Following (Big) Data in the Smart City: Control Rooms, Expertise and Obligatory Passage Points in Santiago's Public Transport.

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Abstract

Smart cities and big data have been at the forefront of urban discussions and projects over the last decade. Big data has arisen as a critical feature of the smart city to face urban challenges, usually framed by projects and policies promoting a direct relationship whereby more volume, variety, velocity and fine-detailed data will necessarily lead to better-informed decisions and, therefore, to the more effective and efficient government of cities. However, these approaches generally lack attention to how big data circulates and what it does.

In this dissertation, I offer an alternative to previous formulations of big data in the smart city. Accordingly, I aim to analyse how data circulates in Santiago de Chile's public transport and what it does when it circulates. Drawing on the case of Santiago de Chile's public transport, I describe and analyse the emergent configurations, practices and governing techniques which enable big data to circulate. This creates what I call the *data dispositif*.

I work with an experimental "following the data" methodology to identify how data circulation problems and their subsequent solutions emerge in Transantiago after more than ten years of implementation. Accordingly, I find that enabling big data circulation requires taking care of three emerging problems: the problem of control room fragmentation, the problem of experts and expertise, and the problem of translation. I argue that these problems are generative of specific solutions, taking the form of policies, indicators, standards, and new skills, which together produce new arrangements that allow data to circulate in ways beyond the initial operational objectives of public transport.

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List of Accronyms

CEDEUS: Centro de Desarrollo Urbano Sustentable – Urban Sustainable Development Centre

CSP: Complementary Services Providers

DTPM: Directorio de Transporte Metropolitano – Metropolitan Transport Directorate. Public organisational body overseeing Transantiago, dependent of the Ministry of Transport.

ICF: Índice de Promedio Frecuencia del Servicio – Bus Average Frequency Index

ICPH: Índice Tiempo Promedio de Ocupación - Average Seating Time Compliance Index

ICR: Índice de Promedio Cumplimiento de Regularidad – Bus Average Regularity Compliance Index

MTT: Ministerio de Transportes y Telecomunicaciones – Ministry of Transport and Telecommunications

ANT: Actor-Network Theory

ONEMI: Oficina Nacional de Emergencias

OPP: Obligatory Passage Point

PTUS: Plan Transporte Urbano de Santiago - Santiago's Urban Transport Plan

PUC: Pontificia Universidad Católica de Chile – Pontifical Catholic University of Chile

SECTRA: Secretaria de Transportes – Transport Secretary, in this case refers to a division within the Sub-secretary of Transport, despite the apparent incoherence, SECTRA is below the Sub-secretary in the MTT's organigram.

UCH: Universidad de Chile – University of Chile

UOCT: Unidad Operativa de Control de Tránsito – Operational Traffic Management Unit

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1.Introduction

Today big data is everywhere. It is widely present in public and corporate discourse as a tool to enhance organisational processes, improve service delivery, conduct more acute research, and quantify life pervasively. It equally circulates as an ideology of progress, as a form of truth, and as a commodity. It embodies different tales about a new stage of modernity with massive societal consequences. For example, Chris Anderson (2008;n.p.), more than a decade ago, announced that the data deluge would represent the end of theory and scientific methods as we know them. In his words: *"This is a world where massive amounts of data and applied mathematics replace every other tool that might be brought to bear. Out with every theory of human behaviour, from linguistics to sociology. Forget taxonomy, ontology, and psychology. Who knows why people do what they do? The point is they do it, and we can track and measure it with unprecedented fidelity. With enough data, the numbers speak for themselves."*

Similar overstatements have been made about big data, like the very well-known "data is the new oil" (Yonego, 2014). Big data has been depicted as the most significant commodity of our age to generate profit and an ideology of progress supported by a pretension to a higher form of knowledge varnished by an “aura of truth” (Boyd & Crawford, 2012). In alignment with these extravagant and utterly normative visions, a massive body of knowledge has emerged based on enhanced computational capacities, required technical skills, and flourishing data-centred disciplines to make numbers speak for themselves.

In this chapter, I will introduce my dissertation and how it seeks to contribute to the debates on the increasing presence of data in our lives and cities, focusing on the processes by which big data is constituted as a complex configuration of digital technologies, institutions, organizations, services, products, and, of course, people.

My work starts from three overlapping considerations about the big data deluge. First, I adopt a non-essentialist approach to big data since data is never "raw" (Gitelman, 2013), neutral or objective (Kitchin, 2014b, 2014c). Instead, I focus on the complexity of big data, and the relational and dynamic configurations composing it (Boyd & Crawford, 2012). Second, and overlapping with the previous point, I focus on the infrastructural components that enact big data as a time-spatial-specific sociotechnical network (Kitchin & Lauriault, 2014). This vision can comprehend -yet not be reduced- to the often used series of V's dimensionalities like volume, velocity, variety, volatility, virtuosity, visionary, vigour, viability, vibrancy, or even virility; as well as less enthusiastic terms like valueless, vampire-like, venomous, vulgar, violating, and very violent (Uprichard, 2013). Thirdly, I challenge the idea that the mere existence of finer-grained, vast, accessible, almost-real-time data validates big data as a higher form of "truth", because it does not say anything about how it circulates within and between humans and non-humans, and what it does when that happens.

Big data has emerged as a topic of critical analysis in urban geography (Ashton et al., 2017; Bannister & O'Sullivan, 2021; Batty, 2016; Heaphy, 2019; Kitchin et al., 2016, 2017; Marvin & Luque-Ayala, 2017), digital geographies (Ash et al., 2018b; Dalton et al., 2016; Kitchin, 2014c), and Science and Technology Studies (Jasanoff, 2017; Vertesi & Ribes, 2019).

These studies have increasingly focused on data as sociotechnical, seeking to grasp the enmeshment of digital data and technological development in/with our everyday lives, analysing the effects and the emerging arrangements and configurations between people and the digital. The smart city has burgeoned along with the big data deluge, and in the same way as critical perspectives on big data, an essential body of critiques has emerged about it (Aradau & Blanke, 2015; Bannister & O'Sullivan, 2021; Barns, 2021; Hodson et al., 2021; Kitchin, 2014b; Kitchin et al., 2017; Luque-Ayala & Marvin, 2015, 2020; Marvin et al., 2016; McFarlane & Söderström, 2017; Odendaal, 2016; Rose, 2017; Rose et al., 2020). Part of these critiques suggests not taking the relationship between the smart city and the proliferation of big data for granted. Despite the inclusion of big data as a crucial element, some of the most compelling examples of the uses of big data in cities take place outside smart city projects (Farías & Widmer, 2018; McFarlane & Söderström, 2017); conversely some successful smart city projects work with 'small' digital datasets . Therefore, I aim to analyse big data beyond corporate storytelling about the smart city (Söderström et al., 2014) and the fetishised and spectacular uptake of these narratives by governments and public authorities (Datta & Odendaal, 2019). In contrast, I focus on the complexities of developing big data as part of a key urban infrastructure, which is Santiago's public transport. Drawing theoretical inspiration from the late Foucauldian concepts of *dispositif* and *problematisation* and from Actor-Network Theory, I explore how big data circulation enacts new actors, skills, and modes of governance.

In this thesis, I examine the implementation and development of big data as an urban phenomenon in Santiago de Chile's public transport management. Santiago underwent a massive transition of its transport system in 2007, including the development of a new organisational public-private structure and a management re-organisation. As I will explain later in this chapter, one of the key new features was the creation of a digital infrastructure to support the system operations, including an online GPS service for bus fleet management and the collection of smart card transactional data. In other words, with the new system big data was "born" as an urban phenomenon in Santiago de Chile.

I start by critically approaching the assumption that the mere existence of a higher volume, velocity and variety of data will trigger "better" urban management. Instead, Santiago's public transport system demonstrates that big data is a relational and heterogenous process characterised by its contingencies, by various operations that define what big data is and what data does. The implementation and development of big data in public transport is not static, neither definitive nor standardised. Instead, it is a sociotechnical process defined by the problem of "circulation" as the operational logics of big data are demarcated by its flows and intrinsic dynamism. Yet, that circulation is neither self-evident nor obvious. Instead, it results from multiple configurations and interdependent relations between human and non-human actors who associate by coordinated practices, configurations, and governing techniques.

Therefore, to make data circulate is not easy since a wide variety of emergent situations must be resolved. For example, in the case of public transport, assembling a digital infrastructure to collect transactional smart card data or GPS data from every bus is not enough to ensure its circulation through the transport system. It is not evident what software is required to structure, organise, and analyse that data or what skills are needed to manipulate and make sense of the data; nor are the regulatory frameworks to harvest and create an ethical use of that data. In some way, the emergence of platform capitalism (Srnicek, 2016) and platform urbanism (Barns, 2020; Hodson, 2021; Rose et al., 2020) responds to the problem of structuring data circulation and its contingent trajectories. As Rose (2020) points out, the value that these platforms produce is not just determined by their capacity to extract data but also by their ability to define the elements by which data will circulate according to specific infrastructural arrangements. Despite the standardization of logics of data circulation in urban data platforms, the configurations by which data gets to circulate are very messy, patchy, and hard to anticipate. They rely equally on sophisticated software and on human agency, and it is the combination and recombination of these elements that, in the end, makes data circulation possible.

In the same way, these arrangements are imbricated in previous trajectories; the configurations in that sense are responding to new requirements to enable data circulation, yet the responses are *"a result of previous imbricated interdependencies, these are the heterogenous variety of things that partially hold one another up"* (Lampland & Star, 2009, p. 20). These interdependencies result in unforeseen ways in which data circulates, affecting new groups and processes, and requiring new operations to enable its circulation further.

The question thus arises how we can grasp what happens when data does (not) circulate. I suggest that by *following the data* throughout public transport, it is possible to track down the problems of the data circulation process. That involves much more than focusing on results, or final products, like a particular platform, or a standardised ISO protocol on digital transformation. It requires seeing how these components are integrated through experimental yet coordinated practices and techniques that create novel modes of governance.

Theoretically, the central concept of my thesis is the *dispositif* (Foucault, 1980, 1988, 2008), which refers to the ensemble of networked institutions and technologies created by practices and governing techniques to control both individuals and society (Foucault, 1991a). The dispositif is eminently fluid and pragmatic; it is produced in the movement and the connection between its elements, acting in the interstices of previously existing time-spaces and moving towards contingent possibilities. In my dissertation I use the *data dispositif*—which refers to the heterogeneous ensemble of entities, practices, techniques, and configurations that enable data circulation in public transport. These interdependent components are time-specific responses to *problematisation* (Foucault, 1984), that is, *"a specific response to a historical problem. It is, however, a dominating strategic response"* (Rabinow, 2003, p. 54). In other words, a moment in which data does not circulate that requires a solution, which generates a new association between heterogenous components to make it circulate back.

All of which leads to my research question, which is:

- *How is big data made to circulate among public transport organisations in Santiago, and what are the effects of its circulation?*

Accordingly, my results refer to three problems in the data circulation process. Those are the problem of transport fragmentation of control rooms, the problem of knowledge and expertise, and the problem of translation and the emergence of obligatory passage points. As I argue, the data dispositif is (re)configured through the operations by which these problems are solved, enabling new ways in which data circulates in public transport.

My work is a case study of Santiago de Chile's Urban Public Transport (Transantiago) and its process of implanting big data since the beginning of its operations in 2007. Transantiago has been characterised by implementation problems and a long trajectory of alterations and improvements to enhance and optimise service provision. That trajectory has been hugely marked by the process by which big data has been made to circulate throughout the system's complexities. As Ureta identifies (2014), Transantiago has never simply been built in a particular moment and then put to work to produce specific results. On the contrary, it is constantly emerging in practice, since: *"it is continually changing and being redefined as new elements are included, repurposed, and/or discarded"* (p.369). A vast amount of scholarship has analysed the controversial trajectory of Transantiago, as I will describe in the next section. A small portion of this work has mentioned the importance of big data in Transantiago as an innovation of the new system, mainly focusing on the use of new sources of origin-destination data generated by the system's operations. Nevertheless, very little has been said regarding the challenges of making big data circulate amongst the various areas of management of Transantiago and even less about how big data has shaped what the system is today.

My dissertation is organised into seven chapters. After the introduction, there are three empirical chapters (Chapters 4, 5 and 6), each discussing one problematisation of the data circulation process. In the second chapter, I review the literatures about smart cities and critical big data to situate my project in-between these. At the same time, I develop an analytical framework, presenting the guiding notions of dispositif and problematisation while developing the guiding analytical concepts of my research. In the third chapter, I describe the methodology used to study big data circulation as *following* Santiago's public transport big data. In the fourth chapter, I analyse the problem of fragmentation in/of control rooms. In the fifth chapter, I discuss the role of knowledge and expertise as part of the data circulation. And in the sixth chapter, I analyse obligatory passage points as endurable associations defining the trajectories of big data in public transport. Finally, in the conclusion, I reflect on the challenges of implementing big data in public transport, focusing on the effects of data circulation on the management of public transportation in Santiago.

1.1 Finding big data in public transport in Santiago de Chile.

Santiago is the capital of Chile; in 2017 it had a total population of 7.112.808 people (INE, 2017) and it is part of the Región Metropolitana (Metropolitan Region of Santiago). At the same time, Santiago is part of the Provincia of Santiago which reunites the 32 urban municipalities. Only recently, in 2021, was Claudio Orrego democratically elected as the first Gobernador Regional (regional governor), thanks to a constitutional reform that created regional governors for each of the 16 regions that make up Chile as a country. This reform presents a significant opportunity to answer a structural problem of fragmented governance of Chilean cities. At least initially, the powers of the city mayor are limited in critical areas such as public transport. In the same way, the regional governor powers fall short to revert the problem of urban fragmentation. Therefore, urban fragmentation remains one of the main challenges for urban governance and service delivery since power oscillates between a central government that concentrates on policymaking and budgeting and the atomization of highly unequal[1] municipalities responsible for providing critical services such as education and health. However, depending on the scale and requirements, a few critical public services have generated alternative governance arrangements at a city level in response to municipal fragmentation. One of these is public transport.

As I describe thoroughly in chapter 3, I *found* big data in Santiago's Public Transport through a two-phase fieldwork strategy, which included an initial phase of exploration and observation. In the exploratory phase, the aim was to identify a robust case of big data implementation, hopefully related to an urban public service. Initially, I was reluctant to use Transantiago as a case since I had the idea that the amount of research into the system had exhausted the topic, considering the wide variety of approaches to the issue from disciplines like transport engineering (see: Beltrán & Palma, 2012; Hidalgo & Graftieaux, 2008; Muñoz et al., 2009; Muñoz et al., 2014, 2016; Muñoz & Gschwender, 2008); economics (Briones, 2009; De Gregorio, 2017; Gómez-Lobo, 2012); policy implementation and urban governance (Figueroa & Orellana, 2007; Olavarría-Gambi, 2020); and ethnographies on daily urban mobility (Jirón Martínez, 2009) and policy assemblages (Ureta, 2015, 2017). The last work especially made me hesitant to pursue public transport since it was a detailed analysis of the crises in the implementation of Transantiago from a Science and Technology Studies (STS) and Actor-Network Theory (ANT) perspective. However, despite the huge value of these projects, there were still gaps in the role of data and its circulation in Transantiago. In the

[1] In terms of economic development, budgets, technical skills, policy execution capabilities, infrastructure provision, educational results, etc.

best case, previous research has used big data in quantitative analysis, yet no previous research has concentrated on big data as a topic of analysis by itself.

What finally convinced me about the relevance of Transantiago as a case was learning about the software ADATRAP, which is a joint effort between the transport authority and a group of transport engineers from the Universidad de Chile. ADATRAP is a software developed as a collaborative effort between academics of the Universidad de Chile's transport engineering department and the Ministry of Transport to optimise the operational data generated within the system to be used in Transport Planning and more (see Chapter 6). ADATRAP appears to make the most of two operational innovations of Transantiago: the introduction of smart card transactions (BIP Card) that generate data of each recorded transaction (that is, when a user taps the card to take a bus or Santiago's metro) and the inclusion of GPS tracking devices on every bus operating in the system. Thanks to these two new technologies, the BIP card and the bus-GPS, massive amounts of origin-destination data started to be generated as part of the system's operations. Daily, more than 5 million BIP transactions would be made, and a fleet of 6500 buses would leave GPS data updating every 30 seconds during its operations (Gschwender et al., 2016; Munizaga & Palma, 2012). The new abundance of operational data was a significant change compared to the previous system, which was designed and operated based on the scarcity of data, primarily collected through a mixture of surveys, including the origin-destination survey made every 10 years, and even through informal roles like the *sapos*[2].

[2] The colloquially named figure of *sapos* (frogs) is widely known in Santiago as part of the previous transport system. These were informal workers placed in specific stops of a route

The original contracts of Transantiago established that the operational data generated by the system would be public property, therefore accessible to the wider public based on Chilean transparency laws[3]. A group of transport engineers at the Universidad de Chile noticed both elements: the existence of more fine-grained origin-destination data and the legal support to use it. They saw an opportunity to generate software beyond its operational function—giving birth to a fruitful collaboration between the academics of the Universidad de Chile and a group of specialists within the transport authority to produce what is now known as ADATRAP. Software was developed based on an experimental collaboration to make a more accurate use of BIP cards and GPS data to permeate the transport system management. Accordingly, doing some preliminary interviews with the group in charge of developing and maintaining ADATRAP, I decided that Transantiago was a solid case to analyse the circulation of big data in Santiago de Chile.

In the following section, I describe how Transantiago works, rendering the main actors and how they interact with each other to facilitate the comprehension of the rest of my work about data circulation in Santiago's public transport.

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who gave updated information to the bus drivers about the position of the other buses covering the same route.

[3] Thanks to the law nº20285 "about the access to public information" which secures the access rights to public information, that includes established procedures to request that information and that has made progress towards open data portals among other tools for public access.

1.2 The organisation of public transport big data in Santiago de Chile

In this section I focus on how Transantiago works, tracing a brief history of its development starting in the 2000's. I introduce the organisational arrangements of Transantiago in considerable depth now rather than later in my work. The objective is to delineate the organisational heterogeneity of the public service to provide the reader with detailed context of how the problem of data circulation is enacted and performed in Santiago's public transport.

In Santiago, public transport has been a major public issue, especially after the implementation of Transantiago in 2007. Transantiago replaced the old, semi-informal, and even dangerous bus transport system[4]. It was a radical, premature, and traumatic change, as one of the academics interviewed during my work noted: *"everything that could have gone wrong went wrong at the same time"*. Therefore, the development of Transantiago is contradictory, as it represented improvements and failure at the same time. The original ambivalence is an essential analytical element in understanding the many adjustments and changes in the contracts, key performance indicators, metrics, and software made within the system over time. As I describe in chapter 6, these adjustments, taking the form of obligatory passage points, are tightly connected to the data circulation across the system in much more

[4] Locally known as "micros amarillas", "yellow buses" in English. Dangerous, since despite the initial problems of Transantiago, an immediate effect of its implementation was the dramatic diminution of accidents.

complex, extended, and meaningful ways, beyond original operational expectations.

1.2.1 Main organisations

Transantiago is a multimodal service organised on three modes of transport: i) A private bus network of 7033 buses managed by 6[5] different bus companies[6] covering the city distributed in zones (see fig. XX). These companies have been incorporated into Transantiago since its early days as they participated in the original bids. However, after a few years of operation, the authority negotiated new contracts with these companies to realign the incentives of the system, solving some unforeseen failures related to ineffective performance indicators.

