Journey Planner in collaboration with the FTA, scheduled to open in 2016 and to replace the existing HSL and FTA (called Matka.fi) journey planners. The cost of the project was expected to be €600,000, which would be 55 percent paid for by HSL and 45 percent by the FTA (HSL, 2014b).

In December 2014, as CEO of ITS Finland, Heitanen, with help Mr. Poyry from Eera, with whom he had worked to develop the agenda of the Traffic Lab, organized an important event to kick off MaaS in Finland (IH1, 5, 6, 8). This event was organized as an open call to all organizations interested in knowing more about MaaS. At that time, ITS Finland also received assistance from the Helsinki Business Hub[23] (HBH), which would manage contacts with relevant actors abroad (IH15). About two hundred organizations, from both Finland and abroad, attended this event. From that event, Mr. Hietanen proposed that all companies interested in joining the MaaS journey should pay a membership fee of a couple of thousand euros in order to hire a consultant to create a business plan for MaaS.

> *"[After the 2014 ITS Europe Congress] we said: we do not know how it will look like, but for those who want to join, let's put some money and buy a consultant and make a business plan."* (IH1)

Twenty-four players decided to join this first phase, and a start-up company (MaaS.fi standing for MaaS Finland) was created at that time (IH1). The idea of creating a MaaS company mainly came from the partners of the first phase, not from Hietanen (IH1). The consulting firm contracted to realize the business plan was Eera (IH6), which had to deal with a lot of open questions at that time.

> *"At the beginning we did not know what kind of companies MaaS.fi would eventually become and would it only focus on personal cars or public transport … so there were really lot of open questions. There were only open questions. Nobody knew what would come out of the project."* (IH6)

In 2015, HSL promised in its HLJ 2015 plan to study in depth the concept of Mobility-as-a-Service, from the point of view of trip chains and for the promotion of sustainable modes of transport together with other actors (HSL, 2015). In February 2015, the Finnish Fund for Innovation TEKES opened two calls for organizations that would be keen on developing MaaS projects or would be interested in developing MaaS-compatible transport projects.

[23] Helsinki Business Hub is a non-profit company owned by the HMA municipalities, which aims to attract foreign direct investment in the Helsinki Metropolitan Area, and also has smart mobility as one of its core focus.

At the end of spring 2015, the business plan prepared for MaaS.fi by Eera was ready, and was submitted to Hietanen and the other member companies (IH6). The business plan focused on the development of the company that would be the first MaaS operator and highlighted the benefits for other investors to invest in it. The logical next step was to start looking for investors.

In 2015, the Mayor of Helsinki commissioned a report to the transport planning department of the city to understand how to make MaaS happen (IH13). A report was released during spring 2015. Following this report, the City of Helsinki decided to hire someone who would specifically focus on the development of MaaS for the city. In the same year, 2015, VR started working on its own MaaS solution. After releasing a new mobile application focusing on commuter traffic, which provided it with information and the possibility to buy commuting trains tickets, VR worked on an internal MaaS strategy to identify what role it should play within the Finnish MaaS ecosystem (IH3). A more thorough strategy was eventually conducted in 2016 and VR's "MaaS hackathon" was organized in the same year (IH3).

In October 2015 was held the World ITS Congress in Bordeaux, France. During the congress, the MaaS Alliance was officially established as an independent organization that aimed to gather stakeholders that had an interest in MaaS. The founding members were Ericsson, ERTICO – ITS Europe, FIA Region I, Transport for London, and Xerox (ITS International, 2015). During its launch, the MaaS alliance also received political support from the freshly appointed Finnish Transport Minister Anne Berner, who stated at that time that "*It (was) time to make the transport sector the most advanced sector in digitalism*" (ITS International, 2015). By November 2015, 20 organizations had joined the MaaS Alliance.

In mid-October 2015 a seminar was organized in Brussels by Merja Kyllönen, member of European parliament and former Finnish transport minister from 2011 to 2014 in charge of the transportation revolution work. In this seminar, Kyllönen explained that the EU environmental targets had created a certain context that needed to be understood as an opportunity for Europe to develop innovative transport solutions. Because Europe had one of the most developed transportation systems in the world, and was host to world-class transportation firms, the EU, through its member states and companies, was presented as having everything it needed to become the leader in sustainable transport. Within these innovative solutions, she mentionned the MaaS idea as one of the most promising ones, which was then presented in more details by Mr. Hietanen himself.

In late December 2015, Hietanen resigned as the CEO of ITS Finland to become the CEO of MaaS.fi (IH1, 13), which aimed to become the first MaaS operator in the world. This was followed by a first round of seed investment in February 2016, in which the company raised €2.2 million. Transdev accounted for 20 percent of the initial investment, the same amount as Karsan Otomotiv Sanayii and Ticaret AS (20 percent), a leading car-industry family from Turkey. Hietanen himself decided to invest, as a particular, in the company. Other investors included InMob Holdings, Neocard, Korsisaari, GoSwift, MaaS Australia, Goodsign, IQ Payments, and Delta Capital Force (MaaS Global, 2016a). Transdev, which is a traditional transport operator, commented on its investment:

> *"Transdev's focus has always been on MaaS but has never had the focus on the technology to support MaaS. You can't do every portion of the MaaS Business. So it's extremely important to us for our future that we are part of a MaaS initiative, that we either participate, create, or invest in like we have. Because we think that is really where the market is going. We are going to platform, and the day-to-day operations have already been commoditized, marginalized, and we have been desintermediated by some of the platforms businesses that are out there."* (IH2)

MaaS.fi has a board of five investors, elected by the general shareholders. Transdev holds the chair and the second–largest investor holds the co-chair, and both are responsible for overseeing the fundraising of the entity, while day-to-day operations are left to Hietanen and his team. In March 2016, the Finnish car rental company Veho/Sixt also invested in MaaS Finland (MaaS Global, 2016b) and thus entered the board.

> *"[On the board] we have payment provider, automotive manufacturer, and transportation operators. It is a very interesting board. I have invested in other companies before and usually the board is made up of people that will further invest for the company. So venture capitalists, for example, usually sit on the board. For us, really the board is strategy and operational and administrative support. We are very much an extension of staff in some cases."* (IH2)

In the beginning of 2016, HSL launched an important ticketing and information system reform, starting with the progressive implementation of new card readers in all public transport vehicles (HSL, 2016c), and followed by the replacement of in-use travel cards, which were used for 92 percent of HSL public transport journeys in 2014 (HSL, 2014d), with HSL travel cards conforming to the ISO standard. The change of card is supposed to be free of charge for a certain period of time and should happen when customers top up their cards at traditional sales points.

Also in early 2016, HSL released a mobile ticketing application for smart phones, again operated by Gemalto. The app, called *HSL Mobiililippu*, allowed customers to buy single tickets for specific travel zones (Internal to HSL municipalities or Regional tickets), and have the cost of the ticket added to their mobile phone bill at the end of the month. Customers using the app were expected to show their smart phone ticket upon request of controllers and when entering buses. However, when released, the HSL ticketing app was not integrated with any journey planner and did not allow users to book seasonal tickets.

> *"Last year we also launched the mobile app ticket but so far it is only for single tickets. We will work on that next year to include seasonal tickets. Our basis has been this travel card. We have made a huge system based on the new travel card. But now we have the app coming along."* (IH9)

In June 2016, MaaS Finland changed its name into MaaS Global, as the company started to also look for potential markets of application abroad. According to the CEO of the newly created MaaS Global:

> *"Our new name better supports our global approach as we will be expanding the service to other countries already this year. We are still proud of our Finnish heritage but it is time for a global transport revolution."* (MaaS Global, 2016c)

In the summer of 2016, MaaS Global released its app prototype called *Whim* for 100 customers that it had reached out to thanks to social media. Although the sample of the population was not clearly representative of all types of citizens living in HMA, this first trial was considered important in order to have a first form of feedback from customers (IH2). In August 2016, MaaS global concluded a deal with Lahitaksi that added taxi services to the proposed mobility packages (MaaS Global, 2016d). In September 2016, MaaS Global received the Smart City Award from the City of Helsinki (MaaS Global, 2016e).

In the fall of 2016, HSL edited guidelines for MaaS providers, explaining their ability to provide MaaS providers with APIs of their different single tickets (local and regional scale). At the same time, MaaS Global concluded a deal with HSL to offer public transportation tickets as part of its mobility packages (MaaS Global, 2016f). At that time, HSL agreed to open their single local tickets, meaning a single ticket that would allow users to travel within one single municipality. Users wishing to travel from Espoo to Helsinki were not able to do so at that time with the Whim app.

In the same period, following a series of workshops and discussions that were initiated in the summer of 2015, the Finnish Government submitted a legislative proposal for the first phase of the Finnish Transport Code (*Liikennekaari*) to the Finnish Parliament. This new legislation, which is one of the core policies of the current administration, was pushed by the current transportation minister, Anne Berner (IH10).

The new legislation looked at market access legislation and aimed to create the type of environment that would enable the development of innovative mobility services, especially those relying on digital processes. The Finnish Transport Code has been organized into three phases, with a first phase focusing on road transport, specifically the taxi, passenger, and goods transport markets, and second and third phases that focused on all other types of transports (rail, maritime, air, etc.). Due to the small number of taxi licenses in Finland, and the willingness to increase the number of taxis, as waiting times can be quite long, the law proposed removing the limited number on taxi licenses and pushed anyone to apply for a taxi license. The text also proposed that drivers earning less than €10,000 a year would no longer need to hold a taxi license (this became known as the "€10,000 rule"), opening the door to peer-to-peer mobility solutions such as Uber.

The taxi sector immediately reacted, claiming that this would be unfair competition for their sector, and that Finland should also look at past taxi deregulations in order for Nordic countries to see that total opening up of the market without any rules should not be the way to go. Finnish taxi companies such as Lahitaksi voiced their concerns, which were then amplified by The Finnish Taxi Association (Suomen Taksiliitto), which lobbied against the text.

> *"We did not like it at all. In the same business you would have two different rules. If you see that you are competing against some other companies, which is what we are already doing in small portions today … the only way is to have the same rules for everybody that is functioning as a taxi. If you thing about the new taxi legislation that is coming out, that is actually the most not wanted thing that you want to have (…) If you have different versions of how you work in the field, then it is not nice."* (IH7)

Their concerns were taken seriously by MPs and government members, and particularly by the True Finns party. Finland's nationalist party (Reuters, 2016), in the form of Timo Soini, the vice prime minister of Finland since the 2015 parliamentary elections, stood up particularly against this resolution, following the position taken in 2015 by Minister of Transport Ms. Risikko (NCP) to allow Uber in Finland only if Uber drivers held a Finnish taxi license (LVM, 2015). It was unclear for a long time whether the so-called €10,000 resolution would be left out of the law or not, and taxi companies were quite worried about this:

> *"If you allow the €10,000 rule to be there it will be a game changer. There will be a lot of people using Uber and doing black market business. The black market will explode, as it is an area where people will easily do it as there won't be any control."* (IH6)

In the final version of the text, which was voted in spring 2017, the €10,000 rule was omitted. However, the text introduced two major changes. First, it introduced the removal of the limitation on the number of taxi licenses, thus making it easier to gain access to the taxi market (which was closed prior to the Finnish Transport Code). Second, it introduced the removal of price regulation on taxi fares and the obligation for taxi services providers to inform customers about their prices and basis for fare calculation in advance. The law also meant that taxi licenses were no longer zone-specific and changes from being vehicle-specific to operator-specific (LVM, 2017b).

It is also acknowledged that some innovative mobility companies joined forces in order to lobby in favor of the Finnish Transport Code. A lobbying group was led by the company Piggybaggy, proposing a peer-to-peer goods delivery platform and aimed at proposing much larger changes than those proposed in the initial version of the law. However, as the group was quite small and not "loud" enough, not so many of their claims were taken into account in the public consultation phase (IH11, 2016). The Finnish Transport Code also introduced the whole concept of technology neutrality, proposing, for example, that all essential data from all transport services be made open, in a computer-readable format, including routes, timetables, stops, prices, availability, and accessibility information, in order to enhance new business concepts, and make seamless and mobile travel chains possible. The proposed Transport Code also laid out provisions for the interoperability of ticket and payment systems (LVM, 2016), and interoperability of MaaS systems, requiring all providers of road and rail passenger transport services to open, at a minimum, their single-ticket APIs (LVM, 2017c).

At the same time, The LVM started to develop a proposal to explore new ways of financing transportation infrastructure development, that would be managed by a single state-owned company, potentially financed by the development of a kilometer road tax (road charging), which would complement the revenues coming from the gas tax that have constantly fallen due to declining gas prices (LVM, 2016). The LVM defended the above-mentioned proposition as follows:

> *"[With that new organization], the money put into transport, and especially infrastructure, will not be used depending on who is in the parliament. The big debate is about the ownership model vs. how we organize maintenance and building of the infra. What that brings is basically a national road tax (…) What you need is to go towards user-based model and have a kilometer-based tax, and fine tune it (…) That links to MaaS of course. If there is this kind of fundamental change in the background, and then you have this idea that you plan and organize all your transportation network via one operator, and then you have this whole taxation model change, that is going to affect the MaaS operator business and the kind of logic in there as well."* (IH13)

Opposition parties reacted against this proposal. The SDP Party chair stated at that time that the "*plans to consolidate the country's transport routes into one company would lead Finland down the path towards a market-driven society*" (YLE, 2016), whereas Green League Party Chair said that the consolidation of all the transportation network in a single company would affect and diminish democracy as well as increase costs (YLE, 2016). The first phase of the Finnish Transport Code was finally voted for in the spring of 2017. The clause related to opening of data and single tickets APIs entered into force on January 1, 2018, while the one regarding taxi market new regulations entered into force on July 1, 2018 (LVM, 2017c). The summer of 2017 was marked by a new funding round of over €10 million for MaaS Global, mostly supported by the investment from a subsidiary of the Toyota group into MaaS Global (MaaS Global, 2017g).

In the fall of 2017, the LVM submitted to parliament the second stage of the Finnish Transport Code, specifically targeting the other transport modes and further regulating the opening of data, which was ultimately voted for on March 21, 2018. The second stage of the Transport Code introduces the possibility for third parties to have access to public transport seasonal ticket APIs if this is what their customers want. This second stage of the code builds on the *My Data* approach of the Finnish Government, aimed at refocusing data management around users, and not organizations. The second phase of the transport code is supposed to enter into force on January 1, 2019.

In March 2018, HSL finally hired someone in charge of coordinating the transport authorities' activities related to MaaS (HSL, 2018). On April 2, 2018, HSL launched an open retail interfaces for single tickets, accessible by anyone interested in putting a MaaS-like solution together. Finally, HSL announced that seasonal tickets would be added to this OpenMaaS interface by November 30, 2018. Figure 4.3.9 summarizes the main developments that have led to the development of MaaS in the HMA.

Zoom on the *Whim* solution

Technology: From a technology standpoint, the Whim app (front-end) builds on a back-end, which itself builds on the integration of different APIs (routing, mobility partners, payment, geo-information, etc.). It is highly similar to the technology supporting the SMILE product (see Case 2).

Functionalities: The Whim app has three main functionalities. Firstly, it enables users to plan their trips (trip-planning function) by proposing them all the possible transport options to go from one point to another. Secondly, it enables users to book mobility services in advance (booking function). Finally, it offers users electronic tickets (ticketing function).

Transport modes integrated: As of May 2018, the Whim app has integrated public transport (bus, trams, metro), commuting trains, taxis, and car rental services.

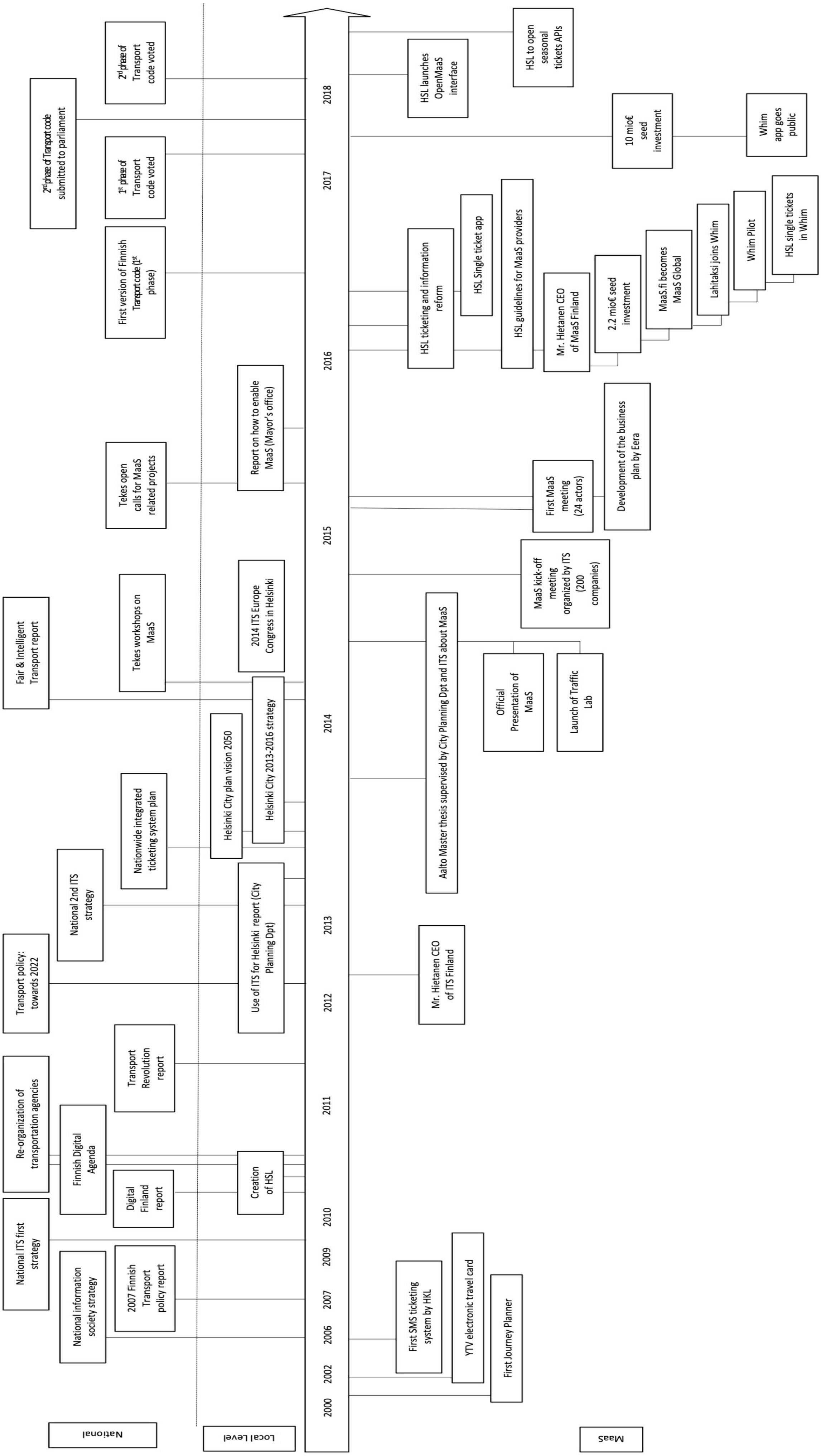


Figure 4.3-10: development of MaaS in the HMA (author's elaboration)

4.4 Conclusion

In this chapter, one could observe that the three studied ICT-supported integrated mobility schemes have taken different paths of development, with smart cards being driven by public authorities in London, IMP being developed as a research project in Vienna, and MaaS having unfold as pushed by the private sector as well as the Finnish government. Before going into more detail in terms of the analysis of public actor's behaviors in the development of these three ICT-supported integrated mobility schemes, it seemed important to briefly summarize the technicalities of the three solutions in order to have those in mind. Table 4.4.1 summarizes the functionalities of the three solutions, as well as the actors who developed them, and the underlying business model for the companies operating them.

	Case n°1		**Case n°2**	**Case n°3**
ICT-supported integrated mobility solution	Oyster	CPCs	SMILE	Whim
Geographical coverage	Greater London		Vienna + other Austrian cities	Helsinki Metropolitan Area
Period of operation	2004–present	2012–present	2014–2015	2017–present
Operator	CUBIC Transportation Systems		Consortium led by ÖBB and WS	MaaS Global
Business Model	Concession between private operator and transport authority		(No business model = research project)	Commission taken on services sold
Functionalities included				
Trip-planning			x	x
Booking			x	x
Payment	x	x	x	x
Ticketing	x	x	x	x
Transport modes integrated				
Metro	x	x	x	x
Bus	x	x	x	x
Commuter train	x	x	x	x
Light-rail	x	x	x	x
Car sharing		(x)	x	
Car rental		(x)		x
Taxis		x (under spending limit)	x	x
Bike sharing		(x)	x	

Table 4.4-1: technical comparison of the three ICT-supported integrated mobility schemes studied

As the table shows, there are differences between the three solutions. Firstly, the geographical coverage differs. While smart cards and the Whim offer cover a metropolitan area (Greater London and Helsinki Metropolitan Area), the SMILE solution had wider coverage, adding other Austrian cities to the city of Vienna. The main difference between Case 1 and Cases 2 and 3 pertains to the functionalities proposed by the solutions. While the Oyster and CPC only propose a payment and ticketing functionality, the SMILE and Whim solutions propose two additional functionalities, being a trip-planning option as well as a booking service. In that sense, the SMILE and Whim solutions propose more functionalities than the Oyster and CPC. In terms of the integration of transportation modes, all solutions integrated all public transport modes. Only two of the solutions (SMILE and CPC[24]) integrated shared mobility services, such as bike and car-sharing. All solutions integrated taxi services, except the Oyster card in London. From the three case of studies, it seems that the SMILE offer integrated the most transport options, followed by the Whim solution and finally by smart cards in London.

From an operating point of view, two out of three solutions (Smart cards in London and Whim in Helsinki) were operated by private actors, being CUBIC in London and MaaS Global in Helsinki. While the former had been chosen by the public authorities to operate smart cards and IMPs, the latter was operating on its own without any mandate from public authorities in Helsinki. On the other hand, the SMILE solution was operated by a consortium constituted of multiple actors, led by two public actors. While the business model of smart cards in London was clear for CUBIC (multiple-year contract with annuity), it is not that transparent for the two other cases. The SMILE offer did not have a business model, as it was a research project that did not worry about covering costs (IV2). The business model of the MaaS solution (for MaaS global) was based on commissions taken from the sale of its mobility packages (B2C). However, to be sustainable, such a business model must ultimately rely on an important number of users. In other words, the more people using MaaS, the more profitable it will be for its operator, which ultimately questions the relevance of such business model for solutions rolled out in medium-size cities such as Helsinki (IH7) and vis-à-vis sustainable transport policy goals, as it will be discussed in the conclusion chapter.

In the next chapter the three case studies will be analyzed to ultimately determine the role that public authorities (and public actors) have played in the development of smart cards in London, IMP in Vienna, and MaaS in Helsinki, and ultimately answer the research question this thesis seeks to address.

[24] CPCs can be used to as payment means for shared mobility services through dedicated platforms. Indeed, most of those platform require users to enter their credit card details in order to pay for the services they consume. However CPC is only an integrated payment system ; it does not allow users to book or acquire information upfront, which is why I have put the symbol (x) and not « x ».

