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Towards transport futures using mobile data analytics

Stakeholder identification in the city of Stockholm

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Towards transport futures using mobile data analytics. Stakeholder identification in the city of Stockholm

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Abstract

English / Engelska / Inglés

The use of big data in urban transport planning is unstoppably gaining momentum and with the help of strategic business partnerships and technological advancements (e.g. transport apps, mobile device location tracking, data processing) the new mobility models are evolving towards an integrated and multimodal urban mobility: Mobility as a Service (MaaS). From the generation of data by Telecom companies to transport end users, a broad range of stakeholders are involved in the data market. This tighter with the call for sustainable alternatives in passenger traffic highlights that business relations are complex, and that businesses in this data market also have long-range transport objectives.

This Master Thesis develops a stakeholder analysis of the network of actors related to mobile data and users. It explores the city of Stockholm as case study to identify who are the market players (i.e. companies) and what are their respective roles and business models. Based on sectoral expertise interviews and literature and website review, a three-cluster organization of *data suppliers*, *data facilitators* and *data end users* set the structure to evaluate stakeholder relationships. Data trading opens a debate on which Telecoms not only address raw data processing methods but also reach less accurate mobility outcomes (e.g. trips per person, OD matrices, travel distance, average speed), or, on the other hand, which delegate the added-value service to third parties. The analyzed actor network outstands frictions between the public and private sector and, certainly, when processed data steps on the transport industry (e.g. PT operators, infrastructure managers, private service operators (Uber), passengers). This is an institutional barrier that prevents a full MaaS implementation in the Stockholm region. The challenge resides on revising actor network gaps (i.e. new roles of *MaaS Operators* or *Collecting Agents*) and easy flow data transactions to encourage integrated modal choice in transport apps offerings. Despite exiting MaaS initiatives (e.g. UbiGo) in Stockholm and little research in data-based stakeholders, this is a first approximation of a stakeholder map to an immature and innovative research area with great potential in the future.

Keywords: *stakeholder analysis, stakeholders' relationships, mobile data, actor network, data-driven market, clusters, urban mobility, integrated transport, MaaS*

Sammanfattning

Swedish / Svenska / Sueco

Införandet av Big Data i stadsplanering har oundvikligen börjat ta fart. Med hjälp av strategiska affärspartnerskap och tekniska framsteg (t.ex. transportappar, spårning av mobila enheter, databehandling) har nya mobilitetsmodeller utvecklats i strävan efter en integrerad och multimodal mobilitet i städerna: Mobilitet som tjänst (MaaS). Från ny datagenerering till att transportera slutanvändare deltar ett brett spektrum av intressenter på en marknad som styrs av tillgång till data. Uppmaningen till hållbara alternativ i passagerartrafik uppmärksammar också komplexa aktörsrelationer som relaterar datahantering till långsiktiga transportmål.

Denna uppsats består av en intressentanalys av aktörsnätverket inom mobilitetsdata och undersöker Stockholms stad som en fallstudie för att identifiera vilka som är marknadsaktörer (företag) och respektive roller och affärsmodeller. Baserat på intervjuer av experter inom branschen, litteratur- och webbplatssökning skapas tre kluster av organisationer, för att utvärdera intressentrelationer. Dessa är datalämnare, datatillämpare och slutanvändare. Datahandel öppnar upp en debatt om hur telekomföretag använder nya databehandlingsmetoder men når mindre exakta mobilitetsresultat (t.ex. resor per person, OD-matriser, reseavstånd, genomsnittlig hastighet) eller, å andra sidan, som delegerar mervärdestjänsten till tredje part. Det analyserade aktörsnätverket utestänger friktion mellan den offentliga och privata sektorn, och denna barriär förhindrar en fullständig MaaS-implementering när det gäller bearbetade datasteg inom transportbranschen (t.ex. PT-operatörer, infrastrukturförvaltare, privata serviceoperatörer) i Stockholmsregionen. Utmaningen ligger i att omarbeta luckor mellan aktörsnätverk (*MaaS Operator* eller *Collecting Agent*) och förenkla dataflödestransaktioner för att uppmuntra integrerat modalval i transportapps-erbjudanden. Trots existerande MaaS-initiativ (t.ex. UbiGo) och en mindre databaserad intressentforskning är detta en första approximation till ett omoget och innovativt forskningsområde med stor potential inför framtiden.

Nyckelord: intressentanalys, intressentes relationer, mobildata, aktörsnätverk, datastyrd, marknad, kluster, mobilitet i städer, integrerad transport, MaaS

Resumen

Spanish / Spanska / Castellano

El uso de big data en la planificación del transporte urbano está ganando un impulso imparable, y de la mano de asociaciones empresariales estratégicas y avances tecnológicos (aplicaciones de transporte, seguimiento de ubicación en dispositivos móviles, procesamiento de datos), los nuevos modelos de movilidad están evolucionando hacia una movilidad urbana integrada y multimodal: Mobility as a Service (MaaS). Desde la generación de datos (empresas de telefonía) hasta un sector transporte como usuario, muchas son las partes interesadas que participan en el mercado de datos. Esto, unido a la llamada de nuevas alternativas sostenibles en el tráfico de pasajeros, hace destacar que las relaciones empresariales son complejas y que los negocios en este mercado de datos también tienen objetivos en un transporte de largo alcance.

Esta tesis desarrolla un *stakeholder analysis* de la red de actores relacionados con los datos móviles y utiliza Estocolmo como caso de estudio para identificar a estos agentes (empresas) y sus respectivos roles y modelos de negocios. Basado en entrevistas a expertos y trabajos de investigación, el análisis organiza los actores en tres grupos *proveedores de datos, facilitadores de datos* y *usuarios finales de datos*, siendo esta la estructura base para estudiar sus relaciones. Así mismo, este intercambio de datos abre un debate alrededor de si las empresas de telefonía desarrollan métodos para procesar los datos, aunque los resultados de movilidad sean menos precisos (viajes por persona, matrices OD, distancia de viaje, velocidad promedio) o, por otro lado, si el servicio de dar valor añadido se delega a terceros. Ciertamente, el análisis de la red de actores destaca fricciones entre el sector público y el privado y, en el momento que la industria del transporte ya maneja estos datos procesados (operadores de transporte, gestores de la infraestructura, empresas tipo Uber, etc), esta barrera institucional es la que mayormente impide una implementación total de MaaS en Estocolmo. El desafío está revisar posibles “huecos” en la red de actores (Operador MaaS o un Agente Cobrador) así como un fácil flujo en las transacciones de datos para alentar una elección modal integrada en la oferta de las aplicaciones de transporte. Así, a pesar de la escasa investigación en quienes son los actores que hacen negocio con datos telefónicos, y las de pocas iniciativas (efectivas) en MaaS (UbiGo) hacen de este proyecto una primera aproximación a un área de investigación que aún es inmadura e innovadora, pero con un gran potencial en el futuro.

Palabras clave: *análisis de partes interesadas, relaciones de partes interesadas, datos móviles, red de actores, mercado impulsado por datos, agrupaciones, movilidad urbana, transporte integrado, MaaS*

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1. Introduction

1.1. Why researching stakeholders related to Mobility Data?

How is it possible that today's society can produce more data in 2 days than in centuries of history? Almost without realizing it, we produce hundreds of data every day just by surfing the Internet. In these terms, the service sector and particularly the transport industry must take advantage of it, and with smart strategies make a profit from this information. Experts predict that Big Data and Analytical Trends will continue to grow, but do stakeholders really know their role to face this challenging Big Data ecosystem? (Martín del Campo, 2018).

Undeniably, Technological Innovation (TI) introduced great advances in a wide range of sectors e.g. transport, urban planning, personal location tracking, finance, web analytics or pattern recognition. This torrent tendency encourages companies to move on and adapt to new circumstances where data management draws special attention. Certainly, the Business Intelligence model will begin to be a reality from large multinationals to small startups where mobile data analytics play an important role. The ownership of technical and intellectual knowledge unfolds new possibilities to anticipate client behavior and companies can adjust their product/service provision to consumer’s needs. Currently, the hype focuses on a technical research of Mobile Data Analytics and puts into practice modeling systems that process these data (e.g. machine learning). However, what is on target in this Master Thesis is relatively different. Here, the core point is on the business sector and how companies build partnerships around the transaction of these dataset.

The increasing funding in telecommunications, IT research and sustainable mobility make the city of Stockholm an excellent case study to assess the data management market. However, since there are not many publications today which identifies data-related stakeholders and their interrelations, this Master Thesis provides an innovative character that can have a great impact on the effectiveness and efficiency of Swedish-based companies operating in the sector. Knowing the modus operandi of commercial operations, kind of alliances and the challenges posed in the future of transportation are three examples of the scope of the investigation.

1.2. Launching big data in transport planning

The close-knit connection between mobile data and mobility in our cities is remarkable. It is broadly demonstrated that the behavior of mobility is rapidly moving from traditional schemes (merely based on “moving people”) to less time-consuming alternatives based on sustainable modes, such as public transport (PT), cycling or walking. Sustainable transport refers to an urban mobility committed to integrate all social spheres with the ability to supply climate-friendly means to travel. Since energy efficient vehicles (e.g. carbon neutral fuel, plug-in hybrid/electric vehicles) and clean modes of transport (e.g. metro, bus, cycling, walking) are components of sustainability, their integration in a multimodal transit-oriented development is key for an effective and efficient transport system. Sustainability also outlines positive contributions with social and economic connections, and dealing with existing data about this entire system (i.e. available data sources but complex to gather and analyze) could stimulate cities performance both in the short and long-term.

Overall, travelling is a mean, not an aim, so, once transportation see in mobile data analytics an extraordinary rewarding opportunity, there will be additional areas (and respective stakeholders) playing a role in data mining. Instances such as land use, environmental impact, demography, urbanism, real state or shopping patterns have their individual characteristics, policies and priorities, but they have common goals shared with the transportation sector. For example, Uber offers peer-to-peer rideshare services that use GPS signals to geolocate trips from one point to another. Inherently, these origins/destinations or travel routes tracked by mobility methods have an influence in forecasting real state promotion, housing densification, new public transport lines or public spaces. The aggregation of various disciplines creates an added-value from mobile data, and future investment strategies must take advantage of it. With all, when city planners design Master Plans, the acquisition of mobility knowledge could be strongly enriched by mobile data tracking tools. So, the picture of mobility and how mobility data spread out through stakeholders is at stake.

Following the same path, more mobility apps and private platforms are gaining momentum with accurate road maps and live information, and what is key today is the integration of multimodal options for urban travelers. So, worldwide, the range of mobility data captured by IT software is worth its weight in gold. Simply, telephones and similar tech devices do generate advanced information capable of revitalizing the transport system, and the possession, management and implementation of raw mobile data drive companies to new scenarios to invest. Undeniably, mobile data is a priced asset responsible for creating commercial networks around it. Telecom companies, transport operators and intermediaries of data recognize its potential and the evident big business left behind this data-driven market.

1.3. Technological innovation & Big Data Background

The transaction of mobile data is a core subject debated along the course of the investigation and, despite the multiple definitions of Big Data, this section explains the concept from a technical and business perspective. Independently, these two spheres match in purpose with the thesis argumentation, however, both can perfectly merge in order to add value to the final product/service as well as when dealing with commercial competencies, negotiations and market profitability.

First, the technical viewpoint commonly embodies the "collection, storage and analysis of large, diverse and complex datasets generated from a variety of sources including sensors, internet transactions and other digital sources, such as mobile networks" (D4D Challenge, 2015). In other words, Big Data is a moving target that needs to integrate a set of techniques and technologies able to (semi-) structure statistics and obtain useful outcomes. Regarding what McKinsey Global Institute states (2011, cited by Roncalli, 2014), Big Data is not a unified science as it comprises multiple aspects: large datasets, unstructured data (networked data but fuzzed relationships), data-driven research, business & decisions and high skills (IT). For instance, machine learning and digital footprint are common tools used for data processing. However, the maturity of the concept is rapidly growing, and a non-technical approach has more relevance for this case study, as the intention here is to penetrate in the market/business left by mobile data.

Over the last decade, monitoring Big Data as the use of Mobile Data Analytics has exponentially gained market share. Both public and private agencies see in raw data an *intangible asset* capable of predicting and tracking demand behavior, and therefore a promising source of wealth. Intangible assets are those daily created resources without physical substance as well as potential creators of economic benefit. According to business legacy, it is quite common to see intangible asset acquisition through methods of self-creation, separate purchase or asset exchange. However, when carrying out these set of operations factors such as asset lifetime must be considered. Regarding the research scope, does timeframe play a key role in asset management? Well, since firm's timelines include every activity/operation, data purchases (data as asset) are one of them. Companies are regularly advised to expense out this asset value in the amortization, and therefore include them on balance sheets at cost rather than perceived value (Goodrich, 2013). Perceived value is the worth that customers ascribe to data products (raw/processed mobile data) or services (e.g. data processing), but this "recent" and newly emerging asset makes difficult to estimate costs of production, as customers are not aware (yet) of involved factors. This is an economical instance closely related to the case study. Individually, business and urban mobility are constantly shifting but inherently they adapt to each other. Time conception is crucial when evaluating assets and their respective useful life and depreciation. When the asset is mobile data, the more updated the content is in time (i.e. recent data from mobile subscribers), the more effective it is in market performance (e.g. more accurate demand forecasts, travel pattern estimations).

1.4. Urban mobility background. The step inside mobile data analytics

This section provides a general overview of the urban mobility concept as well as its connection with mobile data analytics. This trip through the evolution in passenger transport ends up explaining a sustainable alternative less based on the private car and more on integrated and multimodal mobility services: Mobility as a Service (MaaS).

1.4.1. Mobile data & Urban mobility

Over time Big Data and urban mobility are two disciplines that have evolved separated but the Artificial Intelligence (AI) takeoff made it possible for both to feed back and get mutual benefit. These ties have shown great potential not only when attracting new businesses, but also the social dimension emerges strengthened from this communion: a livable city easily accessible by simple, less time consuming and cost-effective modal alternatives. Whether transport becomes "smart" are users (travelers) the first party perceiving their resources optimized and, indeed, this situation will gradually demand the business sector with efficient mobility strategies and effective business cases.

In the case of urban mobility, complex social interactions and new consumption patterns have changed the course of passenger transport in third world countries: from car-based use, fossil-fuel dependency and limited access by PT (e.g. suburban areas, workplaces, leisure activities), to a sustainable, competitive and multimodal transport supply that expands services and cover urban, metropolitan and regional levels. Within a Western city scenario, statistics reveal a continuous population growth and a vast number of daily travelers. Since sustainability is at stake today (Black et al. 2002), urban transport sees in technology a good industry to ally with, and through generating and processing mobility-based data there is evident chance to take competitive advantage. Wireless servers, GPS's or cell-phones are apparatus capable for capturing travel behavior to later convert these raw signals into "trips". This is fair representation of movement that has not only been studied empirically or in a practical way, there is much academical background regarding the new identity of the twenty-first-century mobility. Certainly, and accurately linked with the case study, Urry (2016) identifies five interdependent mobilities and brings new viewpoints on society and transport disciplines. With the exception of *physical movement of objects* (including food and water), the remaining *corporeal*, *imaginative*, *virtual* and *communicative travel* are meaningful when it comes to understanding the origin of raw mobility data.

- From *corporeal travel* the movement of individuals is captured. When activated location-based services, daily commuting activities e.g. work, leisure, migration or family life provide figures of habitual travel routes. This opens a range of possibilities when it comes to tracking habitual route and mode of transport preferences. Staying by the side of Urry's definition, *corporeal travel* also conforms once-in-a-lifetime displacements. Following non-familiar paths derives in using mobile applications such as Google Maps or Uber to reach the last mile. It is important to consider that this category represents a physical and real mobility, representing an overarching reason why raw data ownership has enormous monetary potential to advanced platform servers.

- *Imaginative travel* represents the "*travel affected through the images of places and people appearing on and moving across multiple print and visual media and then construct and reconstruct visions of place, travel and consumption*" (ibid.). These data sources mainly apply when creating models or similar large/small scale scenarios. However, the modeler may manipulate statistics, establish modeling criteria, select a range of feasible variables as well as interpret results. The existing degree of subjectivity throughout the process has importance in the mobility output. The bias diminishes the veracity of the data, and in terms of the degree of uncertainty, models based on *imaginative travel* detracts value from the final product.

- Travel measurement at-a-distance aligns with the definition of *virtual travel*. This modality of moving have the potential to transcend in real time and (re)form communities at a social and geographical distance. Regarding the research line, the fact of obtaining mobility data from i.e. mobile handsets enables a system architecture based on creating Virtual Trip Lines (VTLs) (Amin et al., 2008). VTLs are geographic markers (line segments) that, when crossed, activate client's location updates to monitor traffic (e.g. speed updates, travel time). With client's smartphones and GPSs, the system aggregates travel information and gives room to estimate secondary variables (e.g. routes, occupancy, modal choice) relevant in mobility models. One important characteristic related to VTLs is that "markers are placed to avoid specific privacy sensitive locations" (Hoh et al., 2011).

- In order to better serve *communicative travel* users, privacy policy frameworks may be responsible for regulating to what extent Telecom companies do collect, use, protect or handle the Personally Identifiable Information (PII) (information to identify, locate or contact individuals). *Communicative travel* consists of those one-to-one messages via texts, telephone fax or personal mobile devices, however, there is limited access to this sensitive data. With all, public and private corporations elaborate strategies according to privacy policies or analog legal frameworks to acquire and profitably negotiate with this by-product. For instance, last August 2016 the giant WhatsApp announced new Terms and Conditions that include Terms of Use and Privacy Policy (Morell Ramos, 2016). The agreement comprises measures such as prohibit hiding the location by proxy connection or similar, or a share of information with the rest of the companies of the Facebook family (that is, 8 others). But, even leaving private messages out of this, there is still a big problem deserving more attention. Exactly, what data are shared with Facebook and family? Morell says that everything except messages is shared for all kind of uses, but nothing is said about shared information being made anonymous.

Overall, since many scholars approach mobility vs. mobile data, statistical work gives another perspective to explain the current reality and the "where are we going" in terms of big data utility for transport. Firstly, in 2015 the International Union of Public Transport (UITP) published in *Statistics Brief* a 18% increase of public transport (PT) journeys compared to 2000, representing 243 billion PT journeys made in 39 countries around the world. In the Swedish context, the PT demand per capita shows a mild growth and since the introduction of the congestion charge cordon in the capital in 2006 car traffic has revealed roughly a 20% reduction. On the other hand, the global mobile data traffic is expected to experience an annual growth rate of 47%, from 7 exabytes per month in 2016 to 49 exabytes per month in 2021 (Statista, 2018). There are impressive numbers in the global big data market and the situation in Sweden follows the same path, as depicted in Figure 2.

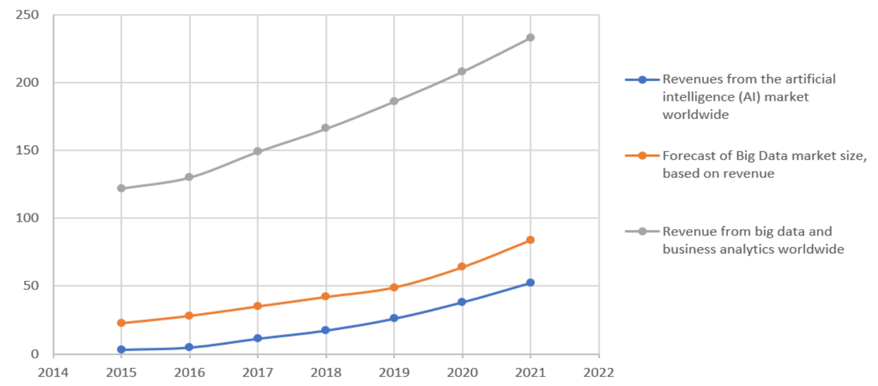

Figure 1. Forecasts of mobile data analytics in Sweden (in billion U.S. dollars)
Source: own elaboration from Statista (2018)

These figures ascertain that the tremendous mobile data expansion is here to stay, and the empire of mobile data analytics leaves no other alternative to the transportation than pure adaptation. Both industries must coordinate and fruitful feed mobility models with Big Data inputs to produce close-to-reality outputs. Data processing and analysis require partnerships between telecom companies, transport end users and even data facilitators providing an added-value service. Understanding what reasons drive alliances and business-based negotiations characterize the nature and further applications of this emergent market.

1.4.2. New Mobility models: MaaS

Today, Sustainable Urban Mobility Plans (SUMPs) address quality of life and business goals to the urban transport system and Mobility as a Service (MaaS) is a fantastic model in line with cities needs among strategic planning. MaaS is a software environment that makes a multimodal transport available to the user (traveler) with constant updates of the most cost-effective, sustainable and rapid way to journey. They are the ones who decide which mode suits best. Figure xx includes some relevant objectives and scopes that MaaS and SUMPs have in common (Wefering et al., 2013).