Table 1 Transantiago private buses operators' breakdown

Zone	Operator	Nº of services	Nº of vehicles	Bidding Period
Unit 1	Inversiones Alsacia S.A.	Services transferred to other operators.		2012 – 2018
Unit 2	Subus Chile S.A.	57	1319	2012 – 2020
Unit 3	Buses Vule S.A.	98	1463	2012 – 2021
Unit 4	Express de Santiago Uno S.A.	67	1678	2012 – 2019
Unit 5	Metbus S.A.	59	1155	2012 – 2020
Unit 6	Redbus Urbano S.A.	65	790	2012 - 2019
Unit 7	STP Santiago S.A.	37	628	2012 - 2019

Table 1 Source: (Hurtubia & Leonhardt, 2021)

[5] In 2018 Alsacia S.A. got expelled from the system due to systematic poor performance being the first time than a bus operator is banned from the system. Their buses and terminals were absorbed by some of the pre-existing players of the system.

[6] Also known within the system as" business units".

Figure 1 Transantiago intermodal services (Bus, Metro, MetroTren). ***Left to right: Bus corresponding to the 303 lines; a Metro wagon; and a Metro-tren wagon. Source:*** https://www.dtpm.cl/index.php/homepage/sistema-integrado-de-transporte *(2022)*

Figure 2 Transantiago's intermodal network map. The image illustrates in different colours every private company operating the system based on a spatial distribution established by the public authorities. Source: https://www.red.cl/mapas-y-horarios/bus/mapas-en-version-imprimible/ (2022)

ii) Santiago's Metro runs a 119km network of 6 lines between 118 stations and 23 municipalities in Santiago; iii) Metro-Tren, also a publicly owned company in charge of one suburban train line. These three modes of transport, private buses, Metro and Metro-Tren, are autonomous organisations hierarchically subordinated to the Ministry of Transport. However, as I illustrate in my work, the relations between these organisations are hard to structure as unwritten hierarchies and governing techniques are in play.

Figure 3 Metro de Santiago Network. Metro de Santiago's Plan including all the current lines in operation. Source: https://www.dtpm.cl/index.php/sistema-transporte-publico-santiago/metro *(2022)*

The Metropolitan Transport Directorate (DTPM) is the general management body of Transantiago and is dependent on the Ministry of Transport. The organisation has intended to centralise governance of Transantiago overseeing the three modes of transport composing it (buses, Metro, and Metro-Tren). However, since both Metro and Metro-Tren are autonomous public companies, the role of DTPM is much more focused on overseeing the bus operations. For that reason, it is common to use "Transantiago" to refer only to buses and not to the whole integrated multimodal service. This situation is reinforced by how the relationship between the private and public sector is structured to operate the bus network. Accordingly, Transantiago is yet to achieve a single integrated governance body as in practice DTPM oversees the multiple private bus providers, while Metro and Metro-Tren operate as autonomous services, not directly managed by DTPM.

I also decided to include the Traffic Operations Control Unit[7] (UOCT) as part of the analysis, even though it is not formally part of Transantiago. It is, however, a crucial element for analysing data circulation in Public Transport. The UOCT is the centralised body that manages all the traffic lights in the city and is primarily known thanks to its control room, which is widely recognised among the public. As I discuss in chapter 4, the UOCT plays a significant role in the daily coordination of city transport along with other control rooms that together produce a model to oversee real-time traffic units that are formally part of Transantiago, like the CMB and the private bus providers.

[7] The UOCT is not formally part of Transantiago, yet I decided to include it as part of an extended idea of urban transport system.

1.2.2 Main technologies – Complementary Service Providers (CSP)

The technological element of the new transport system was highlighted, from the first prospective documents of Transantiago, as a "revolutionary" new element of the system (SECTRA, 2000). One of the key features is the new data infrastructure which would be at the forefront of the system operations, improving the fleet management and sourcing the users of real-time information by using the BIP card and the GIS-enabled buses. The resulting data infrastructure has several functions (Muñoz et al., 2009): i) it furnishes users with valuable advice both before and during their trips; ii) it monitors the location of every bus via GPS and controls bus headways through a communication system installed in each vehicle; iii) it provides information on bus arrivals via message displays at the bus stops, through users phones and on the internet; and iv) implements the BIP! Card to pay for the service, which, among other benefits, dispenses the drivers from handling money and all the associated risks.

The technological provision of the system is ensured by specialised external companies named Complementary Services Providers (CSP). These are responsible for providing critical supporting technology infrastructure for the system in at least two dimensions. First, to provide all the technology related to ticketing and payment collection through the smart card validation (BIP Card). Second, the online informational services involve the entire infrastructure to make operational data available throughout and beyond the system, including BIP transactions and GPS data and database reporting, among several other services. In the same

Figure 4 Bip! card en route payment. Source: https://www.saldo-bip.com/ (2022)

There are different CSPs in the system, yet the most relevant in terms of size of the contracts and general predominance is Sonda[8].

As the leading tech provider overseeing the technological provisions, Sonda has a pivotal role in ensuring big data circulation throughout the system. The

[8] Sonda is a Chilean technology firm providing services to several public institutions as well as private companies. It has a presence in 10 countries in Latin America, including Brazil, Mexico, and Argentina. It is the primary technology provider of Transantiago since the beginning of the system, ensuring all the system's technological infrastructure, the data provision (including transactional smart card data and online GPS of every bus part of the system). According to their integrated report (Sonda, 2019) the company's total revenues for the year 2019 was more than one billion dollars; also, the company has more than 16500 employees and more than 5000 corporate clients along more than 30 years of existence.

contracts between the company and the Ministry of Transport establish commitments to reach more than 18 different services, from technological infrastructure including hardware, software development and services like reporting, data mining, and fleet management. I am especially interested in the services related to providing operational data and transport planning data, both crucial components to configure the data dispositif. Sonda's is responsible for:

1. Ensuring the availability of GPS quasi-real-time data for operational purposes. Therefore, they provide the appropriate functioning of each step of the process like collecting the transactional data and the GPS, the data storage, and the online data service, accessible to other third-party actors through MoUs with the Ministry of Transport.

2. Calculating several key performance indicators (KPI) essential to the management of Transantiago. The KPIs are used to make periodic payments to the service providers of the system like the private buses, Metro, and Metro-train.

3. Generating inputs to other areas at DTPM, including primary databases that include the aggregated data from BIP card transactions and GPS to further processing by the DTPM and other third parties (e.g., ADATRAP).

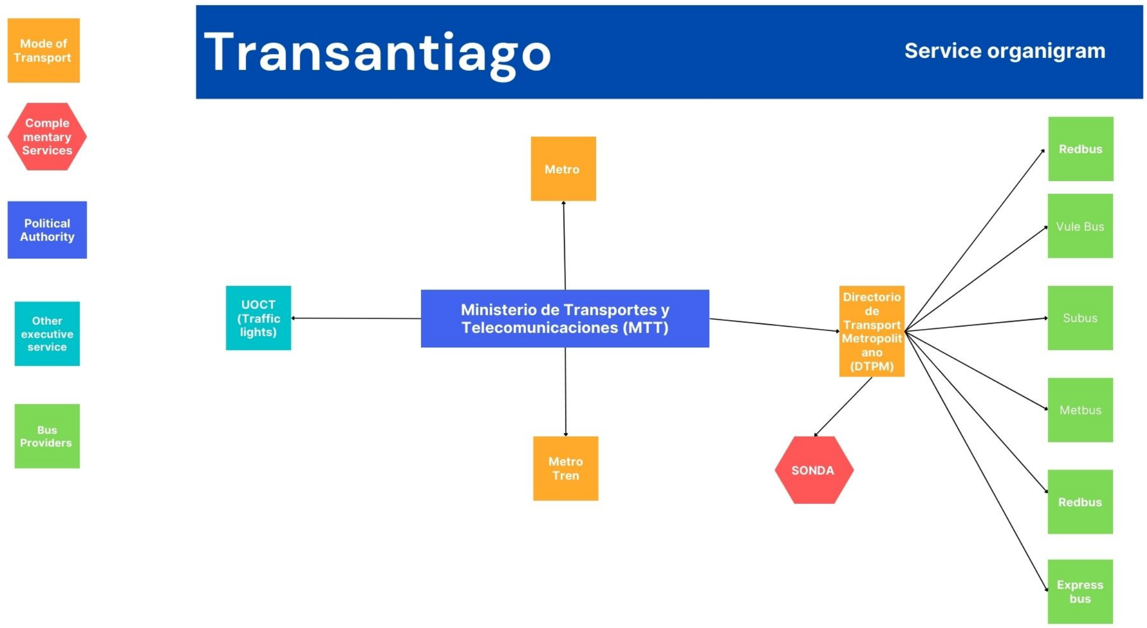

Figure 5 Transantiago Operational Organigram. Source: own elaboration.

1.2.3 Contracts, performance indicators, and incentives

Contracts legally structure the relationship between the public authority and the service providers. These legal devices have been a matter of dispute and adjustment, especially some years after the chaos of Transantiago's initial implementation as the authorities had a clearer notion of what to improve. Arguably, the design flaws of Transantiago's first years are in practice a consequence of poorly designed contracts (Briones, 2009).

The original contracts aimed to provide a low-risk operation in which changes in the number of users had a minimal effect on the revenues received by the private bus companies. Accordingly, it was established that if the effective demand was lower than the reference demand, the fare would rise in such a way as to guarantee 90% of the revenues that the contractor would receive if the offered fare was combined with the reference demand (Hurtubia &

Leonhardt, 2021, p. 13). The early contracts were designed to attract large-size bidders; the guaranteed minimum income therefore worked as an incentive to ensure large-size bidders' involvement. Nevertheless, the guaranteed minimum income generated massive market distortions. For example, it provided minimum incentives for the bus operators to optimise the offer, which in practice meant that during periods of the day it was preferrable to not run their buses; it also provided disincentives to modify routes, resulting in a higher volatility of the service. At the same time, the rigidness of these contracts signed with each private bus operator offered the transport authorities little room for manoeuvre to make changes in the event of major issues.

An essential component of the contracts is the establishment of fines and revenue deductions to the operators in case of poor service delivery – to the point that a systematic bad evaluation of a certain provider could lead to an early contract cancellation, as already happened with one private bus provider. Despite these mechanisms of control and regulation, in practice, operators were "too big to fail" because the system could not afford to lose one of the players. In 2012, the authorities responded to these issues by renegotiating the contracts to modify the incentives structure through the introduction of new performance indicators. The main rationale was to significantly increase the number of buses in operation. Accordingly, the authorities introduced a new seating time compliance index (ICPH) based on the number of buses in operation, to impact directly on the providers' revenues. The ICPH was built based on the aggregate number of seating places offered by an operator for all its services, which was calculated simply as the total number of buses operating every half-hour multiplied by their capacity, divided by the theoretical figure indicated in the operating programme (Hurtubia & Leonhardt, 2021).

However, despite the inclusion of the ICPH the operation was still far from optimal, and new indicators were introduced. Firstly, the Frequency Index (ICF) refers to the percentage of the programmed bus trips that are actually offered (Muñoz et al., 2014). The introduction of the ICF allowed for an increased frequency from 0.75 in August 2008 to 0.95 in June 2011, which is when it incorporated the contracts (Beltrán et al., 2013). Secondly, the Regularity Compliance Index was introduced to avoid buses being dispatched with too much headway difference. The indicator is made as the coefficient of variation (CV) of the headways observed in a period of service. Therefore, the CV is operationalized as an index between 0 (minimum) when the CV exceeds 1.5, indicating that the headway variability is large, and 1 (maximum) when the CV is lower than 0.4, meaning little variability across bus headways (Hurtubia & Leonhardt, 2021, p. 16). The ICR measured at morning peak improved from 0.74 volatility in August 2008 to 0.83 in June 2011 (Beltrán et al., 2013).

As I show in chapter 6, the evolution of these indicators is directly related to the process of data circulation. In other words, the way the operational data of the system was conceived and worked in time allowed the indicators to be redefined. In that sense, the development of tools like ADATRAP helped to shape the standards and incentives structures of the system after enabling data to circulate differently.

1.3 Summary

In Santiago de Chile, the influence and circulation of big data started years before the emergence of the smart city agenda, as part of the emergence of the new transport system in 2007, Transantiago. Therefore, in this research, I describe and analyse the trajectories of big data as a critical component of the internal architecture of public transport from the early days of Transantiago. I focus on the problems that emerged and were recognised and confronted during the process of data circulation and subsequent ways to cope with these. In other words, I analyse how these problems lead to new ramifications, configurations, and forms of strategic action which, ultimately, make data circulate and the data dispositif emerge as an essential component of Transantiago. This leads to the following research question:

- *How is big data made to circulate among public transport organisations in Santiago, and what are the effects of its circulation?*

This dissertation contributes to the analysis of big data as an essential component of how large city services are currently designed, managed, and governed. Accordingly, this work offers theoretical, methodological, and empirical contributions to literatures on urban studies, science and technology studies and transport studies.

2. Literature review: conceptualizing the transport data dispositif

"I thought of a labyrinth of labyrinths, of one sinuous spreading labyrinth that would encompass the past and the future and, in some way, involve the stars." - Jorge Luis Borges, from "The Garden of Forking Paths"

2.1 Introduction

This chapter introduces and discusses the different literatures through which my work is framed; notably, I cover work about smart cities, big data, and how both topics are interrelated. At the same time, drawing on the Foucauldian concepts of Problematisation and Dispositif, and ideas taken from Science and Technology Studies, I present the analytical toolkit used to approach the rest of my work.

In 2015, Shelton et al advocated studying the "actually existing smart city" (Shelton et al., 2015), and this has worked as an invitation to expand smart city scholarship towards empirical research grounded in a specific time-space context. A vast amount of empirical work has sought to situate the analysis of the smart city from a critical perspective (Luque-Ayala & Marvin, 2015; Marvin et al., 2016), mainly by looking at the smart cities as products of corporate practices (Hollands, 2008, 2015; Söderström et al., 2014) as well as enactments of new forms of governmentalities by the enmeshment of novel digital technologies in urban practices and the reconfiguration of governance and city management (Cowley & Caprotti, 2018; Datta & Odendaal, 2019; Klauser et al., 2014; Vanolo, 2014). Recently, research on smart cities has also considered other forms by which "the digital" mediates everyday urban experiences and practices—mainly through the expansion of urban data platforms and the emergence of platform urbanism, expanding the analysis of the infrastructural conditions of big data (Barns, 2020; Hodson et al., 2021; Rose et al., 2020). My contribution to the existing literature involves the development of the Foucauldian concept of the data dispositif as a valuable tool for comprehending the heterogeneous circulation of data in a smart city. Specifically, my research draws insights from the implementation of big data in the public transport system of Santiago de Chile to examine its ramified effects of big data circulation.

The role of big data as a governing technology has been part of smart city scholarship primarily as an operationalization of a long-standing technocratic imaginary to implement computational logics in the city (Kitchin et al., 2015; Mattern, 2017), and either celebrated or criticized as such. Most of the critical approaches are closely related to the emergence of a "digital turn" (Ash et al., 2018; Rose, 2016, 2017) in human geography, as well as in the wider social sciences, including urban studies (Barns, 2018; Barns et al., 2017; Kitchin et al., 2017; Leszczynski, 2016). As I demonstrate in the first section of this chapter, these visions have offered new avenues for critical analysis toward understanding the role of big data as a sociotechnical urban infrastructure. Most of these works have focused on digital technologies (actors, infrastructures, platforms, apps, etc.) fueled by the expansion of big data; however, not much has been written about the specific uses of data, its circulation(s), and what big data does during that process. A concrete effort to apprehend the latter is the notion of *data assemblage* (Kitchin & Lauriault, 2014) which defines data less as a finalised product than as a complex human and non-human arrangement that can be unpacked by tracking its internal configurations. Nonetheless, in this chapter, I critique that perspective is not sufficiently comprehensive to identify what big data *does* in cities.

My case study is the public transport system in Santiago. As I showed in the introduction, this system has undergone significant changes since transitioning to Transantiago in 2007. Creating an information infrastructure to facilitate the use of big data is one of the technological innovations of this transition. It is thus an excellent example to better understand the process in which big data becomes central for Transantiago's operations and as a system.

The chapter is divided into three sections. In the first section, I discuss how smart cities are conceptualised particularly, but not exclusively, from a critical smart urbanism (Marvin et al., 2016a) perspective. In doing so, I link the notion of the *smart city* as part of a trajectory of ideas conceiving the urban from a computational logic, including early applications of cybernetics, complexity theories, and the expansion of Informational Technologies (Batty, 2013a; Krivý, 2018). However, I aim to move beyond these traditions, which I see as closer to what Farías and Widmer (2018, p. 44) refer to as the *"unbearable ubiquity and simplicity of the mainstream smart city discourse"*. Accordingly, I move beyond the smart city's binary self-congratulatory/critical examinations to focus on big data circulation as a *locus* of problematisations enacting specific pragmatic situations of urban inquiry (Barnett & Bridge, 2016).

In the second section, I connect the discussion of the smart city and big data with the notion of *(data) dispositif* (Foucault, 2008; Foucault et al., 1991). The third section presents the "problems of data circulation: fragmentation, expertise and translation". Here, I engage with three bodies of literature emerging from the Science and Technology Studies (STS) tradition. I suggest a conceptual reference to three forms in which the data becomes a problem that requires a reassembling of the data dispositif to ensure its circulation in public transport. I focused on these three problems, discarding others, as they emerged more distinctively during my fieldwork. In other words, they represent, and they are limited to, my specific interpretation of big data circulation in Transantiago. First, I present the concept of *oligopticon* (Latour, 2005; Latour et al., 1998) as a way to deal with the issue of fragmentation in Urban Operations Systems (Urban O/S) and control rooms — in terms of building a network of individual observers that allows data to circulate coordinately. Then, I briefly address the problem of *expertise* in the data dispositif, arguing that experts produce knowledge practices and group demarcation to influence how data circulates in public transport. Finally, I suggest that the data dispositif can overcome problematic situations through *translation,* and more specifically through the establishment of *obligatory passage points* (Callon, 1984a), enabling data circulation and defining how data circulates. I argue that these configurations are forms to problematise data in public transport into a more endurable trajectory which allows for "lock-in" data circulations for a certain period.

2.2 Approaching the smart city as a site of problematisation

Smart cities and smart urbanism are not as new or innovative as the hype and claims by some of their evangelists seem to suggest. They follow a genealogy of ideas and projects seeking to apply computational logic to the urban (Graham, 2004; Luque-Ayala & Marvin, 2020). Generally, these ideas around the computational city have arisen in the context of a general ideology of "high modernism"[9] intending to rationalise urban processes based on technocratic and

[9] Scott argues that "high modernism" ideology "is best conceived as a strong, one might even say muscle-bound, version of the self-confidence about scientific and technical progress, the expansion of production, the growing satisfaction of human needs, the mastery of nature (including human nature), and, above all, the rational design of social order commensurate with the scientific understanding of natural laws. It originated, of course, in the West, as a by-product of unprecedented progress in science and industry" (Scott, 2008, p. 32)

depoliticised conceptions of progress/planning. For instance, early in the 1960s, the principles of cybernetics were introduced in urban planning and urban research. At that time, practitioners increasingly understood the city as a "communication system" (Meier, 1962; Webber, 1965, 2016), combining cybernetics ideas with informational technologies developed by scientists working in the defence industry in the United States. Based on a strong sense of technical authority and a war-like narrative, these experts manifestly attempted to produce projects with verifiable outcomes advocating for a value-free, neutral perspective, thus depoliticizing the planning process (Luque-Ayala & Marvin, 2020, p. 10). Although introducing cybernetics principles to planning brought fresh avant-garde perspectives to the study of urban systems, some of their most iconic examples are now remembered as significant failures. That is the case of the redesign of New York's fire system by the RAND Corporation which led to catastrophic fires and extended shortages of service provisioning in the city (Offenhuber & Ratti, 2014). Closer to my case is Cybersyn[10] (Espejo, 2014; Medina, 2011), a project developed during the democratic socialist government of Salvador Allende (1970-73) in Chile, which is another example of the technocratic high-modernism behind the application of cybernetics in the State apparatus.