Chapter 5 Analysis

I start this chapter by presenting how the analysis will be conducted. I follow this by analyzing each of the case studies separately using an analytical framework building on the governance literature, and then conduct a cross-case analysis called the governance analysis. Thirdly, I conduct a cross-case analysis using a second analytical framework building on the socio-technical transition literature, and called the transition analysis. Finally, I draw conclusions and make the synthesis of both the governance and the transition analysis.[25]

5.1 Introduction

Having presented the three descriptive case studies in Chapter 4, it is now time to analyze the empirical material, which is the main focus of this chapter. As presented in the introduction, ICT-supported integrated mobility schemes have triggered the interest of stakeholders from the public and private sectors, although not always for the same reasons and not always towards the same goals. Therefore, the development of smart cards, IMPs, and MaaS calls for the development of new governance structures in order for the full potential of those schemes, from a public policy perspective, to be harvested. As the organization of transport usually falls under the responsibility of the public sector, and as the public sector is also known for lacking the ability to drive digital transformations, this thesis has aimed at answering the following research question: "*How are public authorities governing the development of ICT-supported integrated mobility systems?*" **(RQ)**

To answer this research question, a so-called "governance analysis" is first conducted, where a conceptual framework building on the urban and innovation governance literatures is used to analyze the role played by each public actor involved in the development of smart cards in London, IMPs in Vienna, and MaaS in Helsinki. However, the aim of the thesis was not just to depict the behavior of public authorities, but also to make recommendations for other public actors interested in engaging in the development of ICT-supported integrated mobility schemes. Thus, due to the limitations of the governance literature in terms of looking at dynamic bottom-up innovation development, the emergence of smart cards, IMP, and MaaS is also looked at from the socio-technical transition literature, through a so-called the "transition analysis". The transition literature[26] appeared indeed to be quite complementary to the urban and innovation governance literatures in terms of ultimately obtaining a comprehensive understanding of what public authorities had done in the development of ICT-supported integrated mobility schemes, and of what they should ultimately be doing to ensure those schemes develop successfully.

[25] This chapter has lead to a specific publication, see Audouin and Finger (2018c), which was presented at the 2018 mobil.TUM conference in Munich, and has been published in Transport Research Procedia.

[26] The complementarity of the governance and socio-technical transition literatures is described in greater details in the methodology chapter (Chapter 3), subchapter 3.3.6.

Both the governance and the transition analysis were conducted along dedicated conceptual frameworks,[27] which are presented at the beginning of each analysis. The remainder of this chapter is organized as follows. Firstly, the so-called "governance analysis" is conducted on each of the cases separately and then comparatively across the three cases of studies. This sub-chapter concludes by discussing the extent to which what happened in some cases might have happened in others (transferability). Secondly, the so-called transition analysis is conducted comparatively across the three cases of studies using a conceptual framework building on the socio-technical transition literature. The chapter concludes by briefly combining both analysis and answering the research question.

For the rest of the chapter the following denomination is used, which builds on the order in which the cases were presented in the empirical chapter (Chapter 4). Case 1 refers to the development of smart cards in London (Oyster and CPC), Case 2 deals with the development of IMP in Vienna (SMILE and follow-up projects), and Case 3 relates to the development of MaaS in Helsinki.

5.2 Governance analysis

This sub-chapter begins by presenting the analytical framework that builds on the governance literature and more particularly on different governing approaches proposed by urban and innovation governance scholars. A cross-case analysis is then conducted before the findings are summarized in Table 5.2.2.

5.2.1 Analytical framework

Although it has not been used extensively amongst transport researchers so far, the governance lens has been increasingly used to look at the development of innovations in transportation. Recent examples include for example looking at the development of carsharing schemes (Akyelken et al., 2018). However, the governance literature has not yet been extensively used to look at the development of ICT-supported integrated mobility schemes, which is intended here.[28]

The theoretical propositions used to structure the governance analysis build on Bulkeley and Kern (2006), as well as Etzkowitz (2008). Bulkeley and Kern proposed centering the focus of a governance analysis on public authorities' "governing approaches". According to them, public authorities might actually adopt four distinct governing approaches. First, public authorities might choose to adopt a *governing by authority* approach, where they usually employ traditional top-down mechanisms to govern. Example of such approach can be found in the definition by public authorities of coercive regulations towards a specific goal. Second, they might decide to *govern by enabling*, by facilitating and encouraging actions with non-public actors through partnerships and incentives development. Third, public authorities can opt to *govern by doing*, where they basically take care of all service production and delivery and avoid collaborating with private actors. Finally, public bodies might also choose a *self-governing* approach, where they would govern by "showing the way" themselves. For example, a municipality replacing all its municipal ICE vehicles by electric cars to sensitize its population to transport decarbonisation would be categorized as adopting a self-governing approach. To those four governing perspectives, one might add the *governing by laissez-faire* approach, where public authorities essentially allow the network of actors to reach a stable state, without getting involved at all (Etzkowitz, 2008), as this governing approach is not captured by the typology proposed by Bulkeley and

27 The use of the term "conceptual framework" here refers to what Yin (2003) called "key theoretical propositions". For more information about the case analysis process, refer to the methodology chapter (Chapter 3).

28 For a review of the literature on transport governance and the existing research gap, see Section 2.3.2.

Kern. Table 5.2.1 summarizes what one might expect from public authorities in the development of ICT-supported integrated mobility schemes depending on the governing approach selected.

Table 5.2-1: expected actions from public authorities in the development of MaaS depending on different governing approaches

Governing approaches	*Corresponding actions expected in the development of MaaS schemes*
Governing by authority	• Develop specific legislation/regulation that enforces in a top-down fashion the development of ICT-supported integrated mobility schemes • Procure smart cards, IMPs or MaaS to a third-party through traditional tender mechanisms
Governing by enabling	• Initiate public–private interactions • Define vision with strong quantitative objectives • Provide funding • Influence negotiations in favor of ICT-supported integrated mobility schemes and leverage opponents using horizontal network governance
Governing by doing	• Develop an ICT-supported integrated mobility schemes in-house in a closed way • Minimize collaboration with third parties
Self-governing	• Provide all government employees with smart cards, IMPs, or MaaS to show the example to be followed by citizens
Governing by laissez-faire	• Adopt a wait-and-see approach/avoid getting involved

5.2.2 Case analysis

As it is usually agreed that governance needs to be multi-level in order to be effective (Benz and Eberlein, 1999), it seemed important to consider different territorial levels when looking at the behavior of public authorities into the development of ICT-supported integrated mobility schemes. Therefore, this section is structured as follows. It starts by looking within different territorial scales at the role that public actors have played using the five governing categories presented above. The following actors (which lie at different territorial scales) are analyzed: governments (national level), funding agencies (national level), state-owned railway companies (national), city governments (local level), and public transport authorities (local level). In a second time, a cross-case analysis is conducted in order to compare the behavior of public authorities across cases in order to draw cross-case conclusions. In the cross-case analysis, the transferability of public authorities' behavior from one case to another is discussed. Finally, building on the cross-"governance" analysis, public authorities' best and worst practices for the development of ICT-supported integrated mobility schemes are summarized in Table 5.2.3.

5.2.2.1 Case 1

- National government

There are basically three kinds of actions from the UK government that deserve to be analyzed in order to understand the governing position they have adopted in the development of smart cards in London. The *first* kind pertains to the development of long-term visions of how transport should look like in a more or less distant future. For example, this was done with the 2000 *Transport Ten-Year Plan*, which set a target of a 12.5 percent reduction in transport-related GHG emissions by 2010 compared to 1990 levels. Similarly, the *2000 Transport Act* presented transport integration and integrated transport as the direction for local authorities to follow. By setting those visions, the UK government basically set the course for the evolution of transport in the UK, ultimately creating the need to embrace solutions that have the potential to reach those visions. As it was acknowledged that smart cards had this potential, the definition of visions can be understood as having pushed for their development, ultimately acting as an enabler for smart cards to come to life. The *second* kind of action from the UK government that deserves to be analyzed here pertains to the promotion of smart cards as a means of reaching transport policy objectives. Given that the Oyster card was actually launched in 2002, one must consider policy documents that were published prior to that. The first such document is the 1998 White Paper on Transport entitled "*A new deal for transport: better for everyone*", which called for the development of "through-ticketing" as a means of moving towards a more sustainable transport system. Similarly, the 2000 *Transport Ten-Year Plan* suggested the implementation of integrated information and ticketing systems as a means of reaching the vision presented in the document. By formally proposing ways to implement their transport vision, the UK government gave smart cards the status of a means to reach policy goals, ultimately pushing for their implementation. The promotion (and support) of smart cards as a means to achieving a goal can also be considered as having contributed to their takeoff, and can therefore be understood as an enabling action. The support of the DfT for smart cards solution actually continued with the 2004 *Future of Transport Strategy* and the 2009 *Smart and Integrated Ticketing Strategy,* where both of which presented the Oyster card as a success story. The *third* and final kind of action from the UK government that must be analyzed here pertains to actions having influenced the collaboration of TfL with a private actor (CUBIC). Although it does not seem that the decision of TfL to contract a private company for the operation of its smart ticketing scheme was directly influenced by the UK government, it may have been influenced by the public sector's habit of collaborating with private actors in the transport sector, which is a direct consequence of UK's government NPM-led policy of the 1980s. Indeed, with the *1984 London Regional Transport Act,* as well as the *1985 Transport Act* and the *1993 Railway Act,* the UK Government basically institutionalized public–private collaboration in the transport sector, which might have influenced TfL's choice of collaborating with a private company instead of developing the scheme by itself. Although those policies largely predate the development of smart cards in London, they can be understood as having had an impact on the way the Oyster and CPCs developed; that is, in collaboration with the private sector. Somehow they can be understood as having loosely enabled private companies to propose smart card solutions.

So, having set visions, promoted smart cards as way of achieving those visions, and enhanced public–private collaboration, The UK government can be understood as having adopted an ***enabling*** position for the development of smart cards. One could also observe this enabling approach in the definition of a dedicated organization for the development of smart card standards (ITSO). However, ITSO was founded after the PFI between Transys and TfL was signed, which means it cannot be considered as having enabled the London smart ticketing scheme to come to life.

- City government

There are basically three kinds of actions from local public authorities (Mayor of London and Greater London Authority) that deserve to be analyzed in the development of smart cards in London. The *first* pertains to the development of a strong vision for the future of transport in London. With the 2001 *Mayor Transport Strategy (MTS)*, the mayor of London targeted, by 2010, a 15 percent traffic reduction in central London, zero growth of traffic in inner London, and a reduction of traffic growth by one third in outer London. The development of this vision can, as with visions developed at the national scale, be understood as an enabling action for smart cards to have developed, as it created the need for those to be embraced. The *second* action pertains to the decision of the mayor of London to implement smart cards to reach this vision. Unlike the national government's suggestion of using smart cards to reach vision objectives, the mayor of London basically decided to use smart cards to reach his vision's objectives, thus acting in a top-down fashion that fits the governing by authority characteristics. The *third* action of the local government pertains to the development of a massive communication campaign about the Oyster, giving out 100,000 free smart cards to the most vulnerable users (TfL, 2007) in order to have the London smart ticketing scheme gain in visibility and be embraced by many. This can be understood as an action that did not enable the development of smart cards, but enabled their uptake (at least of the Oyster) by the population, and thus as governing by enabling.

The development of positive incentives, such as the non-augmentation of fares for Oyster users compared to paper ticket users in 2004 (TfL, 2004a), must also be quoted here as a governing-by-enabling measure. To sum up, the local government in London can be understood as having adopted both ***governing-by-enabling*** and ***governing-by-authority*** measures in the development of smart cards and CPC in London.

- PTA

Here is analyzed the behavior that TfL has adopted vis-à-vis the development of smart ticketing in London. As explained below, TfL has been using a ***governing by authority*** as well as ***self-governing*** approach. The "authority" measures from TfL actually started in its 2003–2004 business plan, which included a ticketing and boarding strategy, with the aim of having the entire transport network able to receive cashless payments by 2008. It was also TfL that decided, in 2008, to terminate the Transys contract, and (still on its own) launched the Future of Ticketing Project (FTP), which paved the way for the development of CPCs. TfL also launched a bid for the Future Ticketing Agreement (FTA). Finally, TfL awarded the Electra contract in 2014 that established which company would operate London's smart ticketing system. All those actions from TfL can be understood as top-down, meaning that TfL took the initiative and reached out to relevant third parties to implement them, without considering that a better solution might emerge in a bottom-up fashion. It is because TfL really drove the development of smart ticketing in London that its approach has been categorized as governing by authority. The authority governing approach that TfL adopted can also be understood as a direct consequence of the governing-by-authority measure of the mayor of London vis-à-vis the development of smart cards. By adopting such an approach, the mayor of London did not leave much choice to TfL on what to do, as TfL is considered to be the mayor's "armed wing" for transport. Last but not least, the self-governing measure relates to the decision of TfL to use its employees to test the Oyster system in 2002, and to provide all TfL's employees with Oyster cards once implemented.

- Funding agency and state-owned railway company

It appeared there was no national funding agency involved in the funding of the Oyster experiment (in the pilot phase in 2002), or in the development of the CPCs. Therefore, it is irrelevant to categorize the behavior of UK funding agencies involved in the development of smart cards in London, as they were none. Similarly, the role of a dominant state-owned railway company in the development of Oyster and CPCs cannot be conducted, as they were none. As seen in chapter 4, the privatization of the rail sector in the late 1980s resulted in a very fragmented rail market in the UK, and the absence of a dominant railway undertaking.

5.2.2.2 Case 2

- National government

Given that IMPs in Vienna actually started in 2012 with the SMILE project, one must here consider the actions from the Austrian government that happened before that year. There are four actions from the Austrian government that can be understood as having influenced the development of the IMPs in Austria and, more specifically, of the SMILE project. First, the BMVIT created a vision for transport with the *1991 Transport Master Plan*, which targeted a 20 percent reduction of CO_2 emissions related to transport by 2005 compared to 1998 levels. As seen in Case 1, the development of a vision can be understood as a governing by enabling action, by creating the need for new solutions, such as IMPs, to be embraced. The second action of the BMVIT to be analyzed concerns the promotion of IMPs, either through the definition of strategic areas for research or through the development of a dedicated strategy. By defining research areas, the BMVIT highlighted the importance of some key topics related to transport, including intermodal transport/transport integration. For example, the 2006 IMPULSE Programme I2V aimed at funding research that would support the development of solutions that "*enable efficient transfer between the modes of transport (…) and ensure connections and flexible schedule management*" (BMVIT, 2006). By proposing this program, the BMVIT enabled research to be conducted on the intermodality and interoperability of transport systems, which constituted a knowledge base for the development of IMPs; this is why this kind of actions can also be considered as governing by enabling. On the other hand, the development by the BMVIT of its ITS Action plan in 2011 can also be understood as a promotion of IMPs. Among other things, the action plan highlighted the importance of developing systems that provide transport "*information to the individual travellers*" as well as "*booking and invoice services*" (BMVIT, 2011: 12), again helping promote and raise awareness about IMPs and ***enabling*** it to come to life. However, while the Austrian government was adopting an enabling position upfront of the development of the development of IMPs, it appears it never stood up in the development of the SMILE project, and only let it happen (IV4).

> "*My suspicion is that* [the BMVIT] *said: 'two strong partners, let's see what comes out. If they are successful, we will get some glory, but if not we will say that we were not involved, and thus not responsible'.*" (IV5)

- Funding agency

Having financed the development of projects related to SMILE, and of the SMILE project itself, Austrian funding actors (Climate and Energy Fund as well as FFG) can be understood as having ***enabled*** the growth of IMPs. The first important enabling action from the Climate and Energy Fund that should be acknowledged as having played a role in the development of the SMILE project is the funding of the GIP and the VAÖ. From 2006 to 2011, the Climate and Energy Fund funded the development of both systems, which actually served as the technical backbone of the SMILE solution. Without the funding from the Climate and Energy Fund, the digital infrastructure supporting the SMILE project would have probably never come to life, which would have certainly been a bottleneck for the development of the SMILE project. The Climate and Energy fund later continued its enabling actions by awarding funding to the SMILE project, as part of the third Austrian Electric Mobility Flagship program, aimed at supporting projects that would enhance the "*development of interoperable mobility information, electric mobility offers and electric mobility billing by public transport service providers and operators and their integration in a functioning system environment by using linked ICT systems*" (Klima und Energiefonds, 2011: 11). By providing the necessary financial resources (€2.9 million) for the SMILE project to develop, the Climate and Energy Fund can be considered to have acted as a true enabler. Similarly, the funding from the Austrian Research Promotion Agency (FFG) awarded to the SMILE consortium can be seen as having enabled the success of the SMILE project. As seen in Chapter 4, the SMILE consortium was not making any money out of the operation of the integrated mobility platform (it had no business model, as this was not the purpose of the project) and thus could not have survived without any external funding available to cover the costs of all the stakeholders involved in the project.

- State-owned Railway company

The main governing approach adopted by the ÖBB in the development of the SMILE project has been a ***governing-by-doing*** approach. Having been the co-leader of the SMILE project (with the Wiener Stadtwerke), the ÖBB clearly demonstrated its willingness to be in the driving seat for the development of integrated mobility platforms. This governing approach can also be observed in the strategy that the ÖBB adopted at the end of the SMILE project. By deciding to pursue the development of an IMP of its own with iMobility and WegFinder, and to stop the collaboration with the Wiener Stadtwerke, it is clear that the ÖBB decided to adopt a governing-by-doing approach at the end of the SMILE project (IV7; 13; 14).

"They [ÖBB] *want to integrate everything to death. They are taking it all (…) they are not acting in a partnership mode. They are like in Star Trek."* (IV4)

With IMPs, ÖBB actually saw the opportunity to become mobility provider for the entire travel chain and not only long-distance capacity providers (IV9). In particular, it saw in IMPs an opportunity to also generate profits (IV9; 10). The willingness of the ÖBB to do things by itself was not new. In 2010 the ÖBB had been the leader of the eMORAIL project, which aimed to develop a digital platform integrating mass transit with electric mobility. Prior to that, the ÖBB also decided to create, on its own, a multimodal information app (Scotty), as well as a digital ticketing solution, again clearly illustrating its position vis-à-vis the development of IMPs.

- City government

Although the sole owner of the Wiener Stadtwerke (and thus of WL), the City of Vienna is acknowledged for not having been directly involved in the development of IMPs (IV1; 2; 4; 5; 7; 8). While the City of Vienna did develop a vision for transport (with the 1999 KLIP I and the 2003 Transport Master Plan for Vienna), it has not developed transport visions coinciding with the beginning of the SMILE project, and therefore cannot be categorized as having enabled it. Hence, the governing approach of the City of Vienna vis-à-vis the development of SMILE can be understood as a ***governing-by-laissez-faire*** approach. One could see the Smart City Framework Strategy as a strategy that has paved the way for the development of IMPs, with the quantitative objectives it includes. However, the strategy is considered to be "*weak*" on mobility (IV4), as it does not have clear CO_2 emission reduction targets for transport and does not propose any means (such as IMPs) to reach those objectives. Furthermore, the Smart City Framework came in 2014 – that is, after the SMILE project – and therefore cannot be understood as having influenced it.

- PTA

In the development of the SMILE project, the behavior of Wiener Stadtwerke (and of course Wiener Linien) can be understood as quite similar to that adopted by the ÖBB.

"The ÖBB think they are the key player to integrate everything, and so does the WS." (IV7)

Hence WS's approach has also been categorized as ***governing by doing***. Indeed, having initiated and led the SMILE project (IV9), the WS clearly demonstrated its willingness to be involved in the development of IMPs. Such behavior can also be observed as previous developments by the ÖBB in terms of digital transport services. The WL's development of a multimodal journey planner in 2009 (Qando), as well as a ticketing app in 2011 (Wiener Linien app) for public transport, should also be understood as a governing-by-doing approach.

However, it seems the governing by doing approach from the Wiener Stadtwerke has somehow evolved since the end of the SMILE project. Although the Wiener Stadtwerke wanted to continue being in the driving seat by creating Upstream, which was 51 percent owned by the Wiener Linien and 49 percent by the Wiener Stadtwerke, it somehow shifted towards a more ***governing-by-enabling*** approach. By deciding with Upstream to create an open backend service, and allow third parties to use its digital platform (IV1) to create their own front-ends, Upstream finally adopted an "open" approach to IMPs, seeing itself more as a digital infrastructure provider than an IMP operator.

"We think it [the digital infrastructure*] is a public good. As a public company (…) we have to provide the digital infrastructure (…) it is an open platform so we treat everybody the same way!"* (IV3)

5.2.2.3 Case 3

- PTA

As explained below, HSL has basically been using three governing approaches in the development of MaaS in the HMA: governing by doing, governing by laissez-faire, and ultimately governing by enabling.

Having developed services that can be considered as MaaS building blocks, such as their own multimodal journey planner in the 2000s, SMS ticketing system in 2012 (Gemalto, 2016), or a dedicated ticketing app in 2016 (HSL, 2016c), HSL can be seen as having sought to be in the driving seat for all developments related to ICT-supported integrated mobility schemes, and thus as having adopted a ***governing-by-doing*** approach, even though the Helsinki Metropolitan Transport Authority never concretely announced it was interested in developing its own MaaS app.

At the same time, HSL should be understood as having used a ***governing-by-laissez-faire*** approach for a long period. Developing a MaaS solution (from the MaaS operator point of view) depends on the willingness of transport authorities, and other transport providers, to open their information and ticketing APIs, to constitute the back end on which a front end can be developed. While HSL finally agreed to open its single ticket API in December 2016, it took about one and a half further year to agree on opening its seasonal ticket API, which actually acted as a major bottleneck for MaaS Global to develop a sustainable solution (IH10, 13). While MaaS Global customers were given the possibility to use public transport as much as they wanted (as part of their subscription), they actually had to book single tickets each time they used it, which HSL kept track of and billed MaaS Global at the end of each month. There is nothing wrong with that, apart from the fact that single tickets are not subsidized, whereas monthly and seasonal tickets are (IH9), which ended up being much more expensive for MaaS Global than if seasonal tickets were available to them from the beginning. Consequently, the Helsinki Metropolitan Transport Authority has been depicted as not having "*done so much*" (IH3) to push MaaS forward, as not having been "*easy*" (IH15), not as "*enthralled as we would have probably expected them to be*" (IH6), and as having tried to "*slow the progress*" (IH13). HSL's governing-by-laissez-faire approach ultimately joins Bond's understanding of PTAs behavior vis-à-vis innovation for whom PTAs often fail to "*understand the environment of change and the need for innovations*" (1984: 39).

Ultimately, HSL finally changed its position vis-à-vis MaaS. After having developed an HSL strategy and organized a MaaS stakeholder meeting in Spring 2017, HSL finally hired, in March 2018, someone in charge of coordinating the transport authorities' activities related to MaaS (HSL, 2018). On April 2nd 2018, HSL launched an open retail interface for single tickets, accessible by anyone interested in putting together a MaaS-like solution. Finally, HSL announced that seasonal tickets would be added to this OpenMaaS interface by November 30th 2018, finally putting a theoretical end to the single-ticket API issue, and thus ultimately adopting a ***governing-by-enabling*** approach.

- City government

The City of Helsinki undertook three main actions that can be analyzed as having had an impact in the development of MaaS. The first was the promotion of the MaaS concept in its 2013 Helsinki City Plan vision 2050, in which the transport system of the Finnish capital is presented in 2050 as being "*an uncomplicated public transport network, cycling, private cars, Demand Responsive Transportation, shared vehicles, city bikes and walking into a seamless whole, in which travel chains have been optimized via efficient transfers. City residents can purchase the 'transport package' of their choice, similar to current mobile call/data packages*" (City of Helsinki, 2013a: 41). While the term MaaS was not mentioned specifically, all its building blocks were there. The promotion of MaaS by the City of Helsinki also happened through its acceptance as the host city of the 10th European ITS Congress (16–19 June 2014), the motto of which was "ITS in your pocket – proven solutions driving user services". By clearly standing up as a partner of the ITS Congress, the City of Helsinki directly supported the key themes of the congress, and in particular three themes directly related to MaaS: new mobility apps for consumers and businesses, smart transactions, and multimodal transport. In the program of the ITS Congress, the City of Helsinki described itself as an "enabler rather than a service provider" and stated its motivation to "*become the world-leader in Mobility-as-a-Service*" (ITS in Europe, 2014: 2). As seen in the two other cases, promotion of a solution by public authorities can be categorized as governing by enabling.