Table 1. Common Scopes and Objectives for MaaS and SUPMs (Wefering et al., 2013)

Objectives	Scope
Ensure all citizens are offered transport options that enable access to key destinations and services	Long-term vision and clear implementation plan
Integrated modes and all forms of transport	Participatory approach
Improve safety and security	Balanced and integrated development of all transport modes
Reduce air and noise pollution, greenhouse gas emissions and energy consumption	Assessment of current and future performance
Improve the efficiency and cost-effectiveness of the transportation of persons	Regular monitoring, review and reporting
Contribute to enhancing the attractiveness and quality of the urban environment and urban design for the benefits of citizens, the economy and society as a whole	Consideration of external costs for all transport modes

The Institutional framework for integrated mobility services in future cities – IRIMS – is a pioneer project in boosting the concept of MaaS and argues what institutional arrangements are necessary to meet this shift in travel behavior (Karlsson et al., 2017; Smith et al., 2017). In order to explain the institutional implications related to the stakeholder analysis, this thesis considers the three dimensions explained in IRIMS: *macro*, *meso* and *micro levels.* Macro refers to the national scale and deals with general societal patterns, private vehicle culture and public transport (PT) finance in the line of the

Swedish economy model; meso embraces the regional and local level where private service providers and public bodies relate; and micro comprises the level of individuals or transport users (passengers) that buy an integrated MaaS service. Since all these spheres are generally touched in the stakeholder assessment, what draws special attention to diagnose the situation in Stockholm is the meso level or metropolitan mobility behavior.

While this Service Level Agreement (SLA) stands out, experts in urban traffic, transport engineering and infrastructure management agree on the cruciality to make MaaS simple. The MaaS model can integrate all mobility services in a single solution tailored to the passenger. In a cooperation environment of stakeholders, the purpose of MaaS is to make available to users all modes of transport, at any time and depending on their needs. These are clear factors that benefit travelers but in practice MaaS may include an integrated payment system of all modes in a single app/platform: the challenge is on a single ticket to use the e.g. metro, commuter train, taxi or carpooling services.

1.5. Aim and scope

The aim of this Master Thesis is to *first* to provide a clear picture of the stakeholders involved in the Mobile Data Market and *second* to analyze how this actor network contributes to the future of the transport sector. Since data management is a promising business today, this research conducts a stakeholder analysis and explains the chain of roles from the generation of new data (e.g. geolocated data from cell phones, sensors, transport ticketing system), data processing services (add-value from raw data) to a data implementation by an end user operating in transport industry. In other words, the chain of roles related to the transaction of data i.e. who collects, who buys, who processes, who sells and who uses data for transport modelling.

Benchmarking analysis, business models and companies' practices are used to help understand the relationships between stakeholders. What is the company position related to data management, what interests or driving forces encourage them to belong to the mobile data market, what attributes can measure their power relations or to what extent the public and private sector create a barrier in urban mobility are questions that needs to be answered.

The city of Stockholm is the case study chosen to base the stakeholder network identification (firms) and sets the reference context to explain how the big data produced by Swedish companies has utility for urban transport. The motivation lies in gaining knowledge in individual/collective stakeholder characteristics and how partnerships influence transport in the near future. Moreover, since transportation is inherently connected to technological development (e.g. internet-based services, transport apps), social behavior and public-private frictions, this is a far-reaching process that also scopes the investigation in the long term. Overall, this thesis strives to respond to the following research questions.

(1) How can the transportation system can take advantage from Mobile Data Analytics/data processing? What is mobile data analysis used for in urban mobility planning? How can Big Data be described in new mobility models?

(2) Who are the stakeholders playing a role in the mobile data market and what attributes distinguish them? How stakeholders can be classified according to their relationship with mobile data? To what extent Swedish-based companies represent these stakeholders?

Although it is not directly included in the aim and research questions, it is important to clarify that throughout the investigation the concept of transport is oriented to a sustainable transport. In this case sustainability refers to a transport system responsible with the social (i.e. accessible, healthy, comfortable), economic (i.e. affordable costs and economies of scale) and especially with the environmental dimension (i.e. greater use of PT, bikes, etc and less dependence on the car). In particular urban mobility focuses on a Mobility as a Service (MaaS) scenario that constantly provides travelers the best (in time, costs) and most sustainable mobility alternative. What allows data transactions are urban mobility models (MaaS) fed from processed data, and in this sense approach a climate-friendly transportation that strives to cover passenger's needs.

1.6. Limitations

1.6.1. The innovative character of the research topic

There is not an available extensive work context that links together data management and transport planning, and even the considerable development in mobility engineering does not touch (enough) the integrated urban traffic concept in mobile applications. Data-related market niches and derived activities have recently pop up and the lack of professional information or publications slows down the research process and increases the degree of uncertainty of findings. Semi-structured interviews is the preferred method to capture context insights, but the "immaturity" of this market still "confuses" interviewees and their responses are sometimes open, fuzzy and even contradictory. Although the multitasking confidential information and the opacity to share business models, alliances and specific data-usage is not "innovative" per se, all are already existing elements that continue constraining a more detailed market understanding.

However, the fact of choosing Sweden as case study is one important opportunity that somehow reduces this barrier. Sweden is country with open-data sources that perhaps other contexts would not facilitate. The culture of transparency provides little more detailed information at company's websites or institutional reports (e.g. profitability, services, some business strategies, etc) as well as direct contacts of experts to conduct interviews.

1.7. Structure

This master thesis follows a structure made of nine chapters and each chapter is organized in sections. This first is the **introduction** chapter and the remaining are described below.

Chapter 2 introduces the **theoretical background** that explains specific concepts used along the investigation besides giving support to the method, analysis and research findings. Since the thesis aims to build knowledge on data-related actor networks, this chapter combines stakeholder theories (stakeholder theory, power relations and network analytics) with the business dimension by the side of business models and a benchmarking approach.

Chapter 3 comprises the **method** and presents the structural framework adopted during the investigation. The type of research methods and the sequence of research tasks are described.

Chapter 4 explores the **case study background** conditions and defines relevant factors of the city of Stockholm that influence the stakeholder analysis. It is an overview around socio-demographic conditions, smartphone usage forecasts and a vision of the current transport supply in Stockholm, as well as the range of measures adopted in the line of a multimodal and integrated transport system.

Chapter 5 provides a preliminary **stakeholder identification** and sets a framework to organize them in three clusters: *data suppliers, data facilitators* and *data users*. Presenting a seed scenario of stakeholders answers part of the second research question.

Chapter 6 comprises the **analysis of stakeholder relationships within clusters**. In each of the three clusters the study deepens into stakeholder types as well as their roles, attributes and how they relate in the data-driven market. Using Stockholm as a reference context, the analysis investigates the degree of involvement of stakeholders in a series of policy areas and also expresses in a graphic the relationship between their interest in adapting to the demands of the future and their power to impact the market today (merely based on profitability and technological/knowledge means). In addition, Swedish companies are identified with each of these stakeholders and classified according to their profitability.

Chapter 7 comprises the **analysis of stakeholder relationships between clusters**. Representing interviewees' responses, the main source of information, a range of Swedish-based companies exemplify the general market behavior and these network ties are assessed in pairs to simplify the analysis.

Chapter 8 introduces a **discussion** on how the analyzed institutional relationships impact the Mobility as a Service (MaaS) development in the city of Stockholm. This chapter debates over the utility of this stakeholder analysis into a future MaaS, the current situation of MaaS in Stockholm as well as a range of challenges and limitations that the capital is facing today and with importance for the future.

The last Chapter 9 embraces a **concluding discussion** that gathers research findings and all answers for the research questions.

2. Theory

This section presents the theoretical framework that is used to analyze the case study City of Stockholm. It sets a basis to comprehensively follow the terminology and structure adopted throughout this research.

The project will be conducted in line with different *Stakeholder Theories* (Reed et al., 2009; Jensen, 2010; Freeman, 2004) and relevant sciences exploring the business relationships in between actors in the network. *Stakeholder Theory* and complementary research in *Power Relations* (Cars et al, 2002; Healey, 2003; Agger & Löfgren, 2008) as well as *Clustering* (Wu & Leahy, 1993) dig into the nature of relations between actors and offer a structured order to analyze market players. It will also make use of Business theories such as approaches in *Benchmarking Theory* (Camp, 1989), *Business models* (Redman, 2015; Schroeder, 2016) and *Business Intelligence & Analytics* (Hsinchun et al., 2012) provide a vision of business performances around mobile data. This stakeholder analysis is ultimately applied in a *MaaS* model to meet the goals of a sustainable transport future.

2.1. Stakeholder theories

Mobile Data Analytics (MDA) is a quite recent market niche that rapidly gains new players. Companies sharpen their instinct of competition and strategically support "the need to know from others" with constant knowledge exchange and advances in communication. This phenomenon creates commercial relationships and the identification of current and potential actors. How they interplay in the network is a complex task to draw attention. The intention here is to justify the decisions of creating clusters in order to clarify the relationships within and in-between them and above all serve a basis to support research questions.

2.1.1. Stakeholder Theory

Stakeholder Theory is the first stage to identify stakeholders and their relations. Traditionally, a stakeholder is a character who “can affect or is affected by the achievement of the organization’s objectives” (Freeman, 1984:46), and the theory distinguishes two dimensions of stakeholders: *individual* and *collective*. While *individual stakeholders* are single human beings distinguished from a group, the term *collective* implies aggregation or collaboration between various individual stakeholders (Reed et al., 2009). In general, this research project deals with *collective stakeholders’* particularities (e.g. companies or governmental organizations) and the concept of *individual stakeholder* only shows up in terms of the transport user/passenger figure.

The stakeholder theory introduces recommendations to characterize actors and it simplifies the wide range of (possible) features into two categories of *independent* and *interdependent attributes*. Independent attributes refer to exclusive and internal characteristics of the company itself such as business models or company size, meanwhile interdependent attributes relate to the influence by external market companies (competitors) operating in the Stockholm region, as is the case of decision making, leveraging knowledge or even delegating data-processing services (Ching-Lai & Kwangsun, 1981). When structuring the actor network the analysis of attributes is fundamental, and depending on similitudes in data management attributes even sub-networks of stakeholders can emerge in order to detail stakeholder relationships.

From a business perspective, several authors explore this facet of the stakeholder theory that is in line with the case study business environment. One hypothesis taken in the research agrees on Jensen’s assumption (2010) that firms are optimizing their performance (e.g. strategic decision making, use of resources) in front of the competition. The play between economic and ethics theoretically accepts that *"values are necessarily and explicitly a part of doing business"* (Freeman, 1994), however, when making hypothesis in the stakeholder identification this study conducts a narrow view of Freeman's theory. The hardness in set moral principles in business and value creation (related to added-value services to mobile data) concludes that the actor network analysis bases on business performance and company profitability of *collective stakeholders* (e.g. turnover), and only takes into consideration ethic values in terms simplifying the urban mobility journey experience to *individual stakeholders* (e.g. an accessible, equal, easy, rapid and sustainable MaaS transit).

2.1.2. Power Relation Theory

During last decades "governance" models put more interest in social order and in sharing responsibilities in the multi-level polity (Cars et al, 2002). As grassroots, Healey (2003) treats the concept of *power* and remarks big complexity next to actor networks: power is not a solely force to make things happen, it is a dimension strongly based on "relations". In general, stakeholder involvement is an interesting topic researched in multiple disciplines, but its connection with the new data-mobility model in the city of Stockholm is a good example of the emergent changes. Policy-making is not only accountable for those politicians regularly elected, but also corporations or even community-led organizations should be "somehow" playing this role (Agger & Löfgren, 2008).

The *power relation theory* is a social network approach helpful in illustrating network properties and relationships among participants in the mobile data market. There is a debate around the creation of power and what facets have the greatest influence in the stakeholder identification. Related with data acquisition and management, the ownership of high-quality information is the *power* that lead actors to gain a privileged position, attracting more businesses to take over competitors.

Following the reflection on the same path, another face of power is *consensus.* It mainly centers in networks of communication. Consensus gives the power to predict actions and derived conflicts (Haugaard, 2003), and data-related business transactions see clear benefits from company-to-company dialogues: it is an opportunity to get "know-how" insights and valuable knowledge to an operational task optimization.

2.1.3. Data clustering theory as operational framework

In a scenario where urban mobility models are powered by mobile data, there are many stakeholders underway from observing common roles and business cases. The fact of owning certain attributes opens up different possibilities to organize the actors in the network, and *data clustering* is a fantastic approach (Wu & Leahy, 1993). Data clustering is a graph theoretic technique that relates nodes in hierarchies, flows, trees and can reduce the network scale creating sub-partitions. In practice, the stakeholder analysis applies *clustering* through a flow or value chain sequence, representing this the operational framework that classifies stakeholders. By definition, networks consist of a large system made of *nodes* and *links* between nodes through which information is distributed (Hsinchun et al., 2012) (Figure 1). Corporations and individual end users (travelers) are these nodal points, and mobile data is the information that connects nodes (links), reflecting which nodes are related and also the direction / orientation of the information flow.

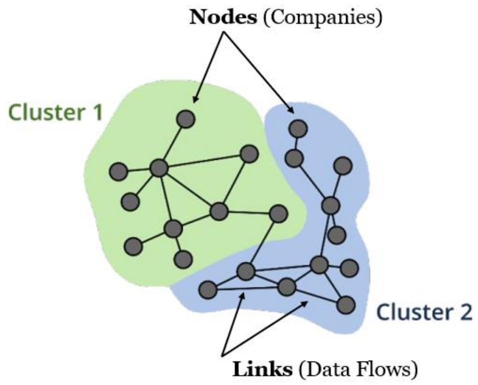

Figure 2. Clusters, nodes and links in graphs
Source. Own elaboration from Burrieza (2018)

2.2. Business theories

From a business perspective, the following theories of *Benchmarking, Business models* and *Business Intelligence and Analytics* provide academical knowledge to comprehend stakeholder's performance and reach a detailed analysis of their relationships.

2.2.1. Benchmarking theory

Since the modern economy is far from following stable guidelines and continually faces changes, companies strive for playing a role in the global competition context. There are multiple theories exploring economy improvement or effective business performances, however, since decades benchmarking properly fits in these challenging environments.

One of the most accepted definitions of Benchmarking relates to "the search for the best industry practices which will lead to exceptional performance through the implementation of these best practices" (Camp, 1989), encouraging key themes of business measurement, comparison and improvement. The essence of benchmarking is to gain quality beyond the competition, technology before the competition and costs below the competition, and therefore push companies to gain market share and reach competitive advantage.

So, this research applies benchmarking from the perspective of a business environment where mobile data (e.g. geolocated from cell phones, sensors, etc) is core subject (product) to open a market study around. The diagnosis of business cases, business models and (internal and external) company behavior assumes that companies are "doing their best", so this hypothesis relates to benchmarking in the line that stakeholders struggle to optimize their resources.

2.2.2. Business models

If we could take a picture of how companies organize and develop business strategies, the result would be very diverse. Business models have developed dramatically in recent years due to technological innovation, but above all due to the use of new data sources as "promising" asset.

There is a wide range of possibilities in data collection and analytics and this circumstance leads companies to "flex their strategic muscles" and compete against commerce competitors. In line with a business model rapid innovation, Redman (2015) highlights four popular ways based on making better decision with the better data: (1) cost reduction through improved data quality, (2) "content is king", (3) data-driven innovation and (4) become increasingly data-driven in everything one does. In general, these proposals conform the typical concept of competence, based on innovating in a better product provision and lowering cost. However, Redman argues that what is novel is not related with making the better decision, it is “driving the efforts with data”.

These strategies broad a spectrum of actors where they interrelate as individuals or in groups. The better business performances, the complex actor associations. With all, *pure service providers* (collect novel data e.g. Uber, Telecoms), intermediators (data facilitators e.g. Google) (*infomediation*) and platform interfaces (servers of customer needs) (*informationalization*) exemplify to what extent data is an elementary resource for new business models (ibid). By and large, this great variety of agents in the market corresponds to a great variety of business models. For this reason, to make this study more understandable and practical this section explains Schroeder’s (2016) proposal as a theoretical basis to dig into business models. The following lines introduce *informing business decisions, data brokers, data analytics as a service* and *tool providers* regarding Schroeder’s perception as well as a personal interpretation that connects them to the case study.

- Informing business decisions: The generation of big data can be initially associated to those trading activities where monetary profits are at stake, however, the usefulness of the data goes further and remains a crucial input for internal decision-making. Data enable business process refinement and open paths to innovative management strategies that benefit any company performance (Schroeder, 2016). One example related to the case study are those network service providers firms when playing their business-to-business (B2B) role. Since primary business models are based on capture subscribers and an increase smartphone sale, the launch of special low fare promotions or by reward cards enable telecom companies to collect data about customers patterns when moving from one to another network operator. This type of strategies provide data applicable in internal decisions regarding pricing, stock, business models, etc.

- Data brokers: Within a business scenario brokers are the market intermediaries that serve a product that does not primarily create to a third party with an added value (Schroeder, 2016). This thesis labels brokers as data facilitators that fundamentally buy big data to one party and sell it raw to another, besides providing benchmarking and the deliverance of analysis and insights. Depending on the reasons and the work areas of companies, market research firms and social media companies put in practice this business model. While the former collects data from data provider entities and adapts the delivered content/structure in function of client needs, what the latter does could is selling the access of the daily generated data (e.g. location, downloads, clicks) to website owners that, likewise, act as broker in the face of external parties.

- Data analytics as a service: The essence of the *data analytics as service* business model is that companies want data in a practical way, not incomprehensive raw material hardly applied in doing business. When the issue is in the lack of mediums to process large amounts of data, the idea is to provide services based on differentiation and create new service offerings with contextual relevance. The use of data (internally generated at the company or acquired from external parties, or a combination of both) to is to elaborate outputs such as trade analysis, summary, feedback or enable advertising (Schroeder, 2016). One instance explained in the analysis relates to those startups with transport apps that provide data-driven advice about travel routes/ times to their consumers, improving their experience and ensuring customer “loyalty”.

- Tools providers: Companies with expertise in software and hardware for servers and workstations, storage media, statistical analysis, remote sensors, encryption technology or other networking tools use this type of business model (Schroeder, 2016). Regarding the broad range of mobile data stakeholders (e.g. Transport Operators, transport apps, Public Administration) tool providers operate within the telecommunication industry and serve the technological equipment and network infrastructure (e.g. Telecoms, Handset manufacturers) to monitor the big data used in business.

Furthermore, the way of applying rationale in business structures is a challenging task demanding further regulation, and at this point there is an emergent figure in charge of safeguarding individual privacy, the *data broker*. The issue of *commercial trust vs. public good notwithstanding* (International Transport Forum, 2016) draws attention in the controversial share of personal information. Do citizens rely on company's performance that use personal data? are there enough legal frameworks controlling data monetization? to what extent is these data protected? These questions could weaken business models if they apparently prioritize personal gain rather than privacy.

2.2.3. Business Intelligence and Analytics Theory

Contemporary research is progressively including the concept of *Business Intelligence and Analytics* (BI&A) since companies are facing a massive growth in computing tools and data-based problems. Including a wide range of applications such as e-commerce, transportation, outsourcing or market-intelligence, Hsinchun et al. (2012) see in BI&A a discipline provider of methodologies and practices dealing with data mining. The recent hype in *big data analytics* mirrors complexity in solving large amount of data. Increasing knowledge in BI is gaining momentum in business markets and it creates enormous opportunities used by enterprises in terms of strategic performance management, high-impact predictions and data analysis. The integration of internal and external data from the market and "listening" its voice reinforce simultaneously the business community and individual actions. Next to BI ideals companies count with tools and schemes to solve complex data problems.

Both academia and industry recognize the importance of understanding the evolution of BI&A. Regarding Hsinchun et al. approach, his overview illustrates key characteristics and capabilities of BI&A and aggregates them in three phases: *BI&A 1.0, BI&A 2.0* and *BI&A 3.0*.

First, initiated in 1950s, *BI&A 1.0* draws a new data management field with priorities in searching *stru*ctured content and Data-Based Management Systems (DBMS). Dashboard, scorecards, data mining and statistical analysis were tools applied to interactively visualize and make specific-data-based predictions.

Second, in the 2000s Internet explosion and new Web-based interfaces lead a transition to BI&A 2.0. This technological growth revolutionized business performances with innovative data collection strategies and consequently, affecting those interactions between companies and customers. At that point, web intelligence, opinion mining or spatial-temporal analysis characterize this second cycle, and unstructured content mainly drive researchers and practitioners work.

Third, Mobile Business Intelligence (MBI) stars the third BI&A 3.0 era. MBI is a discipline ruled by human-mobile interactions and the potent inertia from "the Internet of things" (Atzori et al., 2010). This illustrates the current context where data is the resulting outcome from mobiles and sensor-based technologies. Measuring and assessing location-related, person-centered and context-relevant information is imperative for company's interests. New market opportunities emerge as well as profitable partnerships.

3. Method

This section introduces the research tasks and methodology used during the investigation. There are seven research tasks used in this study and this section addresses in detail the work sequence, applicability of methods and the range of research words and tools used to get the results.

3.1. Case study as methodology

There are not many research or professional publications discussing actor networks based on mobile data, and a set of quantitative and qualitative methods (Denscombe, 2010) best approach this debate with knowledge of sector experts. The city of Stockholm is the case study on which the thesis revolves around, and one motivating factor is its international recognition as developer of sustainable future challenges (e.g. fossil-fuel free by 2040, dense bike infrastructure in the inner-city). Advanced technology and budgetary resources make the city an interesting case study, and this added to an extensive research culture may facilitate contacts to interview and better market insights. The numerous profitable companies related to data is another favorable circumstance and, if compared with other countries, general policy transparency and (partial) sharing of internal information may reduce barriers during the investigation and turns website review a highly efficient method.