After the cybernetic period, as pointed out by Marvin and Luque-Ayala (2020), the networked city emerged (1990s-2000s). Representing a shift based on the idea that information technologies would redefine the urban through the acceleration of electronic informational flows reconfiguring the global and local

[10] The project attempted to centralise state decision-making based on applications of cybernetics in organisational management. The project involved a single centralised control room that aimed to oversee the national industrial production based on the continual input of informational flows. However, the project had short existence because of several problems like crossed incentives between the project engineers and the political authorise added to difficult external contingencies (Medina, 2011; Offenhuber & Ratti, 2014).

networks facilitated by the increasing expansion of ICT's, software, hardware and the internet (Castells, 2002). The period unfolded new forms of global and local urban inequality as *splintered urbanism* (Graham & Marvin, 2001), denoting the technological infrastructures that allow digital connectivity -copper wires, fibre-optic, telecommunications antennae- to produce different modes of organisation and governance, resulting in an "unbundling" of services. Which ultimately provoke the demise of integrated service provision in favour of passing off and concentrating on premium services. According to Graham (2000b, 2000a) this would produce the subsequent emergence of new urban exclusions and inequalities.

Along with these tensions, the rise of critical academic perspectives in human and urban geography emerged, focusing both on the space and the materiality of the digital world and arguing that (digital) technology mediates the social, physical, and cultural relations from which the city is constituted (Graham, 2004 in Luque-Ayala, 2018 p.26). Some of these early works analysed new forms of control through the massification of digital surveillance (Graham & Wood, 2003); the increasing relevance of software in space as an assert of digitally mediated techniques that produce *software-sorted geographies* (Graham, 2005); and discussions of urban politics and everyday life experiences as shaped by the configuration of code/space, that is, the capacity of software and space to be mutually constituted, to the point that the failure of code would imply the non-constitution of space (Kitchin & Dodge, 2011).

How are these early ideas about space, cities, and technologies entangled with a smart city? I argue that the notions around smart cities continue the computational logic of the city seen in the early cybernetic and networked city periods. As Mattern (2017; n.p.) claims: *"Modernity is good at renewing metaphors, from the* *city as a machine, to the city as organism or ecology, to the city as cyborgian merger of the technological and the organic. Our current paradigm, the city as a computer, appeals because it frames the messiness of urban life as programmable and subject to rational order*".

In line with the previous point, a common first element of smart cities is the ambition of a new rationality, framed in terms of a "smarter" or more "intelligent" way to address the challenges and management of cities through digital technologies (Albino et al., 2015). Amidst multiple definitions, some of how smart cities have been defined include ideas around technically oriented innovation, creativity and entrepreneurship, and projects on the development of ubiquitous ICT infrastructures to monitor, regulate, and manage cities in real-time (Albino et al., 2015; Anthopoulos, 2015; Batty, 2013b; Coletta et al., 2018; Townsend, 2013) to enable efficient control of urban utilities and services, the enforcement of public safety and security, and effective responses to environmental and economic shocks (Kitchin, 2015, p. 131). Amongst these visions, the predominance of optimization and efficiency of urban management is commonly tied to the increasing prevalence of big data, which is facilitated by the deployment of enmeshed digital infrastructures (urban sensors, user-generated-content-data, cloud services, urban apps, data platforms and algorithms) capable of collecting, integrating, processing, and analysing massive amounts of real-time data thanks to enhanced computational capacities (Batty, 2018).

Smart cities have burgeoned in the last decade as a research topic in a wide variety of areas such as urban studies, geography, sociology, planning, transport, computer science, information systems, public administration, amongst several others areas and disciplines (Lim et al., 2019). Recent work on systematic literature reviews found seven main areas of smart city project development including services, transportation, urban infrastructures, living, government, economy and coherence (Anthopoulos, 2015). Similarly, recent work have concentrated on the governance aspect of the smart city literature, either categorizing the type of governance models based, too, on systematic literature review (Castelnovo et al., 2016; Dameri & Benevolo, 2016; Meijer & Bolívar, 2016), or more recently looking into the accumulated smart governance practices based on global case study surveying (UN Habitat, 2022).

In the same way, work focused on global south cities have described smart cities initiatives as in between worlding and provincialising practices (Burns et al., 2021; Cardullo, 2021; Charnock et al., 2021; Irazábal & Jirón, 2021). At a global scale, now has become increasingly evident that smart city attempts take on different meanings and manifestations in different socio-political contexts around the world, and that common processes may operate with disparate effects in different places (Burns et al 2021:462). More specifically, in Latin America, the worlding-provincialising tensions are underpinned by top-down attempts of urban elites to follow northern models of smart cities which then are confronted locally by situated knowledges and previously existing practices (Irazábal & Jirón, 2021, p. 529).

Early on, there were more "optimistic" analyses on the widespread benefits of digital technologies, as well as an ambition to generate a 'new urban science' that explores the increasing complexity of the city (Batty et al., 2012; Offenhuber & Ratti, 2014). Likewise, early critical accounts questioned how "real" smart cities are, arguing instead that these are repackaged projects of entrepreneurial urban development (Hollands, 2008); as well as radical contestations "against the smart city" (Greenfield, 2013) since they would be the ultimate embodiment of all that is wrong with capitalism, democracy, and society; discussions on the "intelligence" of the smart city as they may be reduced only to information processing (Mattern, 2017). Hence, a large body of scholarship has interrogated the smart city differently, questioning the self-congratulatory corporate tendencies of these projects and making visible the ideological dimensions and the political implications about how urban processes are reconfigured through new *smartmentalities* (Vanolo, 2014). These generate a dual disciplinary order characterised by: *"on the one hand, a group of policies that support new ways of imagining, organising and managing the city and its flows; on the other, they impress a new moral order on the city by introducing specific technical parameters to distinguish between the 'good' and 'bad' city".* (Vanolo, 2014, p. 883).

Along with these early critiques, a wide variety of literature can be clustered as *critical smart urbanism* (Luque-Ayala & Marvin, 2015; Marvin et al., 2016). More recently, Mouton & Burns (2021) have identified three foci that distinguish critical approaches to smart cities: critiques of smart as a capitalist strategy (Hollands, 2015; Sadowski & Bendor, 2019) and as a variety of neoliberalism (Cardullo & Kitchin, 2019); the unpacking of the smart city as a discursive strategy made mainly by big tech corporations; and the use of smart cities to achieve varied modes of governance. In different ways, these approaches question the politics of smart cities concerning the current capacity to produce transformational change (Luque-Ayala & Marvin, 2015).

Similarly, the "actually existing smart city"(Shelton et al., 2015) emerges as a demand to promote more grounded, context-specific empirical work on the smart city. The idea is to consider smart cities as a complex assemblage of actors, ideologies, governing techniques, and practices —beyond the hype of corporate storytelling and mobile global policy frameworks, as well as to suggest some level of agnosticism towards some of the raging critiques which do not necessarily have a solid empirical basis. Correspondingly, Shelton et al. (2015) focusses on the space-time-specific elements of each smart city project defining historical circumstances with a radical commitment to unpacking the politics of smart cities beyond preconceived critical statements. That leads to a pragmatic conception of the politics of the smart city as a strategy not to make the same three foci of critical formulations (i.e., novel varieties of neoliberalism, corporate discourse, and entrepreneurial governance) repeatedly. Likewise, Farías & Widmer (2018, p. 44) suggest focusing on the "ordinary smart city"[11] since some of the most interesting data-related initiatives are not occurring under mainstream smart city projects (i.e., local smart city programmes). In their vision, focusing on the ordinary is a strategy to find projects beyond the boundaries of smart city projects and narratives, as some of the most interesting developments are probably hidden in complex city infrastructures away from the fuss of corporate storytelling. For them, part of smart city research has become repetitive since they haven't been able to look beyond the mainstream ideas of urban smartness (Farías & Widmer, 2018).

Indeed, I see the problem of repeating the same critical formulations in Santiago de Chile's critical smart urbanism research. For example, Jirón et al. (2021) argue that the LED lights intervention made by the Smart Santiago programme is no more than an *urban placebo*. For them, the programme:

"Works through the fictions of effective interventions and urban image improvement that seek to participate in worlding practices whilst, in reality, very little is being improved or effectively addressed in the city. The intervention

[11] Following Jennifer Robinson's (2006) idea of "ordinary cities" which is an invitation for urban theory to overcome prefix categories such as "world cities" or "third world", so urban analysis could grasp the diversity and complexity of cities beyond the "usual suspects" and the dichotomical comparisons.

presents a narrative of modern, sustainable and technologically advanced urban planning in the form of specific material interventions when in fact, it involves very little modernity, sustainability or technology and is little more than a continuation and evolution of the neoliberal urban model." (Jirón et al., 2021, p. 601)

The problem is not that the critique of the LED lights intervention is wrong; indeed, it is true that the intervention overlaps with the neoliberal trajectories of Santiago. However, the analysis misses the opportunity to focus on the complex politics of the smart city infrastructure beyond the mainstream local smart city agenda. So, by solely focusing on the projects developed within the smart city agenda the authors overlook alternative infrastructures and arrangements which could lead to more transformational accomplishments. Similarly, this vision presumes the identities of the heterogeneous components of the project, ignoring how these human and non-human entities are assembled; and what power relations are enacted in the process. It also overlooks the continuities and discontinuities of sociotechnical change, missing the coevolution of novel and precarious modes of governance with endurable institutional arrangements including new actors and technologies.

In other words, the risk of focusing solely on the smart city "smartness" is to disregard other processes in which digital technologies are permeating, and provoking, urban transformations. The potential cost of the excessive focus on the critiques to "smartness" is to miss the opportunity of shaping a global alternative to the smart urban agenda that focuses on digital technologies as a tool that "supplements people, place, knowledge, and politics (politics comprehended as the priorities, often neglected or misunderstood, of marginal groups themselves) (McFarlane & Söderström, 2017, p. 314)".

Here, I offer another alternative approach to smart city critiques. I propose to think about smart cities as a *problematisation* (Barnett, 2015; Barnett & Bridge, 2016; Foucault, 1984). What do I mean by problematisation? The notion has two interrelated definitions. This concept was defined by Foucault (1996) as a "barbarous word" as it says many things at once or nothing at all. However, in this case, he refers to the "history of problematisations" as: *"How things become a problem. How, why and in what exact way, does madness become a problem in the modern world, and why has it become an important one?"* (Foucault, 1996, pp. 413, 414). As Barnett (2015) explains, Foucault characterised the genealogy of problems as involving a double movement *"in which one tries to see how the different solutions to a problem have been constructed; but also how these solutions result from a specific form of problematisation"* (Foucault, 1984, p. 389). Two forms of looking at this would work like seeing a problematisation as *"an act of critical inquiry" (expressed in the verb form as "to problematise") and "a nominal object of inquiry" (described in the noun form as "a problematisation")* (Koopman, 2013, p. 202). The first indication of the dual movement in which a problematisation becomes an act of critical inquiry points to the historical process in which problems have emerged as a situation in which specific solutions are required; those are solution-oriented practices. A second indication aligns with what Foucault identifies as (1984, p. 389) : *"to one single set of difficulties, several responses can be made. And most of the time different responses are proposed. But what must be understood is what makes them simultaneously possible: it is the point in which their simultaneity is rooted; it is the soil that can nourish them all in their diversity and sometimes despite their contradictions".* This is the form of problematisation to which Barnett refers.

There are responses connected to emergent problems, embedded in specific situations that are produced according to a root, with some form of shared assumptions and not just pure contigency. Therefore, on the one hand, problematisation is an object of analysis. For example, the process by which smart cities or big data, or both, become problems is what is meant by problematisation as a verb, "to problematise". Problematisation as an object of analysis is how Foucault uses the term most of the time. It is for this reason that it is sometimes claimed that his work was concerned with developing a genealogy of problems, one which investigated *"why a problem and why such a kind of problem, why a certain way of problematising appears at a given point in time."* (Barnett, 2015; n.p.). On the other hand, the second idea of problematisation refers to a necessary form of analysis or as a proper Foucauldian "method of problematisation", a method that is critical, not in the sense of good or bad, but in the sense that things are not obvious, so they could be different, precisely because they become a matter of concern, a problem, in a precise moment that requires a response that is contingent but framed by a particular strategic domain (Lemke, 2019).

An interesting example of how both approaches to problematisation can be identified in the visual representations of the smart city made by some of the prominent big tech market players. As Rose (2017) argues, on the one hand, these companies carefully create promotional visual representations to establish urban overcrowding as "a problem" that requires some type of solution. On the other hand, they offer potential solutions to the problem based on their own catalogue of digital services.

In sum, the duality of problematisations supports a model of critique in which the critical task is presumed to expose specific contingencies of naturalised formations, that is, to question the obduracy of the objects of inquiry. Barnett

(2015) accordingly, argues that *"problematisations are an object of analysis"*. In turn, the second assumption is that the task of critical analysis is to expose the contingency of the stable and taken-for-granted definitions of problems. In this second sense, a problematisation is *"a prerogative of the critic as the active subject of a revelatory truth"* (Barnett, 2015, p. np). I will come back to this last definition of problematisation later when I associate the notion with my proposal to emerge a *data dispositif* in Santiago's public transport.

In my case, problematisation is bound up with the potential capacity of big data to circulate in public transport. In my work, this produces a new focus on the ways in which data circulates in public transport. In the following section, I discuss some of the entanglements of big data and the smart city. At the same time, I propose how to unpack big data as a heterogenous ensemble by offering the notion of the data dispositif —to identify how big data has become a problem in Santiago's public transport. In the next section, I will discuss what big data is and how I use it in this dissertation.

2.3 "What makes Big Data, Big Data?"

The incitement to *"turn to the digital as both object and subject of geographical inquiry"* (Ash et al., 2018a, p. 25) is tightly connected with the smart city. This "turn" towards the digital has reframed several discussions about space/place, flows, mobilities, migrations, borders, and cities are revisited after the massification and spatial extension of digital technologies. In this context, various helpful insights (Anderson, 2010; Ash et al., 2018a; Kitchin, 2013; Kitchin & Dodge, 2011; Leszczynski, 2016; Thrift & French, 2002) have been made on what big data are and do -yet these insights need to be pushed further.

Likewise, many ideas about big data have followed similar trajectories of high modernist computational logic similar to the smart city (Mattern, 2017). These ideas have been widely spread by seductive narratives led mainly by corporate interests and the configuration of a global cultural circuit of technology enthusiasts. A widespread definition of big data along these has referred to the 3V's (volume, velocity, and variety) (Kitchin & McArdle, 2016), the 5V's (add variability and value to the mix) (IBM Watson, 2016) or even more V-dimensions (Uprichard, 2013). These congratulatory definitions of the special qualities of big data probably say more about the corporate interests trying to sell a product or service rather than the potential effects and uses of big data in society.

However, there are alternative approaches focusing on big data as a complex and relational ensemble beyond the commodified market rhetoric. For Boyd and Crawford (2012, p. 663), big data is *"less about data that is big than it is about a capacity to search, aggregate, and cross-reference large data sets"*. In their definition, big data is at the same time a cultural, technological, and scholarly phenomenon that is constituted in the interplay of i) technology considered as computational power, capacity, and algorithmic accuracy to gather, analyse, link, and compare large data sets; ii) an analytical form drawing on large data sets that can identify patterns to make claims about social phenomena; and also iii) the belief that its abundance (of big data) offers a higher form of intelligence and knowledge capable of generating insights previously impossible and varnished with an *"aura of truth, objectivity, and accuracy"* (p.664). Which suggests that big data represents some form of higher knowledge mostly as part of both a utopian and dystopian representation of a pervasively metricised reality. That idea of omnipotence and truth is what makes big data so powerful as a concept; as Beer (2016, p. 5) indicates: *"the very concept of big data itself that shapes decisions,* *judgments and notions of value – as it brings with it a vision of particular types of calculative or numerical knowing about individuals, groups and the social world".*

Another idea about how to seek a more comprehensive definition of big data is made by Kitchin & McArdle (2016) when they identify that the variety of definitions of big data are variable between communities of practice; in other words, what certain groups *do* with big data becomes what big data *is*. For the authors, ontological qualities operate as boundary markers demarcating big data from what it is not. From this perspective, despite the current predominance of catch-all definitions of the term, ideas around big data are mostly defined by the practices by which big data is configured and mobilised. But more importantly, this approach suggests that big data is a relational phenomenon as, by itself, it has no real significance —big data becomes meaningful according to how is worked, and how sense is made with and given to it. As Gitelman (2013, p. 3) sharply asserts: *"Data are familiarly collected, entered, compiled, stored, processed, mined and interpreted. Less obvious are the ways in which the final term in this sequence –interpretation– haunts its predecessors"*. The latter point is especially relevant for my dissertation, as I identify big data as complex, relational, heterogeneous, and contingent regarding its potential trajectories, conflating stability and change into a common path.

An additional element in the discussion is to consider big data as related to a longstanding historical trajectory of social statistics as technologies of government (Beer, 2016). As Beer (2016, p. 5) establishes: *"It is difficult to imagine a world that is not ordered by metrics or defined by the prominence of the desire to metricise everything".* However, that in no way means that the intention of counting things and people, to try to metricise everything is a recent situation that only emerges with big data. These trajectories enact forms of government made *through* and performed *by* new quantification methods and techniques (censuses, surveys, statistical methods, accounting, population records, etc.). These changes are representative of an epochal shift where control begun to focus over population rather than the territory (Foucault, 2007, 2008). Indeed, Ian Hacking refers to the "avalanche of numbers", a particular period of time that occurred around 1820 and 1840 that brought about a "new enthusiasm for numbers"; that is, data and systems of measurement as producing a novel apparatus for data-gathering (Hacking, 1991, p. 186). Consequently shaping a bureaucratic machinery that goes far beyond the mere provision of information but is itself part of the technology of power in the modern state (Hacking, 1991, p. 181).

In this sense, statistics and data-gathering machineries enact forms of knowing society at a particular time and space, producing social facts as a matter of public concern. In other words, they problematise specific situations, people, bodies, and materials, which then are controlled and managed. The genealogies of statistical techniques enabled new modes of problematisation or "making up people" (Hacking, 1990), defined less by natural laws and more by the practices of categorising, separating, modelling, and normalising people and societies' behaviours through statistical knowledge[12].

[12] "The systematic collection of data about people has affected not only the ways in which we conceive of a society, but also the ways in which we describe our neighbour. It has profoundly transformed what we choose to do, who we try to be, and what we think of ourselves. Marx read the minutiae of official statistics, the reports from the factory inspectorate and the like. One can ask: who had more effect on class consciousness, Marx or the authors of the official reports which created the classifications into which people came to recognize themselves? These are examples of questions about what I call 'making up people' (Hacking, 1990, p. 3)

Therefore, how can big data follow the traces of a historical trajectory of statistical knowledge as a technology of control? I argue that big data is connected to these historical trajectories of social statistics as it is strongly embedded in the bureaucratic machinery of the state as a technology of control. In this sense, it represents a continuity with the epochal shift identified by Hacking, but also by Foucault in the early 19th century in terms of producing social facts that are at the same time possible to be governed (Beer, 2016). Yet, I also consider that it represents a change that involves novel forms of practices, configurations, materials, and tools producing different ways to demarcate problems, and therefore opening new avenues for political action. In the next section I offer an entrance into a very specific demarcation which is the relationship between big data and the city.

2.3.1 Big Data and the City.

In this section I approach some of the current discussions about big data and the smart city. Today, there are widespread visions about how big data is reshuffling the ways in which cities are being quantified and governed, usually depicting big data as a tool to achieve better and more efficient urban planning, transport, and so forth (Batty, 2013b). Opening up the possibility of creating what has been called *the real-time city "wherein computation is embedded into the fabric of cities producing rea-time data flows that can be used to know and manage city services in the here-and-now"* (Kitchin et al., 2017, p. 3). Aligned with this perspective, de Waal argues that the introduction of such data-driven systems is changing the empirical approach to cities in at least three ways (de Waal, 2017). First, through the adoption of an action-oriented epistemology where a new type of scientific knowledge about cities is enabled through real-time data and machine learning techniques which allows for the analysis of the urban as a complex system, and that technically possible by new digital technologies. Second, challenging the scientific principles and epistemology of the previous complex systems scientific approach, opening ontological questions concerning how real-time data and data-driven cities transform the production of space, the nature of place, and the experience of living in the city. A third approach asks more normative questions and argues that cities cannot be analytically detached from other complex systems, such as galaxies and rainforests, because they are social-cultural-political in nature. From that perspective, a data-driven science of cities needs to be conversant with wider political concerns about the kinds of cities we want to create and how to produce them (de Waal, 2017). Otherwise, the enhanced computational and analytical capacities of the real-time data-driven cities are likely to keep struggling to make sense of the vast amounts of available data, and to accomplish any kind of significant urban change.