The second set of actions pertains to the City of Helsinki's lobbying to push the MaaS subject forward, for example through negotiations undertaken by the some city council members with HSL so they would open their ticketing APIs (IH13, 4), and the work done by Forum Virium and Helsinki Business Hub to make HSL change its position (IH15, 16). Negotiations were to be directly linked with governing by enabling, as it aims to find common ground to avoid bottlenecks, without using binding mechanisms. The third and last set of actions pertains to the City of Helsinki collaboration with non-public actors interested to push MaaS forward. The best example of such actions is the acceptance of the City of Helsinki to co-supervise, in partnership with Sampo Hietanen (at that time director of ITS Finland) and Aalto University, a master's thesis that would explore the role that public authorities should play in the development of MaaS. The main building blocks of MaaS were basically developed during supervision meetings between the student, the head of the transport department of the City of Helsinki, and the head of ITS Finland (IH13). Those collaborations with non-state actors should also be considered as ***governing by enabling***, as they enabled the subject to gain in visibility among local politicians, and other stakeholders of the Helsinki transport ecosystem.

- National government

The national government must be understood as the shadow architect of the development of MaaS in Helsinki (and more generally, in Finland), where it adopted ***governing by enabling*** and, ultimately, a ***governing-by-authority*** approach. More specifically, there appears to be three broad sets of actions falling into the former category, and one falling into the later. While the definition of visions, promotion of the MaaS concept, and development of networks of actors having facilitated public-private interactions, fall into the governing-by-enabling category, the development of a legislation specifically targeting the development of MaaS must be categorized as governing by authority.

The first kind of governing-by-enabling actions pertains to the definition of strong visions by the LVM having put pressure on all (public and private) actors of the MaaS ecosystem, and pushing them to collaborate with one another. For example, the first and second National ITS strategies (in 2009 and 2013, respectively) specifically targeted making Finland one of the five most advanced countries in the world in terms of ITS by 2020; this undoubtedly put pressure on the private sector, as well as on public transport authorities to develop MaaS.

The second kind of action that falls into the enabling category basically deals with the development of policy documents, where MaaS (or at least its building blocks) was presented as a way to reach the objectives targeted by the policy. For example, as early as 2006, the *Finnish National Knowledge Society Strategy* (VNK, 2006) promoted smart cards, route navigation, and electronic timetable information systems as solutions facilitating the transportation of people. Similarly, the support of the government for transport solutions relying on "*information technology*" was re-emphasized in the *2008 Transport Policy Guidelines* (VNK, 2008:

40) and in the *2011 Transport Revolution Report* (LVM, 2011). Other similar examples include the video[29] presented by the LVM in the ITS Europe Congress in June 2014, entitled "*Could mobility be viewed as a service?*", as well as repeated joint appearances of the LVM with MaaS Global at conferences (such as MaaS Market conference in London in 2016)[30] or the report *Transport and Communications Architecture 2030 and 2050*, that presents MaaS as a way to reduce emissions in the transport sector. Although none of the above-mentioned documents proposed strategies to specifically develop MaaS (instead leaving that to third parties [IH10]), they did mention the utility of MaaS to reach policy goals, thus acting more as promotional documents. In other words, by mentioning integrated ticketing and integrated travel information system in transport and climate policy documents, the Finnish public authorities at the national level helped raise awareness among transport actors (including local transport authorities and local governments) regarding the availability of those solutions and the potential benefits that could be harvested from their use.

The third kind of action that can be categorized as governing-by-enabling approaches for the development of MaaS in Helsinki pertains to the development of "places of exchange", or dedicated networks, where non-state actors could actually influence state-actors vis-à-vis the development of ICT-supported integrated mobility schemes. Those networks acted as places where the private sector could also influence the development of transport policy so it would serve their interests and so on. Four examples of such "places of exchange" are provided here. The first is the think tank that was developed along the 2011 *Transport Revolution report*, which aimed to gather public and private stakeholders to think about the future of transport. This think tank basically gathered several bodies such as the ministry of transportation and communication, local Finnish transport authorities, local governments, and non-profit organizations, such as ITS Finland,[31] which could use the network to represent the private sector interests in the development of MaaS. A second example of public–private collaboration facilitated by the LVM is the working group that prepared the second ITS strategy, which was composed of representatives of the FTA, TraFi, the Finnish Meteorological Institute, the City of Helsinki, ITS Finland, and Nokia. This working group was an opportunity for non-state actors (ITS Finland and Nokia) to influence the definition of the strategy and push MaaS forward on the political agenda. The third example is the so-called Traffic Lab, developed to gather private and public actors to put together data from different traffic services and develop innovative digital services. As a member of the Traffic Lab, ITS Finland took part in the discussions and this was a way for the non-profit organization to position MaaS as a subjet of interest (IH6). It is estimated that the first phase of the Traffic Lab program provided "*a good framework for developing the MaaS operator model on a conceptual level*" (VTT, 2016: 46). The final example of such networks of exchange is related to the development of the Finnish Transport Code. The development of this piece of legislation was highly consultative and non-state actors were closely consulted (IH10), which can be seen as having influenced the final version of the law. One might wonder what would have happened if the code was not consultative, or more specifically how supportive of the MaaS concept the Transport Code would have been if its definition had not been based on a consultation exercise.

However, the strongest (and final) set of actions from the ministry for the development of MaaS undoubtedly pertains to the development of a dedicated legislation (the Finnish transport code) aimed at making MaaS a reality, which should be understood as the governing-by-authority mechanism. By making "*providers of road and rail passenger transport services, providers of brokering and dispatch services, or actors managing a ticket or payment system on behalf of these*" forced to "*give mobility service providers and providers of integrated mobility services access to the sales interface of their ticket and payment systems, through which*

[29] Accessed on https://www.youtube.com/watch?v=ZQieTU7_5xo on April 18th 2018.
[30] http://ertico.com/event/maas-market-concept-to-delivery-2/ accessed June 4th 2018
[31] Headed at that time by Sampo Hietanen, the CEO of MaaS Global and considered by many to be the father of the MaaS idea.

it is possible to purchase a ticket product at a basic price that, at minimum, entitles the passenger to a single trip", the first phase of the Transport code (LVM, 2017c: 13) basically forced PTAs to open their single-ticket APIs, ultimately making the future of MaaS dependent on the willingness of PTAs to open (or not) the rest of their tickets; that is, acting as a demonization strategy.

Despite having announced that it would be "*ridiculous to go that far*" (IH10), the LVM finally included in the second phase of the Transport Code (which was voted for on March 2018) a clause forcing all PTAs to open all their ticket APIs (including subsidized seasonal tickets). By making it possible for MaaS operators "*to incorporate tickets for all modes of transport, car hire service, various serial and seasonal products as well as discounts into a combined mobility service by acting on the customer's wishes or on the customer's behalf*" (LVM, 2017d), the LVM untimely found a solution to HSL's long-standing refusal to open its seasonal-ticket API. Given that the legislation does not leave any room for PTAs to maneuver, the second phase of the transport code can be understood as governing by authority and not as governing by enabling. Indeed, it seems that HSL would not have opened its OpenMaaS interface and announced the opening of seasonal ticket APIs if the second phase of the transport code had not included a binding clause:

> *"The main reason in the change of position is the new legislation (…) honestly I don't know that if there was not the Finnish Transport Code how the situation would be." (IH16)*

- Funding agency

Finnish public authorities also provided public funding that basically enabled MaaS Global to grow. Indeed, by offering a €50,000 grant to eight of the 13 companies that had responded to the call (Eltis, 2016), TEKES enabled MaaS experiments to come to life in Finland. In February 2016, TEKES also directly invested into MaaS Global in the first investment round of the Finnish start-up (MaaS Global, 2016a), which also played a role in the development of Whim. In the spring of 2014, the Finnish innovation agency undertook another ***enabling*** approach by organizing three workshops focusing on MaaS. Those workshops, to which all relevant stakeholders were invited, basically acted as public–private networks enhancing public–private interactions to happen and private actors to "preach" their MaaS ideas to the public sector, which was also one of the strategies adopted by the LVM, as seen above.

- National Railway company

Although not highly involved in the development of MaaS Global's solution, as it did not see "*any clear business proposal or product proposal*" (IH3), the Finnish Railway company (VR) has been involved in the development of MaaS in Helsinki by working on its own MaaS product. The development of an internal strategy vis-à-vis MaaS and its stated willingness in a more or less distant future to develop its own MaaS schemes (IH3), are examples of the position adopted by VR, which can be understood as a ***governing-by-doing*** approach.

5.2.2.4 Supra-national level (EU)

In order to be able to analyze in depth the role that public authorities played at the supra national level in the development of ICT-supported integrated mobility schemes, it was important to select cases of studies that had developed under the same macro institutional context. As explained in the methodology chapter (Chapter 3), this requirement could only be satisfied by looking at cases in Europe and, more specifically, in countries that were members of the European Union, and thus subject to the same European directives as was the case for the UK, Austria, and Finland. Therefore, the role that EU authorities have played in the development of the three ICT-supported integrated mobility schemes studied has been analyzed, using the five governing approaches framework presented above. It appears that EU authorities have mainly used two governing approaches in the development of the studied ICT-supported integrated mobility schemes: ***governing by enabling*** and ***governing by authority***.

First are presented actions pertaining to the former. The Commission adopted an enabling approach by defining a vision and clearly formulating the means to reach it. In so doing, it promoted some solutions to reach policy objectives and ultimately helped those solutions increase in visibility, which is why such actions have been categorized as enabling actions. Considering the timescale of the case studies, with the London case starting in the early 2000s, the first policy document that should be considered (at the EU level) is the 2001 white paper from the European Commission, entitled "*European transport policy for 2010: time to decide*" (Commission of the European Communities, 2001). The document, presented as the second white paper for the future development of a common transport policy, primarily aimed at shifting the balance between modes of transport; that is, to enhance by 2010 a modal shift from private motorized transport to other transportation modes as those were in 1998. Regarding passenger transport, and in order to contribute to the general target of the white paper, the document emphasized the need to develop high-quality urban transport (p.17) and to develop intermodality for people (p.80). In particular, emphasis was given to the benefits of integrated ticketing systems, as well as the use of intelligent traffic systems to inform passengers about transport conditions in order to help them reduce the time needed to transfer between modes. The second document that falls into this category is the 2006 report entitled "*Keep Europe moving – Sustainable mobility for our continent*", which re-emphasized the need to produce a shift from private motorized transport towards environmentally friendly modes, especially in urban areas, and proposed increasingly coordinating investment in the development of intelligent transport systems in order to enable "co-modal transport solutions" (Commission of the European Communities, 2006). The third document to be cited here is the 2007 green report entitled "*Towards a new culture for urban mobility*", which specifically presented traveller information systems and smart ticketing system as a means of moving towards the 2001 white paper's vision (Commission of the European Communities, 2007). The fourth document is the communication from the Commission entitled "*A sustainable future for transport: towards an integrated, technology-led and user friendly system"*, which again emphasized the impact that ITS-related solutions could have on the efficiency of the European transport system (Commission of the European Communities, 2009a). The communication was followed by the *Action plan on urban mobility,* which aimed to set out a coherent framework for EU initiatives in the area of urban mobility (Commission of the European Communities, 2009b). The plan re-affirmed the willingness of the commission to work with public transport organizations on facilitating the provision of travel information to transport users, and the support of the commission vis-à-vis the development of multimodal journey planners (p.6) and integrated ticketing schemes (p.10). The last policy document that should be mentioned here is the 2011 white paper entitled "*Roadmap to a single European Transport Area – towards a competitive and resource-efficient transport system*". That paper set out a new vision for transport in Europe (60 percent reduction in transport-related GHG emissions by 2050 compared to 1990 levels) and re-affirmed the availability of specific solutions to reach it, which included multimodal transport information, management, ticketing and payment systems (EC, 2011). Also, by having supported the development of the EU urban expert group in 2010, the Commission acted as an enabler, or more as a facilitator, for the deployment of ICT-supported integrated mobility schemes. By setting up an expert group aimed at showcasing best practices of urban ITS use, the commission basically enabled member states, as well as European public transport authorities to learn from each other. By making recommendations on how to develop smart ticketing, travel information, and traffic management systems, this expert group also acted as an advisor for local public transport authorities, which can also be understood as falling under a governing-by-enabling action from the EU authorities.

As mentioned previously, the Commission also used governing-by-authority approaches. The first document that should be quoted in this category is the "*Action Plan for the Deployment of Intelligent Transport Systems in Europe*", which proposed the development of a framework for the unfolding of ITS in Europe. In particular, it proposed the definition of processes for the provision by private and public actors of EU-wide real-time traffic and travel information (RTTI) services (Commission of the European Communities, 2008a). The second piece that should be mentioned here (and is perhaps the most evolved authority action from the Commission) is the *EU ITS Directive*, which aimed at setting the legal framework for the deployment of ITS in Europe (EU, 2011). The directive basically aimed to develop legally binding specifications and standards for interoperability of ITS systems across member states. However, both documents should be considered as *weak* approaches given their lack of coercive measures and low repercussions for member states. Indeed, the ITS directive only aimed to create a framework for the development of ITS in Europe, and the interoperability of systems between member states, leaving the responsibility and strategy of developing ITS to each member state. The only binding measure that was included in the ITS directive basically required each member state (Article 17) to send the Commission a report on the current state in 2011 of its ITS infrastructure, as well as its future plans for developing ITS. By "forcing" member states to come up with such reports, one can actually understand the Commission as having pushed EU member states to think about what to do with ITS, but without really giving instructions on how ITS should be deployed on their territories. While the requirement for each member state to send the commission a report on its current strategies vis-à-vis ITS might have influenced Finland and Austria in the process that led to the development of MaaS in Helsinki and IMP in Vienna, it would be wrong to think the same for the development of smart ticketing in London. Because the Oyster card predates the ITS Directive, it would be incorrect to think that it played a role in the development of smart ticketing in London.

		Case 1		Case 2		Case 3		
Supra-National level	*European Commission*	•Definition of a vision and promotion of ICT-supported integrated mobility solutions (*2007 Green Paper; 2011 White Paper*) •Definition of specific strategy and legislation (*2008 ITS Action plan; 2010 ITS Directive*) •Knowledge sharing (EU Urban ITS Expert Group) Enabling / Authority						
		Case 1		**Case 2**		**Case 3**		
National level	*Governments*	•Set the vision (*1998 White Paper; 2000 Ten year plan*) •Promotion of smart cards (*1998 White Paper; 2000 Ten year plan*) •Initiation of public–private collaboration (*1985 Transport Act*) Enabling		•Set the vision (*1991 Transport Master Plan*) •Promotion of IMPs (IMPULSE Programme I2V; *2011 Austrian ITS Action Plan*) Enabling		•Set the vision (ITS strategy) •Promotion of MaaS *(2011 Transport Revolution Report*) •Initiation of public–private collaboration (*Transport Revolution Think-tank; Traffic Lab…*) Enabling	•Legislate/regulate (1st and 2nd phases of the Finnish Transport Code) Authority	
	Funding Agencies	-		•Funding of VAÖ and SMILE Enabling		•Funding of Whim Enabling		
	State-owned Railway company	-		•Release of the Qando app in 2009 and ÖBB ticketing app in 2013 •Leader in the SMILE project •Launch WegFinder (2017) Doing		•Development of VR's MaaS strategy (2016) •Developing their own MaaS app Doing		
Local level	*Public Transport Authority*	•Contacting (FTP 2006; FTA 2010; Electra 2014) Authority	•Oyster cards for TfL's employees Self-governing	•Release of Scotty (2007) & WL ticketing app (2011) •Leader in the SMILE project Doing	• Launch of Upstream (2016) Enabling	•Release of the HSL single-ticket app in 2016 Doing	•Refusal to open seasonal-ticket APIs Laissez-faire	•OpenMaaS interface (2018) •Opening of seasonal-ticket APIs (2018) Enabling
	City Government	•Decision to go for Oyster (*2001 Mayor Transport Strategy*) Authority	•Set the vision (*2001 Mayor Transport Strategy*) •Promotion of the smart card solution Enabling	•Set the vision (*1999 Klip I, 2003 Transport Master Plan for Vienna; 2003 Urban mobility plan*) Laissez faire		•Promotion of the concept (*Helsinki city plan vision 2050; Joint supervision of a master's thesis with ITS Finland 2013*) •Support of the concept (*Host of the ITS Europe Congress in 2014…*) •Lobbying in favor of MaaS (City Council members with HSL, Forum Virium, HBH) •Collaboration with non-state actors (master's thesis supervision with ITS Finland) Enabling		

Table 5.2-2: Public authorities' governing approaches in the development of the three ICT-supported integrated mobility schemes studied (author's elaboration)

5.2.3 Cross-case analysis and discussion

Here, the role of the different public actors (national government, state-owned railway company, local government, public transport authority and funding agencies) in the development of the three studied ICT-supported integrated mobility schemes is compared. Given that actors might have adopted the same approach from one case to another but with different intensities, three levels of strengths in the different governing approaches (weak, medium, and strong) have been introduced. The role of EU authorities is also discussed. Ultimately, the possibility of potentially adopting different governing approaches in the three case studies is discussed.

- PTAs' roles

While PTAs have all adopted different approaches in the three case studies, there seem to be conclusions draw from their behavior vis-à-vis the development of smart cards, IMPs, and MaaS. First of all, it seems that the *laissez-faire* approach actually acts as a bottleneck, as it could be observed with the behavior that HSL adopted at the beginning of the MaaS era in Helsinki. By refusing to get involved and embracing a "wait and see" approach, the Helsinki Metropolitan transport authority put the development of MaaS in jeopardy. Indeed, by usually being responsible for ticketing, PTAs naturally play a very important role when it comes to the development of ICT-supported integrated mobility schemes, and it is only by getting them fully on-board that private third parties will be able to develop commercially sustainable MaaS solutions. The approach adopted by the PTA in Vienna has somehow been much more offensive. By first adopting a *governing-by-doing* approach, the WL acted to position itself as a leader in the IMP field, and saw in IMPs an opportunity to be an actor in the digital transport sphere. However, governing by doing might not be the best governing position for PTAs to adopt. Developing an ICT-supported integrated mobility scheme requires (digital) skills and know-how that were never the focus of PTAs. By doing things by themselves, PTAs might actually become trapped in technical difficulties, as HSL was in the in-house development of its single- and seasonal-ticketing app (IH13). Considering how successful the development of smart cards has been in London, one might be tempted to consider TfL's approach – that is, governing by authority – as the relevant one. By putting the operation of Oyster and CPCs to tender, TfL emerged relatively unscathed from the development of smart ticketing in London, avoiding becoming trapped in technical issues, and ultimately reinforcing its image of innovative PTA (Stone and Aravopoulou, 2018).

However, such an approach might not be optimal in all cases, as it locks things into a particular ICT-supported integrated mobility scheme, from which it might be hard to revert. In London, for example, where TfL has used an authority governing approach, the ticketing system is built around Oyster and CPCs. This prevents another more advanced ticketing system (such as IMPs or MaaS) from being implemented, as the card readers installed for Oysters and CPCs would not be able to read any other ticketing means (such as bar codes on smart phones). It is commonly agreed that being an authority that is entirely dependent on a third party to run a digital service (smart ticketing) increases path dependency and lock-in effects (Kitchin, 2014). Therefore, the approach undertaken by TfL with CUBIC could result in a lock-in in Oysters and CPCs. Thus, it seems the governing-by-authority stance might not be the optimal long-term approach to endorse for PTAs.

Ultimately, it seems that the approaches undertaken by the Wiener Linien after the SMILE project, and recently by HSL, are more appropriate. By setting up Upstream Gmbh as a kind of independent public start-up in charge of developing the digital infrastructure for other IMPs to develop, the PTA in Vienna has moved from a governing-by-doing approach to a governing-by-enabling one, thereby avoiding locking itself into a given technological state, and with a given technological partner. This is also the approach that HSL eventually started to adopt (albeit having been forced to because of national legislation), by announcing in March 2018 the development of an online platform where both single-ticket and seasonal-ticket APIs would be made available (HSL, 2018). Although it does not seem to be the governing approach first adopted by PTAs when confronted to the subject of ICT-supported integrated mobility schemes, both PTAs seem to have ultimately shifted towards enabling. Based on a limited number of cases, it seems that PTAs are going through the same stages when considering ICT-supported integrated mobility schemes.

> "*First they say it is not gonna happen. And then they say, 'it is going to be a threat'; then they will say, 'we want to be THE operator' (…) only after that they will get to the strategy where they say, 'we will enable and let our public transport be a (…) part of the MaaS offering'.*" (IH1)

If this pattern proves true, one might expect TfL to adopt an enabling approach in the coming years, to push for the implementation of the more evolved steps of the transport integration ladder; that is, for IMPs or MaaS eventually. TfL has actually already started doing this by opening most of its data to third party developers since 2011 (Hogge, 2015) and is depicted as being the "*ideal organization*" to implement MaaS in London (Kamargianni et al., 2015: 62).

- Local governments' roles

From the three case studies, there is no doubt that London's local government has been the most directly involved. Indeed formally proposing the implementation of smart cards as a way of achieving his 2001 MTS vision, the mayor of London directly pushed for the development of the Oyster and later of CPCs, which is consistent with what Li (2018) recommended for the uptake of MaaS schemes. By continuously promoting and supporting smart cards as a step towards achieving policy objectives (e.g., Mayor of London, 2017),[32] the mayor of London demonstrated his political support for smart cards, safeguarding them from any possible disruptions. This governing-by-authority approach can be seen as quite effective for pushing an ICT-supported integrated mobility scheme forward.

However, one can understand why local governments in Helsinki and Vienna adopted different approaches for the development of MaaS and IMPs (enabling and laissez-faire, respectively). While there was existing knowledge about the benefits of smart cards[33] when the mayor of London chose that solution, knowledge about the impact of IMP and MaaS is still very limited, which might explain the lack of clear and official political commitment and steering from local governments for those solutions (Voß et al., 2007). In particular, the lack of knowledge has created a fear that MaaS and IMP might take away regular public transport users, which would have an impact on the sustainability of the investments made by local governments in public transport infrastructure (and their payback).

> *"If we go in a direction [through MaaS] where the transport system is more based on shared mobility with smaller buses or smaller cars, there won't be enough users for these new developments. And the cities have to pay for [public transport infrastructure] anyway, so that is another point of view. As a region, cities and state together, we have decided to invest in transport infrastructures, so of course we have to build our city and system so that we use them!"* (IH16)

Although it would have helped to have a clear political commitment from the Mayors (IV5), it would have been quite risky for the mayors of Helsinki and Vienna to publicly push and steer MaaS and IMP without being sure of their benefits. Once there is research available clearly demonstrating the positive impacts of

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[32] For example, in the last Mayor's Transport Strategy, Oyster and CPCs were cited as ways of reaching Policy No. 11, which aims to make the transport system more pleasant to use, enabling customers to enjoy comfortable, confident, safe and secure, informed, and stress-free travel (Mayor of London, 2017: 122).
[33] The Octopus card was launched in Hong Kong in 1997 and quickly declared a success.

MaaS on existing transport systems, local governments might well take an authority approach; before that, however, the adoption of other governing approaches seems to be more logical.