3.2. Research tasks

- The first task consists of exploring the **background conditions of the case study** through literature review and analysis of events and documents via Internet. To clarify concepts and theories *Big Data market, Mobile Data Analytics, stakeholders, urban mobility, MaaS* or *business models* are preferred research words that contribute to set the research basis and get through goals and aim. As an observational snowball sampling, document and website analysis cover a range of scientific publications (academical research, thesis, scientific journals), institutional documents (final reports of urban plans e.g. Urban Mobility Strategy in Stockholm) and non-institutional documents (e.g. organizational documents posted on websites, mobility blogs or MaaS Congresses summaries). This phase provides a comprehensive image of how the mobile data market applies in urban transport today.

- The second task recognizes the stakeholders participating in this data-related network and provides a **seed scenario of stakeholders**. The term “seed” refers to a preliminary scenario of stakeholders that are the starting point to conduct interviews, besides being a flexible group open to progressively incorporate more members during the analysis (Masser et al., 1992). The process to come up with seed stakeholders involves a review of documents available online (e.g. Stockholm mobility plans, transport apps reports, International Transport Forums), stakeholders’ websites (e.g. Telecom companies services, PT operators) and published statistics about profitability rankings in the telecommunication industry, big data forecasts or mobile subscriptions in Sweden. So, this research task fundamentally uses online sources to establish a preliminary scenario of actors.

- The third task consists of gathering contacts and preparation to conduct **semi-structured interviews**. Website review is again the method used to search for contacts. Fundamentally developed face-to-face or via skype, semi-structured interviews involve professionals in different disciplines and questionnaires adapt to their roles and potential findings from Telecom companies, Public Transport Operators, Transport Administrations, Data processing experts or individual travelers. The respondent can openly answer a structured questionnaire (see Appendix 1), providing comments and developing ideas. Communication between parts is allowed and the interaction is recorded. Interviews are manually transcript and a schematic summary, respectively, accompanies them to facilitate the analysis. The research schedules a two-week period to conduct semi-structured interviews to collect first-hand information from experts. Due to the recent hype of the research topic, this data is not available in articles, reports or websites. Open interviews are the primary method to understand stakeholder attributes, business models, collaborations and future strategies allocated the Swedish context.

- The fourth task consists of a **qualitative assessment of interviews** and uses the answers to **classify stakeholders in clusters** based on their independent attributes. Answers about business models, company size and specially on actions in data management (e.g. creation, processing, applications) confirm the suitability of organizing stakeholders along a value chain flow of *data providers, data facilitators* and *data users*. Clustering is the operational framework to analyze the stakeholder's interrelations using a double scale: relationships within clusters and relationships between clusters.

- The fifth task analyzes **stakeholders' relationships within clusters**. Based on interviews, *graphical mapping* and the *power-interest grid* are methods that complement the network analysis. The strategy is to put the *Power Theory* into practice and illustrate in an image the "real" stakeholders in Sweden and their relationships within each cluster. Firstly, Swedish-based companies are classified by the independent attribute of company size (number of employees and annual turnover), and, secondly, the Power-interest grid further applies the *Power Theory* to evaluate the actor network. Eden & Ackermann (1998) introduces that the power versus interest grid is a 2x2 matrix made of four categories of stakeholders: *players, subjects, context setters* and *crowd* (see Figure 9). However, this thesis adapts this method and understands the interest dimension as the degree of involvement of stakeholders in the cluster or issue at hand while the power dimension measures the stakeholder competence to affect the cluster or issues in the future (Bryson, 2007).

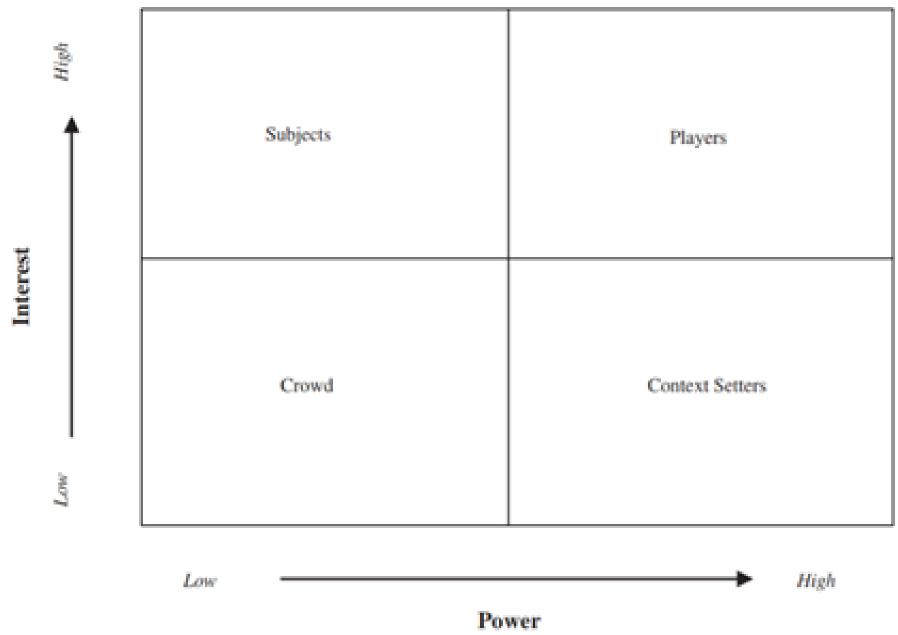

Figure 3. Power versus interest grid
Source: Eden & Ackermann (1998: 122)

- The sixth task analyzes **stakeholders' relationships between clusters.** The methodology bases on diagnosing interdepencies between clusters obtained from expert opinions.

- The seventh task consists of **evaluating the references** and **discussing how the stakeholder analysis can contribute to a sustainable transport** future. Since MaaS is a mobility model that uses technology and big data (apps, platforms, location systems) to boost green urban transit, analysis of external case studies and professional publications encourage reflections about how MaaS is in Stockholm today. This is done in line with previous interviews of task three to traffic managers, transport operators and infrastructure managers, that also oriented questions to Maas. All together sets the basis to identify gaps in the actor network that prevent a complete MaaS implementation in Stockholm, besides inspiring the last discussion and related recommendations.

4. Case study background. Explanatory factors in Stockholm

This section explores some characteristic features of the city of Stockholm that connect urban mobility with the new coming torrent of data. This is the starting point to construct the research on the actor network and their implications in MaaS. The task of describing the following factors sheds light on the type of collaborations between the Telecommunication and Transport industry

4.1. Socio-demographic conditions

Stockholm is facing one of the most rapid growths of the metropolitan areas in Europe and with 952,000 inhabitants in 2017, only the municipality concentrates roughly 10% of the Swedish population. According to the Urban Mobility Strategy, *"Stockholm will have 25 per cent more inhabitants by 2030. The City's Vision 2030 describes what it will be like to live in, work in and visit Stockholm. Exactly how the city will grow is described in the City Plan, the Walkable City: the density of existing housing developments is to increase and 100,000 new homes are to be built thus enabling more people to live and work in the same area"* (Stockholms stad, 2012).

Since *population density* measures the aggregation of citizens in specific areas, it contributes to estimate urban mobility patterns. The city hosts 4,937 inhabitants/km^2 and as can be seen in Figure 3 the urban morphology denotes a scattered distribution. However, when zooming in there is much higher compactness in the inner city (innerstad) in comparison with the average of the county region.

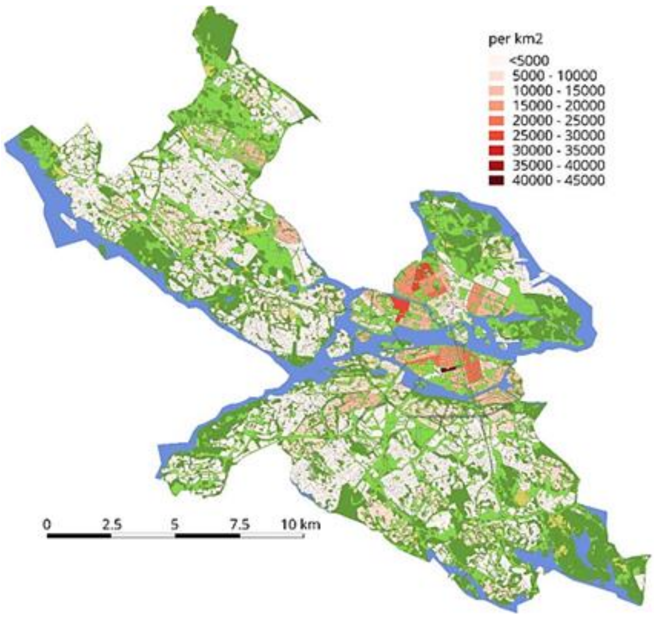

Figure 4. Stockholm city density by neighborhoods.
Source: Burrieza (2018)

Levinson & Kumar (1997) consider a correlation between the concentration of people and the reduction of commuting distance. Models of future mobility behavior often see in mobile data signals a useful input, but in terms of the determining an area for data collection the commuting average distance draws these "boundaries" in 10 km in the inner city and 12 km in the Municipality of Stockholm (SLL, 2015).

4.2. Mobile terminals in Sweden

Apart from urban density, the number of cell-phone terminals is another variable that influence transport planning: first due to an "always located" provision of real-time information, and second considering the range of apps linked to transport operators that convert these raw data into trips. Almost 8 out of 10 in the EU surfed via a mobile or smartphone in 2016 (Eurostat, 2016), and in Sweden statistics forecast a substantial growth in the number of smartphones users, from 6,5 to 9,3 million between 2015 and 2022, respectively (See Figure 4, Statista, 2018). The number of transport apps is increasing (e.g. CityMap, GoogleMaps, Uber, SL) in consonance with a higher quality of their services (accurate positioning, real-time information or traffic congestion). More and more subscribers access apps across smartphone interfaces, showing the massive power of technology and telecommunications industries in the business sector.

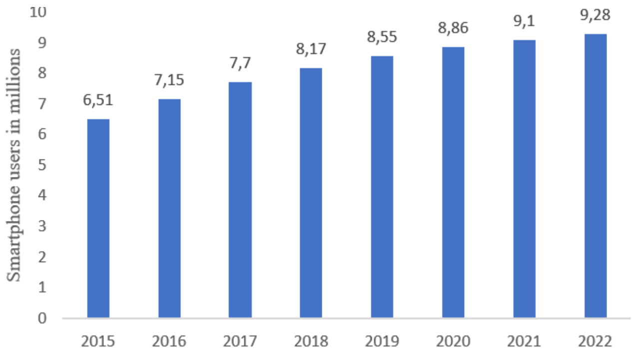

Figure 5. Forecast of smartphone users in Sweden from 2015 to 2022 (in millions). Source: Statista (2018)

4.3. Transport supply in Stockholm

This section summarizes the transport supply in the city of Stockholm. Table 2 introduces the different modes of transport that are operating in the city and lists the number PT lines. How the modal split situation is in the capital today is also mentioned below.

Table 2. Transport supply in Stockholm

Mode of transport	Lines	Characteristics
PT – Bus	540 Bus routes 5319 Bus stops	Blåbuss (Blue buses): 18 lines, 5 in the inner-cityRed bus: regular buses
PT - Tunnelbana (subway)	Green line (3 lines) Blue line (2 lines) Red line (2 lines)	Inner-city & metropolitan area (Figure 5)
PT - Spårvagn (Tram)	4 lines	
PT - Lokalbana (Light rail)	Saltsjöbanan (2 lines) Roslagsbanan (3 lines)	
PT - Pendeltåg (commuter train)	Pink line (7 lines)	
PT - Ferry	4 lines	Hammarby ferry, Djurgårdsfärjan, Archipelago traffic, Sjövägen
Airport Express Train	1 line	Arlanda Express
Airport Bus Shuttle (Flygbussarna)	4 lines	Connect Stockholm city and Arlanda, Skavsta, Bromma and Västerås Airports
Uber – car based		Inner-city ride hailing
Car pool		Car rental & Leasing Inner- city & metropolitan area
Car rental		Inner- city & metropolitan area
Bike rental & sharing		Inner city
Scooter renting		Inner city

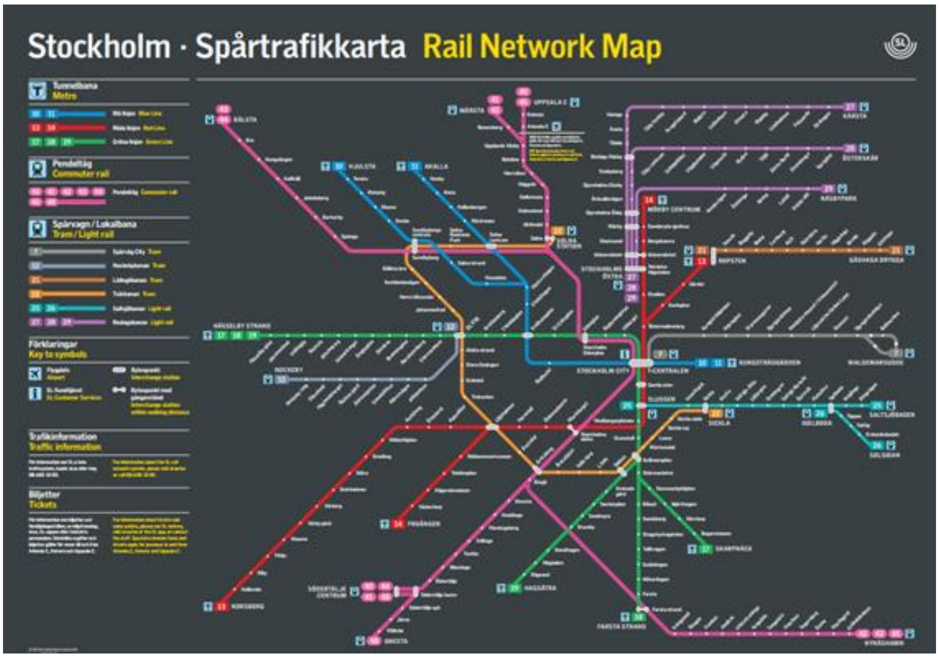

Figure 5. Public Transport, Railway system in Stockholm.
Source: Rail services, SL: http://sl.se/ficktid/karta/vinter/SL_Sp%C3%A5rtrafik.pdf

Although the land distribution of Stockholm is quite dispersed, the capital counts with a robust PT system that connects the inner-city and suburbs. The bus, metro, commuter train and tram cover Nacka, Norrtälje, Södertälje, Värmdö, Sigtuna, Österåker, Stockholm, Ekerö, Haninge and Huddinge (see Figure 6): the longest bus line (639) runs 94 km with 76 stops, while the shortest (507) 1 km with 2 stops. This transport supply makes the city less car dependent and attractive to commute. Accessibility to transport is vital in Stockholm and some examples are the buses ramps and floor level access, same level between trains al platforms or audio-visual displays with digital information.

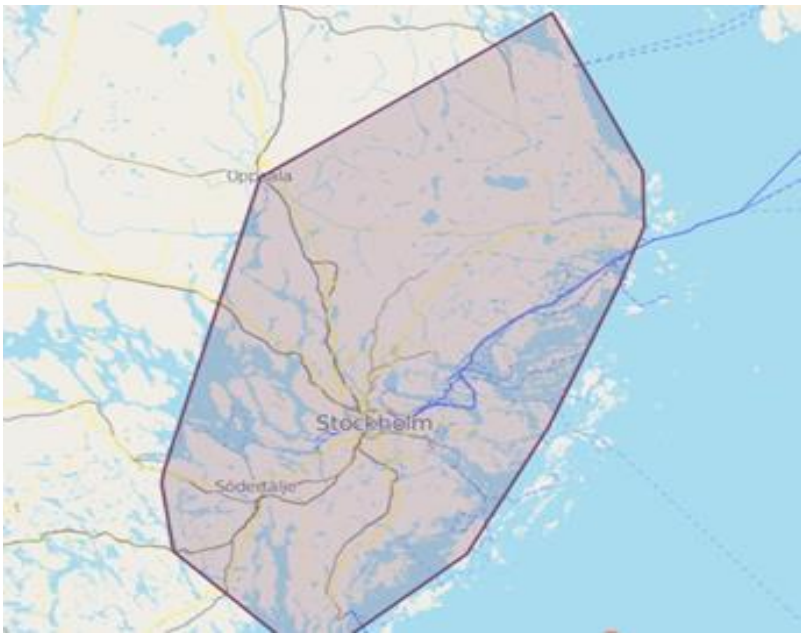

Figure 7. SL coverage area map.
Source: https://moovitapp.com/index/en/public_transit-lines-Stockholm-1-1083-10211

Currently, the economic incentives to PT and the permanent congestion tax in the city area (between 1€ - 2€) shows a modal split with roughly 25% of private cars, 30% of PT and a share of 45% for the soft modes (walking and cycling). The city of Stockholm aims to increase cycling from the 9% (2013) to 12% (2018) and a minimum 18% by 2030. Figure 7 illustrates how is the modal split today, with a high share for sustainable modes in detriment of individual cars.

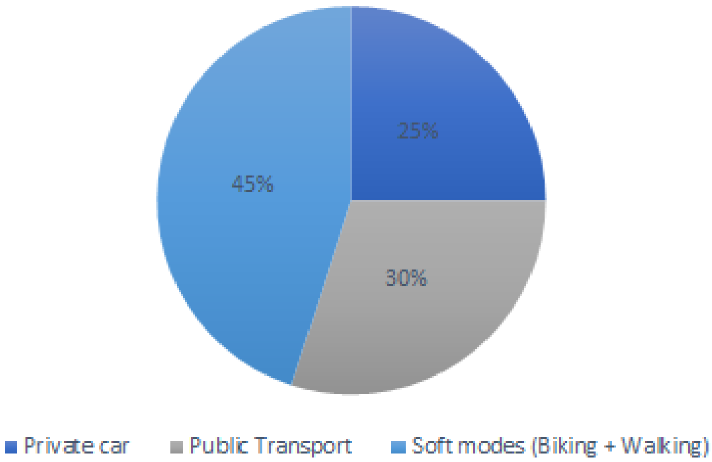

Figure 8. Modal Split in Stockholm
Source: own elaboration from Sootfree for the climate (2018)

4.4. Mobility towards multimodality in Stockholm

Increasingly, the city of Stockholm and other traditional stakeholders (Table 3) join forces to readapt the transport of passengers and to make the city accessible, vibrant and sustainable. The Vision 2030 and the City Plan (The Walkable City) carry out an *Urban Mobility Strategy* oriented to an efficient car travel future, but most importantly is the prioritized move to high capacity modes (pedestrian, bicycle, PT), freeing public spaces from cars: *A city with cars – not a city for cars* (Stockholms stad, 2012).

Table 3. Actors included in the Urban Mobility Strategy of Stockholm.
Source: own elaboration from Stockholms stad (2012)

Actors included in the Urban Mobility Strategy of Stockholm
Swedish Government
Swedish Transport Administration
The City of Stockholm Planning Administration
The City of Stockholm Development Administration
The City of Stockholm Traffic Administration
Public Transport Authority (SL)
The Waste Management Committee
County Council (regional public transport agency)
The Urban Environment Council
Environmental and Health Administration
Others: Local police, Neighboring municipalities, delivery and private companies
The city's inhabitants

Since 2006 the fact of circulating through the metropolitan area requires a congestion tax payment to all private car drivers. Additional measures relate to the limiting parking spaces in the inner city and the city of Stockholm is responsible for parking management. The operator Stockholm Parkering runs off-street parking facilities, and to make it simple, the parking app "Betala P" (Pay P) offers customers the possibility to pay both on-street and off-street parking in all places of the city (Stockholm Parkering, 2018). The city encourages modal change by 32 Park & Rides with 3546 parking spaces, bike parking next to metro stations and free charging stations for electric cars (only to pay parking fees), but what is foreseen is that by 2030 parking demand should not surpass the 85% of current available lots.

By and large, the local commitment promotes multimodality and the current era of "sharing" challenges Stockholm to become a city of easy transit. Despite the quite recent interest in MaaS in Sweden, in 2011‘The flexible traveler’ (*Den flexible trafikanten*) is the first project that feasibly introduces the ideal of multimodality. This initiative conceives an integrative mobility package that increases metropolitan accessibility, provides flexible commuting alternatives, reduces mobility costs and gives support to the urban sustainability goals (Boethius and Arby, 2011, cited in Smith et al., 2017). This is a preliminary business approach that in 2014 is further developed in the Go:Smart project, that in 2014 launched a pilot named UbiGo in the city of Gothenburg. UbiGo offers a multimodal service based on a city-wide subscription and its success lies in integrating in one app PT, car sharing, taxi, pool, car rental and bike.

In order to support the MaaS community, the city of Stockholm also initiated the UbiGo pilot in March 2018. With UbiGo app travelers have the opportunity to book a car, plan a route or download a PT ticket. There is much controversy related to the current reality of MaaS, and it is in the following chapter 8 where this thesis deeply analyses the Swedish case and also provides an image of the bodies that conform the actor network that see MaaS their central issue.