Many scholars have made sense of big data in the city, therefore, by considering who or what has responsibility for the emergence of a wide variety of urban data related challenges. That is the case of debates about the politics of big data production; data ownership, data control, data coverage and access; taking into account the potential social, political and ethical effects (Kitchin et al., 2017). It also brings new challenges like the emergence of questions about trustworthiness and veracity (Thatcher & Dalton, 2017); discussions about statistical representativity (Crampton et al., 2013; Kitchin, 2013; Schwanen, 2017); and the potential uses of the data that emerges from the smart cities as new official statistics (Kitchin & Stehle, 2021). Along the same lines, there are debates about how urban data visualisations, city operation systems, and dashboards are reshaping city management (Barns, 2018; Kitchin et al., 2016; Lock et al., 2020; Luque-Ayala & Marvin, 2020; McNeill, 2015; Wigley & Rose, 2020), as well as how novel forms of algorithmic governance rearrange and dispute endured institutional arrangements (Coletta & Kitchin, 2017; Williamson, 2017). These are valuable ways in which data is an element of the smart city that changes the ways cities are known and governed. This work has pointed out how big data allows the city, its materialities, flows, people, and non-humans to be made up and known differently from what has gone before.

Only a portion of the work mentioned so far has interrogated the infrastructural relations of the urban data and its technologies (Kitchin, 2021; Picon, 2018; Straube, 2016, 2017). However, a further unpacking of these heterogeneous relations is needed if we want to understand the effects of big data in the city. An example pointing on this line is Gabrys's (2014) analysis of how environmental data technologies operate as spatial modes of governance, altering the material-political distributions of power and the possible modes of subjectification. Rose (2017) signals a similar point when pointing out the co-constitution of human agency with technologies in the digital city, producing posthuman subjects in the process. Ultimately, this allows agency to be understood as reinvention.. These examples are an expression of a more extensive debate on how big data enables new forms of knowing the environment and urban inhabitants, including cities, thereby facilitating new forms of surveillance intermingling between platforms, infrastructures, and governance (Gekker & Hind, 2020).

Amongst alike approaches which now are centring the discussion on urban platforms as a *new* urban condition since, increasingly, urban lives are constituted by platform interactions (Barns, 2020). These platforms are mediators of various network actors enmeshing digital devices, software and big data to provide a wide array of marketed services (Hodson, 2021; Srnicek, 2016). Platforms are now a condition to how we shop, what we buy of both products and services, how we pay, how we socialise and so forth. Needless to say is that cities are subjected to processes of platformisation, in part because cities provide the largest and richest markets for their service (Hodson, 2021, p. 23). Yet, in my work the analysis is not centred on platforms but in processes that could be identified as precondition to a wider urban platformisation in Santiago.

In the case of transport and mobilities, according to Schwanen (2022), since the first rise of internet and mobile phones, rapidly evolving constellations have arisen, including the most recently entwined processes of datafication, algorithmisation, automation, and platformisation —with important effects for the production and use of urban space. These processes of digitalisation of transportation and vehicle technology primarily entail i) datafication —the increasing mediation of, and dependence on, digital data in the operation, governing, and use of transportation systems; and ii) algorithmisation —the growing reliance on artificial intelligence for (dynamic) algorithms for the operation and governance of transportation. Both processes shore up the more visible processes of automation and platformisation (Schwanen, 2022, p. 2). In the first case, automation has been widely exposed by the emergence of autonomous vehicle (AV) experimentation usually paired to smart city agendas (Bissell, 2021; Hopkins & Schwanen, 2021; Pink et al., 2018). In the case of platformisation, most research has concentrated on how platforms are reconfiguring everyday mobilities, including the daily mobility of people using bikes, cars, ride sharing schemes, and/or Mobility-as-a-Service[13], all technologies deeply sustained on big data collection integrated to a wider platform of services. Most of the work done in this dissertation focuses more specifically on big data as part of the datafication of public transport in Santiago de Chile, even though rapidly and

[13] As for other alike concepts, Mobility-as-a-Service does not have a unique catch-all definition. However, I will consider it as the integration of multiple transport related digital services (informational, transactional, operational) to customers by mobility operators (Mladenovic, 2021).

widely datafication and algorithmisation are increasingly interlaced in transportation services. However, in this work the focus is on the variegated associations and configurations that enable big data to circulate in Transantiago, in a process of mutual constitution and change between data circulation and the transport system.

In the next section I will define how big data becomes a dispositif as part of Santiago's public transport.

2.3.2 What is a (Big) Data Dispositif?

Existing work which approaches data as a heterogeneous ensemble often uses the concept of the *data assemblage* (Kitchin, 2014c; Kitchin & Lauriault, 2014). For Kitchin and colleagues, a data assemblage consists of *"more than the infrastructure that makes data possible but several other technological, political, social and economic apparatuses that frame their nature, operation and work"* (Kitchin & Lauriault, 2014:p. 7). Here, the authors explicitly try to assimilate the data assemblage with Foucault's concept of *dispositif* (Foucault, 1980) as an equivalent arrangement that produces "power/knowledge" and fulfils a strategic function or as a set of strategic relations of forces supporting and being supported by some specific types of coordinated knowledge. The implication is that data *"is never neutral, essential, objective; their data is never raw but always cooked to some recipe by chefs embedded within institutions that have certain aspirations and goals and operate within wider frameworks"* (Kitchin & Lauriault, 2014, p. 9).

In general terms, Kitchin and Lauriault's concept of the data assemblage is valuable as it pinpoints the preconditions, characteristics, and practices of the data, identifying its performative role as a heterogeneous ensemble that frames the generation, circulation, and deployment of data. The data assemblage clarifies that the data is nothing by itself but a set of complex relations, materials, knowledge, and practices. This term concurs with STS approaches to infrastructure (see Bowker & Star, 1999; Edwards et al., 2011; Leigh-Star, 1999); which also has been increasingly reinterpreted in a wide variety of emergent research on platform urbanism which considers the complexities and trajectories of the data as an assemblage or an ecology (Barns, 2020; Hodson et al., 2021; Stehlin et al., 2020). A common idea linking these approaches is the interest in data as a sociotechnical configuration which is equally heterogeneous and contingent, that is, a composition of a variety of human and non-human components that is at the same time stable but subject to change. Despite the existence of a wide range of definitions of what "sociotechnical" means, and more specifically sociotechnical change, in my dissertation I follow the early ANT discussions on the concept (Bijker et al., 2012; Law, 1987b; Law & Callon, 1988). Briefly, these ideas refer to the notion that technologies are processes, involving technical, cultural, and social characteristics, which operate as a network of multiple components, a network that is stable enough to accomplish obduracy, yet without fully neglecting contingency, or that a particular technological object could become something else (Bijker et al., 2012).

However, despite commonalities between the different ideas behind what data or big data is, for my dissertation I criticise Kitchin's data assemblage because while it explicitly establishes an alignment with Foucault's dispositif, it does not engage with some of the fundamental insights generated by the concept.

But first, let's concentrate on defining *what is a (data) dispositif*?

Foucault refers to the *dispositif* as a *"thoroughly heterogeneous ensemble consisting of discourses, institutions, architectural forms, regulatory decisions,* *laws, administrative measures, scientific statements, philosophical, moral and philanthropic propositions'"* (Foucault, 1980, p. 194). In a dispositif, power circulates as an ensemble of institutions and technologies being produced and deployed through interrelated elements that operate on a micro and macro-level, controlling individual bodies and society (Foucault, 1991b). Therefore, power emerges *from* and is exercised *through* this set of networked rules, institutions, architectures, and so on (Foucault, 2007), which are at the same time built contingently in response to a time-specific rupture, and structured in terms of a particular frame of strategic function. The dispositif is a political enunciation as it produces something new from a break, crack, or disruption; and historical, as it is a time-specific answer, a change of orientation that creates something new that emerges over a horizon of potential trajectories. *"An apparatus (dispositif) is thus defined by its content of newness and creativity, which at the same time indicates its ability to change or even to break for the sake of a future apparatus unless, on the contrary, there is an increase of force to the hardest, most rigid and solid lines"* (Deleuze, 2006, p. 344). Therefore, a dispositif involves both *"lines of stratification or sedimentation and lines of actualization or creativity"* (p. 347). That is, continuity and change at the same time.

There are complementarities between Foucault's thinking on dispositif and problematisation. Both refer to a process of objectification at times that require a form of agency, a sense of rupture, and a novelty that is flexible enough to produce something new among a wide variety of options but without resulting in pure contingency. Yet they are not the same. More specifically, things become problems, which are generative of active solutions, these solutions reconfigure pre-existing associations turning into something new, and that process is what ultimately produce a dispositif.

A dispositif takes the form of an association of devices, tools, and techniques that are strategically assembled as a response to a problematisation (Rabinow, 2003). As we know already, a problematisation is historically objectified as a situation of inquiry (Barnett, 2015); and second, as a practical form of thought that channels action as a solution to *a problem* (Koopman, 2013). The point then is that a dispositif, as a historically situated formation, can emerge and grow out in response to a problem (Rabinow, 2003). Therefore, for example, big data is presented as becoming *a problem* that requires specific responses which can enact emergent forms of coordinated knowledges, practices, and techniques to enable data circulation.

Despite the similarities between the data assemblage and the data dispositif, seemingly, from my point of view the data assemblage can be developed further in at least 4 ways. First, Kitchin's (Kitchin, 2014a) understanding of data assemblages starts from a fixed list of elements and apparatuses with pre-established characteristics; in contrast, the components of a data dispositif are not self-evident as a problem or as a formation. Quite the opposite, the *ensemble* is contingent upon a situation that under certain conditions gradually becomes a *problem*. Thus, a data dispositif is an active and coordinated response to that problem which produces a reconfiguration of the ensemble of techniques, tools, and forms of knowledge into something new. From this point of view, it does not make sense to anticipate a rigid list of elements as these are hard to anticipate and have limited temporal endurance. Instead, it seems more appropriate to analyse empirically what emerges from the emergent associations to understand in which way data relationally creates new orders of possibilities.

A second shortcoming refers to the lack of reference to the notion of circulation in the data assemblage, which I argue is one of the characteristics of the data dispositif. Specifically, Foucault (2007, p. 35) refers to the *problem of circulation*[14] as a "*major characteristic of the seat of government, whereas discipline structures a space and addresses the essential problem of a hierarchical and functional distribution of elements, and security will try to plan a milieu in terms of events or series of events or possible elements, of series that will have to be regulated within a multivalent and transformable framework*". In that sense, for Foucault (p.40), the notion of circulation is one of the *"typical features of modern societies as it is attached to a principle of freedom which is facilitated by the capacity of dispositifs to reconfigure its components episodically as a series of contingent possibilities"*. The data blockages, the lack of data, the existence of bugs and network crashes, and the role of humans and non-humans in dealing with these all exemplify how the data dispositifs rearrange their internal components to ensure the process of circulation. Although circulation is not necessarily a central feature of every possible dispositif, as in the case of the dispositif de sécurité described by Foucault —but for the case of the data dispositif it is central as its own influx is shaping as well as being shaped by data moving through it.

A third shortcoming, related to the absence of circulation, is the lack of explicit reference in Kitchin and colleagues' understanding of data assemblages to the productive role of its internal configurations of heterogeneous networks. In contrast with Kitchin, I argue that this is a crucial aspect of the data dispositif. Indeed, *"Foucault often repeats that he is interested in the productive character of power. How bodies, selves, and discourses are created and shaped are much more far-reaching than simple codes of allowed and banned activities"* (Bussolini,

[14] The problem of circulation is central to a particular apparatus or modality of power (i.e., security) but less so to others. The notion of the dispositif is not tied to a specific modality of apparatus of power, so it is important to remark that in other dispositifs circulation is less central than in the case of the data dispositif.

2010:93). Again, the active side of problematisations, enacted in coordinated action or a series of responses among a wide variety of options, is generative of a new regime, which prevails until a new problematisation emerges and further configurations are required. When data circulates, it makes descriptions about things or reality, and in that description process, it also creates what is described. Or in other words, *"it means that counter-intuitively, realities are not real outside the chains of practices that perform them"* (Law, 2009b:242). So, the definite capacity of "things", or dispositifs, or the "real", is only realised in concrete form within networks of practices that enact or perform these. However, by no means does this imply that the dispositif is a static, preformed object that precedes data circulation; quite the opposite, it is a formation in permanent flux which shapes and is shaped by data circulating through it.

Finally, unlike the notion of data assemblages, the dispositif concept acknowledges that subjects are also constituted through a variety of associations, practices, and configurations. The political consequence of this omission is to overlook the political a/effects of data circulation by informing relations and ways of life (Gabrys, 2016). The arrangements, practices, and configurations between heterogenous entities produce a particular type of subject, which ultimately is capable of problematising data circulation according to their position and interests in how data should circulate. This is tightly connected with modes of relations of experience amongst the actors involved which are differently configured, and *"how these modes of experience are also ways of making worlds"* (Gabrys, 2019, p. 725). In other words, these modes of experiencing and making worlds can trigger process of contestation and transformation to produce alternative arrangements to the predominant narratives and political economies where a data dispositif is held (i.e., the smart city). In sum, the configuration of subjects and identities through *the* and shaping *a* dispositif is an effect of the type of configurations and arrangements made, denoting power relations between the actors conforming the network. An example of this point is the way transport engineers are able to make data circulate in particular ways according to their technical vision of public transport, I will provide more details about this in chapter 5.

2.3.3 Summary: Data Dispositif and Problematisation

In this section, I have discussed the relation between big data and the smart city and defined how I will approach big data in my dissertation. I presented an alternative approach to analyse "data-in-the-smart-city" focusing on unpacking the data dispositif—an ensemble of heterogeneous and coordinated elements that are *a response to* and *constitutive of* a problematisation. I argue that these shared problematisations related to big data are, on the one hand, are situations in which data circulation becomes a problem, pointing a path-defining tension about continuity and change, innovation and tradition, inclusion, exclusion, and the prevalence of certain forms of expertise over others. On the other hand, these tensions perform the data dispositif as a practical technology that acts in conditions of contingency and uncertainty – it reconfigures its components by generating a solution (which then is subjected to change as well) to a problem accomplishing some level of obduracy that allows data to circulate and public transport to work.

In the next section, I will focus on some of the problems of data circulation in the smart city and public transport, suggesting some theoretical routes to analyse how data circulation is enabled in Santiago's public transport.

2.4 Making data circulate in the smart city: control rooms and fragmentation, experts and expertise and obligatory passage points.

Within data dispositifs, data can generate many different problems, and responses can be equally variable. Here I will consider three problems that are explored in more detail for the case of public transport in Santiago's public transport in chapters 4-6. I will focus on three specific ways in which this is enacted amongst my work on smart cities, big data, and public transport in Santiago de Chile: Control Rooms and Fragmentation, Experts and Expertise, and Obligatory Passage Points. These three[15] problems emerged through my research and fieldwork as moments of rupture, fragmentation, blockage, dispute, or controversy. All sharing the requirement of enacting a particular form of a coordinated response to ensure data circulation configuring the data dispositif as a technology of government in Santiago's public transport. These emerging problems are no more inevitable than other potential objects or subjects in the data dispositif—yet these are consistent with the subsequent empirical trajectories of my research, so I focus on these three to analyse how big data circulates, and what it does when that happens in Santiago's public transport.

Accordingly, in this section I will discuss the relevant academic literature to underline how these problems are generative of solutions that, ultimately, allow data to circulate.

[15] In chapter 3, I describe in more detail the implications of this methodological and analytical decision towards framing big data circulation on empirically grounded problems.

2.4.1 Control Rooms and Fragmentation

Control rooms are widely present in the smart city and public transport. For my research, I identify some of the key examples in the literature on the role of urban Operating Systems (Urban OS) and control rooms as enactments of the expansion and intensification of the big data circulation in the management of cities, as they are especially relevant to my project. More specifically, they respond to the problem of fragmentation of public transport operational management providing an alternative form of integration to enable data circulation and the operational management of the system.

Urban OS are software and hardware packages that have been adapted from the corporate sector, usually versions of ERPs[16] or, more recently, data analytics tools turned into novel packages for use in urban management. Urban OS are increasingly more relevant in cities, often included as essential tools for real-time management in control rooms. Usually, these products are framed under the corporate big-tech narrative by companies such as IBM, Cisco, Siemens, and Hitachi developing products like the IBM Smarter City, the Microsoft's City's Next, the Urbotica's City Operating System or the Siemens SCOOT tool for traffic light management. These companies produce seductive narratives framed by the computational logic of the smart city to sell these products at a city and municipal level, which at the same time are providing the necessary resources (infrastructure, skills, policy, regulation, funding) for these tools to operate in the background of public services, mainly at an operational and management level (Luque-Ayala & Marvin, 2016). The idea of an urban OS is that of *"essential*

[16] Enterprise Resourse Planning (ERP's) are a "framework for organizaing, defining, and strandardizing the business processes necessary to effectively plan and control an organisation so the organisation can use its internal knowledge to seek external advantage" (Blackstone Jr & Cox, 2005).

hardware, software, and data components that quietly sit in the background directing urban flows [and] providing shared languages towards interoperability across multiple infrastructures" (Marvin & Luque-Ayala, 2017, p. 84).

On the one hand, urban OS are material enactments of the smart city information processing made into software/hardware that configures a particular type of management and control of the city beyond its material form in connection with a broader apparatus. That apparatus configures a bundle of interdependent infrastructures operating as formal institutions and organisations, laws and regulations, management protocols, buildings and control rooms, software and hardware, dashboards, and other visualization tools. On the other hand, urban OS represent a metaphor for carefully crafted ideas of "smartness" enacted in discourses of real-timeness, optimization, anticipation, precision, control, and surveillance —*"all of which underpins new ways of thinking about the urban and new rationalities underpinning it is governing"* (Marvin & Luque-Ayala, 2017, p. 92). However, these ideas of a new rationality can be seen as grotesque and obscene forms in which *"the technology becomes a moral signifier that removes the affect, emotion, morality and corporeality that are deemed to be embodied by the disorderly city and signifies how power works through supposedly objective instruments"* (Datta & Odendaal, 2019, p. 389).