At the end of the day, the approach adopted by the City of Helsinki seems to have been the most relevant vis-à-vis the development of MaaS and IMPs. By avoiding pushing too hard for MaaS (and especially pushing too hard HSL), the City of Helsinki adopted an enabling approach that seems to have paid off. By using tools such as lobbying, promotion, support, and collaboration with the private sector, the City of Helsinki, especially through Forum Virium (IH13), managed to contribute to the change of mindset of HSL, which may not have been the case if it had used "stronger" instruments such as the development of a vision that would have specifically planned the implementation of MaaS. Such approach adopted by the City of Helsinki is to be linked with the use of network governance and negotiations in networks in order to steer system development (Voß et al., 2007). While some might criticize the City of Helsinki for not having done enough (IH10), especially vis-à-vis the single-ticket API issue, there is not much more that could have been done. It is true that the City of Helsinki partially owns HSL, and that HSL receives about half of its operating budget from the City of Helsinki. However, there is no way the City of Helsinki could have used that to leverage HSL to change its position. Indeed, HSL is also owned by six other cities of the Helsinki Metropolitan Area, with whom the City of Helsinki is known to have conflictual relations, because of its economic domination and differences in political views (Heinelt and Kübler, 2005); this would have presented another issue in terms of reaching a consensus. Therefore, except from informal negotiations between politicians and members of the HSL board, the use of hybrid mechanisms, for example through its innovation agency Forum Virium, through Helsinki Business Hub, were the only available instruments for the City of Helsinki to push MaaS forward.

It is also not clear whether having had the city of Vienna adopt an enabling approach, while it adopted a laissez-faire approach, would have changed anything. It seems that, in the Austrian context, the less involved local governments are (in the development of ICT-supported integrated mobility schemes), the better. From that perspective, having political actors not opposing the development of IMP was already perceived as a kind of support.

> *"Knowing the Viennese politics …* [laughs] *you must say that it was a success having them not opposing the project (…) at the end we are in a situation where the city, because they own the utility company, can still go against them (…) not intervening in the negative sense is always kind of support."* (IV5)

Ultimately, the embracement of the solution by city actors themselves is also expected to boost the uptake of ICT-supported integrated mobility scheme. Therefore, it seems cities would also have to adopt self-governing approaches if they were to really push those solutions forward, leading by example (as was the case when every TfL employee was given an Oyster Card when it was launched in 2002).

- State-owned railway companies' roles

From the three case studies, it is clear in the Vienna case that the state-owned railway company has had the most pro-active behavior. By clearly demonstrating its willingness to be in the driving seat for the development of ICT-supported integrated mobility schemes, the ÖBB has adopted a governing-by-doing approach, having put the development of IMPs in jeopardy in Austria. By having a monopoly on long-distance rail ticketing and refusing to open those to third parties, the ÖBB has acted as the sole governing actor for the development of IMPs at the national level.

> *"We would be interested in providing ticketing, but our shareholders don't let us provide that. In particular, the ÖBB says: 'we provide tickets and you provide information, basta!'"* (IV14)

Although not as strong, VR has also stated its willingness to do its own MaaS, and refused to collaborate with MaaS Global, slowing down the process of MaaS development in the HMA. There are two reasons why VR did not act as boldly as the ÖBB. Firstly, it is acknowledged that VR has not focused closely on MaaS since it has been using most of its resources to prepare for the rail market opening, which is supposed to happen in the HMA by 2024.

> *"We committed that if we decrease our prices by 15 percent, HSL would be ready to postpone the RFB process (…) when you are decreasing prices you also have to go for cost savings (…) I guess this postponed our role in MaaS for a little bit, and made us not so active in the area."* (IH3)

Compared to VR, the ÖBB seems to be under less pressure regarding rail market opening, which has allowed it to focus on new strategic areas, such as IMPs. The second explanation for the bolder move of ÖBB compared to VR pertains to the leadership and management of the two railway undertakings. While it seems that the MaaS subject has not been pushed strongly by VR's top management (as mainly focused on coping with rail liberalization), the position of the Austrian RU vis-à-vis IMPs was promoted heavily by ÖBB's CEO at that time, who later became president of the republic of Austria.

> *"Of course Mr. Kern was really one of the drivers of this initiative [iMobility]. He had good contacts into the start up scene so he brought a lot of people together. And this was very helpful. One of the main success factors of what iMobility is, what it is today, is that Mr. Kern was really supportive."* (IV9)

As for local governments and public transport authorities, there is little evidence that state-owned railway undertakings are the best option for developing ICT-supported integrated mobility schemes by themselves, as it is not obvious that they have the necessary (digital) competences to do so.

The only case where the ICT-supported integrated mobility scheme has really taken off was where no state-owned railway company was involved (Case 1). Due to heavy liberalization and privatization in the 1980s, the UK rail sector is not dominated by any state-owned railway company, but is shared by a consequent number of private railway operators. For example in London, there are 14 train operating companies (TOCs) providing commuting rail services (Nisar and Prabhakar, 2018), all of which have less power than would have a single RU dominating the market, as it is the case in Austria and Finland. Hence, the development of smart cards in London was not put in jeopardy by a dominant state-owned railway undertaking. Because they had limited power, the TOCs adopted an approach close to governing by enabling in London, by agreeing, with TfL (after a long period of negotiations from 2006 to 2009) for Oyster PAYG readers to be installed at all National Rail stations in London (TfL, 2011). In sum, it seems that having one monopolistic RU might not be optimal for the development of ICT-supported integrated mobility schemes, as the RU might want to do the development by itself. A case (like Case 1) where there are more actors with less power might be easier.

However, it is not certain that rail fragmentation would act in favor of ICT-supported integrated mobility schemes. Fragmentation is often associated with conflict (Vass, 2003), so it should not be assumed to be the answer to the monopolistic behavior of RUs when it comes to the implementation of smart cards, IMP, and MaaS. Furthermore, rail liberalization and privatization in the UK has led to increased transaction costs, losses of economies of scale, and negative impacts on costs and safety (Wellings, 2014), which is why it might not be the optimal solution for pushing ICT-supported integrated mobility schemes.

- National governments' roles

In all of the three cases of studies, national governments have been quite heavily involved in the development of ICT-supported integrated mobility schemes, and all have adopted an enabling position. However, they have done so in different ways, and with different intensities. From their observed behaviors, there are seven kinds of actions that can be understood as having had an influence in the development of smart cards, IMP, and MaaS. Those are the development of a vision, the promotion of the solution after its implementation, the provision of funding, the initiation of public-private collaborations, the development of specific legislation targeting the development of the solution, as well as some actions related to rail liberalization and with the creation of metropolitan entities. The positions of national governments in all those seven categories across the three case studies are compared below.

All three national governments have proposed visions for the future of their transport systems, which is an integral part of steering activities (Voß et al., 2007). However, only the UK and the Finnish governments mentioned ICT-supported integrated mobility schemes as means of reaching their proposed visions. While the Austrian Ministry of Transport proposed a vision for the Austrian transport network (with the 1991 Transport Master Plan), it failed to mention ICT-supported integrated mobility solutions as a way of reaching it. By defining a vision and highlighting the possibility of certain innovations to reach the vision objectives, the UK and Finnish national governments set the course for the development of those solutions, although this unfortunately did not happen in Case 2. Secondly, national governments can also set visions specifically for the development of ITS (which include ICT-supported integrated mobility schemes). While this happened in Finland and Austria with specific ITS strategies that predated the development of MaaS and IMP, the UK government's ITS strategy did not precede the development of smart cards in London and thus cannot be seen to have had an impact on the development of Oysters and CPCs in London. The definition of an ITS vision, in parallel to a transport vision mentioning ITS-based solutions as a means of reaching the vision's objective, appears to be an important component of the role that national governments can play in the development of ICT-supported integrated mobility solutions.

> *"Authorities should also make a decision about their own roles. What they want to do by themselves, and what do they want the companies to do, and communicate it with the companies! Because nothing will happen if nobody knows what are their roles. When a company knows what its roles are, it is easier to create new services. Of course we can create new services, but if we are not sure any money will come in, maybe we won't create new services, because companies want to be profitable."* (IH8)

Secondly, while the Finnish and the UK government openly promoted MaaS and smart cards and publically supported both solutions, the Austrian government has failed to do so with IMPs. This might be explained by the presence in Austria of an actor that does not exist in Finland and the UK, or at least is not so powerful. According to one of the interviewees, the Austrian federation of car drivers is immensely powerful, and the federal government is careful not to do anything that would go against the federation's principles. In other words, the BMVIT's lack of official support for IMPs might be explained by its unwillingness to openly support a solution that is targeting private car ownership, which is at the core of the Austrian federation of car drivers.

> *"We have this federation of car users in Austria, which is the biggest one in the world related to the size of the population, and the car in Austria is something like the Holly cow. People are really sensitive about their car, and owning it, and having the right to go everywhere and so on. So it is a very unpopular policy field if you want to restrict it in a way. Politicians are very careful with that (…) they just can't make it happen because on a political level, it will be like suicide (…) If politicians do something too strongly about cars, in any case they will lose the next vote."* (IV11)

Thirdly, only two of the three national governments provided funding for the solutions to take off. While the Austrian and Finnish Governments decided to provide funding for IMP and MaaS to develop, the UK Government did no such thing to enable smart cards to come to life. Again, this can mainly be explained by the fact that the smart card technology was more mature when launched in London than when IMP and MaaS were developed in Vienna and Helsinki, respectively. Knowledge about the Hong Kong Octopus card was available for London, which was not the case for IMP and MaaS, as knowledge about the impact of such schemes on existing transport systems was (and still is) very limited. So, it appears that national governments funded projects where knowledge was limited in order to potentially gain more knowledge. Therefore, investments by the Austrian and Finnish governments in IMP and MaaS can be understood as investments in so-called pilot and demonstration plants (PDP), which basically aim to generate knowledge, but also to establish a bridge between basic knowledge generation and industrial application (Frishammar et al., 2015).

One action that was undertaken by the LVM and not by the two other ministries is the development of places of exchange between the public and the private sector. The LVM did such things with, for example, the creation of the Transport Revolution think-thank, the definition of the ITS strategy, the Traffic-lab, etc. The DfT did not appear to be involved in any similar activities where it would have invited, for example, public transport authorities and private smart card providers. It had enhanced public–private collaboration in the transport sector (through NPM-led policies), but had not created places of exchange between the public and private sector for the development of smart cards. Similarly, the BMVIT is not acknowledged for having directly enhanced such meetings that would have brought together the different stakeholders of the IMP scene.

Where the LVM has really made a difference with the DfT and the BMVIT is in the development of legislation specifically targeting the development of MaaS (first and second phase of the Finnish Transport Code), requiring all transport providers to open all their data and (all) ticketing APIs to MaaS operators. The legislation is so powerful that it was categorized as governing by authority, which is something the DfT and BMVIT have not done at all, and is very unlikely to happen, especially for the BMVIT in Austria. One of the explanations for this is that Austria is a federal country, unlike Finland and the UK, which can be classified as centralized states. Consequently, the Austrian central government has less “power” than the UK or Finnish governments.

> *“The difference between many member states and Austria is that Austria is a federal country. The federal ministries are responsible for certain federal issues. And then there is a regional level. Regions are quite autonomous. They have their own governments and responsibilities, and cities also have their own governments (…) the role of the BMVIT is to ensure that other governmental actors, such as the road authority, or the ÖBB, cooperate to a certain extent. They are funding programs that deal with integration, but the BMVIT cannot write a legal act that forces everybody to integrate. They can’t do it, and they don’t.”* (IV12)

As observed previously, state-owned railway undertakings are usually resistant to the development of MaaS and IMP, or want to do it by themselves. For the cases of Finland and Austria, national governments actually have a role to play in helping to avoid this bottleneck, as they basically own the national railway company. More importantly, national governments might use EU requirements for member states to open their internal rail market to competition in order to ultimately make national railway company understand that they can no longer think in terms of monopolistic behavior, as they used to do when they had a monopoly over rail passenger market. Without saying that national governments should entirely liberalize their rail system, as it might have some serious drawbacks in terms of cost and safety, it seems that central governments have to adopt a clearer position vis-à-vis national railway companies (IH3, 2016). It is up to national governments to decide whether they wish to keep protecting their railway companies from competition, and at the same time reinforce their “winner takes it all” situation, or if they want to introduce competition in order to improve performance of railways, which might make them understand that they must compete to gain market shares (even in the digital world). In Finland, for example, the opening of the rail market has been postponed several times and will only start to open in the early 2020s. The central Finnish government is somehow contradicting itself by being very supportive of MaaS, and at the same time avoiding pushing rail market opening. Similarly, although it has already started in Austria, rail market opening is very slow, which contrasts with the willingness to develop IMP stated in the 2011 Austrian ITS action plan.

> *“*[The BMVIT] *always protect* [the ÖBB]*. So stop protecting them, and just treat them like everybody else in the system. This could be a cure! (…) How they are protecting them is just wrong, especially in the context of MaaS, where you have to attract new customers through new partnerships.”* (IV4)

The fact that smart cards took off so well in London is largely because of the governing-by-authority approach adopted by the mayor of London and TfL. However, it is also linked with the jurisdictional level at which the actors having ordered their development acted; that is, the metropolitan level (Katz et al., 2003). Having those solutions develop at a metropolitan level was indirectly enabled by the UK central government that created TfL as the armed wing of the Greater London Authority, with the *1999 Greater London Act*. The way transport in Helsinki is organized is more complex, as HSL is basically the only metropolitan authority, that “sits” on top of HMA cities. Consequently, HSL can be perceived as being stronger than its seven owning cities when it comes to transport, as the seven cities will have to agree on something to leverage the Metropolitan Transport Authority. Therefore, it seems that the Finnish government might also have a role to play in strengthening metropolitan organization, perhaps not by applying a top-down legislation that would create metropolitan governments, but by pushing for more bottom-up cooperation between cities. As Finland is known to be a unitary state with strong local governments, it is very unlikely that central government will impose the creation of metropolitan bodies (Söderström et al., 2015). The way transport is organized for the Viennese metropolitan region would also necessitate more involvement from the Austrian Government. While most of the traffic issues in Vienna are known to be linked with the amount of cars commuting from towns in surrounding regions (Lower Austria and Burgenland), the WL only has jurisdiction over the city of Vienna, and thus has no power to develop a metropolitan solution. Consequently, the WienMobil app, developed by Upstream for the Wiener Linien after SMILE, only works for the city of Vienna and does not integrate transport solution that would benefit people commuting from outside Vienna. For example, it does not integrate public transport options of neighboring towns or the option to book commuting trains. Although an organization in charge of organizing transport at the metropolitan scale does exist (the VÖR), it has not been involved in the development of SMILE and follow-up projects, as it developed its own routing information system, named ANachB. Therefore, it is relevant to question whether it would not make more sense to have the VÖR take over the digital infrastructure currently being developed by Upstream, instead of having several platforms being developed in parallel.

> *“You have to upscale IMPs from the city level to the regional level. It is important! (…) We need more integration at a metropolitan level, so you will see in your routing, as a customer, that a mobility solution is waiting for you outside the city as well. We will need this in the future.”* (IV8)

Again, however, it is very unlikely that the Austrian Government will get more involved in metropolitan governance as Austria is a federal state and the central government has no power in local politics. Creating an intermediary metropolitan government in Vienna might also be perceived as the fragmentation of power across multiple political institutions, which would create new barriers to tackling ‘wicked issues’ and more coordination needed across different sectors and levels of government (Katikireddi et al., 2016).

- EU authorities' roles

By setting the vision, promoting means to reach the vision objectives, and developing directives and action plan to frame the development of those means, the EU has mainly acted as an enabler. From a more indirect perspective, although it came quite late (2016), the fourth railway package, which required member states to open their rail markets to competition, can be seen as potentially contributing to solve the "state-owned railway undertaking lock-in".

However, one might understand the actions of the EU directly targeting the development of ICT-supported integrated schemes as not being strong enough. There has been a difference of support among EU authorities for the development of smart ticketing compared to the development of multimodal information systems, which together constitute the building blocks of MaaS (Li, 2018; Kamargianni et al., 2016). While the Commission has been quite supportive of the unfolding of multimodal information systems, most recently with the 2017 delegated regulation regarding the provision of EU-wide multimodal travel information services (EC, 2017: 14), EU authorities have not yet proposed framework conditions to promote the development and use of smart ticketing, although this was initially proposed in the 2011 White Paper (EC, 2011: 23). There are several actions that could be undertaken at the EU level for the development of ICT-supported integrated mobility schemes, such as the development of a delegated regulation requiring all transport operators to open their ticketing APIs (as done in the Finnish Transport Code, for example), or the development of standards for the interoperability of smart ticketing schemes across Europe.

	Worst practices	**Best practices**
Local Governments	Laissez-faire (lack of strong and recent vision [City of Vienna])	Enabling (strong vision with clear objectives and proposed means to reach those [Mayor of London]; use of network governance [City of Helsinki]; initiation of public–private interactions [City of Helsinki])
PTAs	Doing (might prevent having the best solution [WS]) Authority (might prevent selection of the best solution [TfL]) Laissez-faire (put the development of the solution in jeopardy [HSL])	Enabling (let the best option emerge [Upstream and HSL 2.0]) Self-governing (have PTA staff embrace the solution [TfL])
National Governments	Laissez-faire (lack of vision [BMVIT])	Enabling (set the vision [DfT and LVM]; provide funding [TEKES and Climate and Energy Fund]; promote and support the solution ex-post [DfT and LVM]) Authority (develop enabling framework [LVM]; ex-ante rail sector liberalization [DfT]; top-down creation of metropolitan entities [UK Gov])
(State-owned) Railway-Undertaking	Doing (does not have the competences [VR and ÖBB])	Enabling (accept the proposed solution [TOC in London])
EU authorities	Weak enabling (lack of framework for integrated ticketing [EU Commission])	Enabling (set vision; push for rail liberalization) Authority (develop directives)

Table 5.2-3: Summary of good and bad practices of public authorities for the development of ICT-supported integrated mobility schemes

The comparative governance analysis has shed light on the different governing approaches adopted by public authorities in the development of smart cards, IMPs, and MaaS. However, there are still some questions related to the processes of development of ICT-supported integrated mobility schemes that remain unanswered. While the questions related to the reasons underlying the choice of governing approaches of certain actors will partially be answered via the so-called Transition analysis, it is important to underline the fact that the way some public actors have acted was actually grounded in the constitutional context of each of the cases. Said differently, although we have been criticizing the behaviour of some actors, it is almost impossible they could have acted differenty, because their actions were directly shaped by the contitution of their own countries, that can be understood as falling under what Healey (2004) calls “external influences”. The behaviour of certain public actors can thus be understood as almost “natural” or “inevitable” given the importance of the constitutional context. For example, although this is what we would recommend, it is almost impossible that the central Austrian government adopts a stronger governing approach in the development of IMPs because Austria is a Federal country where central government has very limited power on states and cities. Similarly, it is quite normal that the central government in Finland proposed its highly interventionist and authoritarian transport code given that Finland is one of the most centralized country in the world. In the same fashion, if public authorities at the local level (TfL and Mayor of London) for the case of smart card development in London adopted such an authority approach, it is mainly because of the autonomy/rivalry of London vs. central government in the UK.

Last but not least, the behaviour adopted by EU actors can also be understood as quite natural. It is actually not in the intrinsic principles of the EU to adopt a governing-by-authority approach, or even a strong governing-by-enabling approach. Indeed, EU intervention is shaped by the principles of proportionality and subsidiarity. Proportionality relates to the idea that EU action can only be justified if suitable and necessary to realize EU goals, and if the realization of those actions does not affect other interests. Subsidiarity refers to the fact that EU authorities should not intervene when the power to act actually remains in the hands of member states. Because those principles dictate EU intervention (and cannot be overcome), there might be a long wait to see a directive forcing member states to force transport operators to open their data, or forcing coercively all public transport authorities within Europe to collaborate in the development of ICT-supported integrated mobility schemes. The EU simply does not have the power or the ability to develop such governing mechanisms, and even if it did, “*has no intention of prescribing one- size-fits-all or top-down solutions*” (Commission of the European Communities, 2009b: 3). The governing approach of EU authorities is closer to an approach where “*member States would be free to determine where to concentrate their efforts, and what measures to bring into play to leverage change*” (CEC, 2008b: 7) than a top-down and authoritarian approach. Hence, even though a stronger role of EU authorities might be needed, it seems unlikely to happen any time soon.

5.3 Transition Analysis

Having looked at how public authorities behaved in the development of the three ICT-supported integrated mobility schemes studied, one might now wonder why things developed the way they did, in order to ultimately be able to make recommendations for policy makers for things to develop differently. In this section, the literature focusing on socio-technical transitions is used to better understand why things developed the way they did in the three case studies. This subchapter begins by presenting the analytical framework and then conducts the cross-case analysis by applying it across the three case studies. The findings of this transition analysis are summarized in Table 5.3.1.

5.3.1 Analytical framework

The theoretical propositions used to structure the analysis have been withdrawn from the transition literature, which is useful for analyzing the development and diffusion of potential system innovations, such as ICT-supported integrated mobility schemes. So far, transition frameworks have been widely used to look at the development of new transport technologies (electric vehicles, human powered mobility solutions, automated vehicles), but have not yet been really used to look at the development of ICT-supported integrated mobility schemes.[34] Below are detailed the eight propositions drawn from the transition literature that constitute the conceptual framework along which this transition analysis has been structured.

As socio-technical transitions are known to be long processes (Geels, 2012), they have been divided into different phases (Rotmans et al., 2001). Transitions usually start with a pre-development phase, where the status quo is known to stay relatively constant, and where innovations develop in niches. This is followed by a takeoff phase, during which the state of the system begins to shift, thanks to the diffusion of niche innovations into the regime layer. The takeoff phase is usually followed by the breakthrough phase, in which the main shifts in the regime layer occur. Finally, the pace of changes within the regime layer tends to decrease in what is known as the stabilization phase. Due to the novelty of ICT-supported integrated mobility schemes (10–15 years old), it would be presumptuous to believe the studied innovations have gone through all the above-mentioned phases. Thus, it is pertinent to ask to which phases of the transition the three case studies correspond to. Therefore, the first question structuring the transition analysis will be the following:

(1) To which phase of socio-technical transitions do the three case studies correspond to?

As mentioned in Chapter 2, and according to transition frameworks, socio-technical transitions occur as the interplay and interaction between three key "layers", being the niche, the regime, and the landscape layers. A graphical representation of socio-technical transitions is given in Figure 5.3.1. In more detail, as summed up by Kemp et al. (2001: 277) "*it is the alignment of developments (successful processes within the niche reinforced by changes at regime level and at the level of the sociotechnical landscape) which determines if a regime shift will occur".* The first of these three layers, which lies at the bottom of the MLP, is known as the niche layer, in which system innovations start their innovation journeys. Niches can be understood as incubation rooms, protected from traditional market selection process (Geels, 2002). According to Schot et al. (1994), niches might fail if they are created as the only result of government activity, and not as a multi-actor process. Indeed, the only actions public authorities might decide to undertake to make a niche successful are the steering of their development and subsidizing (Schot and Geels, 2008), but nothing more. In particular, it is generally agreed that public authorities should avoid "picking winners" and should encourage participation from all stakeholders (Foxon et al., 2009) for niche innovations to penetrate the regime layer. Therefore, it is relevant to question what role public authorities played in the process of niche creation in the different cases of studies. The second "framing question" structuring the analysis is the following:

(2) Have public authorities provided both steering and funding in the process of niche development?