Finally, as UbiGo is still a pilot, Xerox GoLA and GoDenver App are two good examples of North American MaaS apps running today, and the intention here is to set a reference framework that motivates active public and private collaborations and get the city of Stockholm inspired with ideas that have succeed, at least in another Western context. Through GoLA and GoDenver, which are multimodal-routing and booking apps platforms, Xerox collects the location data and shares it with city planners of the cities of Los Angeles and Denver, respectively. These public-private partnerships exchange knowledge in the benefit of a sustainable growth of the territory but also encourages a provision of additional mobility services through smart apps: a strategic aggregation of modes of transport (biking, taxi, transit, car-sharing, ride-hailing), routing alternatives according to user's parameters such as the shortest, cheapest or most sustainable (measured CO2 emissions), booking services and payment integration (International Transport Forum, 2016).

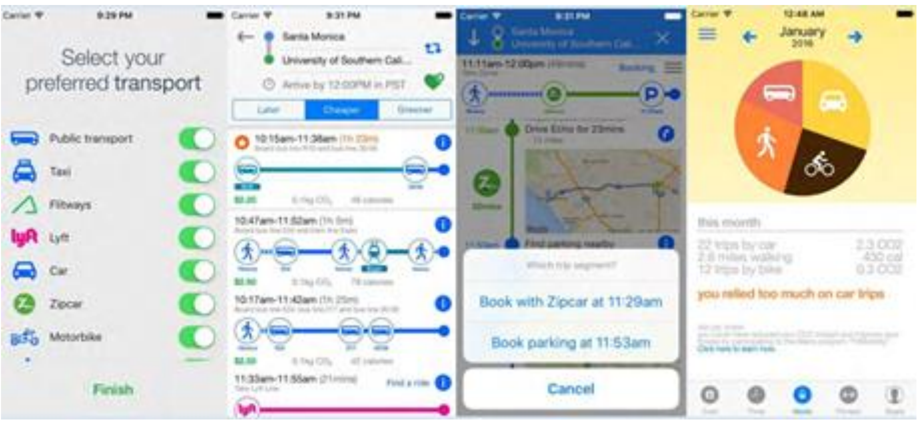

Figure 9. Multimodal transport GoLA app.
Source: http://appadvice.com/review/go-la

5. Identification of Stakeholders. Clustering

This chapter provides a preliminary identification of stakeholders and sets a framework to organize them, as a seed scenario of the data-driven market. This chapter introduces the stakeholder analysis as well as the initial key points to answer part of the second research question.

Regarding theory and background conditions, the evolution of big data and its increasing use in traffic management made to suppose a complex network of stakeholders. These hypotheses are not misguided in the line that every stakeholder has more than one *attribute*, and a debate on *independent attributes* motivates the first phase of the stakeholder analysis. Directly or indirectly, multiple companies take advantage on mobile data to improve their performance: the telecommunication industry, transportation sector, government & politics, passengers, market researchers, etc. They operate with different types of *business models* and develop specific business cases adapted to their *company size* and their financial/technical/intellectual resources. These attributes partially characterize these seed of stakeholders, but what is key to organize them in a network are the attributes related to *actions to data*: generation of new data, data analyzing or a mere implementation of processed data. Figure 10 shows the *independent attributes* of each of the three clusters.

Stakeholder group/ cluster	Independent attributes		
	Actions to data	Business model	Company size
Data supplier	Generation of new data	Data vendors	Generally large companies (Telecom companies)
Data facilitator	Provide added-value services from raw data: data processing	Buyers of raw data and vendors of processed data	All company sizes
Data user	Implement results from processed data (e.g. demand management, fleet operations, traffic congestion)	Data buyers, generally	Transport Operators, Infrastructure Managers, etc

Figure 10. Stakeholder regrouping based on independent attributes

The use of *independent attributes* to regroup stakeholders depends on the process of interviewing experts in the sector, and comments on internal strategies added-value to the clustering task. Since questions also focused on *interdependent attributes*, the study relates companies with other market players and uses this structure of three clusters as network basis. This method expands the debate on stakeholders interactions in the case study, which is developed in the following chapters.

6. Ties in the Network. Stakeholder relationship within clusters

The methodology used in semi-structured interviews, website and literature review coincide that a value chain can organize stakeholder relationships. In other words, and as illustrated in Figure 11, the actor-network of mobile data analytics follows a sequence of three clusters where companies develop and implement specific business activities: data suppliers (first-party data dealers), data facilitators (intermediaries that add-value) and data users (potential customers that integrate these data among transport benefit (MaaS)).
Since interviewees agree that the actor network is a "complex mess" (in the identification of actors and their interdependencies), a double scale analysis (relationships within and between clusters) tames the wicked problem and explains stakeholder relationships within and between clusters. Once this is understood, this chapter drills down each category and describes actor's roles and internal networks, besides providing an imagine of the Swedish market and context characteristics.

Figure 11. Actor network of mobile data analytics in a three-cluster sequence

6.1. Data suppliers

With high-tech apparatus (cell-phones, tablets) and state-of-the-art collecting data tools experts can model patterns of citizens e.g. commuting trends, travel hours, shopping, leisure interests, visited websites, preferred apps, etc. It is the **telecommunication industry** the first party dealing with this promising information (new, original) and regarding what a Telecom interviewee said, "*we know everything our clients do, […] but nowadays these data are transferred in a market that is still immature and we cannot keep us stuck*". This argument demands efforts in innovative business models in the line of activity specialization and product personalization.

From a general perspective of the cluster of *data suppliers*, mobile data industries proceed following a ***value chain*** structure and this convergence of industries adds-value to the resulting mobile data service (Maitland et al., 2002), more focused on the range of services and less on the technology. This organization optimizes production processes and business performances, driving sub-sectors to emerge and therefore an increase in the level of competition to enter the market.

The Telecommunication industry has no choice but to adapt to newer services - 2G, 3G, 4G, upcoming 5G –, to their costs and prices, and overall must control the flow of information and bottleneck facilities (ibid). Depending on the size of companies, the barriers to entry and exit the market compromise the level of innovation and investment. The number of market players vary as well as the likelihood of additional intermediaries. As an example, within the data supplier category, the 3G value chain gathers a range of actors playing the roles of network operators, ICT providers, MVNOs, enablers and network equipment manufacturers (see Figure 12). Their position in the chain is briefly explained below, however, due to Telecoms represent a crucial piece in the puzzle of mobile data analytics, this section penetrates more into the role of Network Operators.

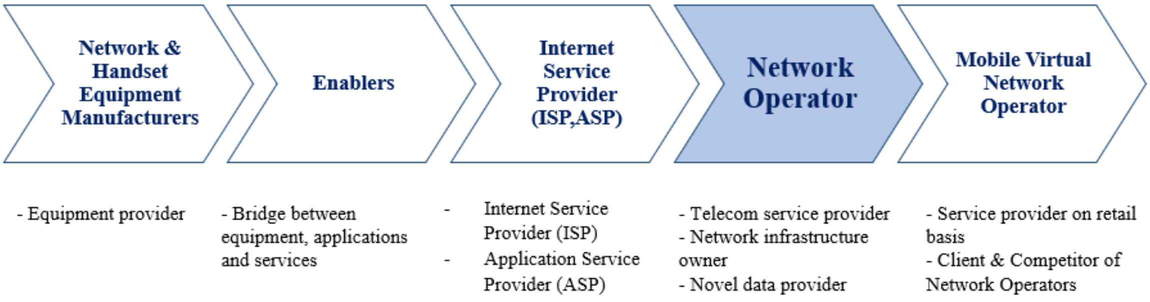

Figure 12. Data suppliers organized in a value chain

Overall, even though each component of the chain owns characteristic features, what all have in common is the attitude to perform in the face of competition with feasible, effective, efficient and acceptable strategies. Some are direct competitors, others exemplify buyer-customer relationships, but, apart from the different types of products they supply, this section identifies the industries operating in the Swedish context, organizes them in terms of annual turnover vs number of employees and, according to the theoretical background, explains their business model. Moreover, the assessment of *providers* interactions bases on a power-interest grid including the most representative policy areas of the cluster.

6.1.1. Network Equipment and Handset Manufacturers

Mobile network equipment and handset manufacturers compound the group of mobile device providers, besides producing other goods such as accessories or telecom equipment for cell-phones (Xia et al., 2010). The number of people connected remotely is today counted by billions and supplying this demand with devices is not an easy task.

The role of manufacturers is highly affected by a continue addition of terminals as well a great diversity in handset equipment. Those vendors of mobile phones compete in a price-driven market where the objective is put in increasing sales while reach the "expectations" placed on the mobile phone.

6.1.2. Enablers

Within the value chain *enablers* comprise the group responsible of interacting between handset, application and service providers, all aiming to jointly provide successful mobile data services. The enabler role is to bridge activities from others stakeholders and to facilitate innovative applications with service-oriented techniques.

Maitland et al. (2002) consider three different types of enablers depending on firm's processes: middleware, content and application service providers (ASPs). Being part of the value chain, it is important to separate between these three performances in order to benefit first internal firm profits, but also to attract new intermediaries or service-oriented platforms.

6.1.3. Internet Service Providers

The third step in the value chain belongs to Internet Service Providers (ISP). ISPs are a set of non-profit, private or community-owned organizations that provide Internet access as well as transit. Develop wireless technology and user-friendly services are suitable strategies to web-host and maintain subscriptions in the market. However, Maitland et al. (2002) is negative when it comes to understanding ISP role. The strong competition from mobile operators weakens the ISPs' field of action. Within the European context, ISPs business models are not robust enough and there is a likely loss of market opportunities, especially in the field of content and portals.

With all, the situation is that network operators have the capability to bypass ISPs and can even blur the role of ISP and application/content service providers (ASP).

6.1.4. Network operators (Telecom Companies)

Fundamentally, network operators comprise the group of **Telecom Companies** and occupy a privileged position in the *value chain* due to having primary access to clients' information (travel behavior, card payments, etc). Also known as telephone service provider, telco, or telecommunication operator, Mobile Network Operators (MNO) provide a wireless communication service such as data communication access or telephony. Two key characteristics define MNO's position in comparison with other players of the cluster. First, MNOs own and control the necessary elements of the network infrastructure to sell and deliver services to an end user over a radio spectrum license, and second, they also own and control the access to this licensed spectrum (Vegter,2018; Technopedia, 2018), under state-mandated regulation.

The power and interest that Telecoms have for the adaptation of the telecommunication sector stands out to the rest. Their corporate competitiveness high impact the industry, and their role of network infrastructure managers enable alliances within the cluster (e.g. in the provision of telephony services, data collection and preliminary analysis) but also externally with *data facilitators* and the *data users* in case of having the resources to process raw data (e.g. Telia AB). Additionally, since new ICT solutions are constructed with personal data inputs (location, family expense, age, gender, etc), MNOs must preserve the customer anonymity in these range of activities.

Figure 13 includes the largest Telecommunications companies in Sweden and shows its market share based on the number of mobile subscriptions (Fransen & Wigren, 2017).

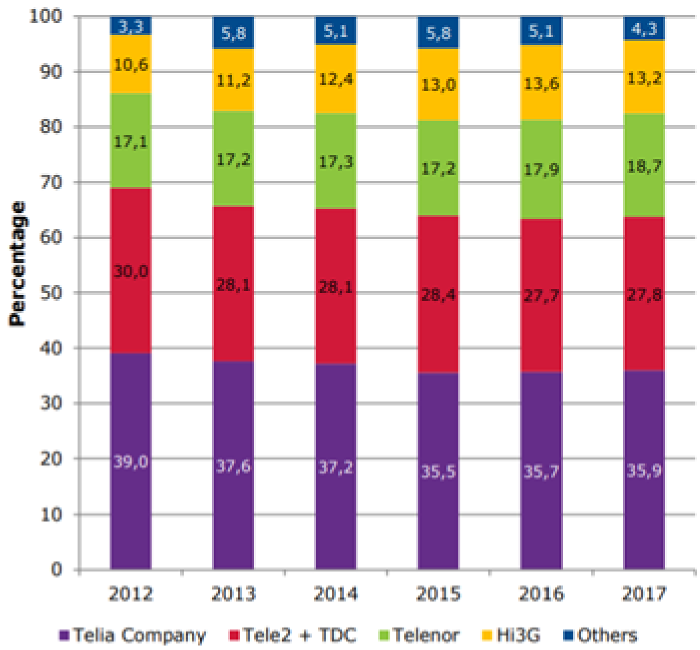

Figure 13: Market share – mobile subscriptions in Sweden.
Source: Fransen & Wigren (PTS, 2017)

6.1.5. Mobile Virtual Network Operators (MVNOs)

A Mobile Virtual Network Operator (MVNO) is an active player of the mobile industry who provides a mobile communication service to customers but does not own either a licensed radio spectrum or network infrastructure (Maitland et al., 2002). MVNOs require from MNOs the access to those wireless network services and they have the possibility to become a wholesale service provider.

Depending on business models and typology of assets involved in business operations, MVNOs can be classified in Telecom, Media or Brand (Maitland et al., 2002). On a retail basis, they can directly sell to customers. This does not represent any operator's business competition since MNOs voluntarily outsource to MVNOs their excess capacity and products (Xia et al., 2010). However, the opposite can happen. Competence arises when MVNOs use their own brand name and develop business strategies to promote their services and applications for their own benefit. So, the national regulatory authorities legislate in order to control the competitiveness to enter this market. In 2003 national telecom regulators, led by the European Commission, conducted a study to assess the competitiveness to access this wholesale market. The result was an increase in legislative framework and the recognition of high barriers (structural and legal) to entry (European Commission, 2003).

6.1.6. Data suppliers in Sweden

The Forbes magazine published in 2018 the world's largest telecommunication companies and places United States and China in the top 3 in terms of total sales, with AT&T ($159.2 B), Verizon Communications ($ 128 B) and China Mobile ($ 109.5 B), respectively, heading the ranking list. Within the Swedish context, Telia Company AB occupies the 30th position in the global classification with $ 9.6 B, but maintaining a reasonable distance with the second Tele2 AB, since Telia triples in turnover.

Despite the significant span with the North American and Asian market in terms of profitability, companies residing in Sweden do compete in the European continent and with greater dominance in Scandinavia. Indeed, the extraordinary growth in the volume of traffic for mobile data services reveal that Nordic telecom firms well-performed during the last decade (see Figure 14), and even forecasts stay optimistic with increasing figures with 4,3 exabytes in 2020 (1 exabyte = 1 000 000 Tbytes).

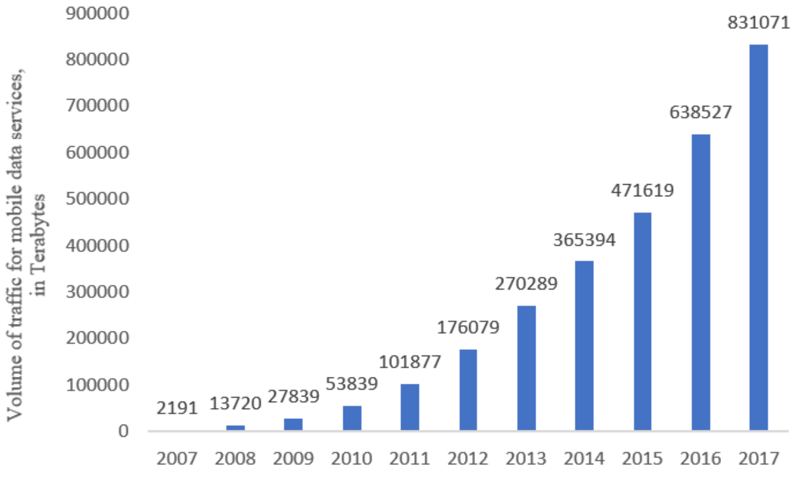

Figure 14: Volume of traffic for mobile data services in Sweden from 2007 to 2017 (in Tbyte). Source: Statista 2018

The Innovation Union Scoreboard 2017 recognizes Sweden to be heading the EU ranking in innovation, investing 3.3 % of GDP in R&D in 2015. However, the management of consumer demand is still a challenging exercise added to the rapidness of technological changes. In Sweden, *data suppliers* comprise firms operating in the environment of telecommunications but putting in practice different business models according to the characteristics of the company. One interviewee with expertise in the field stated that "*the key to thriving in such a volatile market is for companies to focus on business model understanding and to abandon their comfort zones that stuck them to the past*".

In line with this reflection, the investment in innovation (R&D and ICT) made by the Swedish Governmental Agency for Innovation Systems (Vinnova) gives support to the new coming dynamics in business model adaptation. Regarding theoretical considerations of business models (Schroeder, 2016), as a cluster, *data suppliers* use this novel data to get inputs for internal decision making, with data analytics they provide services and even play the role of data brokers when the company size is large enough to compete against *data facilitators*.

As one example, the innovative character in the delivering of mobile phone calls impact the relationship between manufacturers and network operators, both positively and negatively (Maitland et al., 2002). On the one hand, to steadily grow in a twenty-first-century market, manufacturers do associate with apps developers but constantly dealing with the pressure put on by operators. These network operators should readapt and strengthen their role in doing business and to not be debased by the mobile vendor appetite to prosper (MVNOs), as happened when Nokia drew back their relationship with a content provider (Morgan & Andersen, 2000, cited in Maitland et al, 2002). On the other hand, there are instances of fruitful business models related to new built partnerships. The Swedish multinational company Ericsson collaborates with plenty of application and other content developers in the form of commercial alliance, improving the final Internet service (Carroll, 2001, cited in Maitland et al, 2002). Perhaps, these collaborations were unthinkable two decades ago, but nowadays it is impossible not to conceive them.

Furthermore, once business models are explained, a power-interest grid is an adequate tool to further assess the ties in the *provider* network. The power and interest that industries have for the adaptation of the telecommunication sector varies in function of their profitability, but also depends on the level of impact over the policy areas (i.e. subjects of interest for the analysis) of *corporate competitiveness, network infrastructure, service provider, level of data analysis and management, ICT solutions* and *consumer protection.* Table 4 measures the level of involvement in these six policy areas while Figure 15 depicts the power-interest relation of the cluster members.

Table 4. Level of impact/involvement of data suppliers in six policy areas

Groups of data suppliers	Corporate competitiveness	Network infrastructure	Service provider	Level of data analysis and management	ICT solutions	Consumer protection
Network Equipment and Handset Manufacturers	N/A	N/A	N/A	✗	✓	✗
Enablers	N/A	N/A	✓	N/A	✗	✗
Internet Service Providers	✓	N/A	✓	N/A	✓	✓
Network operators (Telecom Companies)	✓	✓	✓	✓	✓	✓
Mobile Virtual Network Operators (MVNOs)	✓	✓	✓	N/A	N/A	N/A
✓ High impact/involvement ✗ Low impact/involvement N/A Not Applicable*						

* Not Applicable means that stakeholders cannot be classified in terms of High / Low impact by not contrasted information in interviews / document review

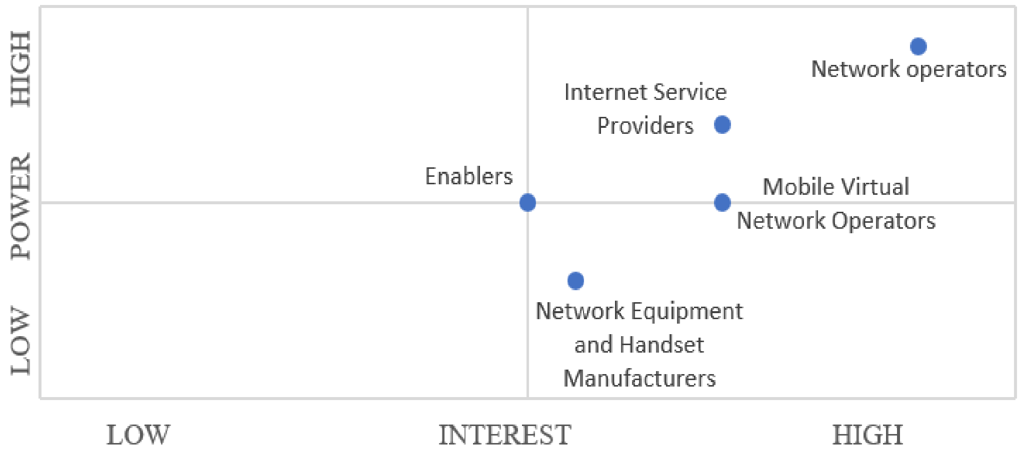

Figure 15. Power - interest grid of data suppliers in function of six policy areas

Finally, as an advance, to assess later data providers relationships between data facilitators and data users, company size is a key attribute used when identifying the firms playing in Sweden (see Figure 16 and Appendix 2 for further details in the *number of employees* and *revenue* of companies on the year 2016). The term "size" is the capacity of any organization to attract investors and built partnerships and can be quantitatively measured in terms of profitability (i.e. turnover and number of employees). This strategy of organizing companies might not be innovative per se, however, it remains meaningful and an accessible source of information despite the tremendous confidentiality from companies. Thus, the more annual revenue, the more *power* a company has over interfering far-reaching market circumstances. What can be original is that this *power* owned by telecoms could make them *surpass* the *data facilitator* cluster, and therefore integrate a business model directly oriented to an end user (see chapter 7).