Control rooms are distinctive infrastructures enacting a particular form of smartness in urban management and control of urban digital data flows. It is common to find representations of sophisticated buildings filled with full-size screens, displaying data over dashboards in visually attractive forms[17]. The most

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[17] Wigley & Rose (2020 p. 303) go further by suggesting that the widespread use of the Rio Operations Centre itself makes a reality claim. Photographs have long been understood as an indexical record of what was there when the camera shutter snapped (Tagg, 1988). By picturing

circulated image is probably the case of the Rio Intelligent Operations Centre (ROC), created as a partnership between Rio de Janeiro and IBM (see, for example, Barns, 2020; Luque-Ayala & Marvin, 2016; Wigley & Rose, 2020). The project was part of a strategic action plan to prepare the city to hold the 2014 FIFA World Cup and the Olympic Games in 2016. Designed to integrate data from 30 different urban agencies into a single control room, the ROC aimed to provide a complete view of how the city operates 24/7. At the same time, the ROC incorporated urban OS through repurposed business intelligence analytical tools manufactured by IBM with a double function of overseeing day-to-day city management and acting as an emergency response centre. Luque-Ayala and Marvin (2016a, p. 192), argue that *"through a renewed emphasis on organisational integration, the collapse of the everyday and the emergency and the use of a variety of digital and visual techniques for engaging the public within infrastructural operations, the city's infrastructures gain new forms of transparency, increasingly appearing un-black boxed and open to the public"*. That capacity of remaining invisible as a given infrastructure but equally visible as an infrastructure interacting with the city and its inhabitants is crucial to the constitution of the ROC as a technology of city management. It acts as a huge urban panopticon but rather than sustaining a *"disciplinary power it is a governmental technique of visibility, as the eyes of the multiple are not only those of the ROC but also the public"* (Luque-Ayala & Marvin, 2016, p. 201). Therefore, the infrastructure and the subjects embedding within it operate in a retrofitting capacity, enacting the need for a permanent state of crisis and —a consequential— urgent intervention as a motif to enable the city's circulation. For them urban circulation refers to *"a key instrument and target of*

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what looks like. This combination of the city being converted into a quantitative data, and the widely circulated photograph of the operations centre having an indexical relation to the centre, alerts us to the ways in which multiple kinds of realities are being constituted. Multiple strategies for picturing the 'actually existing smart city' or 'real smart city' are possible.

governing processes" (Aradau & Blanke, 2010, p. 45 in Luque-Ayala & Marvin, 2016) which establishes a form of *laissez-faire* by letting things happen in the city based on a certain economy of intervention. In my case, I refer to circulation as a component of the data dispositif, so although it is related in terms of how circulation operates within a certain dispositif, I am referring to a different dispositif.

Similarly, the high modernist ambition of controlling disorder through the visual capabilities of the control room is widely present in smart city narratives. Accordingly, control rooms are ways of seeing the city varnished with an aura of certainty and objectivity representing "single versions of the truth" (McNeill, 2015, p. 35). They need to be placed in a historical trajectory of how city management (and more specifically public transport[18]) has tried to build a capacity to "see itself", which is fundamentally associated with techniques and strategies to grasp the city as total and single unit.

Nevertheless, that idealisation of totality is no more than an aspiration of both city managers and Urban OS developers (such as IBM). This is first because of the lack of spatial correspondence between city managers and technology developers since city managers understand the notion of totality as an aspiration of control, of governing every single aspect from the "centre". Yet, for the Urban OS developers, the appeal of the smart city as a centralised vision of totality is different, as they rely less on a physical entity (such as the control room in its architectural form) and more on a decentered, flexible, and multi-accessible platform, especially considering the expansion of cloud-based services. Indeed,

[18] Public transport is never only seen at the city level or by the city actions and practices in many different sites; it is almost always multi-scalar and translocal.

as McNeill (2015) also suggests, the synoptic vision of totality is contrasted by the multiplicity of assembled urban governing techniques.

In my case, I go further into the idea of network and multiplicity of control rooms as technologies that require coordination and integration to enable data circulation. However, that does not necessarily happen through a single material infrastructure as it is intended in cases like Rio de Janeiro. Instead, I refer to control rooms as *oligopticons* (Latour and Hermant, 1998). The notion suggests that what constitute a city as an entity is its fragmentation, dissection, and complexity of its everyday experience. Using the example of Paris, the authors identify oligopticons as the way by which the city is recentered as a network despite its disorder, dissections, and fragmentations. In some form, Latour and Hermant go beyond the readings of control rooms as a form of panopticon to foreground two other qualities: partiality and selectivity.

Latour and Hermant ask themselves what defines the city as an entity despite the fragmentation, dissection, and complexity of its everyday experience. They argue that, notwithstanding increasing fragmentation, standardization, continuous monitoring, and the impression that the social cement has been broken, somehow Paris endures. The authors suggest that this endurance is achieved by diverse and very detailed visions enacted by many interconnected and interdependent *oligopticons*. As Latour & Hermant (1998, p.48) point out: *"every panopticon is an oligopticon: as it sees little but what it does see it well".* An oligopticon then is, at the same time, partial as it visualises a specific aspect of the city according to its function and selective as it determines what must be visualised. However, it is only through the network, that is the interconnection of multiple oligopticons, that a vision of the collective is attained. Ultimately, those processes of selectivity in what, in the city, is rendered visible are the result of a series of problematisations.

Hence, an oligopticon is only enacted in association to other oligopticons. In the case of control rooms in Santiago's public transport, as we will see in chapter 4, despite these functioning individually, control rooms cannot avoid a permanent communication and coordination with the other control rooms composing the network. In other words, despite blind spots, these are *"plugged in, partially intelligent, temporarily competent and locally complete"* (Latour and Hermant, 1998, p. 68). Ultimately oligopticons create a spatial and temporal configuration to the problem of fragmentation of the city through a myriad of shared and coordinated practices and techniques. But this version is different to the commonsensical assumptions of big tech, which suggests that the "total vision" of the smart city can be achieved through a unique technology in the form of software or a dashboard. It is the exact opposite, because the vision is generated by and through a network of heterogeneous actors (humans and non-humans) that create the world as a fragile and performative composition (see Latour, 2010). It is fragile because it is sustained by the performative forces of fragmentation, dissensus and frictions. At the same time, it is performative as the temporal endurance of those relations is what creates what the city is. Accordingly, the city's vision is only achieved in temporal form, as responding to the problem of fragmentation, by the shared composition of individual actors that conforming a network produce response to problematisations of how data allows certain visualisations of the city.

In chapter 4, I use the notion of oligopticon to explain how control rooms coordinate to deal with a previously existing problem of governance fragmentation in public transport. My argument, however, goes beyond the ways these control rooms coordinate responses *between* them to enable data circulation. I also focus on how control rooms generate responses to problems of data circulation *within* each of them. To do so I use the concept of *synthetic situation* (Knorr-Cetina,

2009) to analyse how data is made to circulate internally at each control room as a blend of mutually constituted practices that are at the same time presential and virtual. It relies on the existence of digital informational analysis, usually enacted through individual or larger screens where data is visualized and observed by control rooms analysts acting in some level of physical co-presence. Therefore, synthetic situations are characterised by the introduction of digital information and their representations into an embodied communicative action (Knoblauch & Löw, 2017, p. 15). Synthetic situations are also temporarily defined as inherently in flux, as the control room analysts *"perform their activities in a moving field by changing, incoming, and disappearing bits and pieces [of data]; as the information scrolls down the screens and is replaced by new information, a new situations –a new reality– continually projects itself"* (Knorr-Cetina, 2009, p. 72).

Synthetic situations can be seen as a patchwork or bricolage of multiple digital and non-digital information sourced from CCTV images, data visualisation software, dashboard screens, social media platforms (such as Twitter and WhatsApp), platform mapping tools (like Waze or Google Maps)— processed by analysts or operators in the control room. A synthetic situation can be constituted both individually and collectively, for example when a specific individual in a control room defines how to deal with the information received from a wide variety of sources to take care of a determined situation like a traffic jam. At the same time, it is built on the shared experience, in the collective experience of individuals dealing with shared problems together –making sense of the available data in order to act according to a determined objective. This lines up directly with the idea of problematisation, as it produces specific actions to solve emerging situations (problems) requiring precise attention.

Then, If we consider control rooms as a *bricolage*, that is, a *"hybrid informational ecology"* (Marvin & Luque-Ayala, 2017, p. 86), then control rooms analysts would be their *bricoleurs* as they command over a diverse toolbox of skills and materials, kept well-maintained to make do with whatever is at hand just in case its needed (Offenhuber, 2019, p. 1570). Offenhuber (2019, p. 1569) relates an urban data bricolage/bricoleur with the importance of using *improvisation* seeing it *"as the confluence of planning and doing, which often takes place when a solution is required in the face of an urgent challenge or need"*. Taking the idea of improvisation from organisational studies, which at the same time are inspired by jazz improvisational practices, the importance for the case of control rooms' synthetic situation building is based in its inherent social and relational as actors conflate meaningful and articulated *ad hoc* responses to each other's actions, usually oriented towards a common goal (Offenhuber, 2019; Offenhuber & Schechtner, 2018). Finally, I consider improvisation not as purely eventual action but as practices that can become stable —especially if they are a result of persisting forms of problematisation as it happens to be the case of control rooms in Santiago's public transport. From that perspective, improvisation despite demanding experimental action, it also involves *habits* as recurrent forms of controlled action-enquiry, in which thought is a shared communicative activity, regarding some sort of problematisation (Bridge, 2020).

In the current subsection I have covered the analytical concepts which I used to examine the role of control rooms in the data circulation process in Santiago's public transport. I introduced a revision of how control rooms have been described and taken as indexical elements of the smart city. I also presented some conceptual tools to explain how I dealt with the problem of control room fragmentation and the ways in which data circulations were enabled between and within control rooms. In the next subsection, I will focus on a different set of conceptual tools which I use —in chapter 5— to analyse the role of experts and expertise in the configuration of the data dispositif in Santiago's public transport.

2.4.2 Experts and Expertise

The role of expertise and experts is the second part of the analysis of data circulation and the data dispositif in Santiago de Chile. My objective is to analyse how knowledge is created, negotiated, and established by expert groups to enable data circulation in Transantiago. In other words, the emergence of big data circulation also becomes a problem of expertise as it requires specific knowledge and skills to be enabled. Not as a replacement of a previously existing configuration of experts, but as a rearrangement of actors, their skills and tools to direct the possible forms and directions that big data can take in the transport system. Expertise, and more specifically the influence of transport engineers as the most predominant expert group in Transantiago has been already analysed since the early days of the system's implementation (Olavarría-Gambi, 2020; Ureta, 2015, 2017).

As I discuss in more detail in chapter 5, the starting point will be to analyse the overarching role of transport engineers who appear almost every single step of the way in the data circulation process. Throughout this process, transport engineers prevail over other groups of experts and transport specialists, mainly supported by their technical capacities, the high legitimisation of its discipline, and their enclosure as an *epistemic community* (Haas, 1992). For this purpose, I consider epistemic communities as groups configured around shared technical expertise, capable of building a common frame of values and objectives, as well as shared notions of validity, and joint policy enterprises often strategically focused on helping decision-makers to identify and deploy solutions to solve problems (Haas, 1992). The smart city has generated with its expansion a variegated and largely influential topic specific epistemic community, with the characteristic of not solely being driven by beliefs but also motivated by a desire to provide solutions and generate profit (Kitchin et al., 2019). In any case, an epistemic community proves itself successful if their ideas and practices becomes the “norm” over time, continuing to shape how problems and solutions are identified and tackled (Kitchin et al., 2019, p. 205)

An epistemic community is enacted by a specific community of practice that creates a frame of inclusion establishing the limits of what knowledge is accepted as valid, generating mechanisms of group self-affirmation and preconditions for participation. Further, epistemic communities aim to identify the formats by which knowledge is produced, processed, and disseminated as well as to establish the essential skills required and the standards of quality to safeguard the technical legitimacy of how data will and should circulate.

The concept of epistemic community is closely related, and in many ways overlaps with the notion of *epistemic culture* (Knorr-Cetina, 1999). This concept refers to *“those amalgams of arrangements and mechanisms-bonded through affinity, necessity, and historical coincidence-which, in a given field, make up how we know what we know"* (Knorr-Cetina, 1999, p. 14). Accordingly, it evokes the depth and diversity of the machineries of knowing, and how these are sustained and structured by group knowledge practices. In the same way, an epistemic culture highlights the symbolic aspects of expert groups, not in parallel with technical (instrumental, productive, rational) activities but as mutually constituted by the social and symbolic processes.

In my research, I examine the influence of transport engineers as an epistemic community that seeks to effectively participate in the transport policy discussion by deploying specific kinds of engineering expertise. The creation of a specific culture, with explicit and implicit visions, values, mechanisms of legitimacy, rites of passage, and internal hierarchies is a substantial characteristic to achieve an effective an influential position in the political landscape. The importance of epistemic communities for my research is marked by their capacity to establish themselves as unavoidable elements for the discussion of public transport, based on their technical legitimacy yet exceeding the limits of the technical enclosure. Closely related to this argument is the idea that engineers themselves become an obligatory passage point to participate in large processes of transport sociotechnical change (Latour, 1996). In the same way, I argue that epistemic communities can become epistemic cultures if they are capable to produce endurable and epistemically relevant arrangements beyond the factualness of empirical work combining it with symbolic non-factual processes to determine what is validly defined as expert knowledge (Knorr-Cetina, 1999, p. 251).

The idea of "boundary" is recurrent when it comes to define how expertise is delimited, demarcated, and validated. Particularly relevant to my research is the strategic use of *boundary work* (Gieryn, 1983). This term refers to the practices and techniques developed by technical groups, or in this case, epistemic communities, to demarcate disciplinary borders between those who have the legitimacy and competency to participate in specific domains of technical decision-making from those who have not. Moreover, the demarcation of expertise, and science in general, are not given or subjected by a unique form of technical practice but is also constituted by the ideological efforts of experts to distinguish their work and its products from non-validated forms of expertise. Boundary work could operate according to three different forms of demarcation

(Gieryn, 1983, p. 792). One way is using boundary work to expand the expert authority into domains claimed by others technical groups or professions. A second way is when the goal is to monopolise the professional authority to exclude direct disciplinary rivals from within by alluding to their work as lacking in legitimacy or rigor or as amateurish. A third way is when the goal is to protect autonomy over professional activities; here, boundary work exempts experts from responsibility for consequences of their work blaming outsiders for any unintended results.

In my work, I use the boundary work concept to analyse the specific practices used by an epistemic community to configure their domain of action in the configuration of the data dispositif. In other words, I am interested in the political effects of group demarcation, identifying techniques of exclusion, legitimisation, and incentive-building to make data circulate according to their vision of how Transantiago should be. In other words, it is through boundary work that a certain epistemic community is made; but more than this, I argue that these communities can build an epistemic culture potentially transcending their disciplinary boundaries and expanding their own domain of influence and decision making on public transport big data.

These practices, techniques and ideologies are translated into strategies of actor enrolment to enable data circulation with some state of temporal endurance. The latter has been well documented on early ANT discussions on sociotechnical change and the role of engineers and engineering as a discipline in those processes (Bijker et al., 2012; Callon, 1987; Law, 1987b; Law et al., 2012; Law & Callon, 1988). For them engineers are much more than just "technical" actors involved in technology, rather they are *heterogeneous engineers* (Law, 1987a) or *engineers-sociologists* (Callon, 1987). A concise definition is made by Law &

Callon (1988, p.284): *"Engineers are not just people who sit in drawing offices and design machines; they are also, willy nilly, social activists who design societies or social institutions to fit those machines. Technical manuals or designs for nuclear power stations imply conclusions about the proper structure of society, the nature of social roles, and how these roles should be distributed".* At any rate, for these authors the main capability of these heterogeneous engineers is to pay scant attention to the divisions that most of us detect when we separate the technical from the social, then subdivide the social into the economic, the political, the sociological, and everything else (Law & Callon, 1988).

A final conceptual tool on the role of experts enabling data circulation and configuring a coherent data dispositif relates to the notion of *boundary spanner* (Levina & Vaast, 2005; Nochur & Allen, 1992; Williams, 2002). The term mostly used in organisational, informational management, and public management studies relates to specific individuals or organisations capable to mobilise knowledge and ideas spanning expert boundaries in complex organisations. This is a competence that organisations develop to deal with the emergence of multisectoral problems or new requirements in complex organisations (ie. State bureaucracy). Although related to the idea of the heterogenous engineer, a boundary spanner is much more specific in relation to enable data circulation in a complex organisational setting like is the case of Santiago's public transport. In other words, usually a boundary spanner which could be enacted by a specific individual, most certainly would be part of the wider epistemic community of heterogeneous engineers. Yet not all the members of the transport engineering community are boundary spanners within the data dispositf. Boundary spanners usually emerge with new organisational requirements often are related to more than one area of technical expertise (ie. how to implement big data in public Transantiago). Legitimacy is essential to become a boundary spanner, in terms of being able to participate directly in multiple areas of the organisation, as well as in cross-sectoral and multi-hierarchical negotiations (Levina & Vaast, 2005). Ultimately, a boundary spanner is an actor capable of coordinating, arranging and bridging group boundaries -between transport engineering in academia and the transport bureaucracy- to ensure data circulation in Santiago's public transport.

In the next section, I will explain further how I conceive translation as a conceptual tool to analyse how the data dispositif achieves moments of temporal stability and obduracy in the data circulation process.

2.4.3 Enacting Obligatory Passage Points.

In this subsection I introduce the concept of *translation* (Akrich et al., 2006; Callon, 1984a; Latour, 1993, 2005), and more specifically the notion of *obligatory passage point*, which corresponds to one of its critical internal components. I use these concepts in chapter 6, to analyse specific operations to stabilize data circulation as the data dispositif acquires moments of temporal endurance.

The concept of translation is perhaps one of the most significant and widely circulated theoretical ideas of Actor-Network Theory (ANT). In general terms to translate is to associate heterogeneous components in order to build a network (Akrich et al., 2006; Callon, 1984b; Callon & Latour, 1981; Latour, 1993, 2005).

Translation emerges in the early development of ANT, even before it was established as a theory in full. As an early definition of translations puts it: *"By translation we understand all the negotiations, intrigues, calculations, acts of persuasion and violence, thanks to which an actor or force takes, or causes to be conferred on itself, authority to speak or act on behalf of another actor or force. 'Our interests are the same', 'do what I want', 'you cannot succeed without going* *through me'. Whenever an actor speaks of 'us', s/he is translating other actors into a single will. ... S/he begins to act for several, no longer for one alone. S/he becomes stronger. S/he grows."* (Callon & Latour, 1981, p. 279; in Michael, 2016). A translation according to this definition involves a relation between actors sharing a situation of tension, disagreement, or a problem in need of attention. In that sense, the network is a result of a translation, and the more translations an actor is capable to perform, the bigger its relevance turn out to be for the composition of the network, becoming more powerful. So, to translate is to enrol other actors into one's network, or in other words, to translate the interest of other actor(s) into one's own. At the same time, the actor that is enrolling the rest through translation needs to ensure that those translations are robust and so obvious that they are automatically accepted. Ultimately, the result of these successful translations is a "*blackbox that contains that which no longer needs to be reconsidered"* (Michael, 2016, p. 33). Analysing translations is useful to identify the association of heterogeneous elements, following how power relations are structured along a determined problem, and tracking down which actor is in the end able to stabilize its power by associating the largest number of irreversible linked elements (p.33).

From this perspective, sociotechnical change is neither inevitable nor static, but rather is the result of complex associations and configurations of alliance and conflict among differing actors and their interests (Sovacool & Hess, 2017). As networks, such as a dispositif, gain credibility or solidify, they move through what Callon (1986) structures the translation process: problematization[19], framing an

[19] Callon (1986) use of problematization is slightly different to the Foucauldian definition. Callon's refer to problematization as one of the steps of a rigid sequence by which a translation is made. More specifically, problematization refers to the first moment of the translation process, when the one actor sought to become indispensable to other actors by defining the nature and the problems

assemblage as a vital way of addressing some pressing problem or fulfilling a social need; interessement, the strengthening of the network between actors and other support structures; and finally, the enrollment and mobilization of allies that anchors them to the network.

In my dissertation, I present these steps not as following a rigid sequence but as part of a story of how data circulation is enabled. Some of the elements that are present in my approach to the concept are: the presence of actors that are part of a network, in this case the data dispositif, enacted by institutions, politicians, practitioners, experts, software, regulations, or a contract. These actors are connected according to their mutual concerns over the data circulation process. They also identify what is unavoidable in the situation that brings them together in the data circulation process. That unavoidable component is defined as an *obligatory passage point* (OPP) referring to a place (a geographical one or an institution) or a procedure that becomes unavoidable in the quest to solve problems(Söderström et al., 2014). Then, the same actors encountered over a controversy now have found a common problematisation and, consequently, are enrolled in a mutual path. This last point is central to my interpretation of the concept since it refers to how the actors intend to solve the lack of convergence in their agendas, by finding a point in common that becomes unavoidable to enable the data circulation process. Without meaning that an obligatory passage point could not at some point be contested, disputed, or even reversed as other actors becomes involved in the network and new problems emerge. As will be seen in chapter 6, obligatory passage forms can take different forms in order to structure and stabilize the data dispositif, for example, the production of certain type of

of the latter and then suggesting that these would be resolved if the actors negotiated the "obligatory passage point" of what the first group is defining as problem (p.196).

contract between the transport authorities and the complementary service providers, the establishment of key performance indicators to evaluate bus providers performance, among others.