Niches are known to be successful when they respect three criteria (Schot and Geels, 2008; Caniëls and Romijn, 2008). First, niches should enable learning among niche actors, via learning by doing, learning by using, and learning by interacting (Geels, 2002). In particular, the development of both first-order (facts, data) and second-order learning (that should enable the change in cognitive frames) are important for niches to be successful. Secondly, to be successful, niches must rely on the building of deep social networks, involving a wide array of stakeholders, including outsiders, and providing necessary resources (money, people, and expertise). Last but not least, expectations between stakeholders must be articulated in order for niches to succeed. It is generally agreed that niches might not be successful without the development of a common vision among the different involved actors. In particular, it is acknowledged that the shared expectations must be robust, specific, and of high quality to enable the niche to be successful. According to Schot and

[34] For a deeper description of transition frameworks, see Subchapter 2.4

Geels (2008), failed niche developments can often be linked to insufficient involvement of outsiders and the lack of second-order learning, as well as the lack of involvement of regime actors in the niche network, resulting in insufficient availability of resources and institutional embedding. Those three criteria provide the three following framing questions:

(3) Have social networks developed in the niches?

(4) Has the niche enabled learning processes among actors?

(5) Did a common vision exist among members involved?

The second layer of the MLP is known as the (socio-technical) regime layer, which basically bundles the rules (embodied in standards, skills, designs, and government regulations) for how to manufacture, utilize, and regulate a specific technology (Schot and Geels, 2008). More specifically, socio-technical regimes (that, bundled together, form what is referred to as a "patchwork of regimes") are known to be structured among seven dimensions (Geels, 2002), being the technology itself, its symbolic meaning, its supporting infrastructure, its related industry structure, its associated set of policies, the user practices associated to it, and the techno-scientific knowledge linked to it. Personal transportation, for example, is mostly organized around the automobility regime, which is structured around a specific technology (internal combustion engine), associated with symbolic meanings (masculinity, freedom, social success), user practices (how and why people decide to use their cars), and supported by a dedicated infrastructure (road network, signals, parking, fuel infrastructure). Automobiles are also supported by a dedicated industry (OEMs) that builds on specific techno-scientific knowledge (for example, engine optimization) and are regulated by dedicated policies (road safety, environmental regulations). A second regime also structures personal transportation, known as the public transport regime, although this is much smaller and weaker that the dominant automobility regime (Parkurst et al., 2012). Elements of established socio-technical regimes (such as automobility) are known to be stable because they are linked with one another, and hence contribute to reproducing the regime over and over, with little hope to see changes emerge (Geels, 2002). This is because Incumbent regimes are known to be subject to technological and/or institutional lock-ins (Foxon, 2002), defined as "*mechanisms, which reinforce a certain pathway of economic, technological, industrial and institutional development"* and potentially *"leading to path-dependency"* (Klitkou et al., 2015: 23), thus preventing radical innovations from emerging. Within the regime layer, innovation is known to be incremental and to happen '*down the design hierarchy*' (Geels, 2002: 1272). The regime can be seen as a double-edged sword vis-à-vis niche innovations. On one hand, it can act as inhibitor. In general, regime actors (that is, actors that are part of the incumbent socio-technical regime) are reluctant to change because of sunk investments, vested interests, habits, and bureaucracy (Whitmarsh, 2012). On the other hand, the regime can act as an enabler because of its important organizational power (Rotmans et al., 2001). Therefore, it is pertinent to focus on the level of involvement of the regime actors in each of the three case studies, as it appears such actors should be involved, but not too much, for system innovations to take-off. Thus, the sixth question used to structure the transition analysis is the following:

(6) How involved have regime actors been in the development of each of the ICT-supported integrated mobility schemes studied?

In order to penetrate the regime layer, system innovations need to develop through dedicated 'windows of opportunity', which can be understood as 'cracks' in the incumbent regime allowing regime actors to acknowledge the added value of niche innovations. The availability of windows of opportunity can be understood as the output of external pressures originating from the third layer of the MLP, known as the landscape layer (Geels, 2002). This ultimate layer of the MLP, which one might also understand as the context, bundles all kind of macro-trends in which socio-technical transitions are set to happen. Economic growth, digitalization, climate change, cultural and normative values are examples of factors that are located at the landscape layer and have the ability to create windows of opportunity in the regime. This leads to the seventh framing question:

(7) Did windows of opportunity exist and, if so, were they large enough to enhance the development of the studied innovations?

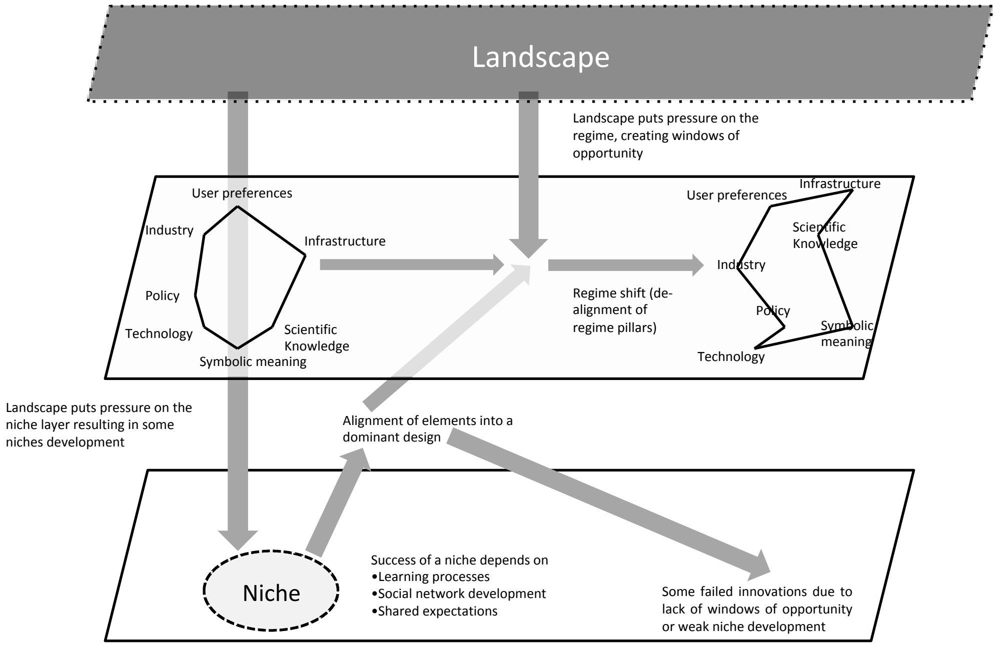

Figure 5.3-1: MLP Framework (Author's elaboration, based on Geels [2002; 2012])

Last but not least, it is acknowledged that a third kind of actor needs to be included in the governance of socio-technical transitions. According to Loorbach (2007), it is only by involving societal actors, along with governments and the private sector, that socio-technical transitions will be effective. Therefore, it is relevant to ask whether, in the three cases of studies, societal actors have been involved in the decision making process, as this might explain why some potential system innovations failed to grow from the niche into the regime layer. The eighth and final question is:

(8) Has civil society been involved into the development of the ICT-supported integrated mobility schemes and, if so, how?

5.3.2 Cross-case analysis

In this subchapter, the three cases studies are analyzed through the eight questions (analytical framework) that have emerged from the literature on socio-technical transitions. For each of the questions, examples are provided as well as, where possible, illustrative quotes from interviewees.

(1) To which phase of the transition do the three case study periods correspond?

MaaS and IMPs are relatively young solutions, for which Vienna and Helsinki were among the first cases of application worldwide; this was not the case of London, as other smart card solutions had already been implemented elsewhere. The technological know-how of putting a MaaS or IMP solution together did not exist before these two cases (Helsinki, 2011–2018; Vienna, 2012–2018), which is why it is relevant to look at both cases from the pre-development phase perspective, which is characterized by technological experimentations and learning in so-called niches (Schot and Geels, 2008; Loorbach and Rotmans, 2006). The case of London (1998–2018) is somehow to be understood differently, as the technology that supported the Oyster was not actually developed for the case of London specifically. The smart card technology and associated technological knowledge had existed for some time before the Oyster. Smart card technology was created in the 1970s,[35] and employed in the transport sector since the late 1990s (Blythe, 2000). For example, the Hong-Kong-based Octopus card system, which was the first smart transport card system ever, dates back to 1994 (Poon and Chau, 2001); that is, four years before TfL awarded the PFI to Transys to develop a smart ticketing scheme. Although the implementation of the Oyster in London also contributed to generating knowledge, it is not associated with technological knowledge development, which was carried out by specific technological suppliers outside the transportation industry, such as Sony, Mitsubishi, and Phillips (Poon and Chau, 2001). For the case of CPC, London is the first city worldwide to have developed such a scheme. Again, however, CPCs as such already existed and the implementation of CPCs in London does not go hand in hand with the technological development of CPCs, which have been in use for commercial transactions since the early 2000s (Polasik et al., 2013). The real technological innovation in the London case was enabling Oyster card readers to also read CPCs. This should be understood as technological integration, as technological know-how on Oyster and CPCs both existed upfront.

Another reason for looking at the London case from a different perspective than the Helsinki and Vienna cases pertains to the number of people using the solution. Oyster and CPCs are now part of Londoners' everyday travel behavior, as they are by far the most used ticketing and payment solution for most public transport options in the city. In 2017, for example, Oyster and CPCs were estimated to have been used for about 88 percent of all travel on the London Underground (TfL, 2017b). By contrast, a relatively limited number of people are MaaS and IMP users in Helsinki and Vienna, respectively. The fact that the number of users is also a characteristic of the phase of the transition is another reason for looking at the Vienna and Helsinki cases from a pre-development phase perspective and looking at the London case from the takeoff perspective, defined as a phase where "*structural change picks up momentum*" (Avelino and Rotmans, 2009: 545). Looking at the processes that led to the birth of smart cards technology – that is, looking at it from a pre-development phase perspective – would be interesting, especially given that there is a lack of research on the subject. However, it would be far beyond the scope of this study.

For the Helsinki and Vienna cases, it is now pertinent to determine the type of niches in which MaaS and IMPs have evolved. According to Geels (2005b), there are two types of niches. The first are technological niches, in which protection is provided in the form of subsidies or strategic investments from firms, and where rules are unstable and the social network is precarious. The other type are market niches, which are more stabilized than technological niches and where it is clearer what the users really want. As MaaS and IMP both received public subsidies and investments from private companies in the period being looked at, it appears more relevant to look at the development of both ICT-supported integrated mobility schemes from the technological niche perspective. Both solutions are still in their infancy and quite fragile, and are subject to high uncertainty regarding their future.

As the London case (take-off) does not correspond to the same phase of the transition as the Vienna and Helsinki cases (pre-development), some of the following questions (2, 3, 4, 5) that really look at the nuts and bolts of niche development processes are not relevant for the London case. Therefore, greater care has been given to the Vienna and Helsinki cases for those questions.

[35] For an early history of smart cards, see Rankl and Effing (2004).

(2) Have public authorities provided both steering and funding in the process of niche development?

As seen in the governance analysis, public authorities have been closely involved in the development of IMPs and MaaS. However, as also mentioned earlier in this chapter, Finnish and Austrian public authorities have adopted quite different approaches in supporting the development of both solutions. In the Vienna case, it appears that public authorities mainly became involved through the provision of dedicated funding to create the "Viennese IMP niche". By investing heavily in the development of the SMILE project, the BMVIT provided the necessary resources for SMILE to develop. The IMP scene would not be as developed if such funding had not occurred, as the following quotation shows.

> *"Since it was a research project, the risk to make this project was not that big, and the probable benefit overweighed the risk. So I guess that was one key factor (…) one enabler was also that the project was subsidized. If we had to carry all the costs ourselves, the decision would probably have been another one."* (IV1)

However, while public authorities are, in theory, expected to also steer the development of niches to maximize the ability of system innovations to make it to the regime layer, it seems that this did not happen for the case of Vienna. Steering from public authorities has been described as "*weak*" (IV4). It appears there were no policy documents establishing strong visions that would have steered the development of IMPs forward, which was in turn, left to the decision of the actors developing those solutions: that is, in the case of Vienna, the ÖBB and the Wiener Linien/Stadtwerke.

In the Helsinki case, it seems that Finnish public authorities did more what they were expected to do than for the case of Austria. The LVM provided a lot of steering through multiple policy documents, such as the 2009 and 2013 ITS strategies, the 2011 Transport Revolution report or the 2013 National Energy and Climate Strategy (and more recently the Finnish Transport Code). The steering from LVM is also to be directly linked with political leadership of the transport minister, whom is known to have somehow championed MaaS.

> *"We have a fearless minister who really stands behind the whole idea of MaaS and is really, you know, pushing the agenda forward. She wants to see things happening (…) hell yes, she is the boldest transport minister ever!"* (IH10)

At the local level, the City of Helsinki also provided steering with its 2013 *Helsinki City Plan Vision 2050*, where it depicted the future of its transportation system as being quite close to the MaaS promise. In this document, MaaS was presented as being *"part of everyday life*" (City of Helsinki, 2013a: 41). However, the steering from the City of Helsinki has also been criticized for being weak and overly top-down and for not taking the user perspective into consideration enough (IH13).

As seen above, the LVM also provided funding through its dedicated funding agency TEKES, which funded several MaaS-related projects and then directly invested in the first funding round of the start-up MaaS.fi. However, one might criticize the LVM for having done more than just steering the development of MaaS. Indeed, although the second phase of the Finnish Transport code served as a response to the behavior of public transport authorities (in particular HSL, which refused to open the seasonal-ticket API), it should still be categorized as a top-down policy from the national government on local transport authorities. Governments are not supposed to act as great commanders or enforce change to make socio-technical transitions happen (Rotmans et al., 2001); this is why the interventionist transport code can be criticized. One might wonder the rationale behind such top-down action from the national government. While it appears that the LVM believes MaaS might be used as a means of achieving transport and climate policy goals (IH10), one might also understand the strong support of the national government for MaaS as a way of supporting business creation and pushing their innovation agenda. Indeed, the Finnish Transport Code can also be understood as a text that enables new businesses to come to life, which might produce positive economic benefits and contribute to growth, and not only enable solutions that might help reaching policy targets.

> *"[MaaS] is a future perspective for business, and a sustainability perspective for mobility (…) if (MaaS) is not there to solve the transport problem, it is there maybe to create some business op-tions. Might be smarter in the end."* (IV4)

> *"And then the other side of it … what comes from our current government program, that is really important for our minister, is to be driving the right type of business environments for new digital businesses."* (IH10)

Enabling new businesses to come to life in the transport sector might be a good thing from a short-term economic growth point of view, but there is a risk that such new business-pushed transport solutions actually have negative consequences on transport systems (Hensher, 2017). Thus, in the steering of MaaS, the LVM should ensure that although Finland is a small country with relatively few traffic problems, it does not favor the innovation and business creation agenda over the transport and sustainability agenda, which could be synonymous with negative impacts on the Finnish transport system

Government funding can sometimes result in the "*funding to death*" phenomenon that happens when niche actors have to allocate a significant part of their own funds and scarce human resources to meet government grants (Weber et al., 1999). While this did not occur in the case of Helsinki, as TEKES only provided limited funding that did not heavily influenced the behavior of MaaS operators (in particular of MaaS Global), such a phenomenon may have occurred in the Vienna case. Although the ÖBB and WS were not impacted by this heavy funding, as they were large organizations and regime actors, some smaller Austrian technology companies, such as Fluidtime or NTT data, that were in charge of the IT part in the SMILE project, may have felt "trapped" in the SMILE and faced pressure to meet the grant provided by the Climate and Energy Fund as well as the FFG. By heavily funding the SMILE project, Austrian public authorities may have actually restrained other MaaS schemes from smaller companies to come to life at the same time, which would have created the competition needed between MaaS providers for MaaS to ultimately penetrate in the regime layer (Foxon et al., 2009).

> *"The project was subsidized for the main players but not for us. So we had to invest and finance our parts (…) we had to finance quite some things, but we would not get that much in return."* (IV10)

While the lack of steering might be used as an argument to explain the failure of the Austrian IMP niche, and therefore the decisions of both project leaders to split apart after SMILE, it also appears that providing the right amount of funding is a difficult exercise. With too little funding, niche actors might not have sufficient resources to experiment, while with too much funding, the experiment might become too demanding and actually have negative impact for niche actors. The LVM in the Helsinki case seems to have attended to both its steering and funding missions. However, one must again underline the ambiguity of the strong push of the government for MaaS, as something potentially favoring the innovation agenda more than the sustainable transport agenda. When it comes to the London case, the local government seems to have provided steering, especially with the 2001 MTS, which has helped smart cards to really enter the takeoff phase. However, this steering did not directly target the unfolding of a smart card niche, as smart cards were already a mature technology before their implementation in London.

(3) Have social networks developed in the niches?

A social network can be understood as a system of interrelated actors "*that are willing to invest time and resources in a fledgling technology, because they believe in its potential*" (Verbong et al., 2008: 556). It seems that social networks were constituted in both technological niches in Austria and Finland.

In Finland, the "MaaS social network" actually developed through two distinct paths. On the one hand, it developed thanks to actions from the national government. By initiating interactions of private actors with public bodies, the LVM pushed for the development of a dedicated MaaS network bringing together state and non-state actors. For example, by launching the Transport Revolution think tank, the LVM brought together public (HSL, municipalities) and non-state actors (ITS Finland). Similarly, by delegating the ITS strategies to a steering group constituted of public (HSL) and private actors (ITS Finland), the LVM pushed for interactions between public and private sectors, and thus for the development of a public–private MaaS social network. The development of this social network was also facilitated by the organization of some events bringing together public and private actors, such as the three workshops organized by TEKES focusing on MaaS in 2014, or the ITS Europe Congress organized in Helsinki during the summer of 2014. On the other hand, the development of the MaaS social network was also pushed by private actors themselves. By organizing an open MaaS business meeting in December 2014, and by inviting 200 actors from the public as well as the private sector, MaaS Global initiated the development of the MaaS social network. This network was later consolidated by the creation of a company (MaaS.fi) in January 2015 with 24 of the 200 companies that attended in December 2014. The MaaS network appeared quite precarious at that time, as not all the actors were originally interested stayed in it and it was not clear what the goal of the network was, which is typical of social networks in technological niches (Geels and Schot, 2007).

> *"You needed to create the ecosystem[36] (…) creating the ecosystem takes a lot of time (…) we did not have any business plans (…) if you don't have the player involved and open for this, you have nothing (…) Then we thought: let's make an open call, and we formulate the world first mobility operator. Two hundred companies came from everywhere."* (IH1)

One of the reasons why HSL adopted a laissez-faire approach, by refusing to open its seasonal ticket API, could be its lack of participation in the Finnish MaaS social network. MaaS Global could have been more insistent about them joining the network. Other actors, such as the City of Helsinki, could have also acted to make HSL join the network. If HSL had been more integrated in the Finnish MaaS network, it might have resulted in better collaboration with MaaS operators, and potentially avoided the single-ticket API issue. This is ultimately what happened with Helsinki Business Hub, which made HSL a member of their MaaS steering committee in 2017, in order to discuss MaaS (IH15) and potentially made mindsets evolve.

> *"What I would necessarily change is how* [public transport authorities] *are involved. I would bring them in from the beginning and help them co-create, so that they don't feel threatened."* (IH2)

In Austria, the IMP social network seems to have mainly developed through the SMILE project. Although it was not opened to every stakeholder (IV2), it is thanks to the two project leaders that the SMILE consortium (which was comprised of about 18 different organizations) came to life. However, due to the end of the project, the Austrian IMP network also seems to have shrunk somewhat. Some of the actors that used to interact and collaborate with one another are no longer doing so. While both the ÖBB and the WS are working on their own IMPs, interaction between the two has been limited since the end of the SMILE project in 2015

[36] Ecosystem can be understood here as a social network employed to designate a system of actors interelated to each other and acting under the influence of rules.

(IV9). Unlike the case of Finland, the BMVIT in Austria did not play this role of "matchmaker" and of social network development facilitator, which can be criticized. The BMVIT helped in the creation of the network by funding its development, but could have also been more involved by acting as an "arranger".

> *"If the ministry had stepped inside already in the last year of the project, saying clearly that they wanted this collaboration to move forward, it could have helped. At least the ministry could have played a much stronger role."* (IV5)

While local networks seem to have developed in Austria and Finland, it seems that both country niches contributed to the emergence of a global network of actors (see Raven and Geels, 2010) interested in ICT-supported integrated mobility schemes. For example, it is quite common to see Austrian and Finnish actors share the stage at certain events related to the subject (such as joint sessions with members from MaaS Global and Fluidtime at the 2017 World ITS Congress[37]). Another example is the collaboration of Finnish and Austrian actors. For example, in 2017, the consultancy company SITOWISE launched a MaaS-like pilot project in the HMA, directly collaborating with Fluidtime (IH14), which was in charge of the technical integration in the SMILE project. A third example is the founding of the MaaS Alliance, which aimed to bring all public and private actors around the world interested in playing a role into the unfolding of MaaS.

As the London case is not analyzed through the pre-development phase, it is not relevant to look at social networks that developed around the smart card technology. As explained earlier, the smart card technology indeed developed way upfront the Oyster and CPC implementation and is therefore not "linked" with the London case. Although it might be interesting to look at social networks that developed in the smart card technological niche, this would be beyond the scope of the present research.

(4) Has the niche enabled learning among actors?

As mentioned above, the generation of learning among niche actors is crucial for system innovations to evolve from the niche to the regime layer. It appears that, both for the Helsinki and Vienna cases, learning did develop among actors of the social network.

For the Helsinki case, learning occurred between actors of the social network as several other similar solutions have developed from actors of the MaaS social network since the "official" presentation of the MaaS concept at the European ITS Congress in Helsinki during the summer of 2014. In late 204, for example, the Finnish consulting company SITO, which was one of the 200 companies that participated in the very first meeting organized by ITS Finland about MaaS in December 2014, decided to start its own MaaS-related project jointly with the City of Salo in Southwest Finland. Finally, it was with the City of Seijanoki (Southern Ostrobothnia), that SITO developed a MaaS pilot, for which it was awarded funding from TEKES (IH8). By April 2015, SITO had launched its KERAVA app, proposing to its users different mobility packages, very similar to what Whim proposed in 2017. Similarly, in 2015, the MaaS operator Tuup was founded, which also received financial support from TEKES and had its first ticketing product ready by the fall of 2015 for the city of Turku, which then won the best Finnish mobile application award at Flush 2015. The solution developed by Tuup can be taken as an example of knowledge spillover generated from the MaaS social network, as one of the advisors of Tuup in 2016 was actually the advisor of the Aalto University master's student whose thesis focused on the development of MaaS in Helsinki, and was supervised by the City of Helsinki and the head of ITS Finland, Sampo Hietanen. Another example of learning that occurred through the MaaS social network is the decision of the Finnish Railway company to also develop its own MaaS solution, which also participated

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[37] Program accessed on http://itsworldcongress2017.org/wp-content/uploads/2017/09/ITSWC17_EventProgram_092917web.pdf, 19 June 2018.

in the open MaaS meeting gathering 200 partners in December 2014 (IH3). After two successive MaaS strategies, VR finally announced it was interested in developing its own MaaS product, for which it had already approached some potential partners, such as HSL (IH3). City Car Club, the main car sharing company in Helsinki Metropolitan Area, which was also approached to participate to the Open MaaS meeting of December 2014, also stated its wish to develop its own MaaS solution (IH11), which can also be understood as a knowledged spill-over from the Finnish MaaS niche. In general, learning has been cited as one of the main reasons for different actors to be part of the MaaS social network.

> *"One of the points here is also to learn: to see how it functions, how we function, to see how we can be or cant be a part of it (…) we have to see if this is a good thing for us or not, and that is actually what we are doing here too."* (IH7)

However, different types of learning do exist. According to Geels (2011), there are six learning dimensions, related to technical design, market demand and user preferences, infrastructure requirements, organizational issues and business models, policy instruments, and symbolic meanings. While the development of MaaS solutions by other actors of the social network correspond with learning in terms of technical design,[38] business models, and infrastructure requirements, not a lot of learning has been generated regarding symbolic meanings, policy instruments, and user preferences. MaaS solutions have not been available for long enough to be able to generate knowledge on such dimensions. However, given the openness of the MaaS social network in Finland, one could expect learning to happen in those dimensions later. Especially, learning on policy might be generated once the Finnish Transport Code comes into force in the summer of 2018.