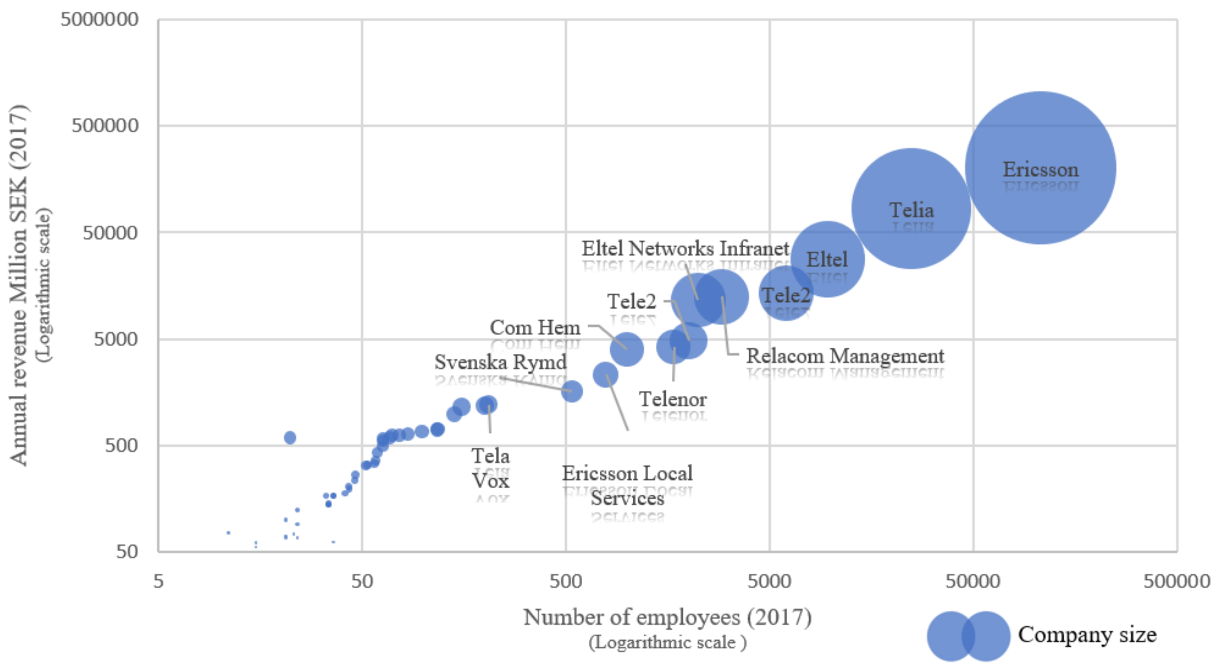

Figure 16. Data suppliers in Sweden in function of company size (annual revenue vs. number of employees)

6.2. Data facilitators

The organizations involved in transacting big data from the initial producer (telecom company) to the ultimate consumer (e.g. transport operator) are defined as market intermediaries or facilitators. Within a context where *"a large number of firms are reorganizing to make data more central to their business*", Schroeder (2016) explains that *data facilitators* are stakeholders encompassing a *"range of activities that support third parties that are lacking in infrastructure or expertise. These data facilitators perform a range of services including advice on how to capitalize on big data, the provision physical infrastructure and the provision of outsourced analytics services".*

Accordingly, there is an umbrella of *facilitators* dedicated to data processing in a general way (not only to mobility), however, this section conceives this cluster as a composite of experts with tools to analyze new data sources e.g. mobile phones and provide information on mobility demand and urban transport. By and large, in function of client's needs intermediaries offer additional qualities to data and get specialized in pre-processing, analysis and consulting activities. They emerge as technical organizations that apply their technical capital into big data, that they either produced it themselves or bought it in the market. So, depending on these two business models, data processing tools and other particularities on data sources, this section distinguishes between three types of *data facilitators:* consultancy companies, providers of mobile equipment and ICT and transport applications.

6.2.1. Consultancy companies

Consultancy comprises a set of companies that treat the product (datasets) in the same way: they buy, process, add value and sell it to third parties. The initial acquisition of data is commonly done by purchase agreements between Telecom companies and facilitators (e.g. of geolocated data) or other transaction contracts with open-source data agencies (e.g. of travel times, information from ticketing systems, pilots). Once handling this data consultancy facilitators develop a sequence of activities in consulting, data collection, data management and data reporting (see Figure 17) to fit the process to what is requested and best reproduce client's needs.

Figure 17. Data-related activities developed by data facilitators

First, consulting services base on seeking expert information to give advice and support to client's projects. Intermediaries get in touch with professionals in e.g. transport, telecommunications, finance, tourism, geo-marketing or even sociology to adapt to user needs. Second, data collection embraces a range of versatile methods to gather in-time large samples of data. The more technology used the broader and more precise sample, but a lack of resources (technological and economical) is still an issue for some SMEs or startups. The company size is a key factor to go beyond traditional methods (surveys, personal/telephone interviews, focus groups, etc) and according to interviewees, invest in an innovative data collection is one key attribute that outstands companies from the competition: Norstat AB carries out *mystery shopping* services (a direct and "clandestine" evaluation of customer experience at retail basis (Amber Arch, 2018), meanwhile Kineo AB promotes a *passive data collection* strategy. This latter relies on personal interviews to provide precise data that can be updated at any time and analyzed in few days. Third, data management embraces tasks of formatting, cleansing and extensive integration of data. This step attempts to bridge gaps with integrated data and a structure to the existing data sets according to what is at question. Privacy is ensured and at this point *facilitators* must double check and serve anonymized information. Fourth and last, data reporting constitutes a service to hand in information. From raw figures, *facilitators* report functional data tailored to client requests and reasonably applicable in practice.

With all, consultancy facilitators offer various services to the transport industry, but in terms of the degree of detail of the result (trips, average speeds, origins-destination, etc) and the process to manage raw data this section classifies them in two groups:

- Consultancy facilitators that collect, manage and elaborate a product useful to the end user, but not applying data processing methods to transform data directly into trips or mobility matrices. These facilitators are in general firms with professional expertise in computer consultancy, advertising, market & opinion surveys, company organization, b2b research & mobile phones and IT solutions. They follow the proposed four-step sequence, and some instances of formats in the delivered data could be interactive dashboards, client panels, tracking studies, ad-hoc studies or product tests (Norstat AB, 2018).

  The strategy is to combine results from each method (e.g. interviews, surveys, workshops) to take advantage of strengths and compensate their weaknesses (e.g. limited sample size, *overfitting* problems). Merge traditional methods with more advanced data processing tools from external parties may produce accurate outcomes on travel time, purposes, distance, routes and even modal choice.

- Consultancy facilitators that run a programming software to analyze raw data and construct transport models in specific areas. From personal cell phone signals, sensors, ticketing systems, Wi-Fi/ Bluetooth networks or even street cameras these facilitators computerize samples and produce outputs that can complement some traditional mobility methods (e.g. transport demand surveys, interviews) with less time consuming and cost-efficient techniques. One example is the interviewed company Kineo: they buy geolocated data and sell Origin-Destination matrices, mobility statistics, indexes and even short distance trips in the urban environment. It is important to clarify that the interview was conducted with an spanish employee and, despite the fact that Kineo operates in Sweden (Kineo Sverige AB), it was impossible to schedule an interview at the Swedish headquarter. In Spain Kineo works with data from the telco Orange, which captures approximately 28% of mobile phone subscriptions, behind Telefonica and Vodafone. Data is processed with the Python language program, and travel matrices are sold at prices of 10,000 € - 20,000 € or more to transport operators, engineering companies with transport projects (e.g. TYPSA) or highway concessionaires.

> *"Each record provides spatio-temporal information of the device each time it interacts with the network, both for active events (calls, SMS, data connections) and for certain passive events (changes in coverage area, network updates, etc.). For the vast majority of users, mobile data allows determining the location of the device throughout the day with a temporal resolution that is typically around 20-30 minutes"* (Kineo Mobility Analytics SL, 2017).

The analysis of this last consultancy facilitator has been made based on a comparison with the Spanish market for three reasons: first, companies such as Kineo are investing in mobile data analytics innovation and have an interesting profile towards an improvement of urban transport; second, there were enormous difficulties in Stockholm to identify analogous consultancy facilitators to Kineo AB who agree to be interviewed; Lastly, the reasoning to compare Sweden vs. Spain in this area is based on the hypothesis that Telia and Telefonica are the leading companies in mobile telephony (they carry out raw data processing internally at the company), and that Tele2 / Telenor and Orange subcontract the service both in Sweden and Spain, respectively. This is an assumption fundamentally based on the size of the companies.

6.2.2. Providers of mobile equipment and ICT

Companies providers of smart phones and ICT infrastructure serve the equipment and collect and gather user's data in their devices. Since they belong to the *data supplier* cluster, they have a dual face and their role of facilitators lies in the exchange of information they produce.

In Sweden Ericsson is the second largest company and is also a leading global provider that manages around 40% of mobile network infrastructure in the world with customers in 180 countries. As Ericsson is an excellent source of information for the research, regarding their interview they assert to use software components for ticketing system. Although they use data for internal management (e.g. demand behavior, sales), Ericsson sells services to telecoms and builds partnerships with operators (e.g. car logistics, Volvo) and Municipalities (*Landsting*). Additionally, they collaborate with the platform *Connected Urban Transport,* that provides PT information of the city of Stockholm in real time.

6.2.3. Transport Applications & Platform servers

Online servers, platforms, transport applications and social media that provide users (travelers) with information about routes, transport modes or traffic congestion are permanently monitoring and tracking mobility behavior. These facilitators do not buy data, they produce their own, and in hands of Transport Operators or Administrations there is potential for defining areas of improvement for public transport and even open new communication channels for MaaS.

Although these *facilitators* have born few years ago, their strategic partnerships and modus operandi in the actor network are gaining momentum. Recently, in the international market these companies are signing agreements where a future sustainable transport system is at stake. For instance, in Madrid the transport app Moovit collaborates with EMT (Municipal Transport Company) in the share of travel-related Big Data to track and enhance public transport mobility (EMT Madrid, 2018). Moovit, who is a pioneer in MaaS, also announced las November 2018 an urban mobility brand partnership with the ICT provider Huawei with goals in integrating Moovit's *"premium urban mobility features into Huawei's premium features"* (Moovit, 2018). Another example relates to the @GamesTravel2014 Twitter account that in 2014 during the Commonwealth Games in Glasgow, Scotland travel and passenger information was shared to public transport agencies (Cottrill et al., 2017).

So, despite these facilitators operate through interfaces, more alliances are emerging with them and they deserve the place they occupy in the actor network. Launching more effective communication networks with transport users is a key point overlooked by transport operators and authorities.

6.2.4. Analysis of data facilitators in Sweden

The numerous companies offering expert advice and consultancy services to third parties makes difficult to provide an adequate sampling of facilitators in the Swedish context. From large firms to startups, from consultancy to IT providers, all take part in the cluster of *facilitators.* All company sizes are included in the study due to their joint influence in market trends, and the exclusion of any type would provide an unrealistic vision. For instance, when tracking the evolution of large firms (e.g. Ericsson, Telia) it can show an image of a *consolidated* market (if there is a favorable market share increase) and this may attract new companies to enter the market (startups). However, only looking at SMEs Johansson (2018) argues that *"Big Data [is] not yet being adopted to a high degree in Sweden, the adoption rate for SMEs being low, and the Swedish market for Big Data Facilitators still being in its infancy*". Thus, it is important to consider all business viewpoints, and Figure 18 gathers a set of representatives of each large, SMEs or startup scale. Additional information regarding Figure 18 is included in Appendix 2.

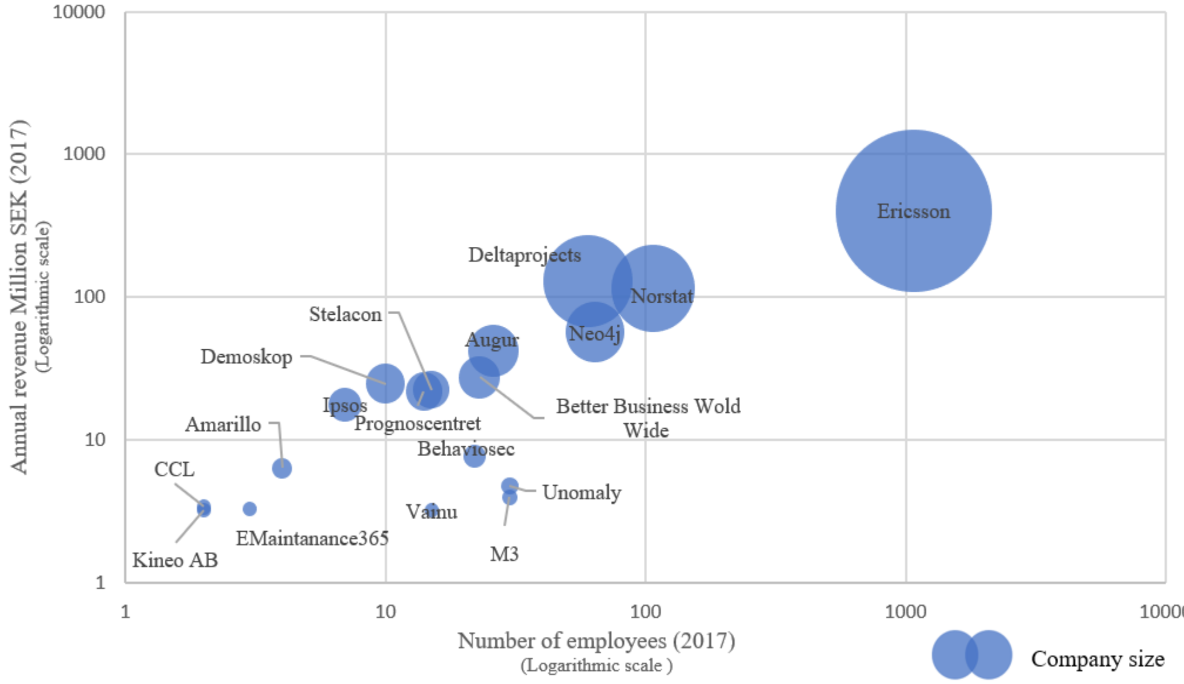

Figure 18. Data facilitators in Sweden in function of company size (annual revenue vs. number of employees)

In this way, in order to deep understand the four types of facilitators in Sweden the analysis explores some interdependent attributes (or policy areas) related to the cluster nature . Since Table 5 introduces the eleven most relevant case study policy areas, Table 6 measures the degree of involvement of data facilitators in these categories. Answers from interviewees and the *Adapted Force-Field Model* of Johansson (2018) motivate the assessment and to what extent the policy area selection satisfies the study.

Table 5. Description of the policy areas related to data facilitators

Variables – policy areas	Description
Data production	First party generating raw data
Articulation data demand	Effective linkages between providers - users
Technology as an enabler	AI, machine learning, deep learning, software & platforms
ICT solutions	Create novel applications (e.g. cloud services, apps) and innovative foundation (front of technology and mover advantage)
Advanced results in mobility	Data analysis and outputs related to trips, O-D matrices, distance, travel time, etc
Open-source data	Short term donor funded with re-use of open data
Organizational knowledge	Technical expertise & long-term experience
Finding correct expertise	Inadequate academic instruction in Sweden and barriers in attracting expertise
Agile organization structure	Flexibility, rapidness and agility in business models and decision making
Process difficulties	Data acquisition, storing, cleaning and analyzing
Security	Issues in data legislation and security demand

Table 6. Level of impact/involvement of data facilitators in ten policy areas

Variables – policy areas	Consultancy Facilitators(1)*	Consultancy Facilitators (2)**	Providers of mobile equipment and ICT	Transport Applications & Platform servers
Data production	✗	✗	✓	✓
Articulation data demand	✓	✓	✓	✓
Technology as an enabler	✓	✓	✓	✓
ICT solutions	N/A	N/A	✓	✓
Advanced results in mobility	✗	✓	✗	✗
Open-source data	✗	✗	✓	N/A
Organizational knowledge	✓	✓	✓	✗
Finding correct expertise	✗	✗	✗	✗
Agile organization structure	✓	✓	✓	✓
Process difficulties	✗	✗	✗	✗
Security	✗	✗	✗	✗

✓ Positive impact/involvement ✗ Negative impact/involvement N/A Not applicable

(1)* Consultancy facilitators that do not produce outcomes related to trips, O-D matrices, etc
(2)** Consultancy facilitators that do produce outcomes related to trips, O-D matrices, etc

Furthermore, to continue analyzing stakeholders' relationships within the data facilitator cluster Figure 19 depicts the four types of facilitators in terms of their low/high impact in future transport. So, the power-interest grid represents again an effective strategy that correlates in the horizontal axis the interest (or potential) of facilitators to benefit transport in the future (e.g. expanding data trading relationships, accuracy in mobility results, advanced data processing), and in the vertical axis their power to satisfy the policy areas (based on their resources, profitability, etc).

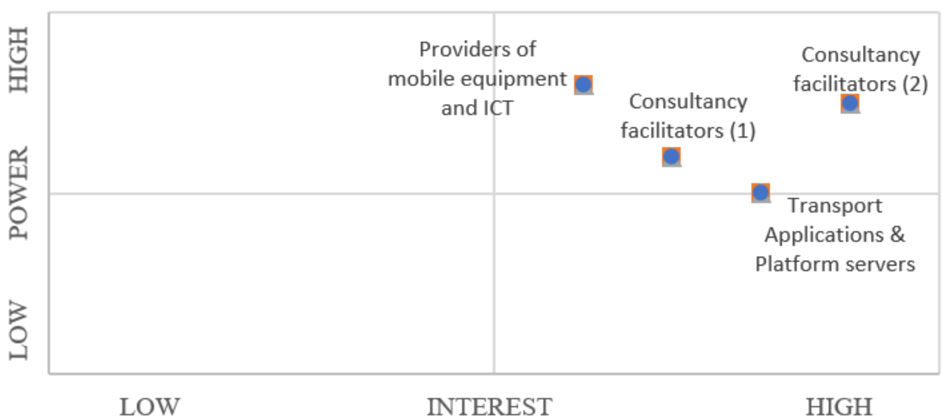

Figure 19. Power - interest grid of data facilitators in function of eleven policy areas

The fact of presenting results consistent with the identification of a number of trips per person (based on mobile data) positions the consultancy companies (2) as the most interested in adapting their business for the benefit of transportation. Transport Applications & Platform servers follow closely since the "online" phenomenon is unstoppable and increasingly this type of facilitators formally ally with transport bodies for the sale of data. On the other hand, regarding the dimension of power, mobile & ICT providers and consultancy facilitators (2) develop business models more oriented towards compliance with the 11 policy areas. Thus, the figure of companies such as Kineo AB must be remarked since they play a fundamental role in the network actor, and in achieving better estimation, adaptation, improvement and optimization of urban transport.

In any case, there are particular problems for the analysis that reveal its complexity on the one hand, and on the other the effort to not lose track of the theme of mobility / transport: one is connected to the numerous companies in Sweden sharing attributes with data facilitators. They process big data but a reduced time and interviewee availability prevented further investigation regarding their possible specialization in mobility data; and second, it relates to amount companies with interest that are not residing in Sweden. Perhaps uncertainty is one limiting factor that strongly influences the performance conditions of this steadily changeable cluster.

6.3. Data users

When data is collected, manipulated and tailored to specific purposes, there are multiple bodies or *data users* eager to produce outputs from datasets. At this point it is important to clarify three aspects that make the reading more comprehensive. First, regarding the broad spectrum of *data users* this thesis narrows it down and particularizes to the transport industry. Second, the dual face of the term *user*. As mentioned before *data user* is a collective stakeholder operating in the form of a company (e.g. transport operator, infrastructure owner, private concessionary company, administrative body, etc), but from now on *user* refers also to the individual passenger purchasing services to the transport community (public transport, Uber ride, bike-sharing, etc). Third but not the least, this section 6.3. explains the significance of the data user cluster and introduces the type of transport stakeholders interacting in the actor network. However, the following chapter 8 comments on same stakeholders but draws attention to the potential MaaS scenario in the city of Stockholm.

Once this is clarified, the use of data has relevant functions from the build of products/services as well as informing strategic decisions. Regarding internal business, self-generated (e.g. sensors) or bought datasets can apply to demand management, fleets or in the case schedule infrastructure maintenance work, and, on the other hand, towards more external profiles, one way is to promote transport apps feeding traveler’s needs. Data is processed in order to serve the community with optimal transport modes/routes and real time traffic information. By and large, the representative bodies installed in Stockholm are gathered in Table 7. The *power-interest* grid developed by Trinks et al. (2012) reasonably suits with this case study and therefore the same variables and procedure is used here. The limited research period constraints a deeper analysis of secondary actors and further details.