In this subsection I presented the concept of translation and the derived notion of obligatory passage points. I use these notions to explain how the dispositif achieves moments of stabilisation allowing data to circulate in public transport by the establishment of obligatory passage points shared by the involved actors.

2.5 Conclusions

This chapter has charted the ways in which my research is framed within a wider set of theoretical and conceptual discussions about the smart city, big data, dispositifs, and problematisations.

I started the chapter by situating my research as part of the wider literature of critical approaches to the smart city. Taking some distance from some of the most predominant critiques of the smart city projects, I focused on the idea that the smart city could become "something else" if we look beyond the mainstream critical ideas about technocracy and political economy. Accordingly, I propose instead to focus on the role of big data but not as an essential quality or as taken for granted along the smart city. Rather, I argue that big data is a technology that needs to be unpacked as an ensemble of heterogenous, contingent, and unpredictable set of relations between human and non-humans. Therefore, I propose the concept of the data dispositif as a theoretical tool to grasp big data as a complex array of heterogenous elements that has the double characteristic of being constituted by and being an enabler of data circulation in Santiago's public transport. I also argue that data circulation is not necessarily an inherent capacity of big data but a result of these heterogenous actors to deal with problematisation. That is, to establish how determined situations within the data circulation process become problematic in a certain time-space context, affecting the capacity of data to circulate in Santiago's public transport. But at the same time, I suggest that these problems are generative of specific active solutions, so ultimately, are enablers of data circulation through specific processes by which the heterogeneous components of the data dispositif rearrange together as a network.

With this approach I am aiming to contribute to the critical literatures on the smart city and big data, by elaborating on the specific dynamics of data circulation and its problematisations. That is consistent with my research question which, as I defined it in chapter 1, is: *How is big data made to circulate among public transport organisations in Santiago, and what are the effects of its circulation?*

In the last section of this chapter, I presented a set of analytical tools to examine three empirically grounded problems in the public data dispositif: the problem of control rooms fragmentation, the problem of experts and expertise, and the problem of translation and obligatory passage points. As said, these problems are empirically grounded as particular ways by which data has been made to circulate through problem-solving. In the same way, focusing on these problems, and sidelining others, represents a particular strategy of urban inquiry, in which problem formation is attached to responsiveness. That is to see problems as a form of inquiry in which what is at stake is the very essence of things—invigorating critical urban studies through pragmatist imagination (Barnett & Bridge, 2016, p. 1187).

In the next chapter, I will propose a strategy to operationalise the Foucauldian ideas of dispositif and problematisation through an Actor-Network inspired methodology. Hence, I will describe the research design and the methods proposed to empirically approach my research on big data circulation and the generation of the data dispositif in Santiago's public transport.

3. Research design and methods: following big data, configuring the data dispositif.

"How ridiculous is it to claim that inquirers should 'follow the actors' themselves, when the actors to be followed swarm in all directions like a bee's nest disturbed by a wayward child?" (Latour, 2005, p. 121)

3.1 Introduction

In this chapter, I will make an account of the methods used in my research to explore and configure the problem of data circulation in Transantiago. In doing so, I will justify my problem as *emerging-with-the-field* in concordance with the theoretical toolkit presented in the previous chapter.

As I mentioned in chapter 1, when I initially decided to study big data and the city in Santiago de Chile, I had already done some previous research work on the local smart city programme (Sé Santiago). This last experience influenced how I approached the issue of big data and the smart city, knowing that these two agendas weren't always either related or consistent. There was a clear gap or mismatch between the, sometimes, inflated local smart city discourses referring to the uses of digital technologies and big data and the actual execution of projects using big data at the level of urban public services. Occasionally, even the same people disseminating these discourses would admit as much in private, as one of my interviewees intimated: *"in total honesty, none of those projects are more than incipient initiatives*".

Early in my project I had the intuition that the most significant projects on urban big data existed beyond the smart city projects. In accordance with what I described in chapter 2, about not pre-assuming problems as given but as situations that historically emerge as part of a set of complex relations between humans and non-humans, I argue that this process in which *data becomes a problem* is also reflected directly by how my research project unfolded.

I divide this chapter into six sections. First, I describe how I use some guiding concepts from ANT to develop my methodology — in which I situate the approach toward data circulation and *how to follow the data.* Then, I describe the initial exploratory phase of my fieldwork and how I found big data in Santiago's Public Transport. The following section refers to the fieldwork strategy by which I organised the data collection process after deciding on my case in the field. In this section, I discuss the data collection tools and methods used, such as participant observation and in-depth interviews, and how they made me rethink and redefine my initial research objectives. The next section is centered on the data analysis or how I rendered the variety and abundance of qualitative data collected as a consistent narrative about the problem of data circulation in Santiago's Public Transport. Then, I reflect on the situations, concerns and problems regarding research ethics experienced in my research. That involves reflections on my *situatedness* as a researcher and the decisions to find solutions to the problem of following big data, Accordingly, I describe how the breakdowns and decisions made in certain moments, in the end, configured the problem of data circulation, as I describe in my findings, and how these were based on my biases as a researcher, taking responsibility for the said and the unsaid of the problem of big data in Santiago's Public Transport.

3.2 Situating *problematisation* as a methodology with ANT

Deciding what to do, when, and how has been probably the most challenging endeavour of exploring big data in Santiago's public transport. From the beginning of my research, I attempted to take an emergent and pragmatic approach to big data in the smart city. To use the Foucauldian dispositif as a central concept for my research, despite its opportunities and conceptual richness, presented an important challenge to operationalising it as a consistent methodology. In this chapter I present how I approached this challenge presenting a methodology inspired by Actor-Network Theory.

In a certain way, this preliminary approach enacts my theoretical predispositions as a researcher influenced by Actor-Network Theory, and its elaborations around radical empiricism. The anecdote of Bruno Latour receiving one of his students to discuss how to apply ANT empirically is illustrative of my initial idea: *"...ANT is, first, a negative argument. It does not say anything positive on any state of affairs"* (Latour, 2005, p. 141). This provocation sets an important consideration regarding my approach as I take ANT as a method to trace associations between humans and non-humans based on certain principles of following the actors rather than an analytical framework that offers explanations about the world (or the problem of data circulation in public transport in this case). My aim, then, is to establish a theoretical and operational continuity to the Foucauldian notions of dispositif and problematisation by following the data approach inspired by Actor-Network Theory.

3.2.1 Actor-Network Theory early tenets

I started my project inspired by a sort of "classical"[20] ANT approach (see: (Callon, 1984a; Callon & Latour, 1981; Latour, 1987, 1993, 1996; Law, 1987a; Law & Callon, 1988). At that point, I was clear about some of the most typical critiques of ANT, pointing out constraints and limitations of the approach for things like the use of a naïve empiricism, its lack of criticism, and, therefore, the limited political agency and commitment in the work of the ANT scholars. Although I don't want to dwell on these critiques, I consider that the political role of ANT resides in its capacity to produce the object of research as something that only emerges in how humans and non-humans connect, conforming an (actor) network[21]. This had a relevant practical consequence for planning my research and how the projected trajectory unfolded. If I wanted to know what a smart city and big data are in the context of a city in the global south like Santiago, I needed to focus on *following the actors* and to be open to identifying the issue in question through a precise description of how these heterogeneous actors generate associations throughout the process of data circulation. In other words, and making the link with the notion of problematisation, I needed to examine how the actors were producing a data dispositif as a process of alignment between them in terms of enacting and solving shared problems over data circulation.

The notion of *generalised agnosticism* had a decisive influence on how I was thinking about my research topic and the strategy to approach it. Generalised

[20] By classical I refer to the some of the most distinguished early texts and concepts developed by ANT scholars during the 80's and 90's. Although, this comes from a partial judgment based on my own experience traying to work with ANT. As Mike Michael (2016:28) states: accepting that the 'classical' ANT presented here is inevitably a contestable version, the advantage is that we can explicate a series of elements – not least, tenets – that distinguish ANT as an approach to the study of 'the social'.

[21] This is part of the core ontological discussions in ANT. See for example Latour (1993)

agnosticism (Latour, 2005) refers to an attitude of impartiality towards the problem or controversy in which the researcher is involved (Michael, 2016, p. 158). The principle certainly made me take some distance from, firstly, existing consensus on critiques of smart cities and big data. Secondly, to dissect some of the most persistent "big narratives" present in urban critical[22] research —having for example a strong vision about neoliberalism, the emerging variations of corporate-storytelling, and the novel modes of governance. In chapter 2, I presented my critiques of these assumptions at a greater length.

At the same time, I was aware that using ANT demands from researchers to acknowledge that research practices help to enact the social. In other words, the descriptions we make about the world and the tools with which we make those descriptions produce it; that is, the social is *enacted by* the practices by which we try to apprehend it (Law & Urry, 2004). So, theories, methods, tools, and the analytical process are also implicated in this dual form of heterogeneity as they are continuously subjected to being connected differently, and change.

The use of drawings and sketches during my interviews, especially at the beginning of my fieldwork, is an example of how methods themselves enact specific realities. I asked the participants to sketch their vision of the data circulation process by drawing a flowchart. This provocation helped me understand the partial visions of the data circulation processes in the system.

[22] In fact, for the sake of this argument Bruno Latour (2004, p. 237-238) has proposed to take distance from two types of criticism widely present in social sciences. First, criticism as antifetishism in which criticism is simply a projection of the critic's wishes onto a material entity that does nothing by itself; and second, a criticism that turns "those false objects into fetishes that are supposed to be nothing but mere empty white screens on which is projected the power of society, domination, whatever".

Asking my interviewees to situate their work concerning the data and their role within the extended network proved a good starting point for our conversations.

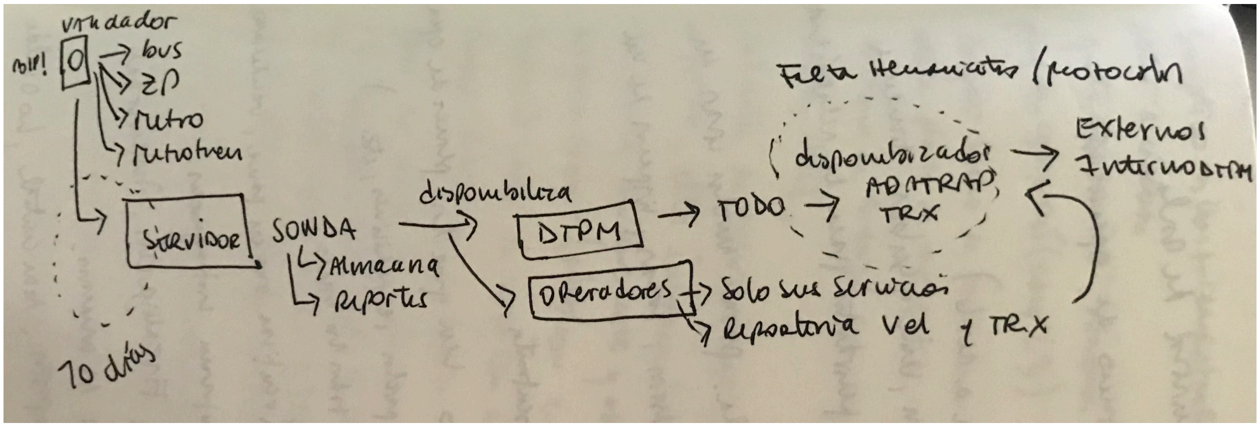

Figure 6 Data circulation sketch made by data team analyst at DTPM. Source: sketch made by DTPM analyst during a visit in March 2019.

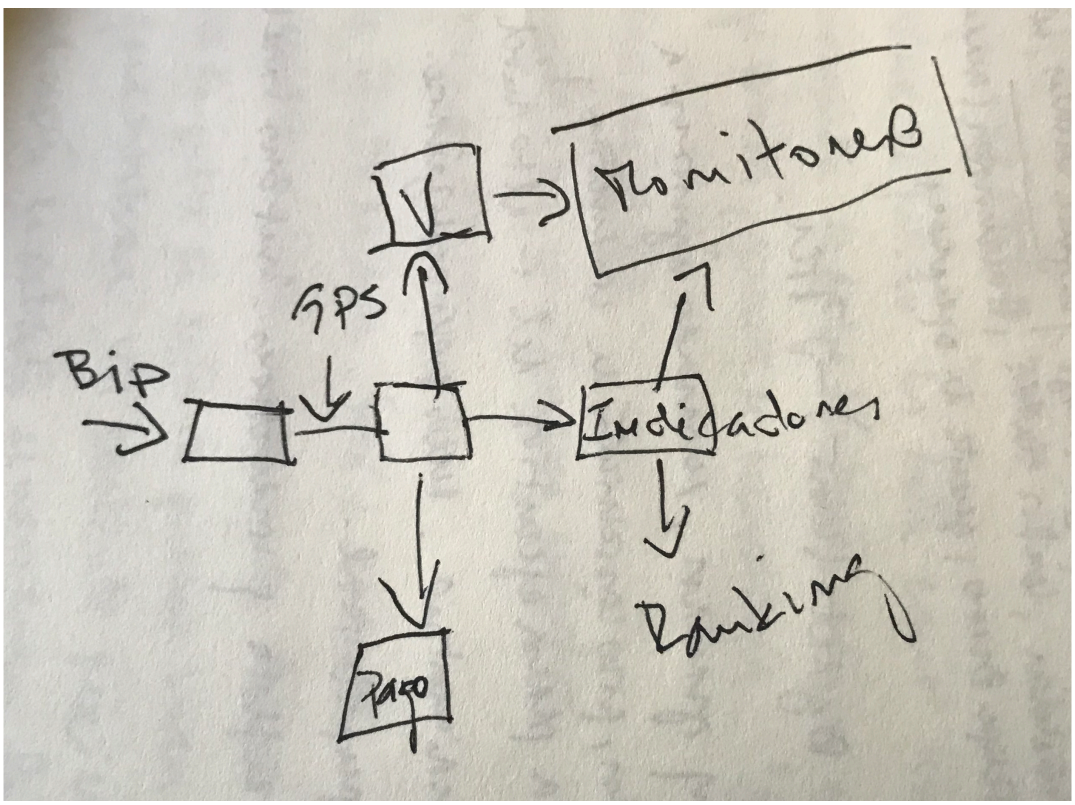

Figure 7 Data circulation sketch made by former DTPM director. Source: sketch made by the interviewee in December 2018.

Figures 6-7 provide two examples. The first thing we notice are the different ideas and visions about the operational data circulation for two individuals working at the same organisation (DTPM). With this, I like to suggest that the drawing exercise was an elicitation device— an activity that was meant (or at least helped) to get things underway and mobilise the process of enactment of the data dispositf. In other words, to assemble a description of the data dispositif is to compose it from a wide diversity of visions, which ultimately is processed and determined by my own role as observer, and researcher, made through my own descriptions.

3.2.2 ANT, Pragmatism, and Foucault

In addition, some of the late theoretical developments of ANT have been tightly connected and influenced by philosophical pragmatism, especially through an extended revision of the ideas of William James, John Dewey, and others (see: (Hennion & Muecke, 2016; Latour, 2013; Marres, 2019; Savransky, 2021). ANT scholars arrived "late" to pragmatism after developing much of ANT's theoretical foundations. But they quickly embraced these "new" ideas to refresh, and complement some of their most foundational dictums on association, agency, and translation (Hennion & Muecke, 2016).

Here I will concentrate on a smaller portion of those linkages as they relate to the concept of problematisation and the *following the (actors) data* approach.

A first element I take from these linkages between ANT and pragmatism is the processual configuration of reality and the dismissal of binaries, such as nature/society (Latour, 1993). It involves moving away from any essentialist positions regarding big data and the city as either an object or discourse. It means identifying objects beyond their bounded entities that can be disassembled to reveal the traces, associations, and the resulting networks that, in the end, create them. In that process, we can see how things could have gone otherwise, so despite the endurance of objects, they can get un-black-boxed and, in that process, reveal themselves as a point of entrance to observe society as a whole (Latour, 1990). From a pragmatist perspective, the Jamesian notion of *pluriverse* summarises the ANT ontology taking reality not as for granted, but made up of plural and open associations, as an expanding tissue of heterogeneous realities, yet connected loosely, *"still in process of making"* (Hennion & Muecke, 2016, p. 302). In other words, *"in the pluriverse there are simply more agencies than philosophers and scientists would have thought"* (Latour, 2005, p. 116). Which means that what emerges from the associations and networks that enact a certain entity is *because of* a multiplicity of potential options, which, as ANT suggests, are traceable.

The focus on tracing connections, not as a fracture but as an enactment, is what makes ANT and ethnography[23] blend so closely through the idea of "following the actors", as a preferred analytical-methodological route. Yet ethnography in the ANT tradition was never about making thick descriptions (Winthereik, 2019). The objective, then, is about following the actors, to establish the way they associate and generate traceable trajectories through dis- and re-assembling their connections (Marres, 2019). In my research, this means that to establish what big data is, how it circulates, and what it does when that happens, is ultimately an analysis of how big data has been undone and redone in the process of becoming an endurable entity, such as a dispositif.

Likewise, the relationship between ANT and Pragmatism and late Foucauldian ideas presents some relevant points in common, but more importantly, differences.

[23] However, of course, several critiques have questioned if ANT ethnography is anthropological enough to be considered as ethnography. In the same way, from the ANT research side, often ethnography has been translated as a soft requirement to follow the actors by attending practices (Winthereik, 2019).

First, as we have seen already in Chapter 2, Foucault's and Dewey's ideas connect with each other in their vision of thinking as an active process of inquiry or problematisation. That is to establish thought as capable of establishing what a problem is, but also and more importantly to evoke a course of action with it (Rabinow, 2011). The realist attitude taken from pragmatism is a shared characteristic of some of the Foucault's late works (Foucault, 1984; Koopman, 2013, 2018; Rabinow, 2003), which is particularly important for my uses of the dispositif and its method of problematisation (Garland, 2014, p. 365). This idea of problematisation as method refers more to a form of generative-historical practice and problem-solving, as a form of thinking about problems, rather than a systemized research programme. In contrast, ANT, and especially some of its late developments have taken the ideas of pragmatism, including problematisation as a form to rethink or even revitalize some of the classical ideas of a theory which is, first and foremost, a research programme as Latour (2005) explains well.

Marres (2019) provocatively declares that is through pragmatism that ANT could be undone and redone, a claim that the author couples to the very idea of problematisation. Likewise, ANT, American Pragmatism (and Foucault) have challenged naturalism and reification by developing a relational ontology. This, briefly put, is the proposition that processes of association are critical to existence and the coming to existence of things. Also, as with ANT, Dewey identified problematisation as a defining operator of these processes. *"The undoing of entities – the loosening of associations – in order for them to be redone – for different associations to enter into the making of said entities – is not a mechanical process, but a profoundly risky one, one that puts entities and their relations at stake"* (Marres, 2019, p. 113). For my research, this is methodologically relevant as it relates the idea of problematisation with ANT's systemized empirical research programme, which as I said is not something that Foucault necessarily tried. *"[Problematisation] is not an obvious and clean authored process, in which to define a problem is always already to render it solvable, but an unsettling occasion, on which the emergence on the scene of an entity that was previously disregarded redefines existing roles, relations and capacities of agents and/or categories (they are not acting, not in control, not having it covered), and necessitates their requalification"* (Marres, 2019, p. 114).