In the case of Vienna, learning also developed among actors of the IMP social network, as both project leaders decided to finally pursue their own directions, built on knowledge accumulated during the SMILE project. In particular, the SMILE project can be seen as having generated knowledge on four out of the six learning dimensions. First, the SMILE project is known to have enabled technical learning. Consortium members of the SMILE project learned about the nuts and bolts of API integration by doing it (IV1, 4), as it was something that had not been done before. Secondly, the SMILE project is known to have generated learning about business models, by demonstrating that the business model adopted by the SMILE consortium was not functioning (IV3, 4), as well as about organizational issues, such as ways to build an IMP.

> *"What my learning has been over the past few months: if you try to decide or build an integrated platform initiative top-down, it does not work. From my point of view, the most effective way is to build it bottom up, which means the companies which are working on that should connect and should build something, and once this is ready they can show it to the authorities and say 'we have it already'."* (IV1)

Third, the SMILE project can also be understood as having enabled learning about infrastructure requirements, specifically considering that the only infrastructure needed to enable IMP is the openness and readiness of different APIs from project partners. Last but not least, learning about user preferences has been generated by looking at users behaviors in using the service. Indeed, 17 percent of the test users actually agreed to answer a survey, with 75 percent stating they were satisfied with the app. While 48 percent of the respondents answered that they had increased their usage of public transportation thanks to SMILE (urban PT 26 percent, regional PT 22 percent), 10 percent acknowledged having increased their use of bike-sharing

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[38] In particular we will note the development by MaaS Global of the MaaS API platform, which is an open repository containing open documents for the development of MaaS compatible APIs by third parties. Accessible on http://maas-api.org

4 percent increased the usage of e-carsharing and 4 percent increased the usage of e-bikes. Twenty-one percent of respondents reduced their usage of private cars and 26 percent reported increased use of public transport in combination with their private cars. Knowledge was also generated about user preferences vis-à-vis billing.

> *"One learning from SMILE was that, for the customer itself, it is not that important to get one single invoice with all the listed mobility services from different mobility providers. It is more important to have the information in the front-end, to be able to compare services, or just to have the info about where is which transportation mode. That is more important."* (IV1)

However, no knowledge was generated on policy instruments as no policy was used in the SMILE project, and no knowledge was gained about the symbolic meaning of IMPs as none of the survey questions covered this aspect. However, one might question the validity of the learning generated on user preferences. It appears that the number of test users who answered the final survey was not representative enough to generate robust learning. The results of the evaluation phase are claimed by some to be biased:

> *"What we did with SMILE is discuss with the frequent users of your service afterwards to see how they have liked it. Because the one who disliked it, they are not even answering your questionnaire! So I think it is a totally biased view on those kind of services. It is good because it helps us to bring it to a higher level, but we don't know if this is really working."* (IV4)

(5) Did a common vision/shared expectation exist among the members involved?

As mentioned above, the development of social networks, the generation of learning, and the articulation of expectations and visions among niche actors are the three key dimensions of successful niches. In particular, shared expectations are known to "*indicate directions for innovative activities and local projects, as they are translated into search heuristics*" (Raven and Geels, 2010: 89). However, although the first two mechanisms seem to have been partially respected in the cases of IMPs development in Vienna and MaaS unfolding in Helsinki, it is far from being the case for the third one, which might explain the laborious development of ICT-supported integrated mobility schemes in both cities.

For the Vienna case, the decision of the ÖBB and the Wiener Stadtwerke to split and pursue their own directions at the end of the SMILE project can be explained by the lack of shared expectations and vision among the two actors at the beginning of the project. Neither the Austrian Federal railway company nor the Viennese utility company agreed on what should have been the outcome of the project at the beginning, which ultimately led to its termination in 2015. If both (strong) players had agreed on a common vision at the beginning, they may have remained together after the funding of the Climate and Energy Fund and FFG was over:

> *"There was a different understanding how it should go further (…) [the collaboration] broke up as the two main project leaders decided to have different strategies (…) It would have been better to have it sustain, having a joint project from OBB and the WS. It was ready for a full success story. It could have been much more successful, if the partnership was extended."* (IV2)

As mentioned, the WS saw in IMPs the possibility to develop a semi-open digital platform that would act as the digital infrastructure of ICT-supported integrated mobility schemes (IV3), whereas the ÖBB saw in IMP the opportunity to generate new revenues and increase its market share (IV9). It is likely that neither public company had such expectations at the beginning of the SMILE project; however, expectations evolve. Although expectations usually change following a negative project outcome (Raven and Geels, 2010), it seems that in the case of IMP in Vienna, expectations changed for the two project leaders (ÖBB and WS) despite the successful nature of the project.

The development of shared expectations between public actors is ultimately linked with the steering actions from public authorities. Two public bodies, such as the ÖBB and WS, might have had similar expectations if a clear vision from public authorities had existed that would have pointed towards a common direction. As mentioned, public authorities in Austria have been quite weak in establishing visions for the future of transport and of ITS. The BMVIT has not been able to do this for the federal scale and the City of Vienna has not been able to do so for the local scale. Thus, if the City of Vienna and the BMVIT had established stronger visions, and more importantly had coordinated both visions between them, the ÖBB and the WS may have decided to stick together, as it would have served both the City and the federal government's visions. Hence, it is worth highlighting the importance, in order to guide public companies, of governments at the local and national levels setting strong and precise visions (particularly for transport), and ultimately coordinating visions with each other.

For the case of Helsinki, the lack of shared expectations between MaaS Global (which should be understood as the central node of the Finnish MaaS social network) and HSL can be used to explain the single-ticket API issue, which put the development of MaaS in jeopardy for a period of almost two years. On one hand, the main motivation of MaaS Global (being a private start-up) to develop a MaaS solution was to generate income and become the leading MaaS operator worldwide. On the other hand, the main motivation of HSL was to make transport in Helsinki more sustainable by making people shift from private motorized travel to sustainable mobility modes such as public transport and cycling. Although the innovation provided by MaaS Global could enable sustainable transport, the only way MaaS Global is able to generate income for a medium-sized city like Helsinki was to have as many users as possible in order to generate important network effects (Montero, 2018), which might actually create more unsustainable traffic, especially if users are incentivized to use low-occupancy mobility solutions, and go against HSL's ambition and vision (IH9). For the case of Helsinki, the lack of shared expectations did not emerge as a consequence of the development of MaaS, but was actually there from the beginning. From the very early days of MaaS, HSL and MaaS Global have had conflicting expectations, which is why the project could not move forward.

> *"There were concerns. It was quite a new thing and we did not know how it would affect everything (…) we have been concerned if [MaaS] will change travel habits for people who already move in a sustainable way, or already use sustainable transport modes. What will it do for people that already use bikes and public transport? What if those people start using more car services? It has been the main concern the whole time."* (IH16)

One might now wonder to which actor it would have pertained to articulate expectations between HSL (and public transport authorities) as well as MaaS Global (and private MaaS operators companies). It appears the national government has already done a lot. By developing a vision and initiating public-private interactions, the LVM did everything it could to steer the development of MaaS. However, one can wonder whether the Ministry of Transport and Communication did not do too much; that is, if it over-favored MaaS operators compared to public transport authorities. The LVM appeared to have very strong ties with MaaS Global, and one could wonder if this affected the ministry's judgment.

> *"MaaS Global has had quite tight relationships to the Finnish National Transport Agencies. They have had close connections and discussed deeply how things should be opened and all."* (IH16)

Other signs of close proximity between the LVM and MaaS Global could be found in recurrent joint appearances of both actors at international transport events, such as at the 2017 European ITS Congress in Strasbourg.[39] Perhaps the most obvious sign of closeness between the ministry and MaaS operator was the decision of the person in charge of MaaS since 2014 at the LVM to quit her job and finally be hired by MaaS Global as an "ecosystem manager" in the spring of 2018. Again, it appears worth wondering about the true rationale for the LVM to have been so pushy for MaaS. On the other hand, it seems the local government (City of Helsinki) could have done more in terms of articulating expectations, especially being the main owner of HSL. If the local government had established a stronger vision for the future of its transport system (with strong quantitative targets related to transport), it could perhaps have influenced HSL to adopt a different position, as HSL would have had to act in order to reach this vision. Ultimately, visions from the national government would have had to be articulated with visions of the local government to ensure all actors would move in the same direction.

(6) How involved have been regime actors into the development of each of the ICT-supported integrated mobility scheme studied?

As mentioned, the degree of involvement of regime actors is an important element in the ability of system innovations to evolve from the niche to the regime layer, and ultimately provoke a regime shift. If regime actors are not involved, it is likely that the system innovation will not manage to penetrate the regime layer and will die in the niche layer. On the contrary, if regime actors are overly involved, they might encapsulate the potential system innovation into the incumbent regime they are part of, which might reduce its ability to produce a regime shift (Schot and Geels, 2008). Therefore, it is relevant to ask, for the three cases, the extent to which regime actors were involved in the diffusion of each ICT-supported integrated mobility scheme.

For the case of MaaS in Helsinki, it seems that regime actors have not been involved enough, which is why the potential system innovation has struggled to really take off and is still in its pre-development phase. By not getting involved in the Helsinki MaaS niche, HSL, which must be understood as an actor of the incumbent public transport regime, actually acted as an inhibitor to the MaaS idea, especially by refusing to open its seasonal-ticket API. It is generally agreed that regime actors are usually reluctant to system innovations because of sunk investments and vested interests, despite the promise of niche-based product champions that niche innovations will solve problems in the existing regime (Geels, 2007). This is what happened to HSL in the development of MaaS. Despite the promise of MaaS Global that its solution would help tackle the automobility regime, HSL refused to collaborate because it had invested in a digital ticketing system (sunk investments) and was afraid to lose a direct link with its customers (vested interests) (IH9). Therefore, it again appears important to include regime actors quite early in order to overcome those sunk investments and vested interests as much as possible.

> *"Who is against this whole transformation of the transport world? Well, I think all transport authorities are against it (…) what exactly will the transport authority be doing in the future? They have to re-invent themselves. And of course they are not so enthusiastic. They have something to lose. Of course they might have something to win, which might even be bigger, but to achieve that they will have to be very agile."* (IH4)

For the Vienna case, it actually seems that regime actors were overly involved in the development of IMPs. IMPs in Vienna have been developed, and led by two important actors of the incumbent public transport regime, being the ÖBB and the WS. It is usually agreed that when regime actors are in the driving seat, the developed innovation is more incremental than radical (Geels and Schot, 2007). Thus, while IMPs are devel-

[39] https://strasbourg2017.itsineurope.com/wp-content/uploads/2017/04/04067-Strasbourg-2017-preliminary-programme-20.04.17.pdf accessed June 4th 2018

oping in Vienna (with iMobility and Upstream), one can wonder about their real ability to produce a profound regime shift and pave the way towards a post-car regime, as they have been driven by regime actors. However, according to Moradi and Vagnoni (2018), there are actually two ways to destabilize the automobility regime. While the most common way would be to have system innovations developed by newcomers emerge and destabilize the pillars of the automobility regime (Geels, 2012), having incremental innovations develop and stabilize the existing sub-regimes (such as public transport regime or non-motorized transport regime) might also be a way to disrupt the dominant car-based mobility regime. In the case of Vienna, IMPs seem to be better categorized as falling under the second pathway than the first one, and thus primarily target increases in PT ridership rather than decrease in car ownership (as MaaS would target).

The case of smart cards in London is actually pretty similar to the one of Vienna. Regime actors (TfL) were heavily involved in the development of Oyster and CPCs. Again, smart cards for the case of London might be understood as incremental innovations, having been developed by regime actors, and targeting more a strengthening and stabilization of the public transport regime than a destabilization of the automobility regime. This pathway is to be directly linked with the transformation pathway of socio-technical transitions, in which niche-innovations have not yet been sufficiently developed, and where regime actors are actually leading the transition (Geels and Schot, 2007). One can now wonder if merely reinforcing the public transport regime will be enough to break away with the automobility regime. Three other transition pathways – such as the de-alignment and re-alignment path, the technological substitution path or the reconfiguration pathway – might be more effective.[40] However, the realization of those transition pathways depends on the type of pressure that the landscape applies on the regime, and the resulting existence (or not) of windows of opportunity. I now look at the presence of windows of opportunities in the three cases of studies to better understand why things developed the way they had.

(7) Did windows of opportunity exist and, if so, were they large enough to enhance the development of the studied innovations?

In order to elevate from niches and create a disruption in the regime layer, system innovations need to develop through windows of opportunity, which are created due to sufficient pressure from the landscape in the regime layer (Geels, 2011). While some such windows existed for the London case, it appears this was not the case in Helsinki and Vienna, which is coherent with the fact that London is currently in the takeoff phase and Vienna and Helsinki are still in the predevelopment phase. In particular, it seems that while windows of opportunity did not exist for the case of IMP in Vienna, there are elements pointing to their ongoing development for the case of MaaS in Helsinki.

First, the regimes for the London, Vienna, and Helsinki cases did not all suffer from the same issues. For windows of opportunity to develop, there must be issues in the regime that might create the space for system innovations to come up. In particular, not all the regimes suffered the same levels of traffic congestion, which is acknowledged to be a regime problem (Geels, 2005c). London, which is a far larger city than Helsinki and Vienna, has much higher levels of congestion and traffic problems than the Austrian and Finnish capitals (IH5), which might have influenced the greater embracement of smart cards than IMPs and MaaS were in both cities. Secondly, the embracement of smart cards in London might have also been influenced by a 'crack' (Geels, 2012) in the London urban transportation regime, which could not be observed in Helsinki or

[40] According to Geels and Scot (2007), reconfiguration pathway happens when symbiotic innovations, which developed in niches, are initially adopted in the regime to solve local problems that later trigger further adjustments in the basic architecture of the regime. Technological substitution pathway occurs when there is a lot of landscape pressure and when niche innovations are mature enough. De-alignment and re-alignment paths occur when increasing regime problems, combined with important pressure from the landscape, push regime actors to lose faith, leading to de-alignment and erosion of the incumbent regime. At the same time, one niche innovation emerges from the competition with other niche innovations, resulting in the re-alignment of a new regime.

Vienna. The development of a congestion charge in London in 2003 also created the need for the Oyster to be embraced. Indeed, by incentivizing car users to shift to more sustainable transport means, the congestion charge made Oyster (and later CPCs) appear as the solution that would improve travel experience. In other words, while the congestion charge acted as the stick, the Oyster acted as the carrot to induce modal shift away from private motorized travel. This goes hand in hand with Upham et al. (2013) and Abrate et al.'s (2009) suggestion that in order to move towards more sustainable transport systems, travel demand management policies also have to be developed more systematically, which Helsinki and Vienna should perhaps be considering. A third regime-based element that should be mentioned for the London case and did not happen in Vienna and Helsinki is the decision of the DfT to stop subsidizing TfL (FT, 2015). Fare collection being an important cost for transit agencies, TfL was comforted in its decision to have opted for a smart card system including CPCs, which are even less costly than Oyster in terms of revenue collection. However, while it seems (based on the London case) that having national governments stop subsidizing public transport authorities might have a positive impact for the embracement of ICT-supported integrated mobility schemes, this is not something that all national governments should do, as this might also have drastic consequences in terms of service level and system performance.

It appears that windows of opportunity existed in the London case because of the vision created by the mayor (combined with the above-mentioned cracks in the regime), which unfortunately did not exist to the same extent for Vienna and Helsinki. In particular, this vision was supported by clear quantitative targets that are acknowledged to be "*a crucial element to steering because it facilitates implementation of monitoring*" (Voß et al., 2007: 202). The mayor of London was the only one to set strong quantitative targets to establish its vision with the 2001 MTS (15 percent traffic reduction in central London, zero growth of traffic in inner London, and a reduction of traffic growth by a third in outer London). The only quantitative targets (related to transport and close to the SMILE project) that one can find from the City of Vienna come from the 1990 KLIP I policy, the 2003 Transport Master Plan, or the 2003 Urban Mobility Plan, which were set at a time when technology for ICT-supported integrated mobility schemes was not ready, which is why they could not have motivated its implementation. If similar targets had been set by the City of Vienna in the 2010s, it could have created the necessary windows of opportunity for IMPs to come forward. Similarly, although the City of Helsinki targeted in 2013 to be carbon-neutral by 2050 (City of Helsinki, 2013b), it did not create any quantitative objectives specifically targeting emission reduction in the transport sector in any policy documents. Thus, it seems that having local governments set quantitative targets for transport, in terms of CO_2 reduction, or other KPI such as traffic reduction, might help creating windows of opportunity needed for ICT-supported integrated mobility schemes to take off.

The definition of strong quantitative targets for the transport sector by national governments might also help create windows of opportunity for smart cards, IMP, and MaaS to take off. Unfortunately, such targets, which could have had an impact on the development of the Oyster, were not set by the DfT for the London case. For the case of Helsinki, the government did set targets in 2009 to have transport emissions in Finland reduced by 15 percent in 2020 compared to the 2005 levels (TEM, 2013). For the case of Vienna, the only quantitative objectives set for transport by the BMVIT date back to the 1991 Transport Master Plan, which targeted a 20 percent reduction of CO_2 emissions for the transport sector by 2005 compared to 1998 levels. Again, however, no more recent targets were set by the BMVIT in the 2010s that could have pushed IMP to come through.

In this field, EU actors could have also played a stronger role. Although EU authorities have been quite active in setting (general) carbon reduction targets, they have been quite slow to do it for the transport sector. Where the EU has been quite active in the reduction of GHG emission in ETS sectors (with the development of the EU ETS, and the 2020 climate and energy package), it took longer to establish clear targets for non-ETS sectors (such as transport). It was only in 2009 that the Effort Sharing Decision came in, requiring countries to limit their GHG emissions in non-ETS sectors. With this decision, the UK, Finland, and Austria were all required to reduce their GHG emission by 16 percent by 2020 compared to 2005 levels. This decision was followed by the Effort Sharing Regulation in 2016, which required the UK, Austria, and Finland to reduce their emissions in non-ETS sectors by 37 percent, 36 percent, and 39 percent, respectively (EC, 2016). However, neither the Effort Sharing Decision nor the Effort Sharing Regulation (nor the 2011 White Paper) included binding carbon reduction targets for the transport sector specifically. This is mainly due to the fact that EU climate transport policy is constrained by so-called "*transport taboos*", which makes it not as bold as it should be. According to Gössling and Cohen (2014), it might only be through the re-thinking of neoliberal governance and societal structures that those taboos will be overcome, which will ultimately be needed for the right windows of opportunity to be created. Apart from KPIs targeting the reduction of transport-related CO_2 emissions, the definition of other quantitative targets by national governments, such as reduction of average car ownership, modal share, and air quality improvement, are needed for ICT-supported integrated mobility schemes to penetrate the regime layer. Emission reduction in transport might be reached by the use of more efficient engines or non-fossil-based vehicles, which is other quantiative targets must be developed along.

Another regime-based element that has the ability to create windows of opportunity, and pressure the regime, pertains to urban design, usually carried out by local governments. As mentioned, transport integration can actually be understood as a ladder, with ICT-supported integration steps being placed "after" traditional transport integration mechanisms. A crucial step in the latter category is physical integration, which basically enables users to physically transfer from one mode to another. The use of urban planning to make this physical integration step happen is key in the process of ICT-supported integrated mobility scheme development. What would be the point of having a smart card if people were not able to physically transfer from light rail to a bike-sharing scheme? Similarly, what would be the added value of a MaaS scheme if smart mobility providers were not able to integrate their system to the existing infrastructure? Such an approach was, for example, undertaken for quite some time by TfL in its method of planning the surrounding of public transport stations and stops (TfL, 2015c). It has also been adopted recently by the city of Vienna with its "mobility points" (City of Vienna, 2015b), albeit after the beginning of the SMILE project, which might be a reason why IMPs did not (yet) penetrate the regime layer.

> *"Think about the urban design. Now everything goes from the idea of everybody getting from A to B with their own car. And that's a really hard thing to break in urban planning (…) If a city wants to be good at [ICT-supported integrated mobility schemes], it needs to be pluggable to all kinds of innovations. So cities need to think: 'How do I get all possible innovations within this specific area?'"* (IH1)

The presence of windows of opportunity for ICT-supported integrated mobility schemes therefore seems to be dependent of the complexity of the transport system in a given city. The more ICT-supported mobility services that are available (carsharing, e-hailing, bike-sharing), the more complex the transport system is and, ultimately, the more important the need (pressure on the regime) to integrate them all together, in order to smoothen the travel experience and avoid redundancies. Thus, it is perhaps due to the high number of ICT-supported mobility services in London (compared to Vienna and Helsinki[41]) that TfL decided to opt for CPCs, which are the only payment means accepted to pay for such services. Similarly, if there were more ICT-supported mobility services functioning in Vienna, the development of IMPs may have been quicker. The influence of the complexity on the emergence of ICT-supported integrated mobility schemes can also be

[41] For example, Uber was not allowed to operate in Helsinki in recent years. However, the TNC has recently announced that it will soon be launching its e-hailing services in Helsinki thanks to the changes brought up by the Finnish transport code.

observed for the London case. Indeed, the UK rail industry is so fragmented that CPCs naturally appeared as a solution to bundle all TOC services together in London (all of which had their own ticketing means previously). Perhaps the reason for not having MaaS and IMP emerge (yet) can also be linked to the lack of complexity or lack of institutional fragmentation of the different transport solutions within the public transport sub-regime.

> *"We are definitively lacking lots of pieces. This would be an easier practice if there was a huge amount of car sharing easily accessible and easily servitized and so on (…) we are not the once that will do it, we need lots of new players into the field including Uber and car2go, we need variation. It is not enough to have public transport and Taxis."* (IH1)

Last but not least, in the case of MaaS in Helsinki one might understand the change of mindset of HSL (regarding the opening of seasonal-ticket APIs) as linked with the so-called "transport digitalization momentum", which put increasing pressure on regime actors to reconsider their positions. For example, the DRT service provided by SITOWISE from spring 2018, that involved HSL, might be seen as a project that enhanced the transport digitalization momentum, having ultimately led HSL to change its position. The other MaaS-like projects being developed by VR, CCC, and Tuup can also be described as having pressured the incumbent regime actor that HSL is to adopt a new attitude.

> *"The change [in PTA's behavior] has not been a result of change in people. I used to work there, so I know the people there, and they have not changed. But digitalization has become a bigger and bigger issue every year, and there have been a lot of developments (…) so these processes have been important in the change of mindsets, and get [regime actors] so excited about the idea of MaaS. Digitalization's enthusiasm was needed to see MaaS move forward, which eventually happened."* (IH14)

Again, it is not one of the above-mentioned regime-based developments that will create enough pressure for windows of opportunity for MaaS, IMP, and smart cards to develop. But the combination of all (definition of a vision at the EU, national, and local levels; development of demand management policies; cracks in the regime with congestion; complexity and fragmentation of transport system; transport digitalization momentum) might well do so.

(8) Has civil society been involved into the development of the ICT-supported integrated mobility schemes?

The involvement of societal actors is often quoted as an important criterion to make socio-technical transitions successful. One way for transitions to occur is to destabilize the links between the seven pillars of the incumbent automobility regime. While the misalignment of some regime elements (such as technology, industry structure, infrastructure, policies, techno-scientific knowledge) might be less subject to citizens actions, changes in user practices and symbolic meanings are closely related to citizens acceptance of the new technology. The more involved citizens are in a system innovation development, the higher their acceptance might be and the less likely it is for unanticipated consequences to emerge (Mladenović, 2018). Unfortunately, it seems that in none of the three cases of studies were societal actors involved sufficiently in the development and diffusion of ICT-supported integrated mobility schemes. In Finland, it is acknowledged that no citizen group or network – that is, societal actors – was involved in the development of MaaS Global's solution. Similarly, no societal actors were involved in the development of IMPs in Vienna, apart from SMILE app test users.