Table 7. Representative bodies of the transport system in the city of Stockholm

Data user –Transport Stakeholder	Function	Representation in Stockholm	
Transport Operators to passengers	Provision of Public Transport services	Contractors	Traffic Chief
		MTR: metro, commuter rail	SL
		Arriva: Bus traffic, Saltsjöbanan, Roslagsbanan, Nockebybanan, Tvärbanan	SL
		Nobina: Bus traffic	SL
		Keolis: Bus traffic	SL
		Stockholms Spårvägar: Spårväg City, Lidingöbanan	SL
		Blidösundsbolaget: Djurgårdens ferry	Waxholmsbolaget
		People Travel Group: Tourist bus	Commercial public transport
		Flygbussarna: Airport Shuttle (bus)	Flygbussarna
		AB Stockholm Trails: tram (Djurgårdslinjen)	SL
	Provision of Private Transport services	Sverigetaxi, TOPCAB, Taxi Kurir: taxi services	
		Uber	
		UbiGo Innovation AB: MaaS pilot	
		Carpool Sverige AB: car rental & leasing	
		Citybikes	
Infrastructure managers	Management of state roads and railway infrastructure	Trafikverket	
	Management of public transportation infrastructure in the County Council (Landsting)	Stockholms Läns Landsting (SLL): Trafikförvaltningen (TF) (existing infrastructure), Nya tunnelbanan (FUT) (new subway)	
Governmental authorities	Regulation (policy-makers) and supervision of the implementation	European Union	
		Government of Sweden	
		The Stockholm County Council (Landsting)	
		The City of Stockholm (Stockholms stad)	
		Municipality Administration	
Passengers	Travelers – the transport network users	Commuting users, tourist users	
Research bodies	Investigation in transport innovation	University, private research	
Funding bodies	Financial support	Stockholm County, Government of Sweden, EU, Vinnova, Banks, etc	
Industry - ICT providers	Transport adaptation	Ericsson, Telia Sonera, UbiGo, Smart Resenär, IBM, Google, etc.	

6.3.1. Transport Operators

Transport Operator is a natural or juridical person operating bus, metro, regional rail, tram, light rail and ferry transport services. In case of urban and regional mobility, these are private companies assuming own risk and responsibility and deal with transport adaptation with problems such as reduced demand, variations in private motorization rates and urban expansion. Their additional involvement in crisis prevention is essential to react to changes during operations and their experience in these matters safeguards their efficient performance.

In the Stockholm Region, since 2012 Storstockholms Lokaltrafik (SL) performs as a trademark company of the country-based public transport and from that year onwards there are various contractors (see Figure 20, and for additional data details Appendix 2) responsible for traffic management. Regarding the big data business, the relationship between SL and public transport operators is specified in that contracts. Since operators get the business to run the metro (e.g. MTR), SL produces their own data from the ticketing system or manual observations (where the metro goes, stops, timetables, number of passengers) and exchange it with operators. This is not a monetary exchange, it is included in the contract.

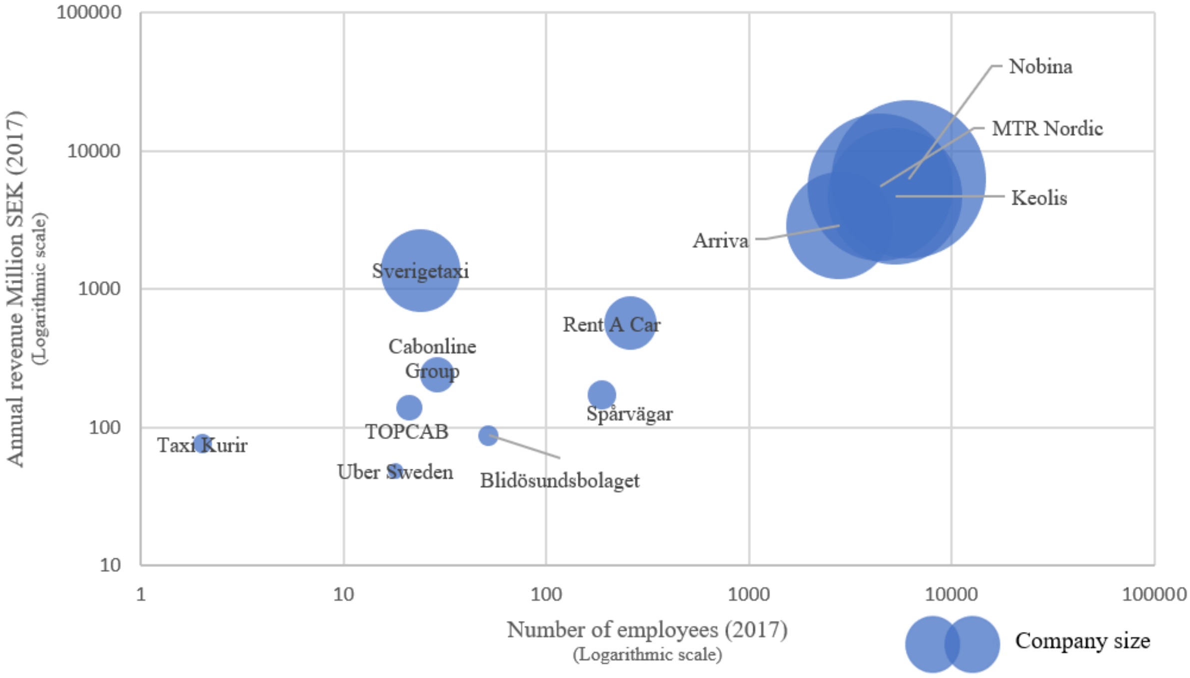

Figure 20. Transport Operators in Sweden in function of company size (annual revenue vs. number of employees)

6.3.2. Infrastructure managers

Infrastructure managers embrace the group responsible for the performance, operational and maintenance management of the transport infrastructure. Infrastructure managers can be independent organizations or entities connected to private transport operators or public authorities. They are investors, innovators and the voice or the customer. Analogously to operators, they involve in crisis prevention and transport adaptation from an intersectoral perspective, and with sufficient flexibility in contracts to adapt to changing contexts.

The competency of the Swedish Transport Administration (Trafikverket), expanded in the work instruction (Ordinance 2010: 185 for the Swedish Transport Administration, 2010), bases on promoting accessibility to public transport as well as the construction, operation and maintenance of state transport infrastructure (road, railway) and planning aviation and shipping.

In the regional and local scale, the County Council (Landsting) embrace the regional autonomous entities with competencies in regional planning and local traffic, and particularly Stockholms Läns Landsting (SLL) represents the public transportation in the county through the SL "brand". Within SLL, it is Trafikförvaltningen (TF) the manager of the existing infrastructure and Nya tunnelbanan (FUT) of the new subways for the future, taking measures also in a sustainable growth between public transport and housing.

It is important to clarify how is the structure of the Transport Administration in Sweden because in few years there have been many changes in terms of Administration and Operation competencies, having an impact of course in the networks based on big data. For example, the transaction of data (traffic, delays) in case of the commuter train on Trafikverket's track is therefore between the administrative body Trafikverket and the operator MTR Pendeltågen on behalf of SL since December 2016. On the other hand, in case of the subway and railway system, the data sharing is between SL - operators - SLL.

6.3.3. Governmental authorities

Governmental authorities embody representatives from the European, national, regional and local level and provide the legislative framework necessary to regulate transport planning, management and emergent needs. They play a role of public policymakers controlling actor's performance and provide guidelines, funding solutions and operational management alternatives for an effective transport implementation. Regarding emergent sustainability issues, they also regulate issues such as climate change and promote sustainability standards. Are the local governmental bodies responsible for direct contact with parties in operation, design, financing and maintenance, as well as auditing effective legal implementation (Doll et al., 2012).

6.3.4. Passengers

Considering metropolitan mobility, passengers are individuals traveling in public transport (metro, bus, tram, etc), private vehicle, bicycle, taxi, ferry or other conveyance with a commuter, tourist or leisure purpose. In general, passengers use the infrastructure and vehicles provided as a mean, not an end, however, walking is another mode of transport although some literature do not consider "walkers" as passengers per se.
This thesis acknowledges the complexity to identify whether pedestrians are "passengers" (e.g. commuting to workplaces), but scoping in a long-term frame, today's technology should cover emitted location-based signals to manage transport services and therefore integrate the operation of all transport modes in urban areas.

6.3.5. Research bodies

Universities and other research organizations investigate areas of transport planning, demand management and environmental issues as well as ICT solutions in operational activities and infrastructure design. Comprising public and private bodies, the goals are oriented to provide deeper insights in e-transit, innovation in infrastructure, climate forecasts, tools to manage traffic flows or context characteristics that facilitate multimodality.

As this Master Thesis does, the Educational system supports academical research to extend previous knowledge in specific areas, although counting with the time drawback. Within mobile data analytics and transport, there are multiple researchers publishing about the evolution, market status and future potential of big data for mobility studies (Gundlegård, 2013; Roncalli, 2014; Redman, 2015; Olla & Patel, 2002, Martín Del Campo, 2018). Other larger bodies e.g. the University of Linköping, KTH Royal Institute of Technology (Stockholm) or the Technical University of Madrid continue in the same path. They take hard work in the provision of cutting-edge research programs, projects and networks in the field of transport through a multidisciplinary team, with special interest in MaaS and a multimodal vision of urban transport, and next to the framework of the European Research Area (ERA) (e.g. TRANSyT, KLIMATe).

6.3.6. Funding bodies

Funding stakeholders financially support projects in infrastructure, public services (e.g. subsidizing public transport ticket) or cutting-edge research projects (e.g. climate change). The power that national and European funds, banks and grants have in social welfare and profit maximization constitute a fundamental part to the growth of the sector. Funding actors high impact the transport industry with economical resources, but the intellectual resources and knowledge in construction, operational and maintenance do not go beyond.

6.3.7. Industry – ICT providers

This group includes a set of ITC companies, ITS providers and light industry that aim a transport adaptation in all facets of planning, operation and maintenance. This adaptation relates to innovative technologies for infrastructure and vehicles in line with a "reinforcement of transport infrastructure but also to the enlightenment of the research sector on related issues" (Trinks et al., 2012). The idea is to focus on the new, the novel, the original practices with functional value.

6.3.8. Data users – transport industry- in Sweden

This set of seven transport stakeholders have the most interest for the Swedish context and Trinks et al. (2012) organize them in a *power-interest* grid (see Figure 21). To do so, their analysis apply variables of *financing, planning, maintenance, design & construction, ICT solutions* and *Operations & management* to study an intermodal transport and the involvement of actors in that policy areas (see Table 8).

Table 8. Level of impact/involvement of data end users in six policy areas

Groups of Data users	Financing	Planning	Maintenance	Design and Construction	ICT solutions	Operations and management
Transport Operations	✖	✔	✔	✔	✔	✔
Infrastructure managers	✖	✔	✔	✔	✔	✔
Governmental authorities	✔	✔	N/A	N/A	✖	✔
Passengers	✔	N/A	✖	N/A	✔	N/A
Research bodies	N/A	✔	N/A	✔	✔	✖
Funding bodies	✔	N/A	✖	✔	N/A	N/A
Industry – ICT providers	✖	✔	N/A	✔	✔	N/A

✔ High impact/involvement ✖ Low impact/involvement N/A Not Applicable

For example, many Transport Operators and Infrastructure managers have and invest in ICT solutions to monitor traffic data with sensors (Bluetooth sensors, radars, microwave-detectors, cameras, FCD data) and process it to provide real time travel-times with 1-minute resolution, as *Trafik Stockholm*. The infrastructure manager *Trafikverket*, despite competencies in planning, maintenance, design and construction of roads and railways, they collect plenty of data from the road side as they have sensors in all different type of environments (e.g. tunnels). They have framework agreements to provide travel time data for sections of the road and ICT is more focused on navigator systems (GPS from Google) for the route planning systems of taxis or lorries. Regarding *financing*, another instance is the support given by banks and governmental authorities to mobility projects. However, passenger demand cannot be ignored as it directly impacts on the transport system financing. Revenue from tariffs is key and it represents a good proportion of the income statement for their economic viability, that is roughly 50% in Stockholm.

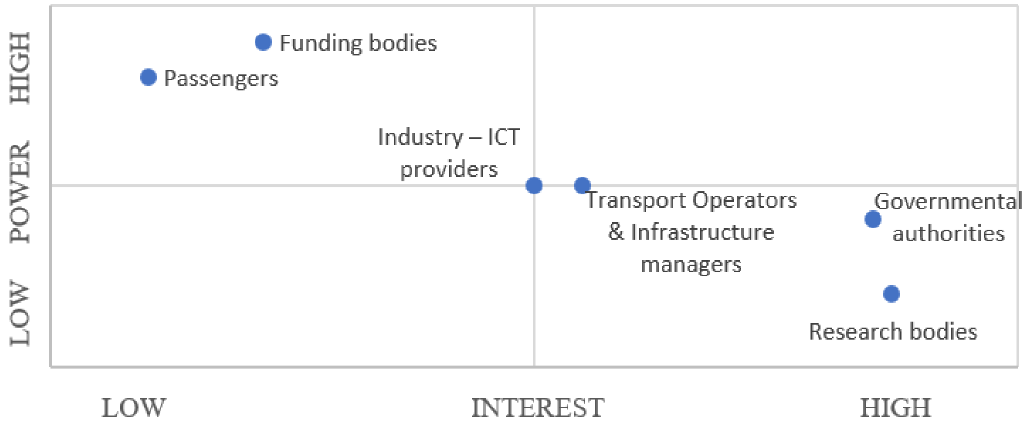

Figure 21. Power - interest grid of data end users in function of ten policy areas
Source: own elaboration from Trinks et al. (2012)

Above all, the interest dimension is the degree of involvement that stakeholders have in the mobility issue, and it relates to the ideals that any resilient city has in boosting sustainability strategies (social, environmental and economical wellness), accessibility to all or in this case an optimal data mining application for urban transport. In Stockholm, the two stakeholders with higher involvement towards a successful movement of passengers today and in the future are the Governmental authorities and research bodies: the former efforts to a community-led livability where transport is a key point, since the latter focuses on innovative data analyzing methods suitable in transport modelling, generally researching on theories that could impact future trends.

On the other hand, the power dimension measures the stakeholder competence that affects the issue of mobility in the future. Regarding Figure 21, funding bodies and passengers have the higher power to impact the use of data in mobility. The former due to economic support to efficient modern infrastructure and fleets or investments in technological advances for the travel-condition-benefit, and the latter due to they are the end users. Clients are the service buyers and their travel preferences rule in any circumstance mobility behavior.

7. Ties in the Network. Stakeholder relationship between clusters

The previous chapter organizes stakeholders in three clusters and digs into the internal characteristics of *data suppliers*, *data facilitators* and *data users*, respectively. Figure 22 gathers in a comprehensive map the umbrella of actors and networks treated during the analysis, where dark blue represents the superior authorities that regulate the entire system, light blue the actors operating internally in clusters (see chapter 6) and red the three-cluster structure. Although the meaning of the red arrows can become intuitive to the reader, this chapter 7 provides a straightforward explanation of the ties or relationships between clusters. Clusters are compared in pairs to make the analysis simpler.

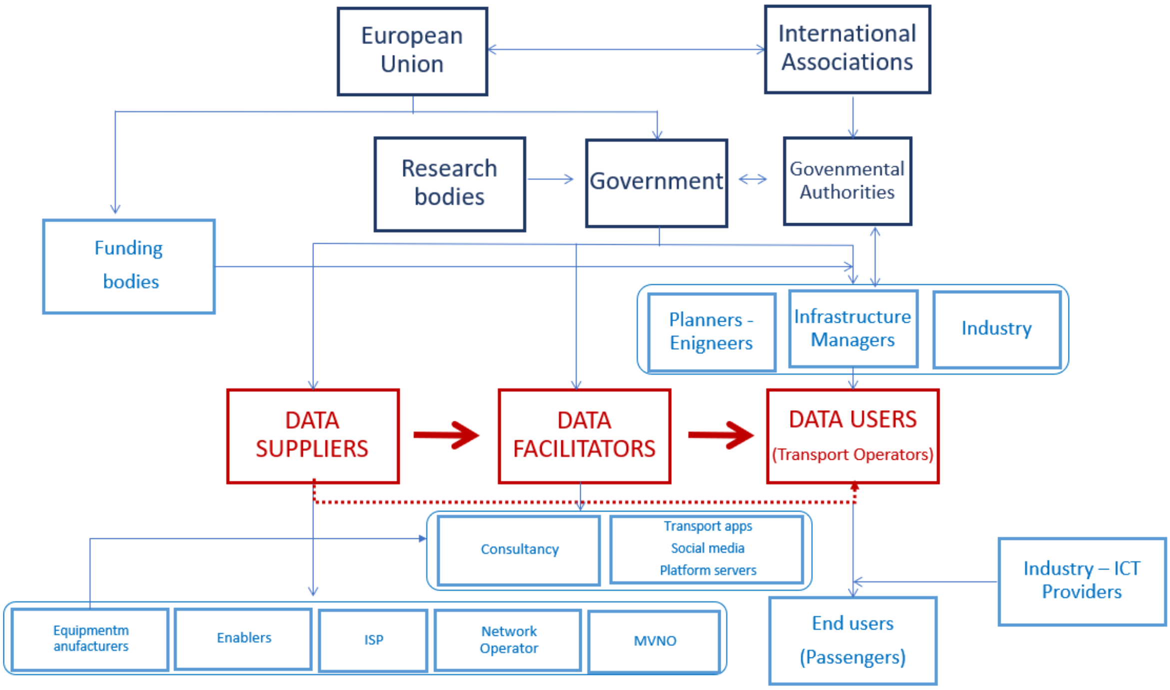

Figure 22. Map of stakeholders operating in the Mobile Data market

7.1. Data suppliers ⇒ Data facilitators

Briefly, what matters between *data suppliers* and *data facilitators* is that the former collects novel data from mobile subscribers and the later buys the rights to process it. Once this precision is made with regard to interviews, the size of the company and the availability of resources for telephone data processing are some of the factors used to made claim that there are two general types of business model in data suppliers:

- First, data suppliers sell the raw data to the facilitators. Among them there are several specialized in transport that have already developed their own methodologies and algorithms for their practical application to projects. These projects are research projects, but they also correspond to public tenders in the context of contracts in which public administrations have opted for the application of Big Data to Transport Planning. The results, in general terms, are more accurate than in the case of the Telia model, although there is still a long road to technical adjustment and its improved application in urban and metropolitan mobility environments. As an example, the telco Orange provides the facilitator company Kineo with telephony signals and by the python programming language they convert raw data into matrices of trips.

- Second, data suppliers carry out the development and processing of data trying to apply the added value of specific sectors (mobility among them) and not lose possession of the data. As this is a relatively young business, this second reason is particularly relevant because the opportunity cost of losing possession of the data and the know-how of a sector that reports benefits in the short term would be unaffordable. During interviews this argument was connected to the company size concern since it remains a key factor to determine whether or not telecoms process data, or, in other words, if they own the *power* to avoid the *facilitators* cluster and directly contact with the *end user* (e.g. Transport Operator). Accordingly, one interviewee argued that "*the power is having the money to assess, linked somehow to the company size. It is the competence to assess, and as a large company we can react to market changes, employ people and allocate resources within the area"*. This is the model of Telia AB in Sweden and also the case of Telefónica or Vodafone in Spain. Apart from data processed by Telia, Telia does collaborate with a pilot in urban mobility and other business cases regarding the sale of processed data to the local commuter bus company Nobina. Telia don't work with intermediaries, they sell directly to the end user. On the other hand, in the specific case of mobility at the international level, the results are discrete because, although the means of data processing of the Telcos are significant, the multidisciplinary nature of their research may not allow the necessary technical particularization that the mobility market seeks in these results and in a research environment where the guarantee of return on investment is not very high.

Today, the trend in Sweden is in the line of this first business model since companies are moving on and there are increasingly more specialized firms (in consultancy) that deliver data processing services in the free market. Data suppliers can monetize their data at almost cost-zero, and delegating data analysis to external parties with expertise may add value to the original product and produce more accurate estimations of trips.

But, how are these transactions done in terms of money? How this by-product computerized in balance sheets? There is much controversy due to this market is "unmatured" and tremendously growing. Added to the "secrecy" when researching these points, even interviewees did not open their hands. Answers were "politically correct" regarding the debatable market transparency and the potential expansion of the IT department. It is understandable that this latter could reveal the degree of commitment of the company in data processing and may have influence on the competition. However, what is clear in data exchange is that the integrity and anonymity of the user is preserved. Extensive legislation and regulation cover this issue, and once suppliers remove any sign of personal identification, then facilitators ascertain that their internal processing meets the requirements.

7.2. Data facilitators ⇒ Data users

Since the moment that facilitators have raw data in their hands, they consult, computerize and adjust the product to buyer requirements. As introduced earlier in the analysis, facilitators have means and technical expertise to manage data, however, this section digs into their role from another perspective as the customer/supplier relationship is the central point of the discussion. Their role goes one step further and facilitators must ease communication links with their customers. They are intermediaries, they are consultants. Within these companies specific teams are responsible to approach end users to "*get inside their minds*". The idea is to understand their strategies of the future and thus sell them what they need. Talking and communicating with the end user (e.g. Transport Operators, private companies working in transport tender projects, etc) is of great importance to go one step ahead of other competitors offering the same service, leaving aside the "cost of operations", since what has been obtained in the interviews has not been enough to draw conclusions in this regard. One common method is to directly visit the end user at headquarters and negotiate there what they want and how and when they want it, as well as the conditions of the service/ contract.

With all, “communication skills” is one important factor to consider in facilitators. Interaction enables knowledge integration and therefore better support customers’ projects from the early stages of the data processing process. Additionally, communication can also take part between professionals in the sector and even with external disciplines. This synergy keeps facilitators updated in e.g. effective algorithms, recent processing methods or emergent customers to serve, but overall it gives room to added-value services with potential to optimize end user performance.