ANT takes these processes further by emphasizing the heterogeneity[24] of these associations and its traceability as a generative process of following the actors. My approach, then, is to operationalize problems as a research method that allows me to concentrate on the emerging associations, the ways things are done, undone, and redone through problematisation. I argue this is achievable using a *following the actors* (or the data in my case) approach to identify by which associations big data circulates, and what happens when it circulates in Transantiago.

In the next section, I describe my fieldwork in Santiago de Chile, focusing on the different stages of the data collection process based on a sequential exploratory strategy.

3.3 Exploration: Finding big data in Santiago de Chile

With hindsight, the way I planned and developed my fieldwork, and the data analysis was mainly experimental. Despite the often-inflated use of

[24] This is an additional take on John Law's notion of "heterogeneous engineering" in which the stability and form of artifacts should be seen as a function of the interaction of heterogeneous elements as they are shaped and assimilated into a network' (Law, 1987 p. 113 in Michael, 2016, p.34). Such networks are rarely easy to put together or sustain: 'heterogeneous engineering may be treated as the association of unhelpful elements into self-sustaining networks that are, accordingly, able to resist dissociation' (p.114).

experimentation in social research, in my work, it points out an effort to capture the non-linearity of big data. It traces a series of loops: try out a possibility, see what emerges, reflect, and adapt or go back to go down another route. In other words, tracing relations and finding problems and solutions is hard, and my work of course is not an exception at all.

I divided my 9-month research fieldwork in Santiago de Chile into two stages: exploration and collection, which I developed between September 2018 and May 2019.

During the exploration phase, I conducted the first group of interviews using a snowballing approach to discover "the data" in the "smart city". I started in a vague role as a research collaborator at the Santiago Smart City programme (Se Santiago). The Se Santiago[25] programme began in 2014 with a roadmap study and a 10-year smart city implementation strategy to Santiago. In this first phase, the main objective was to consolidate the local smart city presence by developing a branding strategy and a territorial approach to connect techno-related start-ups with local municipalities. So, even before my arrival, I was aware of the early stage these technological start-ups'. In other words, I was doubtful about the progress and relevance of these projects as examples of big data circulation in the city.

Once I had arrived in Santiago, these early judgments were confirmed. Most of the SE Santiago big data-related portfolio were at proof of concept or prototype stage. This meant that no data circulation processes existed at a city scale as part of this initiative. Generally, the projects described as using some sort of big data

[25] Se Santiago is a partnership between Santiago's city council (Intendencia), the Ministry of Economy, Fundación País digital (FPD) which is a local NGO, and the funding of CORFO (economic development agency) dependent of the Ministry of Economy.

approach came from the private sector which were either incipient or opaque (as is the case of ride-sharing platform apps like UBER).

In accordance with my preliminary ideas, I decided to use some time to explore potential cases before determining what data "to follow" after the first phase of exploratory multi-sited ethnographic[26] work (Marcus, 1995, p. 96). In the exploratory phase, correspondingly, I conducted a first wave of interviews. I talked informally and formally interviewed people working in areas such as innovation, technology, security, transport, and urban planning. These conversations included organisations and individuals from civil society, academia, the national government, technological entrepreneurs, and managers from private sector organizations providing services like energy, waste management, and urban logistics. I attended workshops, seminars, and other events within and beyond the wide variety of events alongside the local cultural circuit[27] of the "smart" city.

Equally, at this point, I was interested in the role of data scientists and the blooming data analytics market in Chile. This interest became stronger after I negotiated access to a firm making computer vision software that repurposed image identification skills from a group of Doctors in Astronomy to work with facial and object recognition algorithms. I imagined trying to "become" a data

[26] This mode defines for itself an object of study that cannot be accounted for ethnographically by remaining focused on a single site of intensive investigation. "This mobile ethnography takes unexpected trajectories in tracing a cultural formation across and within multiple sites of activity (…). Just as this mode investigates and ethnographically constructs the lifeworlds of variously situated subjects, it also ethnographically constructs aspects of the system itself through the associations and connections it suggests among sites."

[27] Following the distinction made by Thrift (2005) of cultural circuits as a "soft" component of how capitalism reproduces itself through a global circuit of actors/activities to repackage assets and commodities, and therefore, create new markets.

scientist[28], thinking that I would be able to learn enough coding skills to be helpful in their video analytics team. I had a solid start; first, I was enthusiastically supported by the firm's two partners[29] as they saw an "opportunity" to involve someone from a social sciences background in the team. Rapidly, I managed to interview a significant share of the group, yet I never got to settle with the team. I also realised that my role was more uncomfortable for the team than practical as it was not clear how I would help in the projects. I am neither an engineer nor a data scientist, so the development team rapidly started to see me as part of the "marketing" side of the company rather than giving me real project work. I was expecting to help in areas like UX research[30], but even though it was part of their terminology, that type of work was not a core part of their practice. At some point they asked me to help them arrange and prepare business meetings in the transport ministry to sell their video analytics (including facial recognition algorithms) products. After one very uncomfortable meeting with the "big data unit"[31] at SECTRA, I decided to step down from this collaboration with the firm. On the one hand, I was not interested in engaging in business development; and on the other hand, I felt some level of potential conflict of interest as I was thinking more seriously about doing the Transantiago case.

[28] Mainly inspired by recent ethnographic works on data practices in machine learning (Mackenzie, 2017), the role of outsiders in algorithm development (Seaver, 2017), and immersive ethnographic work on malware ecologies (Dwyer, 2019).

[29] One of the firm partners is someone I have known personally before.

[30] UX (user experience) research is the systematic study of target users and their requirements, to add realistic contexts and insights to design processes, including digital developments (What Is UX Research?, n.d.)

[31] Small new unit that is evaluating how big data could be used in public transport but is not directly related to Santiago's Public Transport system operations.

In the meantime, I was conducting several interviews in other areas of potential interest and early preliminary observational work. The first visit was to the building of the Unidad Operativa de Control de Tránsito (Traffic Management Operational Unit or UOCT) agency within the Ministry of Transport. I also visited the control room of the Municipality of Las Condes, one of the highest-income municipalities of Santiago (and the whole country). In this case, the control room was entirely focused on local security, and the analysts were mainly observing CCTV and drone images and inputs from the SoSafe[32] app.

During these visits, I became increasingly interested in control rooms which I realised had a double function as urban infrastructures in Santiago. On the one hand, they represented a way of seeing the city, based on an attempt to centralise decision-making processes to act quickly, aiming to keep the city either in circulation or safe, depending on the objectives, enacting an aura of efficiency and effectiveness control and enhanced service delivery. On the other hand, their internal dynamics and practices looked less rigid and standardised than those represented in the public discourse. Instead, these places were much more subject to contingencies, informal arrangements, and the inventiveness and improvisation of the analysts; typically structured and shaped by internal hierarchies and characterised by the porousness between the control room as a black-boxed infrastructure and the city.

[32] SoSafe is a mobile app for neighborhood security which works through community reporting of suspicious activities or any situation that requires public monitoring (crime, fire, etc). The app developers as part of their services offer tailored support and development to the local municipalities to help them monitoring crime suspicious activities. Las Condes, but also several other municipalities in the country are using these services to manage local security trough which uses a Waze-like platform where everyone that has the app can report an issue which could activate security protocols depending on the municipality.

Yet something else ended up inclining the balance towards focusing exclusively on public transport. I remember finding a few documents about big data uses in public transport in Santiago repeatedly mentioning the name of a female transport engineer in the Universidad de Chile and the development of the software ADATRAP. When I asked about it to the people at SE Santiago, they mentioned that she was "an excellent expert although very unpractical". From their perspective, any kind of academic work resulting in papers rather than "something real in the world" (like a patent or an app, for example), is irrelevant. That did not limit my interest in organising an interview with her as part of the early phase of interviews with people working on big data and the city. That interview was probably the most decisive moment of my fieldwork, as it made me appreciate that big data circulation existed. Yet, it was hidden within the infrastructural contours and configurations of public transport (see chapter 6).

I therefore decided to concentrate on the single case of public transport, dismissing public security[33]. The reason was simple: I realised that, within the available time, it was reasonable to immerse myself in a single case, which was rather complex too. Further, the level of technicalities related to transport engineering, as well as the challenges of accessing an elusive epistemic community, made me realise that some degree of catching-up with literature on transport studies, and predominantly transport engineering, would be required.

As I mentioned in the introduction, I chose big data in public transport despite some initial reluctancy on using public transport as a case for my research based

[33] Despite that I had already a few interviews made related to video surveillance, as well as a few observations conducted in control rooms like the one described in Las Condes, and four interviews made to one of the projects of the Se Santiago portfolio that seek to build a cloud-based platform to integrate the CCTV from (initially) three municipalities and other public and private organisations in a common platform.

on a potential risk of redundancy. However despite of the amount and variety of research about Transantiago, I identified that the “problem” of big data circulation was not covered beyond the specificities of transport modelling and their controversial role in the first phase of implementation of the public transport system (Ureta, 2015, 2017).

So, instead of redundancy, there was a window of opportunity to explore trajectory of big data in the system. Moreover, during an interview with an academic at the Universidad de Chile in the exploratory phase, she mentioned to me that the operational data produced by Transantiago was circulating across Transantiago *“beyond how it was initially planned, being used in several areas of the system”*. Knowing that the process of implementing big data started early with the system, that gave me a trajectory of more than 10 years to trace how big data had get to circulate and a whole new history of problematisations to tell.

In the next section I describe how I followed the data, including what I mean by following the data, which indeed is not working directly with the operational data produced within the system but rather tracing its circulation using an experimental qualitative approach.

3.4 Collection: Following the data.

In this section, I will draw on the activities undertaken, and tools used for data collection -using a following the data approach- during my fieldwork in Santiago de Chile.

Before proceeding further, it is pertinent to provide a brief recapitulation of the concept of operational big data in the context of public transport.

The available data in public transport comes from three sources. First, GPS devices send a position-time observation for each bus every 30 seconds, generating 80-100 million observations per week. Second, Bip! Smart card transactions generate 35-40 million observations per week. A third source is the complementary information, which includes route paths, route assignments, the position of bus stops, the position of Metro stations, and the position of bus stations. According to Gschwender (2016), this raw data can be observed over time (smart card transactions) and space (GPS bus movements), and also on time-spatial coordination. In the next section, I describe my fieldwork is organised based on following the two primary data sources as assembling the public transport data dispositif.

Once I had an idea of what type of data I would *follow,* I started figuring out how to combine the participant observation with in-depth interviews. In some way, once I had clarity on the public transport case and the type of data I was following (the GPS and the smart card transactional data), I moved from the first exploratory phase to a more structured data collection stage. This phase, which I call "collection: following the data", was a significant part of my fieldwork, and it was characterised by the combined use of qualitative methods including semi-structured interviews and participant and non-participant observation. My underlying interest in ethnography was critical in approaching the data collection process. Although there are several discussions about what corresponds to an ethnography, my intention beyond any purism was to keep an *ethnographic attitude* in the sense of being accountable (and responsible) for the effects of my description and the routes of inquiry taken in consequence (Strathern, 2005).

Within that process, two tools prevailed in terms of data collection: in-depth interviews and observation.

3.4.1. In-depth interviews

I used a snowball approach to select the individuals for in-depth interviews. Most of the interviews were completed face-to-face during my period in Santiago de Chile; only a smaller portion (5 out of 64) of the conversations was conducted through telephone, Skype, e-mail, and WhatsApp[34]. I also collected data from informal conversations with people I met in academic and non-academic events, and from short discussions during visits to institutional offices and other meetings that were not part of "formal" interviews.

Whilst based at Se Santiago, I managed to develop a close relationship with the team, particularly with the CEO and one of the programme analysts. These contacts were beneficial to arranging the first interviews in the transport sector and later in my research. At the same time, I started sending e-mails to academics, mainly from the engineering departments at the Universidad de Chile and the Pontificia Universidad Católica de Chile[35], which are the most prominent universities in the country. These interviews were both open and semi-structured. Not all the interviews were of the same quality, as with the progress of my research I attained more familiarity with some of the technical concepts of public transport and conversations became more fluid. In some cases, I decided to conduct follow-up interviews to get more details from my informants after my knowledge about public transport planning and operation had increased.

[34] This applies to both stages of fieldwork.

[35] I did my undergraduate studies at the Institute of Sociology in the Pontificia Universidad Católica yet I did not interviewed anyone from there.

The initial focus on government and academia was deliberate. In the first case, I knew that getting access was difficult given the reluctance of some of the public sector to get involved as an object of analysis for social research. Thus, I started early by using contacts facilitated by Se Santiago to arrange meetings at the UOCT and DTPM. However, after the first couple of interviews, I managed to expand my network quickly, arranging interviews with a wide variety of actors related to public transport, such as the private bus providers, Santiago's Metro, and authorities of a different kind at the ministry of transportation, including high-ranking officials at the Ministry of Transport, Metro's COO, and a former Ministry of Transport.

Media channels like Facebook forums, Twitter, and WhatsApp were also helpful for getting in touch with transport-related actors. An excellent example is when I arranged an interview in the municipality of Las Condes[36] after responding to a video posted on the Mayor's Twitter; he then responded and put me in touch with the responsible person in the municipality. Likewise, I started following and participating in some of transport related discussions on Twitter, which helped me to connect with relevant academics and practitioners in the local field.

In total, I conducted 64 interviews (see Table 2) with the following distribution; 1) the public sector: 37 interviewees in total, including authorities at the ministry of transport, at SE Santiago, UOCT, DTPM, Metro, as well as analysts and people in executive roles; 2) academia: 15 interviews with transport academics coming mostly from transport engineering departments but also urbanists and social

[36] High income municipality located in the north-western side of Santiago. The mayor at the time of my fieldwork, Joaquín Lavín, is a well-known right-wing politician in the country having been presidential candidate three times, as well as ministry of education, and social development. He is also well known by his direct style of making politics, so it is often that he responds comments on Twitter to its followers.

scientists; 3) the private sector: 10 interviews with private, public transport operators and public transport technology providers.

Table 2 Overview of interviews conducted in both fieldwork phases.

Area	Organisation	Whom	Fieldwork stage	Total
Academia	Universidad de Chile	Engineering dept (4) ; Urban Studies (2)	Collection	6
	Universidad Católica	Engineering dept (6) ; Urban Studies (1)	Collection	7
	Universidad Adolfo Ibañez	GobLab School of Government (1)	Exploration	1
	Universidad Andrés Bello	Engineering dept (1)	Exploration	1
Tech industry	Sonda	CEO, COO, CTO, Chief Smart Transport Systems (4)	Collection	4
	Transit UC	CEO (1)	Colleciton	1
	Alto	Chief of Transport Security (1)	Collection	1
	Metric Arts	CEO (1), CIO (1), CRO (1), CTO (1)	Exploration	4
Government	Ministry of Transport	Vice-ministry (1), former Ministry (1), former Vice-ministry (1); SECTRA (4)	Collection	6
	SE Santiago	CEO (5), Analyst (1)	Collection	6
Public Transport	DTPM	Former CEO (1), Planning Division (4), Technology Division (2), Control Room - CMB (4)	Collection	11
	Metro	Operations Division (2), Planning Division (2), Innovation Division (1)	Collection	5
	Private Bus Providers	Redbus (1), STP (2), Vule Bus (1), MetBus (1)	Collection	5
	Transport	Control room manager (1)	Collection	1
	Metro train	President of the board*		0
Municipalities	Las Condes	Chief of public security (1), control room (2)	Exploration	3
Consultants	City Planning	Deputy officer research and planning (1)	Collection	1
	Independent	Consultant to DTPM (1)	Collection	1
				64

The main objective of these interviews, especially but not exclusively in the second phase, was to trace the way in which the data dispositif was configured.

These interviews focused on their ideas about big data and its uses in public transport, including thorough descriptions of the required practices, organisational arrangements, and techniques to make big data work in public transport, that is, to make data circulate. I also asked about details of the processes incurred to make data circulate, including details about where and how the data was generated, its storage, formatting, the ways the actors developed variegated practices, and uses of the data. Likewise, I queried about software and hardware requirements and development; and about regulatory frameworks, the use of standards and KPI's, and their position about the rest of the actors constituting the data dispositif. These interviews helped me to build a narrative about what big data is, what it does, and details on the public transport operations, policies, and politics. Notwithstanding, the preponderance of in-depth interviews over other ethnographic tools made discourse analysis central to build a consistent narrative about the data circulation process.

In some cases, I made up to five follow-up meetings and kept in permanent contact with some of my interviewees through WhatsApp, Twitter, or E-mail. Particularly, this happened with a few key contacts at the DTPM, the UOCT, and the Ministry of Transport. The interviews were conducted in various locations like individual offices, personal desks in a control room, and mobile interviews in settings like a public bus terminal.

The interviews were recorded in digital audio files and safely stored on an encrypted hard disk and then transcribed using Microsoft Word. I did most of the transcriptions myself, although, at some point, I hired a local researcher to help with transcribing a small portion of interview to accelerate the overall transcription process. The interviews were kept partly anonymous following the human participants protocols established in the consent form and the Central

University Research Ethics Committee (CUREC) approval. All transcripts have been saved in a password-protected folder on the fully encrypted personal computer.

3.4.2 Ethnographic observation

I relied extensively on ethnographic observation alongside in-depth interview as a research method during the collection stage of the fieldwork in the period September 2018-May 2019.

Most of the ethnographic observational work was focused on control rooms. I started these observations during the exploration stage by visiting the UOCT and the control room in Las Condes, mainly intending to observe urban management practices impromptu. As seen in chapter 2, control rooms are widely present as part of smart city projects. Likewise, areas like security and transport are often the most common public services monitored through these urban infrastructures. In Santiago, and Chile more widely, the UOCT is undoubtedly the most well-known control room. At the same time, thanks to my involvement at SE Santiago, I knew that the UOCT was participating in the pilot of a cloud-based platform to integrate CCTV from different organisations to make more efficient and extensive use of everyone's images. After deciding to analyse the Public Transport case, I expanded the observational work to several other control rooms within the bus fleet monitoring apparatus of Santiago's Public Transport.

The main objective of the observation in my work was to understand the data practices in real-time management settings, and to get an idea of the internal dynamics of coordination and decision-making.

After identifying the diversity of control rooms, I expanded my observations about the internal activities and practices with the data towards analysing the relationship between control rooms. I visited control rooms at the DTPM, including four visits to the Bus Monitoring Center or CMB, four visits to the Operational Traffic Management Unit (UOCT), one visit to Santiago's Metro Control Room, and three visits to control rooms from three private bus providers (STP, Red Bus and MetBus). The visits varied in terms of days and times based on the availability of my counterparts. If I could do more than one visit, I tried to observe different periods of the day, like peak-hour traffic on weekdays early in the morning or after work during rush hours and quiet times during the day.

For example, at the UOCT, I managed to arrange extended visits to the control room. Every time, I had a control room operator as host, which allowed me to combine a general observation of the control room dynamics, the uses of the screens, and the interactions between the different people with a detailed observation of the operator's work setting and their narratives about what was going on at the control room. Having someone hosting me was very useful since it helped me to ask questions about the different roles in the control room and receive short but detailed explanations about the internal and external interactions, the existing protocols, and even more importantly, about the routinised non-written practices. I also asked about the multiple sources of data and software tools in place, which were used to deal with the data in different ways. I was also interested in seeing the combined uses of the heterogeneous data and how it was translated into a specific action, like adjusting the duration of a traffic light in a particular location in the city. During these sessions, I managed to sit for long periods by my host's side, combining conversation, periods of silence, and moments in which I would just walk around the control room trying to observe the broader situation. This helped me to dig deeper into some specific practices in the control room, to talk to other people, and to give my host some space in order not to annoy them with my presence.

Figure 8 General view of the UOCT's control room. Source: Photo of the UOCT control room taken from one of the management offices during an interview.

Figure 9 Control room operator desk-setting at the UOCT. Source: The picture was taken during one of my visits to the UOCT in December 2018.