> *"That would have been a good idea to also have citizen networks involved in the project development. I kind of always wanted to do that but never had enough resources and time to do it (…) we*

never really had a citizen network directly involved, and that would have been good to have. I just have not been good enough to make it happen." (IH1)

In London, no citizens were involved in the development of the Oyster card, which happened in a top-down fashion. In the development of CPCs, society seemed to have been slightly more involved. In 2011, the transport committee of the Greater London Assembly launched an investigation into the future of ticketing. It reached out to key stakeholders including TfL, ITSO, card schemes, and some London Boroughs, as well as the customer association *Which?*, and all submitted written submissions expressing their views on the future of ticketing in London. In particular, the consumer association raised its concerns in terms of data privacy as well as social exclusion that CPC could provoke (GLA, 2011). The consultation of *Which?* in the process of development of CPCs is the only citizen consultation that was performed in the three case studies. Given that the inclusion of citizens is crucial to harvest the full potential of system innovations, one could be skeptical about the ability of smart cards, IMPs, and MaaS to succeed in enhancing a regime shift.

"Many are developing their offers in the wrong way … they first try to make the technology and then after that, they think about the users. But it should be the other way around. First users, what do they want, what do they need? Then the technology. This should be the right way." (IH8)

Table 5.3-1: Summary of the "transition analysis" (Author's elaboration)

	Case 1 (London – smart cards)	Case 2 (Vienna – IMP)	Case 3 (Helsinki – MaaS)
Phase of the transition? (Rotmans et al., 2001; Avelino and Rotmans, 2009)	Take-off phase	Predevelopment phase	Predevelopment phase
Provision of steering and funding from Public Authorities? (Schot and Geels, 2008; Weber et al., 1999)	•Steering from the Mayor of London (2001 MTS) •No funding, as smart card technology was already a mature one when implemented in London	•Lack of steering from national government (only the 2011 ITS Strategy) and from local government (targets too old) •Important funding from the Climate and Energy Fund as well as FFG, risk of "funding to death"	•Important steering from national government (ITS strategies, Transport Revolution report) and from local government (Helsinki City Plan vision 2050) •Funding from TEKES of future MaaS operators and investment of TEKES in MaaS Global
Has social network developed in niches? (Schot and Geels, 2008; Raven and Geels (2010)		•Development of an IMP ecosystem through the SMILE project. •Shrinking of the IMP social network after termination of the SMILE project	•Development of the MaaS ecosystem by public actors (initiation of public-private interactions by the ministry) and private actors (first MaaS business meeting in December 2014)
		•Development of a global MaaS-IMP international social network (coordination of Fluidtime and SITOWISE in a MaaS pilot in the HMA in 2018 facilitated by HBH; launch of international MaaS Alliance in 2015)	
Has niche enabled learning? (Schot and Geels, 2008; Geels, 2011)		•Development of several IMPs by players of the Finnish MaaS ecosystem •Learning of niche actors in terms of technical design (API integration), infrastructure requirements (need to have public transport seasonal ticket API open), business models (B2C or B2B?), user preferences and behavior (SMILE survey) •Lack of learning in terms of policy instruments (none to evaluate) and symbolic meanings (in development)	•Development of several MaaS solutions by players of the Austrian IMP ecosystem •Learning of niche actors in terms of technical design (API integration, open MaaS API platform from MaaS Global), infrastructure requirements (need to have public transport seasonal ticket API open), business models (B2C or B2B?) •Lack of learning in terms of user preferences (in development), policy instruments (after transport code comes into force) and symbolic meanings (in development)
Existence of shared visions? (Schot and Geels, 2008; Raven and Geels, 2010; Voß et al., 2007)		•Lack of shared vision between OBB and WS •No actor to coordinate expectations of the different stakeholders (lack of involvement of the BMVIT in a matchmaker role)	•Lack of shared vision between HSL and MaaS Global •No actor to objectively coordinate expectations of the stakeholders (LVM seems to have favored more MaaS operators than PTAs)
Involvement of regime actors? (Geels, 2007; Geels and Schot, 2007)	•Smart card implementation being driven by regime actors (TfL): low probability of IMPs being proposed to drive a radical regime shift • Smart cards in London: incremental innovation/add-on •Possible transition pathway: transformation (due to the important involvement of regime actors and insufficient pressure from landscape)	•IMP being driven by regime actors (OBB and WS): low probability of IMPs being proposed to drive a radical regime shift •IMP in Vienna: incremental innovation/add-on •Possible Transition pathway: transformation (due to the important involvement of regime actors and insufficient pressure from landscape)	•MaaS being driven by niche actors (MaaS Global), but lack of support from regime actors (HSL) because of sunk costs (development of a new ticketing system) and vested interests (established link with customers) •Possible transition pathway: transformation (due to the insufficient pressure from landscape)
Existence of windows of opportunity? (Geels, 2002; Geels, 2005c; Geels, 2012; Voß et al., 2007)	•Existence of problems in the regime (high traffic congestion in London) •Existence of cracks in the regime: travel de-	•Lack of issues in the regime (congestion not high enough in Vienna) •Lack of quantitative targets-based vision from the City of	•Lack of issues in the regime (congestion not high enough in Helsinki) •Lack of quantitative targets-based vision from the City of Helsinki

	mand policies in place (congestion charging scheme; end of subsidies from DfT to TfL) •Strong quantitative targets-based vision from the Mayor •Use of urban planning to pave the way towards an integrated transport system •Important complexity and transport digitalization momentum	Vienna and the BMVIT •Lack of complexity and lack of digital transport momentum	•Increasing complexity and increasing digital transport momentum (SITOWISE-Fluidtime DRT project, other MaaS-like projects from VR and CCC)
	•Lack of pressure from EU level: No binding quantitative targets from EU institutions for the transport sector (in terms of carbon emission or traffic reduction, for example)		
Involvement of societal actors? (Loorbach, 2007)	•Limited (Which? Survey for the implemtation of CPCs)	•Nonexistent	•Nonexistent

5.4 Conclusion

In this chapter, three case studies have been analyzed through two distinct theoretical frameworks to answer this thesis' research question. As it appeared in the governance and the transition analyses, there is no single answer to this thesis' problem statement, as different public authorities adopt different governing approaches when it comes to the development of ICT-supported integrated mobility schemes. However, there are still some general findings to be derived from the analysis of the three cases of studies. In all three cases, it appears that public transport authorities were quite reluctant to change or wanted to be in control when change happened, which resulted in their adoption of governing-by-doing, laissez-faire, or authority approaches. This can be explained by the fact that PTAs are incumbent regime actors and thus quite cautious vis-à-vis the unfolding of disruptive innovations such as smart cards, IMP, and MaaS.

At the national level, public authorities (central government) have all adopted a governing-by-enabling approach, with different intensities. This approach encompassed, at least partially, the development of visions including strong quantitative targets, the promotion of ICT-supported integrated mobility schemes as means to reach those visions, the initiation of public-private collaborations by acting as matchmakers, the provision of funding and steering, and the use of network governance to make regime actors change behaviors. In one of the cases, central government also used governing-by-authority measures to make public transport authorities shift from a governing by laissez-faire to a governing-by-enabling approach, but this is to be considered very carefully, as system innovations, to produce a regime shift, must unfold naturally and should neither be enforced, nor driven by state actors.

In cases where such observation could be made, state-owned railway undertakings appeared to be governing by doing; that is, developing their own ICT-supported integrated mobility scheme and limiting collaborations with (private) third parties. Such behavior can be explained by the fact that state-owned railway undertakings are also actors of the incumbent regime, which have vested interests and sunk investments, afraid of seeing newcomers disrupt (and steal) their business. To avoid such situations, governments might learn from the only case where no state-owned railway undertaking was present. It seems that rail liberalization might be a way to avoid getting into a situation where rail companies are too powerful, and consequently avoid putting the development of ICT-supported integrated mobility schemes into jeopardy.

Surprisingly, it is local governments that had the most different governing approaches in the three case studies. While one adopted an authority approach, the second decided to let things happen, and the third to get involved "in the shadow". While, again, a lack of involvement is not to be recommended, as it results in a lack of steering, overly strong involvement from local governments through authority measures might prove to be unsustainable. In order to enable ICT-supported integrated mobility schemes (and their supporting niches) to come to life, governing by enabling, by contributing to the creation of windows of opportunity, might well be the way to follow.

Although those should not be understood as magic bullets, a list of recommendations, based on the two analysis presented above, and geared at policy makers interested to see ICT-supported integrated mobility schemes emerge, is presented in the next chapter.

Chapter 6 Conclusion

In this chapter, I present recommendations, derived from the main findings of this study, for public authorities interested in developing ICT-supported integrated mobility schemes. I also discuss the generalizability of my findings and outline the contribution of the present thesis to research. Finally, I discuss the limitations of this research and propose avenues for future research.

6.1 Findings and recommendations for policy makers

Below is a list of 14 recommendations for public authorities interested in taking part in the emergence of ICT-supported integrated mobility schemes. The recommendations build on a combination of the two analyses conducted with the governance and transition literatures. The recommendations target public authorities that are willing to see smart cards, IMPs, and MaaS develop in order for those solutions to also succeed in delivering public value and to help enhance a regime shift towards a post-car system. For the rest of this sub-chapter, **(N)** refers to recommendations geared at national policy makers, **(L)** refers to recommendations targeting local policy makers, and **(N & L)** refers to recommendations that target both local and national policy makers. Those recommendations should be understood as the main contribution to this piece of research to practice.

The first, and potentially most important, recommendations pertain to policy makers' establishment of visions that include strong quantitative targets for the transport sector. As seen earlier in this thesis, it is by establishing those targets that public authorities will help create windows of opportunity for ICT-supported integrated mobility schemes to penetrate the regime layer. It is also by creating such visions that public authorities will steer the development of the technological niches necessary to unfold smart cards, IMP, and MaaS. Ultimately, such target-based visions must be established by public authorities at the supranational, national/federal, and local scales. In particular, the development of quantitative traffic reduction objectives (as in the 2001 MTS) might be effective for framing the development of smart cards, IMPs, and MaaS. Similarly, the development of transport-related emission reduction targets might help push ICT-supported integrated mobility schemes forward, by creating the need for their development. For example, the recent objective of having London's transportation system carbon-free by 2050, as proposed in the 2017 MTS, is a good example for other local governments to follow. Similarly, the objective of halving transport-related carbon emissions by 2030 compared to 2005, as fixed in the 2017 Finnish National Energy Strategy, is a good practice to learn from.

> *1)* **(L & N)** *Establish a vision that includes strong quantitative targets for the transportation sector both in terms of reduction of traffic and carbon emissions. Develop in parallalel objectives in terms of modal share or car-ownership levels changes.*

It is also important to underline the need to articulate those visions between different public authorities located at different territorial scales. While central governments certainly play a role in setting general directions, it is often up to local public authorities to develop their own visions for urban transport. Thus, the coordination of visions between public authorities lying at different jurisdictional scales is an important point to consider. By articulating their visions, public authorities at the local and national/federal levels might reinforce the creation of windows of opportunity, as well as strengthen the good development of niches. Once visions have been established and articulated between public authorities at different scales, policy makers need to propose means to reach those visions, in order to acknowledge the existence of some technological innovations, such as ICT-supported integrated mobility schemes and send a signal to the private sector. Doing so will also contribute to the steering of the development of smart cards, IMPs, and MaaS and enable those solutions to come to life. Again, the 2001 MTS, where the Mayor of London specifically presented smart cards as a mean to reach its vision, can be quoted here as good practice to learn from. Similarly, the *Transport and Communications Architecture 2030 and 2050* report by the LVM, which formally presents MaaS as a way to improve the energy efficiency of the Finnish transport system, is also worth quoting.

> *2)* **(L & N)** *Coordinate visions between public authorities of different territorial scales and formally present ICT-supported integrated mobility schemes as a means of reaching the vision's objectives.*

As seen in the analysis of the three cases studies, adopting a governing-by-doing approach for the development of smart cards, IMPs, and MaaS might not be the most relevant and effective way to move forward. Thus, collaborating with the private sector is relevant but requires public authorities at the national and local scales to become the "matchmakers" between public (transport authorities for example) and private actors (ICT-supported integrated mobility schemes operators). By doing so, public authorities will contribute to the development of the dedicated niche-related social network, and to the "correct" implementation (and use) of those solutions. The LVM in Finland can be seen as an example to follow at the national scale in terms of having initiated public–private collaborations and pushed for the development of the Finish MaaS social network.

> *3)* **(L & N)** *Act as the matchmaker between public and private actors in order to foster public-private collaborations; for example, by organizing events or launching transport-focused think tanks that bring together state and non-state actors.*

While governing by doing might not be the most effective way for ICT-supported integrated mobility schemes to move forward, governing by authority should also be considered very carefully. While it might help things happen quickly, it might also lock things in a specific state, which could be synonymous with negative consequences in the long term, and difficulty reaching the more advanced steps of the transport integration ladder later on. In the case of London, while governing by authority led to the unfolding of smart cards, it seems now complicated to transition from smart cards to IMPs or MaaS due to technological lock-in. The use of governing by authority must only be reserved to unlock situations from institutional dead-ends. Therefore, public authorities should, as much as possible, opt for governing by enabling, coupled with strong political leadership from politicians and policy makers, and use authority measures only in extreme cases.

> *4)* **(L & N)** *Use governing-by-enabling measures as much as possible and only opt for governing by authority (legislation/regulation) when all other options have proved ineffective.*

For solutions that are not yet mature (as was the case for MaaS and IMP), public authorities should provide funding in order to guarantee good development of niches and of learning among niche actors. In particular, public authorities might be tempted to award funding to consortia that bring public and private actors together, as it might also be a good occasion to play matchmaker and develop a strong social network. Public authorities must also be careful not to overfund niches in order to avoid the "funding to death" phenomenon, and should instead let things develop in a bottom-up fashion, not under the constraints created by the dependence on external funding sources.

> *5)* **(N)** *For not-yet-mature ICT-supported integrated mobility schemes, provide the right balance of funding so that innovations can develop in a bottom-up fashion and avoid the "funding to death" phenomenon.*

As seen in the cases of MaaS in Helsinki and IMP in Vienna, public transport authorities and railway undertakings might put the development of ICT-supported integrated mobility schemes in jeopardy. In order to avoid such dead-ends, public authorities interested in seeing such schemes emerge must adopt a more coherent discourse vis-à-vis PTAs and RUs. On one hand, central governments must stop protecting state-owned RU from rail market opening. By introducing competition, national governments can make RU understand that they have competitors, especially in the digital world, and help push ICT-supported integrated mobility schemes forward. On the other hand, local governments must become more involved if PTAs refuse to collaborate, as they usually own those and might be able to leverage them in some ways. Having local and central governments clearly show political support might be a way to pressure RUs and PTAs, and ultimately make them shift from protectionist behavior to more collaborative behavior.

> *6)* **(L & N)** *Demonstrate clear political support for ICT-supported integrated mobility schemes (horizontal governance) and use parallel mechanisms such as rail market opening, in order to have RUs and PTAs change from protectionist to more collaborative behaviors.*

As mentioned earlier, ICT-supported integrated mobility schemes are currently more of an add-on than a disruptive innovation that has the potential to produce alone a regime shift towards the post-car system. Therefore, I recommend that public authorities, specifically at the local level, develop, in parallel, travel demand policies to make smart cards, IMPs, and MaaS more successful. It is necessary to ensure that there is a "stick" (negative incentive) for people to embrace ICT-supported integrated mobility scheme, as was the case for London, when the Oyster was launched jointly with the congestion-charging scheme. Other mechanisms, such as the implementation of a road charging tax (as proposed in the 2017 MTS and considered at some point in Finland), might also be a way to mitigate rebound effects of ICT-supported integrated mobility schemes. In particular, road charging could be integrated in MaaS and IMP packages at some point, which would create an even higher incentive for people used to travel with their own car to shift for more sustainable transport modes.

> *7)* **(L)** *Develop, in parallel, travel demand policies such as congestion charging or road charging in order to incentivize people to use ICT-supported integrated mobility schemes and to mitigate potential rebound effects.*

ICT-supported mobility services (e-hailing, carsharing, etc.) can be relevant to solve the "last-mile problem" and have a role to play in making people move away from car ownership. However, a potential issue with ICT-supported integrated mobility schemes is that they favor those modes over sustainable transport modes such as PT, walking, and cycling. In order to avoid such unwanted situations, it is important for public authorities to gain access to the operation data of ICT-supported mobility service providers in order to learn how people are using them. There is also a need for public authorities to gain access to the data of ICT-supported integrated mobility scheme operators. By getting access to a MaaS operator's operational data, public authorities might be able to obtain a much more comprehensive understanding of how citizens are moving on a day-to-day basis, through the mobility services they consume, and thus plan for the last steps of the transport integration ladder.

8) **(L&N)** *Develop data-sharing agreements/regulations for ICT-supported mobility service providers and ICT-supported integrated mobility scheme providers to obtain a better understanding of citizens' mobility habits.*

In order for ICT-supported mobility services to complement public transport, rather than cannibalize it, it is important to embrace those new transport solutions, as adopting a laissez-faire approach or banning those solutions will not act in favor of creating an integrated transport system. In particular, and building on the previous recommendation, although no examples were available in the three cases of studies, the development by local authorities of data-led regulation[42] (that is, regulation relying on the opening of operation data by ICT-supported mobility services providers) must be considered. Once such regulations are developed, the integration of ICT-supported mobility solutions in smart cards, IMPs, and MaaS by ICT-supported integrated mobility schemes operators will help ensure those solutions improve the performance of transport systems, rather than worsen it.

9) **(L)** *Develop, in parallel, (data-driven) regulations to ensure ICT-supported mobility services (e-hailing, carsharing, etc.) become available and complementary to sustainable transport modes.*

Throughout the analysis of the three case studies, it appeared that in order to be really effective, the development of ICT-supported integrated mobility schemes was to be considered at the metropolitan scale and not the local scale (cf. the Vienna case). Therefore, more bottom-up collaboration between cities of the same metropolitan area is necessary when it comes to the development of smart cards, IMP, and MaaS when no metropolitan transport authority exists. While central governments might be able to enforce the creation of a metropolitan body to handle this task in some centralized countries (as happened in the UK), it is very unlikely to happen in other administrative settings, especially in federal countries. To push for more metropolitan bottom-up collaboration, EU actors ultimately have a role to play; for example, through the strengthening of regions.

10) **(L)** *Collaborate with local governments of neighboring cities in order to enhance the development of ICT-supported integrated mobility schemes at the metropolitan level, and not only at the city level.*

As seen throughout this piece of work, physical infrastructure is a prerequisite for ICT-supported integrated mobility schemes to come to life. In particular, the presence of physical integration – that is, having transport modes physically connecting to one another – is a crucial element for having a flowing transport system and minimizing friction within it. Therefore, it appears that public authorities must also use urban design if they are interested in jumping on the digitally integrated transport system bandwagon. First, public authorities have to make sure modes are connected physically to one another. Second, they must anticipate the availability of space when planning transport nodes so that soon-to-come mobility services that require spatial components (such as station-based carsharing and bikesharing) can physically "plug in" into the existing infrastructure.

[42] See Voege (2019).

> *11)* **(L)** *Use urban planning to ensure transport modes are physically integrated to one another, and plan transport nodes so they can physically accommodate and integrate new mobility services.*

It is worth underlining the importance for public authorities to know why they want to push smart cards, IMP, and MaaS forward. Such authorities must be careful when enabling those solutions that they do so not only to favor their innovation agenda, but also as a means to reach (sustainable) transport policy targets. Some of those ICT-supported integrated mobility schemes might have unanticipated consequences (especially MaaS), which is why public authorities must also be careful not to push too hard for their development. Of course, having those solutions available and functioning for a city or a country might help increase its competitiveness and attractiveness, especially in a globalized economy, but this should not be the only driver for pushing those forward.

> *12)* **(L & N)** *Consider the underlying reasons supporting a push to develop ICT-supported integrated mobility schemes, and do so to push a transport and climate agenda rather than just an innovation agenda.*

The question of the business model adopted by ICT-supported integrated mobility schemes operators is an important and difficult one. As seen in this thesis, some business models might push operators to actually sell more mobility services, not less, which would actually worsen more than improve the performance of transportation systems. Therefore, the question for public authorities to contract one of those operators and subsidize it to ultimately reduce the risk of having him provide unsustainable transport service remains an important one. It is not clear yet whether public authorities should automatically consider this option, because not enough data is available yet on the impact of MaaS and IMP on people's travel behavior. As soon as this is the case, however, it will become clearer whether public authorities should allow MaaS operators to compete (Finland), select one operator to work with (London), or act in a kind of PPP model where they fund the back-end (data platform) and regulate competition between companies interested in building their front-end on top of it (Vienna).

> *13)* **(L & N)** *Closely monitor research into the impact of MaaS and IMP on existing transport systems to ultimately decide which MaaS operator's business model to support.*

Last but not least, it appeared that societal actors were not involved in niches in our three case studies, which is an important criterion to consider for socio-technical transitions to take place. Thus, public authorities should push for the inclusion of societal actors in order for the ICT-supported integrated mobility solutions to be developed by the private sector to fit societal needs as much as possible. Including societal actors might also ultimately be a way to avoid unanticipated consequences and plan for potential rebound effects.

> *14)* **(L & N)** *In order to avoid unanticipated consequences of ICT-supported integrated mobility schemes and plan for potential rebound effects, push for the inclusion of societal actors in the niches.*

6.2 Generalizability of the findings

Qualitative case studies are often criticized for a lack of generalizability, and the findings of the present thesis may face similar criticism. According to Firestone (1993), there are three models of generalizability: statistical, analytical, and case-to-case generalizability. To begin, I agree that statistical generalization (that is, generalization from the three cases to a larger population) is hard to obtain from the current study, but I ultimately join Polit and Beck (2010) for whom qualitative research does not aim at statistical generalization but rather to provide a rich and contextualized study of phenomena through the intensive study of particular cases. I then argue that the degrees of analytical and case-to-case generalizability (also called transferability) of this study's findings should not be ignored. The analytic generalizability of a case study depends on the similarity of the results of the case(s) with an already existing theory (Yin, 2003). First, my findings proved to be coherent with the propositions drawn from the governance and socio-technical transition literature. It seems that none of my results went against the axioms of the two streams of literature used, which illustrates the non-negligible level of analytical generalizability of the present study.