7.3. Data suppliers ⇐ Data users

Since *Data suppliers ⇒ Data users* is the direct flow for doing business between telecoms and the Transport industry (second business model explained in section 7.1), this section reverses this relationship and provides a new viewpoint, perhaps not intuitive at first glance but crucial for the stakeholder analysis.

Although *Data suppliers ⇐ Data users* may go in the opposite direction of the value chain, we must not forget that big data navigates in a cyclical process in the sense that all industries must feedback to continue growing in a sustainable economy of scale framework. The transport industry is constantly renewing business models towards a multimodal transport less dependent on car use both in the medium and short term. Urban mobility trends are changing and consequently the needs of users. In this sense, companies that provide telecommunication services must advance and promote improved services with e.g. faster services, 5G (e.g. by Ericsson), more network coverage (subway, tunnels), Wi-Fi services in public transport, etc. In Sweden, companies operating or with responsibilities in public transport (SL) do not sell data outside their house, and neither they don’t expect that. They have in some extent experts to process that data, and the data they produce remains accessible in an open data platform. However, even they don’t purchase from Telecoms today, they are looking into that. They have been approached by some mobile operators and ITs that are using data from networks operators, but even if they are not using data from others external sources today, there is an increasing interest.

In short, the relationship between the transport and the telecommunications industry is evident and it is the free market that sets the guidelines for action even if there is no "real" exchange of data. In other words, there is no monetary purchase-sale of data per se today, but the situation is likely to move on.

8. Going beyond. How institutional relationships have an influence in the MaaS development?

This chapter links the previous stakeholder analysis with the current goals put on sustainable travel and some models that integrate urban mobility. The discussion keeps an eye on Stockholm and gives an insight of how the city "lives together" the MaaS model. Challenges and limitations are also presented below, besides some recommendations to unblock and achieve a "real" integration of mobility modes.

8.1. How this value chain analysis helps the future MaaS planning?

When observing the actor value chain, the fact of knowing which parties are involved, how they are organized in clusters, and how networks are both within and between clusters is a good starting point for any sector that uses big data. This analysis allows to identify the strengthens or key points - companies with greater power or interest to improve in the sector - of the actor network, but also its weaknesses in relation to "gaps" or "fuzzy" roles of actors. A deep stakeholder network understanding is crucial to not slow down the progress towards a more inclusive, economic and climate-friendly urban mobility. So, in a primary way, what passenger transport intends (or at least under a public entity regulation) is a client-resource-optimization and make cities increase in dynamism and competitiveness. For a few decades the transport industry has been seriously committed to data collection strategies (anonymously) and a wide range of public and private firms do invest in AI & IT data processing tools for the benefit of consumers.

Currently, MaaS is still a sensitive issue in developed countries and specially within Europe regulation and initiatives are being launched today. MaaS, or in other words the integration of multimodal mobility services, is a mobility model demanding intense collaborations within the transport industry, e.g. PT providers, private operators, transport Administration, Municipalities, Governmental authorities, passenger, etc. However, MaaS has also repercussions of the end user cluster and at this point the present value chain study builds knowledge to understand interdependencies with the role of novel data providers and facilitators. A successful MaaS model implementation cannot set apart the use of platforms or apps that connect operators and travelers. Here, all software, platform design, internet/telephony network license, payments (PT, toll, parking on/off street) and further online/offline services see in the Telecommunication industry a key ally. Telecoms or large equipment providers (e.g. Telia, Ericsson) have the right to access to multimodal-based mobility datasets, and transport operators firsthand know "to whom to turn" to feed MaaS models with real mobility inputs. Data procurement is not trivial but complicated process. Integrated transport operators must consider this actor chain and convert "initiatives" into plausible business cases, reinforcing entities communication, monitoring knowledge, management teams, data sharing, consensus and strategies to inform users with travel information in real time.

Above all, what a comprehensive overview of stakeholders' role set is a preliminary scenario to MaaS. How public and private companies relate and how they deal with data speeds up this initial MaaS phase of "context background", but, what the greatest potential of this thesis is the possibility to identify, in the Swedish-based context, what gaps do exit in the actor network as well as bureaucracy constraints that slow down a MaaS implementation.

8.2. How is MaaS currently performing in Stockholm?

Sweden is a pioneer country struggling against climate change and clean mobility alternatives, and in 2015 was ranked as the Most Sustainable Country in the World. Regarding the evolution of MaaS in

Sweden, Stockholm has a growing interest in MaaS but still insufficient evidence in practice. Since March 2018 UbiGo Innovation AB is running the six-month pilot in the capital through a collaboration program between the public and private sector. The city of Stockholm and funds from the EU project CiViTAS Eccentric invest in this integral mobility delivery and, by the UbiGo app check-in service, multimodality is available to the user with PT, taxi, bicycles, car rental and car pool along the city. And, when the question is, who is providing these services? the Municipality and the Stockholm County Traffic Committee agree on their sectoral experience and assign the operation to SL, TaxiKurir / Sverigetaxi / TopCab through Cabonline, Citybikes and Hertz rental cars, respectively (UbiGo, 2018).

However, despite these promising pilot initiatives, when it comes to assess the MaaS reality in the Stockholm region it is the County Council SLL that is the responsible to act to its development. Theoretically, SLL places itself as service provider but the reality is slightly different, as there are third parties developing the MaaS Operator role. Although SLL works to implement multimodal pilots and greater involvement of politicians with detailed MaaS plans, MaaS is also a noticeable issue at the national scale. The Swedish Ministry of Enterprise and Innovation (Näringsdepartement) and the Swedish Transport Administration (Trafikverket) collaborate in national roadmap’s initiatives and actions plans for Intelligent Transport Systems (ITS) (Smith et al., 2017), that overall could benefit the viability of MaaS.

Currently, plausible efforts are done in form of initiatives but, essentially, Stockholm streets are not living MaaS. The most useful navigation web-apps running in Stockholm do not serve a full integrated mobility service as they focus either on PT route planning or private services on their own risk (Table 9).

Table 9. Transport Web-apps in Stockholm
Source: own elaboration from Globuzzer (2018)

Transport app	Observations of services
Res i STHLM	SL journey planner
Google Maps	Best and fastest route planning but less accurate than Res i STHLM in terms of delays or cheapest routes
LinjeKartor	SL Transit Mapp Stockholm
Mooveit	Similar to Res i STHLM and additional services in live arrival and departure time to nearest bus stop or railway station provided with maps
SL Journey Planner	Official journey planner of PT in Stockholm. Offers accurate trip updates or route changes and a buy-travel-ticket service
Yelp	Walking route planning in Stockholm
Taxi 020	Provision of fixed prices through the app and verification of the average price per km before the ride*
Uber	Taxi alternative with lower prices**

* In Sweden, taxi fares are not regulated
** In Stockholm, Uber is increasing in popularity due to cheaper prices, but people still chose taxis

8.3. Challenges and Limitations of MaaS in Stockholm

In order to meet the goals of a sustainable transport future, Stockholm still see in MaaS a challenging phenomenon to become a vibrant, resilient and transport-integrated city. The entire MaaS community should move one step forward and open up new opportunities to commute around, and, to do so, MaaS should stay in the priority list of the Public Administration and transport industries to face and surpass existing barriers.

Experts agree that today there is enough technology and mobility data processing tools but the newly "integrated" character and lack of traditional MaaS expertise in Sweden blocks an imminent launching. One dominant constraint is the "far distance" between the public and private sector in revenue models and organizational structures. Once the Administration subsidizes roughly 50% PT in the Stockholm region, private firms e.g. Uber operates by its own risk. However, private companies deal with more "simple" and "agile" business models in terms of rapidness in testing-ideas and less bureaucratic processes.

There is little research centered in identifying stakeholder networks and what type of collaborations that could boost MaaS. From an operational-business perspective, there is a gap in the actor network that slows downs a full transport integration, and perhaps, a new mediator could solve the lack of institutional agreement and streamline MaaS in Stockholm: a MaaS operator and integrator (Smith et al., 2017). As Finland does, the new role of MaaS operators is to become a commercial operator that directly contact with the customer, besides negotiating the terms of the provision of services that the customer chose. However, and in line with the stakeholder analysis, MaaS operators should also arbitrate between traditional transport operators and data owners in order to facilitate data transaction and reduce time in knowledge exchange.

Furthermore, another limitation that MaaS faces today relates to the degree of uncertainty in terms of competition and a loss interest in business products (trips), and Smith et al. (2017) agrees that "some existing transport service providers view MaaS as a potential threat in terms of brand, image and customer relationships". During interviews, when we posed the question to PT managers "Is there a risk to lose customers if MaaS operators prosper?" the answer was surprisingly optimistic: "there is a very low risk to lose customers". They argue that today PT is not competing with e.g. car sharing or car pools. They have very loyal customers and what matters is the customer "experience". "We run services on time, our buses are clean and what makes the difference is that is a good service. We don't see that anyone offering another package [e.g. Ubigo] based on cars will compete". However, there are external references from Western cities that are dealing with this issue, as for example Washington DC where UberPool competes with PT in the metropolitan area. Within DC, Figure 23 illustrates how much more travel time takes Uber compared to the metro (horizontal axis) and their differences in costs (vertical axis) (CITYLAB Transporte, 2017).

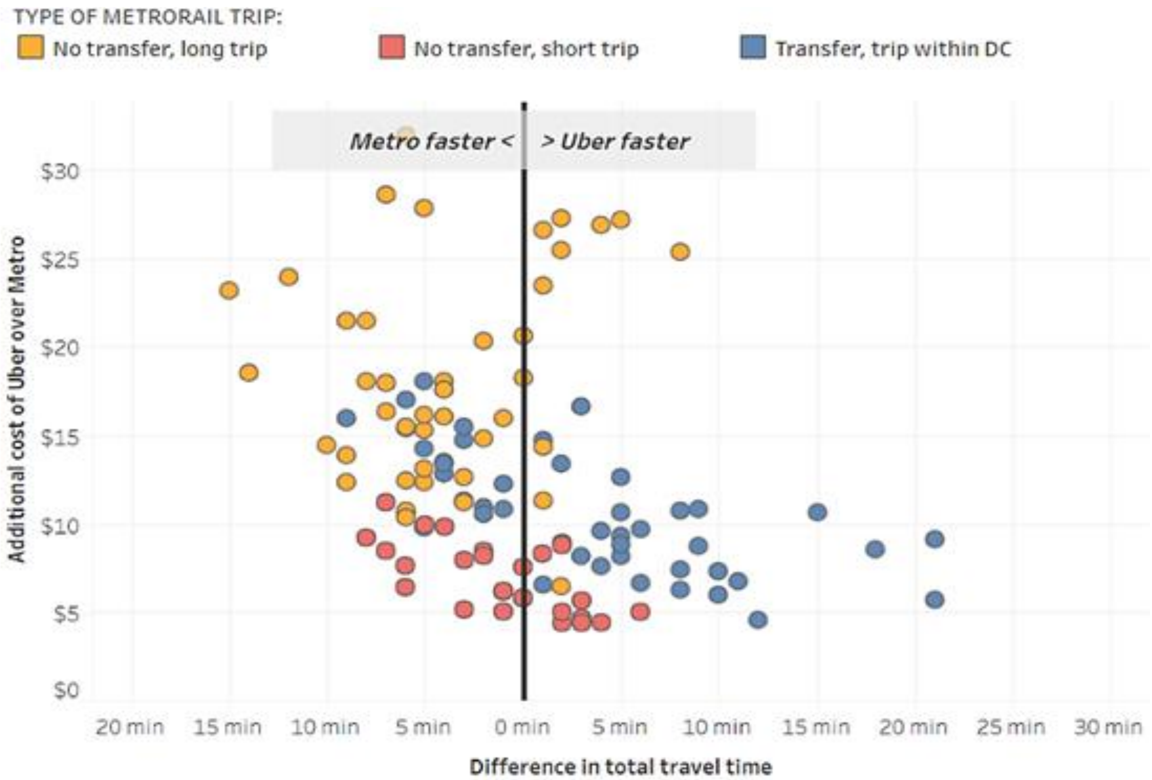

Figure 23. Travel Time and Cost of Trips in DC: Uber vs. Metrorail.
Source: (CITYLAB Transporte, 2017)

"Now, when does Uber become the most attractive option? According to the analysis, this route is faster than the metro in 99 of the 114 trips studied, with the condition that the next train is 10 minutes away from the hypothetical passenger. And during the most demanding hours, Uber is also the fastest option to circulate within the city, at least as long as it is compared with subway trips that require connections from one line to another.

But all that costs. As the chart shows, taking an Uber from […] a 15-minute drive from the city center to a more peripheral stop […] would save you 15 minutes, but it would cost you $11 more. Doing UberPool, instead, you may arrive at your destination 10 minutes early and spending only $2 more" (CITYLAB Transporte, 2017). One limitation of the study is the avoidance of alternative transport options e.g. bus or bicycles nor the others possible trips by Uber in the city.

Approaching this Uber vs. Metrorail opposition in DC is useful to understand the case study situation. It is assumed the premise that on the one hand with 42000 SEK in Stockholm one would need in Washington DC around 58261,14 SEK ($ 6348,49) to maintain the same standard of life (NUMBEO, 2018), and on the other hand that traffic indexes are rather similar (see Table 10) between cities.

Table 10. Comparison of traffic indexes in the cities of Stockholm and Washington, DC
Source. Own elaboration from NUMBEO (2018)

Index	Stockholm	Washington, DC	Index description
Traffic Index	145.55	190.54	Is a composite index of time consumed in traffic due to job commute, estimation of time consumption dissatisfaction, CO_2 consumption estimation in traffic and overall inefficiencies in the traffic system.
Time Index	40.60	41.22	Is an average one-way time needed to transport, in minutes.
Time Exp. Index	1,791.45	1,987.85	Is an estimation of dissatisfaction due to long commute times. It assumes that the dissatisfaction of commute times increases exponentially with each minute after one-way commute time is longer than 25 minutes.
Inefficiency Index	173.07	232.36	Is an estimation of inefficiencies in the traffic, with high inefficiencies it assumes driving, long commute times, etc. It is meant to be more measurements of economies of scale in traffic.

All in all, the increasing share of Uber rides in DC is not the case in Stockholm today. Running UberPool services may be one reason to argue the existing competency between Uber vs. PT, since UberPool is the cheapest Uber Service (pool pairs users heading similar destinations). Stockholm lacks this service and only offer UberX, with typically higher costs per km than UberPool.

Far from this environment of competency, by and large the current situation is that private operators (e.g. Uber) stay reluctant to adopt MaaS models. Informally, it may refer to spend money to get less sales. Full integrated apps reduce the cost payed with the traveler, but from the private company viewpoint it's hard to compete against subsidized services. One of the biggest challenges of MaaS is running operational services like the pilot UbiGo does and explore new horizons that incorporate Uber or other discretional car-based services. Booking, planning the cheapest, shortest, less polluting routes and payment integration (like GoLA and GoDenver apps) is a promising target, calling this latter for additional "Collecting Agent" such as MasterCard or Visa to intermediate between public and private frictions. In line with UbiGo's challenges the idea is to build a formula that explains

> *"[…] how to package a tax-subsidized public service as public transport with commercial services. We believe we have found a contractual model that is revenue neutral, transparent and ensures fair pricing - and not least a service that is flexible enough to reach those customers who are unable to reach public transport (and other services) on their own. Verifying that model is an important part of the pilot phase and for spreading to other cities*" (UbiGo, 2018).

Overall, the application of MaaS may evolve and authorities should intervene with active market-driven measures to unlock barriers. These attempts at regulatory changes have already generated social tensions in the taxi sector in some EU countries (e.g. Uber and Cabify in Spain), even without having entered the market of collective public transport. In short, MaaS builds a "roaming ecosystem" where the winner (traveler) takes all (e.g. reduce car-use, travel time, carbon emissions, travel costs and easy route planning). Once MaaS advantages are clear for the Swedish context (Hietanen & Sahala, 2017), the discussion on public-private relationships, feasible MaaS operators and Collecting Agents are still open, as the area of influence of an ideal "cooperation environment of stakeholders" in MaaS is a very sensitive issue.

9. Concluding discussion

Despite the multiple disciplines involved with Big Data, this thesis delves into data generated for the benefit of public transport in metropolitan areas. Geolocated signals emitted by mobile phones and other tools such as sensors, ticketing systems, street cameras, pilots, etc. comprise valuable sources of information to feed and build urban mobility models. Today, by the fact of applying data processing techniques to raw datasets it is possible to carry out accurate estimations on the number of trips per person, modal choice and even preferred routes in close-knit urban areas. By and large, according to current technological development and the promotion of energy-efficient transport modes, the transaction of data is a key subject that links activities between the telecommunication and transport industries. From a technological and business point of view, the management of Big Data is a market niche with potential to estimate human behavior and people'so mobility patterns, and an increasing number of companies, supported by authorities, do strive to take advantage of it. With business models, business partnerships or by launching new products/services (e.g. data processing) they do not stay stagnant and prioritize in advances towards an innovative transport future. One instance are transport applications that integrate all modes (e.g. in Stockholm *SL.se* plans routes for PT), and besides integrated payment systems the user is provided with the cheapest, fastest and less polluting route: Mobility as a Service (MaaS).

Currently, the application of mobile data into transport planning "is happening" but it is still a relatively "young" and "infantile" field of research. The city of Stockholm is a fantastic case study where to interpret an actor network that, related to mobile data, it reflects an increasing number of firms with interest in reorienting their businesses / initiatives to data management. Since Sweden counts with an advanced technology development and profitable market structures (i.e. competitive companies in the international, national and local scale), this scenario involves stakeholders with activities ranged from the generation of new data (e.g. raw geolocated data) to those data processing services that add-value to the inputs used in mobility models (e.g. demand management by number of trips per person, OD matrices, average speed of modes, etc). Overall, this discussion entails the aim of this master thesis: the goal is to identify what companies play in the data-driven market as well as what characteristics distinguish them from the rest. Understanding how stakeholders use data is a key point to establish a structured framework of the actor network, and therefore dig into how firms relate between each other. There is a debate around which stakeholders have greater / lesser impact power in the current situation of the data market, as well as their interest to look to the future with an adaptation of their business models (i.e. based on power-interest grids). The whole analysis also recognizes possible gaps in the actor network, representing one reason that slows down the implementation of an integrated transport (MaaS) in the city of Stockholm.

Introduced in Chapter 5, the identification of data-related stakeholders combines stakeholder theories (stakeholder theory, power relations, clustering) as theoretical basis to "name" market players in Stockholm, and by the side of business theories (business models and benchmarking), stakeholder relationships and their way of acting in the business field are explained. The different commercial activities related to mobile data (purchase / sale) and other independent attributes (e.g. company size, business models) enable to classify them into the three clusters *data suppliers, data facilitators* and *data in users*, referring this last *data end user* to the transport industry.

First, *data suppliers* mostly cover the telecommunication industry and in general they produce new (raw) data from subscribers that use the network by their personal mobile phones. Between *handset manufacturers, enablers, ISP, NOs* and *MVNOs* the role of Network Operators (Telecom companies) outstands as they own the network and they have primary access to mobile data. In Sweden, Telia AB is the leading Telecom with the largest number of customers. Their company size makes them able to handle raw data and directly sell to Transport Operators (e.g. bus operator Nobina) the data that they process inside the company, without facilitators mediating. However, a second type of data *supplier* is emerging with a different business model: they sell "unspoiled" data to be processed by third parties. Generally, these *suppliers* are companies with less economic and technical resources (i.e. smaller telecom companies) that outsource data processing services.

Second, *data facilitators* act as intermediaries between *suppliers* and *end users* (e.g. Transport operator). There are four types of facilitators depending on whether they purchase (or not) data, or the degree of detail in their data processing services. The role of facilitators is key since they operate "in the middle" of the actor network, connecting producers and users, as a communication and commercial link. This cluster members are firms of all sizes and, increasingly, there is a growing trend in the number of facilitators in Stockholm: it is a market niche with great potential in the future (i.e. closely related to technology development) with room to startups to enter the market or leave when they are not competent. The great competition to attract customers and affordable data sources, from the economic and technical point of view (e.g. high-quality sample sizes, updated data, feasible dataset to process), is getting *facilitators* more and more specialized in their supply (data processing). The focus is on providing added-value product/services specific to client's needs and more detailed than those served by "pure" Telecoms.

Third, according to the course of the investigation the transport industry compounds the *data end user* cluster. *End users'* stakeholders take advantage from processed data (generally bought to facilitators or telecoms) in order to improve the transport system (i.e. from mobility models) and, in the end, optimize travelers experience (e.g. in time, costs, health, accessibility) by using data that they first-hand generated. Regarding transport stakeholders, in Sweden Public Transport Operators, Traffic Administration, Infrastructure Managers, Private Operator companies (e.g. Uber) and passengers play their role for an efficient transport future. Apart from their individual interests, in Stockholm the "transport community" strive together for a real PT and slow modes promotion (biking and walking), less dependent on car use and more on the "sharing" concept (e.g. carsharing, bike sharing, carpools). The sensitive issue in Stockholm is the barrier between the public and the private sector, and the lack of formal agreement in this aspect generates tensions that block a more efficient and effective urban transport, as is the case of an ideal MaaS model. Although there are public-private initiatives for MaaS in the Swedish capital (e.g. UbiGo pilots, SL public transport app), these focus on multimodality between PT, taxis, car sharing and cycling, but the concept of full modal integration is not accomplished yet. Stakeholders such as Uber are set apart MaaS, and there is no review that this trend will change in the near future.

In short, the city of Stockholm stands out for the diverse types of stakeholders and their complex relationships based on doing business with mobile data, whether institutional (public-public, public-private or private-private) or directly between the company and traveler. Although the city clearly efforts in providing an integrated package of transport modes, with a short-medium term scope, authorities still need to focus on legislating or at least intervene with policies that "sweeten" relations between the public-private sector. Using references from external contexts that succeed, one suggestion bases on promoting the figures of MaaS Operator and the Collecting Agent: the former as mediator between transport operators and the latter more oriented to a field of regulations / competences related to a service payment.

The immaturity of the mobile data market remains a task to be explored and it is open to further investigation. The idea of sustainable travel (and also MaaS) taken in the investigation should expand on the consequences of an “excessive” environmental-scale-focus, as rebound effects are likely to happen: strategies towards a climate-friendly mobility promotion such as biking/ walking lanes, High Occupancy Vehicle lanes, optimized PT or carsharing could not guarantee its success. Perhaps it attracts more demand and therefore and increased “transport consumption”, or, on the other hand, this “sustainable and efficient” package is insufficient and does not compensate the advantages given by private car use. The social scale should be carefully taken into consideration, and education (e.g. social awareness campaigns, teaching focus groups (e.g. elderly) about using transport apps, route booking, etc) is key to make people realize of the great advantages of multimodal transport, as well as the extent of “damage” caused to the planet when just moving around the city. In any case, it is a complex area to analyze, but the range of research areas and the critical points touched by this thesis provide a real perspective of internal / external relationships between institutions in the actor network. The levels of validation of the research strategies and their related results make the content of the thesis promising in a sense of being able to favor and support urban passenger transport in the city of Stockholm, and even serve as a starting point for other contexts with similar characteristics.

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Appendix 1 - Interviews

1. Interview grids

The interview grid is the guideline used in semi-structured interviews and it covers the questions asked to the experts. The sequence of questions is taken to facilitate de the flow of the interview and coherence in responses. The enquiry adapts to each stakeholder role.

INTERVIEW 1	
Company	Telia AB
Type	Telecom Company
Date	08 October 2018 (face-to-face)
TOPIC	**Questions**
Introduction	Outline of the project, agreement on recording and results usage.
Mobile data	● What is your job in the company?
	● What relation to Big Data does your company have?
	● How do you define big data/mobile data?
	● In relation to the data collection process, do more stakeholders intervene?
Business in the data market	● If you could draw the chain of actors playing from the generation of mobile data until the end user, for instance an improved urban transit, who would you highlight? Why?
	● Does Telia manipulate/process data, or just sell it raw? To who? ○ [If not commented] Which is the expected outcome from processing?
	● Who are the intermediaries? Could you mention some companies in Sweden?
	● Do you particularly collaborate with any of them? Who buys/sells to Telia this data?
The role of data provider	● What value do you create for your customers?
	● What is the general size of the customers you provide value for? (understanding customers as other companies in the market) ○ [If not commented] What is the general type of customers you provide value for?
	● In what way is this market growing/reducing?
	● In general, are organizations operating transparently in the market?
	● In which fields is there confidential information? ○ [If not commented] Could you roughly estimate the cost of data transactions?
Barriers	● What are your biggest challenges relating to big data? (e.g. within the transportation field)
	● What managerial difficulties are there? (e.g. business constraints from policies/legal framework)
	● Does the size of the company have an impact on barriers? ○ [If not commented] How do you handle the barriers mentioned?
	● Have the impact of the barriers increased or decreased?
Finishing questions	● What do you think about the internal research in your company?
	● How you think academical research contributes with the challenges? ○ [If not commented] Does the company openly share mobile data for academic research? ○ [If so] Through which routes? /[If not] Why not?
	● What is the primary value/potential you have found in big data?
	● Is there anything I have not asked that you think is relevant for the subject at hand?
	● Are there any other experts at your company that would recommend for me to talk to?

INTERVIEW 2	
Company	Trafikverket
Type	Transport Administration
Date	12 October 2018 (face-to-face)
TOPIC	**Questions**
Introduction	Outline of the project, agreement on recording and results usage.
Product: Big data	● What is your job in the company?
	● What is the relation with Big Data?
	● How does Trafikverket use Big Data internally (e.g. fleet or demand management)? ● And externally (e.g. with transport apps)?
	● What is the source of the data you are using? Are you buying it? To who?
	● Are you selling this data? ○ [If not commented] To which type of companies? ○ [If not commented] Do you sell it raw or processed?
Relationship with Transport Operators	● How would you define the relationship between the Administration and Transport Operators?
	● About the price paid by a user on a public transport ticket, which percentage of the total operating cost is subsidized?
	● We are currently living in the “share” era (e.g. car, bike, ride sharing etc) and there are emergent private companies such as Uber competing with PT, what are the positive and negative effects of this tendency?
	● In which others alternative fields Transport Administration and private operators still compete?
Relationship with Infrastructure owners	● How would you define the relationship between the Administration and Infrastructure owners?
	● How is the Administration intervening in regulating the urban transport?
MaaS scenario	● Is Sweden investing in MaaS models?
	● As an Administrative body, how will MaaS improve mobility behavior?
	● What key goals of MaaS are achieved in Sweden and what are not?
	● Do you think that Sweden has nowadays enough technology the develop an integrative MaaS model here in Stockholm? Why/ Why not? ○ [If not commented] Which are the barriers?
	● Which strategies are being implemented?
	● [If transport apps are not mentioned before] Are these transport apps integrating all modes of transport? (Uber + pendentag) And integrated payment methods?
	● What kind of changes in policies or legal frameworks would contribute to change the relationships between public and private bodies?
Finishing questions	● How do you see the evolution toward a MaaS future?
	● Which are the big challenges to do so?
	● How is the potential of big data influencing?
	● Is there anything I have not asked that you think is relevant for the subject at hand?
	● Are there any other experts at your company that would recommend for me to talk to?

INTERVIEW 3	
Company	Storstockholms Lokaltrafik (SL)
Type	Transport Trademark (Administration / Operation)
Date	18 October 2018 (face-to-face)
TOPIC	**Questions**
Introduction	Outline of the project, agreement on recording and results usage.
Product: Big data	● What is the role of SL in the transportation sector?
	● What is the relation with Big Data?
	● How does SL use Big Data internally (e.g. fleet or demand management)? ● And externally (e.g. with transport apps)?
	● What is the source of the data you are using? Are you buying it? To who?
	● Is SL selling this data? ○ [If not commented] To which type of companies? ○ [If not commented] Do you sell it raw or processed?
Relationship with Transport Operators & Administration	● How is the relationship with the contractors operating PT? ○ [If not commented] What type of data do you exchange with them?
	● Since there are emergent private companies such as Uber or "car-bike-ride sharing" that are competing with PT, how this competency influence rates of utility of private car and PT?
	● How is the relationship with the Trafikverket?
	● What strategies use the Administration to regulate the urban transport?
MaaS scenario	● Is SL involved in MaaS projects? Why/Why not?
	● Is Sweden investing in MaaS models?
	● How will MaaS improve mobility behavior?
	● What key goals of MaaS are achieved in Sweden and what are not? ○ Which strategies are being implemented?
	● Do you think that Sweden has nowadays enough technology the develop an integrative MaaS model here in Stockholm? Why/ Why not? ○ [If not commented] Which are the barriers?
	● To what extent the integration of all modes in a single transport app (e.g. Uber + pendentag) and also an integrated payment method, will benefit the user? ○ [If not comment] Does the user really need this type of apps?
	● What changes in policies could contribute to change the relationships between public and private bodies?
	● How do you see the evolution toward a MaaS future?
	● Is there a risk to lose customers if MaaS operators prosper?
Finishing questions	● Which are the big challenges to do so?
	● How is the potential of big data influencing?
	● Is there anything I have not asked that you think is relevant for the subject at hand?
	● Are there any other experts at your company that would recommend for me to talk to?

INTERVIEW 4	
Company	Ericsson
Type	Telecommunication Company
Date	22 October 2018 (Skype interview)
TOPIC	**Questions**
Introduction	Outline of the project, agreement on recording and results usage
Business in the data market.	● What is your job in the company?
	● What is the relation with Big Data?
	● What value do you create for your customers?
	● Where would you allocate the position in Ericsson in the value chain? (Data providers, facilitators and end user) Why?
	● What is the source of the data you are using? Are you buying it? To who? ○ [If not commented] How is the relation with network operators?
	● Does Ericsson manipulate/process data, or just sell it raw? To who? ○ [If not commented] To which type of companies? (intermediaries or directly to transport organizations)
	● To what extent does the size of the company affect in the "existence" of intermediaries in the value chain? (DS+DF+DU)
	● Do you know if any other Telecoms such as Tele2, Telenor, 3, etc, process big data (as Telia does) or otherwise they sell it raw to intermediaries companies?
	● Do you particularly collaborate with any intermediaries, as Ericsson is one on the largest companies in Sweden?
Relationship with the transportation sector	● Is Ericsson investing in sustainable mobility?
	● Does Ericsson supply equipment to collect data from the transportation sector?
	● Is Ericsson collaborating in any pilot in transportation?
	● Is Ericsson collaborating with MaaS projects, in line with apps that integrate all modes of transport?
	● Do you think that Sweden has nowadays enough technology to develop an integrative MaaS model here in Stockholm? Why/ Why not? ○ [If not commented] Which are the barriers?
Finishing questions	● What kind of policy changes would facilitate the relationships in the value chain?
	● What are your biggest challenges relating to big data? (e.g. within the transportation field)
	● Is there anything I have not asked that you think is relevant for the subject at hand?
	● Are there any other experts at your company that would recommend for me to talk to?

<table>
<tr><th colspan="2">INTERVIEW 5</th></tr>
<tr><td>Company</td><td>Trafik Stockholm</td></tr>
<tr><td>Type</td><td>Traffic management</td></tr>
<tr><td>Date</td><td>05 November 2018 (Skype interview)</td></tr>
<tr><td>TOPIC</td><td>Questions</td></tr>
<tr><td>Introduction</td><td>Outline of the project, agreement on recording and results usage</td></tr>
<tr><td rowspan="3">Big Data</td><td>● How does Trafik Stockholm use Big Data?
○ Internally: e.g. type of traffic predictions, and how these predictions make Trafik Stockholm become competitive against other organisms
○ Externally (e.g. with transport apps)</td></tr>
<tr><td>● What is the source of the data you are using (e.g. sensors, cameras)? Are you also buying data?
○ [If yes] To who (Telecom companies, Transport Operators)?</td></tr>
<tr><td>● Is Trafik Stockholm selling these data?
○ [If yes] To which type of companies?
○ [If not commented] Do you sell it raw or processed?</td></tr>
<tr><td rowspan="4">Relationship with Transport Operators & Administration</td><td>● How is the relationship with Public Transport (PT) Operators?
○ [If not commented] What type of data do you exchange with them?</td></tr>
<tr><td>● Since there are emergent private companies such as Uber or “car-bike-ride sharing” companies, how is your relationship with them?</td></tr>
<tr><td>● How is the relationship with the Administration (Trafikverket, SLL)?</td></tr>
<tr><td>● Do you see that Uber, car pools, etc, are competing with PT? (e.g. as it happens in Madrid) How?
○ [If not commented] How do you conceive this competency?
● To what extent Uber, car pools, etc, have an influence on rates of utility of private car and PT?</td></tr>
<tr><td rowspan="4">MaaS scenario</td><td>● How Trafik Stockholm is involved in MaaS projects? (e.g. UbiGo or other pilots/initiatives)</td></tr>
<tr><td>● To what extent is Stockholm investing in MaaS models?
○ Is it possible to fully integrate all modes? (PT, Uber, “sharing” services, taxi)
○ What key goals of MaaS are does Stockholm achieved and what are missing?</td></tr>
<tr><td>● Do you think that Stockholm has today enough technology the develop an integrative MaaS model? Why/ Why not?
○ How the public- private barrier affects? Is there a feasible solution for this barrier (e.g. changes in policies)?</td></tr>
<tr><td>● How do you see the evolution toward a MaaS future?
○ Is there a risk to PT lose customers if MaaS operators prosper?</td></tr>
<tr><td rowspan="3">Finishing questions</td><td>● To what extent do you think this stakeholder analysis helps the future MaaS planning?</td></tr>
<tr><td>● Which are the big challenges and limitations to do so?</td></tr>
<tr><td>● Is there anything I have not asked that you think is relevant for the subject at hand?</td></tr>
</table>

INTERVIEW 6	
Company	Kineo (Spain)
Type	Telecommunication Company
Date	07 November 2018 (Skype interview)
TOPIC	**Questions**
Introduction	Outline of the project, agreement on recording and results usage
Business in the data market	● What is your job in the company?
	● What is the relation with Big Data?
	● What value do you create for your customers?
	● What is Kineo's data source? ○ [If not commented] Who is your data provider? ○ [If not commented] What is your business model regarding purchases?
	● What is Kineo's relation with third parties or *data end users*? ○ [If not commented] Who are these data buyers? ○ [If not commented] How could you characterize these data transactions?
	● Do you know how Kineo operates in the Swedish market? ○ [If not commented] Does Kineo offer in both countries the same services? ○ [If not commented] Do you know what type of business partnerships does Kineo AB stablish in Stockholm? ○ [If not commented] Do you have direct contact with the Swedish headquarter?
Data processing	● How is this raw data that you purchase? ○ [If not commented] Are you using geolocated data? ○ [If not commented] Apart from mobile subscribers, do you combine mobile phone data with other sources, such as car pilots, sensors, etc?
	● What techniques does Kineo use in data processing? ○ [If not commented] How the software/algorithms add value from raw data? ○ [If not commented] How are your services "different" from competitors?
	● What types of results are you selling? (e.g. number of trips per person, OD matrices, average speed)
Relationship sustainable transport	● Is Kineo investing in sustainable mobility?
	● Is Kineo collaborating with MaaS projects, in line with apps integrating all modes of transport?
Finishing questions	● What are your biggest challenges related to big data & urban mobility?
	● How do you see the role of *data facilitators* in 10 years?
	● Is there anything I have not asked that you think is relevant for the subject at hand?
	● Are there any other experts at your company that would recommend for me to talk to?

Appendix 2 - Identification of companies in Sweden

Appendix 2 introduces the largest data-related companies operating in Sweden and organizes them with the same structure taken in the analysis: *data suppliers*, *data facilitators* and *data users* clusters. This appendix characterizes companies in terms of profitability (number of employees and estimated annual turnover) in Tables 11, Table 12 and Table 13. Respectively, each table corresponds to previous Figure 16, Figure 18 and Figure 20 included in the analysis section 6. Is is important to clarify that those figures use logarithmic scales in both axes in order to represent as many companies as possible. This method provides clearer graphs and reduces a company overlap due to similar parameter values.

1. *Data suppliers* in Sweden

Table 11. Data suppliers in Sweden identified in terms of number of employees and annual revenue
Source: own elaboration, data from Statista (2018)& allbolag.se (2018)

	Data supplier company	Number of employees	Annual revenue (Million SEK)		*Data supplier* company	Number of employees	Annual revenue (Million SEK)
1	Ericsson AB	107369	202478,00	23	IT-Mästaren Mitt AB	63	582,93
2	Telia Company AB	24898	84178,00	24	Canal Digital Sverige AB	63	554,36
3	Eltel AB	9613	28292,00	25	Interoute Managed Services Sweden AB	63	494,79
4	Tele2 AB	6027	13371,59	26	A3 Sverige AB	59	432,48
5	Relacom Management AB	2906	12473,96	27	AddSecure AB	58	361,76
6	Eltel Networks Infranet AB	2228	11681,62	28	Generic Sweden AB (publ)	57	338,67
7	Tele2 Sverige AB	1999	4793,83	29	BT Nordics Sweden AB	53	330,02
8	Telenor Sverige AB	1686	4198,61	30	MTG Technology AB	52	327,60
9	Com Hem AB	993	4032,40	31	Invisio Communications AB	46	267,47
10	Ericsson Local Services AB	783	2333,94	32	Celab Communications AB	46	236,73
11	Svenska Rymd AB	536	1613,25	33	Qall Telecom AB	43	208,53
12	TelaVox AB	209	1210,80	34	Netsize Internet Payment Exchange AB	43	194,68
13	CLX Communications AB (publ)	199	1198,81	35	TargetEveryOne AB (publ)	41	177,67
14	A3 Allmänna IT - och Telekom AB (publ)	153	1160,87	36	Sierra Wireless Sweden Holding AB	36	171,09
15	Verizon Sweden AB	141	990,75	37	Sierra Wireless Sweden AB	36	168,82
16	Rebtel Owners AB	117	712,18	38	Ria Financial Services Sweden AB	36	62,19
17	Transtema Group AB	116	710,30	39	Servanet AB	34	140,89
18	Telenor Connexion AB	98	683,71	40	AT & T Global Network Services Sweden AB	34	138,39
19	Zitius Service Delivery AB	84	648,36	41	Orange Business Sweden AB	34	143,10
20	RebTel Networks AB	76	630,00	42	Netett Sverige AB	33	168,82
21	Viafield Sweden AB	70	629,66	43	Quicknet AB	33	42,97
22	Artinsgruppen AB	68	597,21	44	Uno Telefoni AB	32	47,16

45	Telog AB	30	34,13	59	MIC Nordic AB	19	43,57
46	Cellip AB	30	47,96	60	4Pro Teknik AB	17	45,02
47	Tectel i Vindeln AB	25	39,19	61	Teloteket AB	15	56,34
48	Wiraya Solutions AB	24	32,66	62	Lunet AB	15	61,06
49	Net at Once Sweden AB	24	67,77	63	Mediateknik i Varberg AB	15	30,49
50	Colt Technology Services AB	24	124,73	64	Nortic AB	15	43,57
51	Fonia AB	24	91,32	65	iCentrex Sweden AB	14	41,44
52	Netnod Internet Exchange i Sverige AB	23	74,62	66	Vökby Bredband AB	14	36,78
53	Griffel AB	22	30,04	67	ViaEuropa Sverige AB	14	29,67
54	SES Astra AB	22	597,21	68	West UC Sweden AB	12	32,08
55	Bredband100 AB	21	71,28	69	Winther Wireless AB	11	75,16
56	Third Generation Network Services (3GNS) AB	21	38,16	70	Easy pbx AB	10	37,48
57	Link Mobility AB	21	100,09	71	Viatel Sweden AB	10	30,94
58	Soluno BC AB	21	68,22				

2. *Data facilitators* in Sweden

Table 12. Data facilitators in Sweden identified in terms of number of employees and annual revenue
Source: own elaboration, data from Statista (2018)& allbolag.se (2018)

	Data facilitator company	Number of employees	Annual revenue (Million SEK)		*Data facilitator* company	Number of employees	Annual revenue (Million SEK)
1	Ericsson AB	107369	202478,00	13	Unomaly	30	4,8
2	Deltaprojects	60	129,7	14	M3 Research Part Of Bilendi	30	4
3	Norstat Sverige AB	107	115,666	15	CCL Swedish Moderators AB	2	3,41
4	Neo4j	64	56,8	16	EMaintanance365	3	3,3
5	Augur AB	26	42,055	17	Kineo AB	2	3,253
6	AB Better Business Wold Wide	23	27,531	18	Vainu	15	3,23
7	Demoskop AB	10	24,82	19	imagimob	5	0,891
8	AB Stelacon	15	22,566	20	Sentian	3	0,285
9	Prognoscentret AB	14	21,94	21	Peltarion	7	0,23
10	Ipsos Sweden AB	7	17,8	22	Century.ai	3	0,196
11	Behaviosec	22	7,7	23	Meltwater	21	0,025
12	Amarillo Research & Consultancy AB	4	6,377				

NOTE. *Transport Applications & Platform serve*r facilitators are not included. They are foreign legal entities and no profitability data based on Sweden is available

3. *Data users* in Sweden

Table 13. Data users - Transport Operators - in Sweden identified in terms of number of employees and annual revenue
Source: own elaboration, data from Statista (2018)& allbolag.se (2018)

	Data user company	Number of employees	Annual revenue (Million SEK)		*Data user* company	Number of employees	Annual revenue (Million SEK)
1	Nobina Sverige AB	6108	6236,16	8	Aktiebolaget Stockholms Spårvägar	187	170,30
2	MTR Nordic AB	4443	5455,93	9	TOPCAB in Stockholm AB	21	139,13
3	Keolis Sverige AB	5262	4678,90	10	Blidösundsbolaget AB	52	87,37
4	Arriva Sverige Aktiebolag	2785	2893,08	11	Taxi Kurir AB	2	76,00
5	Sverigetaxi in Stockholm AB	24	1363,02	12	Uber Sweden AB	18	48,18
6	First Rent A Car Limited Company	259	569,54	13	UbiGo Innovation AB	1	0,51
7	Cabonline Group AB	29	239,95	14	Carpool Sverige AB	2	0,05

NOTE. Public business institutions are not included: Storstockholms Lokaltrafik (SL), Waxholmsbolaget, Commercial public transport, AB Stockholm Trails, CityBikes