Second, the findings of this thesis might also be generalizable to similar cases (case-to-case generalizability). For example, they might be generalizable for cities that have similar contexts in terms of public transport availability, car-ownership levels, digitalization, and institutional frameworks. Stockholm, Copenhagen, or Singapore could be instances to cite here. However, the number of other cases to which this thesis' findings might be generalized is very limited. Indeed, London, Vienna and Helsinki are currently among the "best" cities when it comes to the quality and sustainability of urban transport. For example, according to the recent *Arthur D. Little Urban Mobility Index 3.0,*[43] all three of those cities rank among the 10 most performant cities worldwide. The above-mentioned cities to which this thesis' findings might be generalized also rank high on the same index. Therefore, it seems that the present findings might only be generalized to "already-doing-good" cities, which could be criticized. In those cities, ICT-supported integrated mobility schemes are perhaps less necessary than in cities where mobility is still heavily dominated by car-based mobility modes. Paradoxically, however, it is only if less-performing cities manage to improve the performance of their transport systems that the present findings will be useful for them. Consider the example of Accra (Ghana), which ranks among the five worst performing cities in the *Urban Mobility Index 3.0*. Given Accra's low ranking, one might assume that it would need to improve more than cities ranking above it in order to improve its position. In other words, Accra seems to be more demanding of solutions that can make it perform better than cities already performing well. However, the context of Accra is too far from that of the three cases studies explored for this thesis' findings to be applied. For example, there is a non-negligible part of transport in Africa – up to 50 percent in the poorest areas (Cervero and Golub, 2007) – that is provided informally and is completely unregulated. Although IMP and MaaS could have very positive consequences on transportation systems in Accra, it would be necessary to tackle the informal (and thus institutional) transport issue before considering developing ICT-supported integrated mobility schemes there. An unregulated semi-public transport system is often synonymous with different fare systems and a lack of physical integration, which are prerequisites for smart cards, IMP, and MaaS. Similarly, Houston, Texas ranks among the 10 worst performing cities in the United States. However, due to the context (urban sprawl, high car-ownership levels), public authorities in Houston would probably be more interested in addressing other transport issues, such as funding of public transport infrastructure, than developing ICT-supported integrated mobility schemes. To conclude, it seems that my findings are generalizable to cities performing at least as well as Helsinki, Vienna, and London, which is somewhat reductionist. For cities that are not performing as well, there are more important things for public authorities to work on, and they should not view ICT-supported integrated mobility schemes as a magic bullet to solve all their transport issues. ICT-supported integrated mobility schemes come after the basic steps of the transport integration ladder, and public authorities should not forget this.

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[43] http://www.adlittle.com/futuremobilitylab/assets/file/180330_Arthur_D.Little_&_UITP_Future_of_Mobility_3_study.compressed.pdf, accessed 3 July 2018.

6.3 Contribution to research

I believe the present thesis has contributed to three important streams of literature and helped address the research gap presented in the literature review chapter (Chapter 2). First, by shedding light on the nuts and bolts of ICT-supported integrated mobility scheme development, I believe my research has contributed to the literature focusing on transport integration. As explained in Chapter 2, most of this literature has sought to understand the impact of integrated transport schemes, but not so much regarding how such solutions come to life and what is the underlying governance of their development. Thus, by emphasizing the role that public authorities play in their unfolding, I believe the present study has added to the literature on transport integration answers to the question of "*how to get there*", while most of the earlier research has been concerned with answering the question of "*why get there*". The present dissertation has also contributed to the transport integration literature by proposing the so-called "new" transport integration ladder. While the transport integration ladder had already been established by transport scholars in the past, it missed the integration steps that had been enabled by the ICTs, which are now integrated all together in the ladder proposed in this thesis. Within the transport integration literature, I also believe the present research work has helped bring clarity to the MaaS concept. As mentioned in Chapter 2, there is a lot of confusion about this term, and I hope that, by having defined it as the most advanced of the ICT-supported integrated mobility schemes, I have provided some clarity to the MaaS concept. Last but not least, I believe this thesis has contributed to the transport integration literature by the use of qualitative case study as research strategy, and by the use of phenomenology as methodology. Most of the studies in the transport integration literature, and more generally in transport research, are more quantitative; however, as suggested by Lyons and Urry (2006), social sciences-based studies have a central role to play in transport research, which is what my work has sought to do.

The second stream to which the present thesis has contributed is the transport governance literature. As mentioned in the literature review chapter, most of this literature has focused on the impact of specific governance tools on the performance of transport systems. The amount of research endeavors that have sought to study the politics of transport policy has, to the best of my knowledge, remained limited. By having looked at the game of actors having supported the development of smart cards, IMPs and MaaS, I believe the present study has helped address this research gap. Secondly, the transport governance literature has mainly looked at the governance of specific transport modes, or the governance of transport and climate change (specifically using the MLG), but not so much at the governance of intermodal transport, which is another reason why I believe the present research work makes a relevant contribution. Last but not least, the transport governance literature has not really looked at the governance of digital transport solutions, as it is quite new. Therefore, by focusing on the governance of transport solutions facilitated by the ICTs, I also feel the present thesis has helped fill this research gap. I have also contributed to the governance literature by integrating Etkowitz (2008) into the framework of Bulkeley and Kern (2006), which I feel lacked a dimension for public authorities adopting a governing-by-laissez-faire approach. I hope this "revised" governing framework will be used by other scholars interested in looking at bottom-up innovation developments in urban infrastructure systems. I believe this thesis has also contributed to the governance literature by applying the governing framework to the organization of the transportation sector. Prior to this study, the (original) framework had only been applied to the governance of cities (and climate change) in general, and more recently to the governance of so-called sharing cities (van den Eijnden, 2017), but never (to the best of my knowledge) to a specific urban activity sector, such as transport. By using phenomenology as methodology, I also feel I have contributed to the transport governance literature that has hitherto been based more on quantitative than qualitative enquiries.

Finally, I believe the present thesis has also contributed to the literature focusing on socio-technical transitions. Although the study of the mobility transition has been at the heart of this literature for a long time, only a limited number of studies have looked at the processes supporting the birth and diffusion of smart cards, IMP, and MaaS, which is what I have done in this study. I believe this thesis has addressed two of the shortcomings of the MLP framework. First, by using the transition literature to conduct a comparative analysis between three cases of studies, the thesis has addressed criticisms of MLP detractors, for whom transition studies often withdraw their findings from the analysis of single cases (Geels, 2006). Secondly, by comparing three cases rooted in different geographical contexts (London, Vienna, and Helsinki), the thesis has answered the critique that transition frameworks often lack a geographical dimension (Hodson and Marvin, 2010; Coenen et al., 2012; Whitmarsh, 2012). Although the MLP does not, as an analytical tool, pay much attention to the geography, it does not restrain researchers from investigating geographies (and, for example, urban design) as important elements of socio-technical transitions, and potential contributors to the creation of "windows of opportunity".

6.4 Limitations of the research

The first limitation of the present research pertains to the choice of methodology. Although phenomenology appeared as the most relevant methodology to generate a thick description of how public authorities react in the development of ICT-supported integrated mobility schemes, other methodologies could have also been used. In particular, it would have been interesting to conduct an ethnographic study to answer this thesis' research question. By being located in a PTA for a defined period of time, I might have drawn different insights into how public authorities react to new transport solutions and to transport digitalization on a day-to-day basis. However, it would have been quite complicated to conduct three ethnographic case studies, which is what I would have had to do to fit my transport integration ladder framework. Conducting three case studies would have been synonymous with conducting three ethnographic studies of three different public transport authorities, which would have been quite complicated given the time and resources I had. Furthermore, conducting ethnographic studies usually requires speaking the language in which the researcher is being "immersed", which would have been a problem for the Vienna and Helsinki cases. However, I believe that ethnographic studies might be something to keep in mind for future research looking at the governance (and politics) of smart transportation system development.

One could criticize this research endeavor for the cases studied. As previously mentioned, this dissertation looked at three cases of studies that already rank well from a transport perspective. Some might say that it would have been interesting to take more extreme cases from more different contexts to compare, in order to increase case-to-case generalizability. However, as explained in the methodology chapter (Chapter 3), the amount of cases available to study ICT-supported integrated mobility schemes development was (and is still) very limited due to the novelty of the concept, which impacted the choice of cases. Still, looking at smart cards (Oyster and CPC) in London, IMP in Vienna, and MaaS in Helsinki seemed to be the best options at the time this study started, back in 2015. Some might also criticize the difference in research methods used to conduct the three case studies. While both desk research and interviews were used for the Vienna and Helsinki cases, only desk research was employed for the London case. This could suggest a lack of triangulation, and therefore a lack of robustness of the qualitative inquiry for the London case compared to the Vienna and Helsinki cases. I agree that I could have conducted interviews for the London case study in order to be as systematic as I was for Vienna and Helsinki. However, one reason for conducting interviews in Vienna and Helsinki and not in London also pertains to the language barrier. As I do not speak either Finnish or German, there were many documents I found online that I could not understand by myself (as they were in one of those languages). Therefore, it was necessary to conduct interviews with stakeholders of Vienna and Helsinki in English to access information. The London case was somewhat different as all of the online documents were in English. Thus, I was able to get access to much more data from documents for the London case, than for the Helsinki and Vienna cases, especially thanks to the research team of students that worked on the London case in 2015 as part of their coursework. According to Miles and Huberman (1994), researchers could get their case studies “checked” by experts in the subject to increase the validity. This is something I have done when submitting papers to conferences or journals. However, I decided not to have experts comment on the cases directly as I doubted their ability to “validate” research in which they have played no role (Sandelowski, 1998).

6.5 Recommendations for future research

More empirical research looking at other cases of ICT-supported integrated mobility unfolding needs to be conducted in order to build a more holistic understanding of the governance of development of digital integrated transport. Although such research endeavors have been undertaken (e.g., Smith et al., 2018b), those remain marginal and only focused on a limited number of countries (Sweden, Finland, UK, and Austria). As MaaS operators have recently announced they will launch their services in Belgium, Singapore, and other countries, I hope that more researchers will undertake inquiries to understand how ICT-supported integrated mobility schemes are developing over there, hopefully using the governing framework presented in this thesis, and further integrating it with the MLP and other transition frameworks. Other conceptual frameworks might also be used to look at the governance of MaaS. For example, using the Multi-level Governance (MLG) framework, given its problem solving capacity in complex governance contexts (Scharpf, 1997), might prove useful[44]. For researchers interested in continuing to use the MLP, and paying more attention to agency and politics into the overall mobility transition, the Multiactor Perspective (MaP) framework proposed by Avelino and Wittmayer (2016) might be also be worth trying.

It might also be worth using game theory to analyse the behaviour of certain actors in the three cases studied in the thesis. In particular, the case of IMP development in Vienna could serve as a relevant empirical basis to conduct a “prisonner’s dilemma” analysis. Case n°2 can indeed be understood as a situation where the two principal (public) stakeholders (the ÖBB and WS) prefer to each pursue their own interests, without taking into account the potential utility resulting from a collaboration with the other, fitting quite well the prisonner’s dilemma (PD) problem definition. PD has been used quite often in the governance literature, see for example Héritier (2003), but has not yet been used in transport governance studies and would make a valuable contribution.

The three cases studied in the present dissertation only had limited time spans (10–15 years). It would be interesting to look at the development of ICT-supported integrated mobility schemes with a longer time span. Indeed, if MaaS really is a system innovation, it will evolve from the niche to the regime layer and alter the incumbent automobility regime. However, as with all socio-technical transition, this will take decades to happen. The innovation journey of ICT-supported integrated mobility schemes will ultimately have to be studied by (transition) scholars in 20 to 30 years from now to understand how those solutions succeeded (or failed) in changing the mobility regime as it is currently. In particular, studying their development on longer time period should also enable researchers to validate (or not) the place of ICT-supported integrated mobili-

[44] For that reason Prof. Finger and myselft realized an MLG analysis of the Helsinki case study in a dedicated publication, see Audouin and Finger (2018a), which has been published in the MaaS special issue of the Journal of Transportation Research in Business and Management (RTBM).

ty schemes in the overall transport integration ladder, to understand if smart cards, IMPs and MaaS are a gateway to more advanced integration steps, such as integrated transport and land use and ultimately integrated transport policy.

The analysis of the case studies was conducted using two different conceptual frameworks, one drawn from the governance literature and the other from the socio-technical transition literature. Having used both literatures, this thesis has partially answered the call of academics to combine both approaches (Hoffmann et al., 2017); this has been done in parallel, whereas it would have been interesting to come up with a framework combining both approaches upfront and analyze the cases comparatively with it. Therefore, I suggest that more theoretical research should be conducted to ultimately come up with a comprehensive framework combining both approaches, which could be used not only to look at the development of bottom-up innovations in the transport sector, but also in other urban utility sectors such as energy, water, waste or postal services.

In all of the three cases studies explored in this dissertation, public transport authorities and railway undertakings were either reluctant to engage with companies proposing ICT-supported integrated mobility schemes, or wanted to do everything by themselves, which is ultimately to be linked with their concerns about seeing their brands fade away or become less powerful. Marketing research has demonstrated that brand equity is positively correlated with the firm performance (Aakers, 1996). PTA's brand equity is directly linked with transit identity, which is known to be a function of vehicles, infrastructure (shelters and stations), and so-called collateral material (Hess and Bitterman, 2008). By not engaging in the development of ICT-supported integrated mobility schemes, PTAs seem to believe they are losing an opportunity to develop collateral material – that is, to increase their brand equity – and thus to ultimately increase their performance. However, the link between brand equity and PTA and RU's performance has not yet been clearly established. While research has demonstrated the positive correlation of the two elements for product industries, as well as for some service industries, such as the hotel and fast-food industries (Kim and Kim, 2005) or telecommunications, payment, and internet services (Chang and Liu, 2009), it has not yet done so for the transit industry. Thus, I believe that research should be carried out to explore the link between brand equity of PTAs and RUs and their performance. If findings indicate that the performance of PTAs and RUs is not correlated with their brand equity, it might be easier to make them understand that being in the driving seat for the development of ICT-supported integrated mobility schemes development may not be worth it.

This thesis was written based on the assumption that ICT-supported integrated mobility schemes are beneficial for transport systems. However, there is an increasingly growing body of literature that has been criticizing this assumption. Indeed, several leading academics have recently questioned the capacity of private-sector provided MaaS to efficiently tackle traffic congestion and improve transportation systems performance (Pangbourne et al., 2018; Hensher, 2018). Additional research must be conducted to better understand the underlying business models (e.g., Sarasini et al., 2016), and their impact of such schemes on existing transport systems. Research must also look at the impact of those schemes on users' behaviors (rebound effects). Building on Geels (2012: 479), it remains to be seen whether ICT-supported integrated mobility schemes really deliver efficiency improvement or are just "*temporary measures that delay gridlock for another 10 years or so*".

Practice theory also seems to be worth using to ultimately look at the diffusion and acceptance of ICT-supported integrated mobility schemes. Practice theory offers ways of "*understanding human action, and its relation with social order and change*" (Watson, 2012: 489) and has been used increasingly in transport research. For example, it has been employed to look at car dependent practices (Mattioli et al., 2016), as a lens to understand domestication of electric vehicles (Ryghaug and Toftaker, 2014), and to analyze the practice of utility cycling (Spotswood et al., 2015). Faivre d'Arcier and Lecler (2018) have also used it to look at the uptake of carsharing. However, to the best of my knowledge it has not yet been used to look at the domestication of smart cards, IMP, and MaaS. Thus I believe that using theories of practice to look at the uptake of ICT-supported integrated mobility schemes might be relevant for future research.

Some more quantitative studies studying the impact on travel behavior of ICT-supported integrated mobility schemes have already been conducted using survey methods; see, for example, Sochor et al. (2016). However, studies looking at the behavior change of smart cards, IMP, and MaaS users should be conducted using data taken directly from the companies operating such schemes. Using surveys always involves a risk of not capturing all the behaviors, which is why using anonymized data from Upstream or MaaS Global, for example, might be more relevant in the future. This will ultimately depend on the willingness of those companies to share operational data with researchers. While Oyster data are partially available for study thanks to TfL, this does not seem to yet be the case for MaaS and IMP schemes. Given the likeliness of being confronted to a lack of data available of how are people using smart cards, IMP, and MaaS, simulation studies that use, for example, agent-based modeling, should be carried out on the subject. Similarly, more research focusing on the impact of smart cards on existing urban transportation systems is required. Although most of the research to date has demonstrated a positive impact on PT ridership, cost reduction for the PTA, it is hard to isolate the effects that smart cards had on other factors such as economic growth and PT infrastructure development. Therefore, it might be worth trying to use randomized control experiments, which might enable to better isolate variables and draw new conclusions on the real impacts of such schemes when not combined with other transport-related measures.

6.6 Concluding remarks

Throughout this thesis, I have tried to provide rich and thick descriptions of how ICT-supported integrated mobility schemes come to life, in order to understand the role that public authorities play in their development. I hope that my recommendations, despite their limitations, will be useful for city and central governments that are keen to see smart cards, IMPs, and MaaS develop on their territories and wish to make the most out of those solutions from a public policy perspective. In other words, I hope my recommendations will help policy makers align smart transport solutions (as ICT-supported integrated mobility schemes) with the sustainable mobility paradigm.

Given that ICT-supported integrated mobility schemes are still in their infancy (especially for IMPs and MaaS that are less than five years old), and the center of much attention from scholars and practitioners, I am very much looking forward to the future. In particular, I look forward to results showcasing the impact of those schemes on existing transport systems. I am also excited about the unfolding of automated mobility services in the coming years, as this will be a game-changer in terms of how people move within cities. Self-driving vehicles will change urban mobility landscapes dramatically, which is why robust ICT-supported integrated mobility schemes need to be in place as soon as possible, in order to minimize the SDV disruption and make the most out of it. Given the time needed for public authorities to react to disruption in the transport sector, there is a need to act quickly, as automated mobility services will soon be burgeoning in cities around the world – I am talking about years, and not decades as some detractors might be suggesting.

This thesis has been an incredible ride for me, where I have learnt deeply about a variety of subjects including urban mobility, governance, and innovation management. As I have observed in this piece of research, the cross-fertilization of those three subjects is a very promising and emerging field to which I hope I have contributed. However, it is now time for me to try and put into practice everything I have observed through this research endeavor. I now wish to put the knowledge acquired through this dissertation to good use by working for a stakeholder looking at ICT-supported integrated mobility schemes in order to help it harnessing the full potential of those innovations. While there is of course an urgent need for more research to be conducted on the above-mentioned subject, I also believe that moves of scholars from academia to practice are needed to pave the way from automobility towards more sustainable transport systems.

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Appendix 1 : List of interviewees

Code	Organization	Mean	Date of the interview
IH1	MaaS Global	Physically	8.2016
IH2	Transdev	Skype	9.2016
IH3	Finnish Rail (VR Group)	Physically	12.2016
IH4	Helsinki city transport (HKL)	Physically	12.2016
IH5	Ramboll	Physically	12.2016
IH6	Eera	Physically	12.2016
IH7	Lahitaksi	Physically	12.2016
IH8	SITO	Physically	12.2016
IH9	Helsinki Metropolitan Transport Authority (HSL)	Physically	12.2016
IH10	Finnish Ministry of Transportation (LVM)	Physically	12.2016
IH11	City Car Club	Physically	12.2016
IH12	City of Helsinki	Written	12.2016
IH13	Forum Virium	Skype	1.2017
IH14	SITOWISE	Skype	3.2018
IH15	Helsinki Business Hub	Skype	3.2018
IH16	Helsinki Metropolitan Transport Authority (HSL)	Skype	5.2018
IV1	Wiener Linien	Physically	5.2017
IV2	Fluidtime	Physically	5.2017
IV3	Upstream + TBWA Research	Physically	5.2017
IV4	AustriaTec	Physically	5.2017
IV5	ETA Consulting	Physically	5.2017
IV6	Taxi 31300	Physically	5.2017
IV7	City of Vienna (MA18)	Physically	5.2017
IV8	City of Vienna (MA25)	Physically	5.2017
IV9	ÖBB + iMobility	Physically	5.2017
IV10	CityBike	Physically	5.2017
IV11	Klima und Energi Fund	Physically	5.2017
IV12	FFG	Physically	5.2017
IV13	Car2Go	Skype	5.2017
IV14	VAÖ	Skype	5.2017

Appendix 2 : Semi-structured interviews guidelines

A) History of [your organization]

1. What has been the History of [your organization]? (How has it been created, when, what is its mandate, day to day operations…)

2. Explain the corporate governance of [your organization] (how many departments, is the CEO elected/appointed, what is the budget, from where does it come from, to who is it accountable to…)

3. Describe the relation of [your organization] with public authorities (city and Ministry of Transportation)

4. Digitalization is impacting transport. How has [your organization] been considering it in its last strategic plans? (Strategy point of view)

5. What actions has [your organization] undertaken to develop digital services/products in the last years?

B) Role of [your organization] in the development of ICT-supported integrated mobility schemes

6. Historically, from the very beginning, explain how did [your organization] get involved in the ICT-supported integrated mobility schemes project: when did it first hear about it, who approached [your organization], when, what was [your organization] first reaction, what were the key actions (meetings / pressure from the city hall?) that convinced [your organization] to join the development of an ICT-supported integrated mobility scheme…?

7. How do ICT-supported integrated mobility schemes fit in [your organization] overall Strategy?

8. Explain with as much details as possible the agreement [your organization] has with the ICT-supported integrated mobility scheme provider (business model, contract …)

9. Has [your organization] been interested in taking the lead in the project (developing its ICT-supported integrated mobility scheme)?

10. From your personal point of view, what are the main remaining bottlenecks (political, economical, social, technological…) for a full implementation of ICT-supported integrated mobility schemes?

C) Role of public authorities

11. In your point of view what should public authorities do to make ICT-supported integrated mobility schemes happen?

12. From your point of view, is it what public authorities in your city did? What should have they done more/better/differently?

13. We see non-public (private) actors trying to take the lead on this kind of projects. How do you see that? will they be successful in your opinion?

14. Overall if you had the power to organize differently the governance of the ICT-supported integrated mobility scheme development in [your city], what would you change? (Would you involve any other actors more/less, create specific policies/incentives?)

15. The Finnish Transport code is regarded by many as a real enabler for MaaS. What is your opinion on it and on similar legislations[45]?

16. How do you see [your organization] evolve if the studied ICT-supported integrated mobility scheme is rolled-out successfully?

17. What is next for [your organization]? (In general and regarding ICT-supported integrated mobility schemes)

[45] For this question, we of course explained what the Finnish Transport code was about for interviewees that were not familiar with it.

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Education

09/2015 – 12/2018	**Ecole Polytechnique Fédérale de Lausanne, Lausanne, Switzerland** PhD, Management of Technology Chair Management of Network Industries (MIR)
02/2015 – 07/2015	**Sungkyunkwan University, Seoul, South-Korea** Master thesis, School of Political Science
09/2013 – 07/2015	**Ecole Polytechnique Fédérale de Lausanne, Lausanne, Switzerland** Master of Science, Energy Management and Sustainability (MES)
09/2009 – 07/2012	**Ecole Polytechnique Fédérale de Lausanne, Lausanne, Switzerland** Bachelor of Science, Environmental Engineering

Professional Experience

02/2015 – 07/2017	**IGLUS (Innovative Governance of Large Urban Systems) - EPFL, Lausanne, Switzerland** Project Manager
07/2014 – 09/2014	**Public Works Department, Government of Ras al Khaimah, RAK, United Arab Emirates** Intern
09/2012 – 08/2013	**Mission Metropole Grand Paris, Veolia Environnement, Paris, France** Intern

Skills

Computer skills	MS Office, MaxQDA, Notions in Matlab, R
Languages	French (Mother tongue) | English (Fluent) | Spanish (Notions)

Research

Peer-reviewed articles	Audouin, M., & Finger, M. (2018). Empower or Thwart? Insights from Vienna and Helsinki regard ing the role of public authorities in the development of MaaS schemes, Forthcoming in Transport Research Procedia. Audouin, M., & Finger, M. (2018). The development of Mobility-as-a-Service in the Helsinki metro politan area: a multi-level governance analysis, Research in Transportation Business and Manage ment, https://doi.org/10.1016/j.rtbm.2018.09.001
Book	Finger, M., & Audouin, M. (2018). The Governance of Smart Transportation Systems, Springer.
Selected presentations	What governance for digital mobility? Forum Avenir Mobilité, Zurich, 23.02.2018. What are the consequences of digitalization on mobility services? 14th Rail Forum of the Florence School of Regulation (FSR), European University Institute, Florence, 22.05.2017.

Areas of interest and expertise

Urban mobility • Transport policy and regulation • Governance • Smart cities • Innovation and technology management

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