In other control rooms, the situation was different. For example, the visits were hosted by people not working directly as control room operators for the bus operators and Metro. Therefore, the observation was less about the operators' everyday dynamics and more from a managerial position. This had implications for the details I managed to capture during the sessions, as I could not engage as directly as I wanted with the everyday experience of the control room from the operator's desk. In contrast, it allowed me to connect the role of the control room to the broader organisational structure and processes. For example, at RedBus, one of the private bus providers companies, I was hosted by the fleet operational manager, who I first interviewed. He then showed me the control room and other places like the bus dispatch room and even showed me the interior of the buses. As an anecdote, during my visits new electric buses were arriving which were not yet formally in operation. Nevertheless, my contact invited me to "try" them, going for a short ride on the bus, taking all the possible safety precautions of course.

3.4.3 Secondary sources

Secondary sources are another important source of information in every stage of my research. In preparation for fieldwork, I started to collect and analyse multiple sources, including local reports on smart cities. I also considered state of the art publications on analysis using big data methods in Chile, including policy reports, news articles, blogs, podcasts, live or YouTube talks, amongst other resources. During fieldwork, I used a lot of complementary information, including public tender documents; terms of references; internal and external memos from ministries; public contracts; sectoral reports on urban policy, smart cities, and public transport; tech industry brochures and reports; academic papers and essays; public presentations; recorded presentations; newspaper articles; and TV news. Most public data was obtained through Chile's existing "transparency law". Thanks to this law, the government is obliged to provide relevant public information after 21 days of receiving a formal request, with the possibility of getting ten extra days of extension if required by the government. However, despite the high ratio of responses to my information requirements, the documents provided were often insufficient or did not correspond to my specific request. The government's open data website[37] where reports, databases and general government statistics are compiled has also been a helpful source for contextual and complementary data for my research.

[37] (https://datos.gob.cl/)

3.5 Data Analysis

The data analysis was the most challenging part of my research project. I decided to undertake some level of data analysis during my fieldwork to be sure that I was grasping the emerging themes with the accuracy I wanted. Based on this preliminary analysis, I was expecting to conduct follow-up interviews and observations to get more detail on themes that were not initially part of my problematisation of the data dispositif. I started the transcription process while I was on fieldwork, which helped me structure and narrow the guidelines of the subsequent interviews. This also helped to achieve data saturation more rapidly. Overall, this work was crucial to making my fieldwork more effective and efficient in the limited time I had to complete it.

After fieldwork, the situation changed completely. Once I came back to Oxford, it took me a great effort to find a common and consistent narrative based on the collected data. In a first attempt, I created a group of vignettes on what I thought were the most relevant themes that had emerged from the fieldwork. With these vignettes, I tried to do justice to the great diversity of themes that had emerged. In practice, it was a preliminary attempt to find a consistent narrative based on the emerging themes before establishing the codes. I wanted to ensure that the coding would be an analytical tool to structure these stories into a single and consistent narrative.

With a clearer idea of the narrative and the "grand" themes, I created a comprehensive first list of codes that gradually converted into a narrower group of codes under the three general problematisations considered in my empirical chapters: fragmentation, expertise, and translation. The gradual nature of this process was influenced by the simultaneous redefinitions of the main analytical concepts through a new extensive literature review.

I used the qualitative analysis software NVivo to structure the coding, store and revise the quotes, to triangulate between interviews, ethnographic notes, and secondary sources. NVivo was also helpful to generate connections through the shared codes and finding the quotes at the same time, which in the end, was essential to create a consistent analysis with direct references to the interviews.

3.6 Ethics: situatedness, language and CUREC protocols.

In this section, I discuss two encompassing situations that emerged as challenges during my research: situatedness and language. The first is my *situatedness*, which refers to my role within the research process, as critically interrogating my biases, limitations, privileges, demarcations, and boundaries as a southern non-white male social scientist studying the global south, in the south, but as part of the academic apparatus in the global north. Situatedness is also about the dynamic and evolving socio-spatial relations in which I am situated and through which, in many ways, I am constituted. That is linked to a second situation which is language, and the fact that I undertook data collection and analysis in Spanish and wrote the thesis in English.

The question of situatedness emerged in the methodological approach, fieldwork, and overall research. I argue that this challenge relates to the issue of translation yet from a different perspective, less as a problem of the duality of language, which is the second interrelated challenge, and more as ontological politics. In this case, my position in the field, as a researcher, male, non-white, Chilean, a sociologist, urban planner, geographer, and student, all elements that define how I observe and describe and create the problem of data circulation. In the same way, these are elements that in concurrence with class, gender, sexual orientation, and even age is hugely important to consider when doing research in a highly stratified and unequal country like Chile.

I deliberatively omit race from the previous list because I think in Chile to define oneself as non-white and privileged is almost a contradiction. In Chile, I don't feel I am in a racial position of disadvantage. This can be explained because of the prevalence of a culture of "whiteness" in Chile that is rooted on the spread assimilation of the modernist European project, which is defined as against to "the other" non-white. The embedded culture of "whiteness" epitomises a type of alterity acting as a racialised imaginary influencing practices and discourses producing a model of inclusion sustained on erasing and forgetting our own non-white origins (Tijoux Merino & Córdova Rivera, 2015). That is reinforced by class, gender and other ways in which privilege is performed, making the racial issue to be less visible than other forms of segregation and exclusion. However, the recent migratory trajectories are transforming this type of white supremacy making it an issue of increasing public interest, which certainly obligates researchers to be more accountable of our own racialised positionalities (Ugarte, Forthcoming).

In Chile, differences between social groups are aggressively marked by social class and different forms of capital (social, cultural, symbolic). I would be a hypocrite not to consider myself as part of the local elite; being a man who is doing a DPhil in a top university and who previously worked and studied in high-reputation institutions is, of course, something to consider at the time to get access to local contacts. I know how things work in Santiago. I know how to navigate the city, where to go and when, who to talk with, and how to approach people. All these things are part of my experience. Although codes and groups are not fixed, these qualities are subject to change. Yet some symbols and credentials remain still highly valued by the Chilean society and are relevant to conducting social research. For example, I understand how to navigate local academia and the State bureaucracy. These are two places where I had the chance to work *at* and work *with* before doing this research. Therefore, I know some people, and they know me, which has been very useful in opening some doors and getting access to senior academics and politicians. In each case, I had to be very explicit about my interests and requirements, while also being direct about what they could expect, and not expect, of my work. In other words, I would not sacrifice any kind of academic freedom to get access to any specific person either in government, academia, or elsewhere.

However, despite my privileged position, how I am situated as a researcher also generates important challenges, in several ways. For instance, what if I had proven experience as a programmer and software developer, as other social scientists do, and thanks to that, had been received differently by the video analytics team? Perhaps I would have stayed doing extended fieldwork with the group of data scientists and, more importantly, problematised and followed the data differently. Of course, at this point, this is purely speculative. However, it denotes a situation of rupture, a bifurcation. Somehow it refers to a moment in which I decided to follow one path while dismissing another. It certainly had consequences; I still feel that I failed the partners of the video analytics firm who received me in the first place (let's not forget that one of them was a friend). I also felt that I could have done more; maybe I should have tried to learn to code faster (or sooner) or spend more time at the office; I don't know, but now it just feels like an unsettling failure. Yet, at the same time, this rupture allowed me to redirect my efforts and concentrate on the public transport case, which in the end, is the topic I cover extensively in my work. This failure was productive: it required me to act to find new solutions, triggering a new order of possibilities and potential new ruptures.

Another example that illustrates the practical consequences of my situatedness relates to how I navigated the transport engineering community. As described in detail in chapter 5, public transport is primarily dominated by transport engineers, and its presence is ramified along the data dispositif in almost every possible way. Unsurprisingly, as a social scientist working with qualitative methods, I felt challenged. This is especially the case since, with the progression of my interviews, I gradually understood how enclosed and rigid the dynamics and codes of the transport engineering community were. To cope with this challenge, I did things like auditing an introductory course of transport engineering at the Coursera platform that was designed by the Pontificia Universidad Católica (which also helped me identify some potential interviewees). Together with some topic-specific reading, this allowed me to understand their language and codes a bit more. Yet, as with the video analytics firm, I realised that becoming an engineer was (unsurprisingly!) simply impossible. Accordingly, instead of focusing on knowing the details of the discipline, I took a different strategy. I relied on my skills as an ethnographer and previous background in quantitative methods to create a narrative to present myself as a researcher with some literacy in the details of the transport engineering discipline but explaining that it was not part of my intentions in any way to become one of them. This strategy[38], and attitude, had significant effects on how the interviews unfolded since the predisposition of interviewees changed. They became more receptive and open about their views on public transport and several other topics of relevance for my research like local politics, transport, and digital technologies. Therefore, the new attitude provoked a different atmosphere between the interviewees and me, where I recognised more explicitly the epistemic authority of my interviewees on the topic

[38] This resonates with the anthropological strangeness when observing the laboratory proposed by Latour and Woolgar (1986, pp. 40–41).

of public transport, reinforcing the existing demarcations rather than challenging them. By doing this, I managed to conduct more interviews, to get better and more detailed information, and to move my interviewees beyond the topic specific boundaries of public transport, which allowed me to understand the predominant role of transport engineers in the data circulation process. Indeed, this challenge of being situated (and lost) between/within epistemic communities helped me to improve my research skills as I practiced my methods.

Both examples indicate in different ways how my situatedness is another form of translation. I use this term in a dual manner. In its most pedestrian form, it refers to the recoding of a particular form of language into another one. Yet it also refers to a *trahison*, a term used in the ANT tradition to denote the impossibility of being a faithful representative since *"all representation also betrays its object"* (Law, 1997, p. 1). In the first example, my disciplinary differences made me understand that catching up with the data science team was not an option. Not catching up was to admit I wouldn't be able to understand their language or to make them know mine. That awareness of the asymmetries between the group and me led me to find an alternative route, creating a new direction for my research within various options. The second example, in which I was in a similar situation of epistemic asymmetry, led me to act differently as I intentionally recognised my disciplinary differences (perhaps, limitations) rather than trying to dispute theirs. Ultimately, this strategy allowed me to enrol my interviewees into *my* situation of inquiry, nuancing the existing epistemic boundaries.

The second situatedness challenge is language. Briefly, it refers to pursuing a DPhil, including writing a thesis in English while I did the data collection in Spanish.

Spanish is my first language, is the main language spoken in Chile, and is the one I used during my interviews, for transcription, in my ethnographic notes, and in my overall fieldwork. Therefore, the overall process of my research has been marked by the tensions of thinking in Spanish and being under the scrutiny of these ideas and the resulting work in English. In other words, the exercise of translation of my work in the literal sense of thinking, making, and doing my research in Spanish but being accountable for it in English has had performative and political effects on how I problematised the circulation of big data in Santiago's Public Transport. The first challenge has been producing academic English work of the expected quality of a top-level British and global university. This has implicated essential efforts in improving my academic writing skills in parallel to improving my English. Even after all these efforts, the quality of the work produced, and the level of sophistication of my writing to indicate what I wanted to say have not been as rich as I believe it would have been in Spanish. In this sense, oscillating between the familiarity of Spanish and the data analysis produced in a sort of hybrid form of *Spanglish*[39] was extremely difficult considering the high expectations in terms of the quality required by my academic institution, which is, indeed, something that I embrace.

The challenge of going back and forth between languages was complicated by the nature of my analytical toolbox, which mainly consisted of concepts constructed *from* the north (mostly Anglo-French) to make sense of events and experiences in a Latin American city. In some way my study enacted the same problem seen by Roy when she suggests that the theory made *by* and *from* the north exceeds its location and acquires a universal scope, and so becomes *the* Theory (Roy,

[39] Colloquial reference to the combined use of Spanish and English, usually used to characterise groups of *latinos* in the United States.

2009, p. 7). So, despite the familiarity of doing research in my language and my own city, it by no means meant that some level of colonialism was absent. Hence, my work is implicated in the *coloniality of power* (Quijano, 1999) as it reflects a pattern of global colonial domination that is redirected within the preestablished powers *"as a totalising rationality that is capable of foreclosing alternatives modes of knowing"* (Lehuedé, 2021, p. 32). This is, of course, well exemplified in my own internalization of the benefits to go and study in the UK rather than somewhere else. In other words, my own trajectory as a researcher reflects a lack of epistemic disobedience, since it is a case of the acceptance of global patterns of knowledge production, and an underestimation of its cultural implications (Mignolo, 2009, 2011).

Later, during the analysis stage, the tensions of the dual use of language took new forms. One of the particularities of qualitative methods is the overlapping of the data collection and analysis, as both are characterised by non-linearity and a continual movement back and forth between description and analysis. According to Strathern (2018), ethnography oscillates between the paradox of producing an overwhelming yet insufficient amount of data. That tension, between too much and too little data collection, makes ongoing analysis a requirement. To analyse, therefore, *"is a formalization practice that is systematic, yet open enough to let the ethnographic material form unexpected relations and draw in contexts that were unavailable during fieldwork"* (Winthereik, 2019, p. 25).

During that period, when I had some emerging ideas on what to write about, the situation became awkward and slightly uncomfortable. Soon after coming back from fieldwork, I remember being asked by my supervisors to send them an excerpt of an interview transcription translated into English and to make a first attempt at coding following a grounded theory structure. In that case, translating the interview excerpt was not difficult, so I managed to translate five pages of content very quickly. However, when I made the analysis by selecting the codes and linking the emerging themes to concepts, the exercise became completely different. Indeed, it felt like being lost in translation, as suddenly the reassurance and confidence of my understanding of the problem vanished into the limitations of trying to generate a consistent explanation in English. In other words, I felt that my knowledge of the problem of data circulation was much more in-depth in Spanish than what I was able to translate into English. In some form, I felt anxious about not being able to transmit that understanding with the level of detail and clarity that I could have done in Spanish.

Finally, from an institutional perspective, before doing my fieldwork I had to obtain research ethics approval from the Central University Research Ethics Committee (CUREC), the Social Sciences division, and more specifically, of the Departmental Research Ethics Committee (DREC) at the School of Geography and the Environment. This process is a formal requirement[40] of the University of Oxford to ensure that activities involving human participants and personal data are conducted in a way which respects the dignity, rights, and welfare of all participants in research; minimises risk to participants, researchers, and third parties; appropriately manages personal data; and aims to maximise the public benefit of research. According to the approved CUREC form, all respondents received in advance, and freely completed, a written consent form to establish voluntary participation in this project. My interviewees agreed with the terms established in the CUREC on matters like data storage, data protection, the uses of the information provided, and their confidentiality and anonymity of their

[40] See: https://researchsupport.admin.ox.ac.uk/governance/ethics/committees/policy#collapse395061

identities in my written work, among other relevant topics. Further, during some participant observation sessions, I was not allowed to take pictures in the control rooms; therefore, some of these sites were not disclosed in my work.

3.7 Summary: following data circulations as a method

In this chapter, I have outlined the research design and methods employed in my dissertation. Broadly speaking, I have explained how I developed a research design that addresses certain methodological gaps in the Foucauldian approach by incorporating elements of Actor Network Theory. I argue that the notion of problematisation could play a similar function -in terms of developing a method- to dispositifs, as Garland (2014) identifies, with Actor-Networks, which is what Marres (2019) proposes after her claim of undoing and redoing ANT. The common point is that problematisation operates to think about the continuities and discontinuities of things, establishing a situation of rupture, that requires some form of problem-solving. In terms of a methodology, I suggest that to follow the data, as following the actors, then, is to explore how a problematisation generates something else, through new associations and trajectories, and how things, including big data get redone after being undone.

Then, I described how I the following the data approach unfolded in practice during my 9-month fieldwork in Santiago de Chile. I employed a two-phase strategy, which consisted of exploration and collection. Throughout this process, I utilised a diverse array of tools, including observation, in-depth interviews, and secondary sources.

Finally, I reflected on the main ethical challenges of my research, paying particular attention to the implications of my own situatedness on my data collection process and the way I analysed that data, and, moreover, how I wrote this dissertation.

Ultimately, I consider that *to problematise* data circulation by the operationalization of concepts into a specific research design and methodology is profoundly implicated in ontological politics. To produce knowledge, as is the intention of my research, is heavily defined by my engagement with and for the problem I am trying to problematise. *"And this engagement, is not an implicit or unconscious one, as epistemological presuppositions are often characterized, but a matter of commitment to obligations that can, if necessary, become a "cause""* (Stengers, 2018, p. 85).

4. Problematisation I: Transport and control rooms fragmentation in Santiago de Chile.

4.1 Introduction

This chapter discusses how control rooms enact a model of spatially distributed governance that allows data to circulate despite the fragmentation of public transport in Santiago de Chile. The problem of fragmentation of Transantiago is seen of one most pressuring issue affecting the operational management of the system. This problem relates as well with the institutional fragmentation of the city, so in many ways both types of fragmentation overlap, and policy responses so far have tried to address them together.

Santiago as a city had recently begun a major urban reform with the first election of a city governor, creating a new tier in the governance structure placed between the central government (macro level) and the 32 municipalities (micro level) that constitutes the city of Santiago. However, the role of the city governor is still at a very early stage in terms of the transferred powers over the pre-existing city institutions, as is the case of public transport; so, for the moment, this is just a first step of institutional and administrative restructuring in Santiago and the rest of the regions of Chile. Accordingly, Transantiago is managed and governed decoupled from the city governance through its own institutional form, which is formally embodied at the DTPM but that is in practice overflown into less formal arrangements. That is the case of the UOCT, which is handled autonomously to oversees traffic lights, or Metro who formally is below the DTPM but in practice does not really accept it.

In this chapter, I will focus on the specific problem of Transantiago's fragmentation, observed through the lenses of data circulation in control rooms. As I explain in this chapter, control rooms in Transantiago configure a complex network of multiple actors involved in public transport, including government bodies like DTPM and the UOCT, the bus delivery companies, and Santiago's Metro. This network of control rooms operates as a complex configuration which disputes Transantiago's institutional fragmentation by assembling an *oligopticon* (Latour & Hermant, 1998). The oligopticon is a network of partial entities observing public transport, at different scales and levels of detail, and allowing the data to circulate across the dispositif.

Also, I describe and analyse the several control rooms that are part of Transantiago. In each case, I present how data circulates within each control room in connection to their specific needs and requirements depending on their role as part of the operational management of public transport. I argue that, despite the fragmentation of Transantiago's operations—reflected in the wide variety of control rooms. The different control rooms operate together, developing ways for data to circulate between control rooms, producing an oligoptic network allowing transport management to work.

Additionally, I argue that control rooms intersect ways of dealing with the coming-together of bits of information that arise from many areas around the city featuring the most diverse and fragmented content. They thus produce what Karin Knorr-Cetina has defined as a *synthetic situation* (2009). These synthetic situations are always being assembled: from automatic and less automatic information feeds, from real-life reporting, from the interactions themselves, instantly mirrored on-screen and generating their contexts (Knorr-Cetina, 2009; 79-80). The concept refers to the capacity of *making sense* of the data in a time-specific context by generating partial interpretations of the data, which are then enacted in institutional, organisational, and material configurations. As I show, the synthesis operates on different levels *within* and *between* control rooms, allowing data to circulate in coordination. Each control room produces different synthetical situations depending on their operational requirements and internal data problematisations. However, to fulfill those requirements demands a coordinated response to the arising problems, so despite the fragmentation, it is only by conforming a coordinated network that they can individually operate.

Control rooms problematise data circulation individually and as a network, simultaneously. As already seen in Chapters 2 and 3, problematisation involves asking how a specific situation becomes a problem, as an emerging situation that requires some level of attention, and an active response to that problem. It is a way to identify why things are not working, and at the same time, to establish a course of action, by producing a new association of elements to resolve that problem. In this case, I track down the ruptures and situations where data ceases to circulate, and how that specific situation is solved (Barnett, 2015). Therefore, data circulation occurs as a historical process-*"[marked by] connections, encounters, supports, blockages, plays of forces, strategies, and so on"* (Foucault, 1991a, p. 76)-that results in their emergence as object in control rooms (Bacchi, 2012).

I structure this chapter by firstly situating control rooms within smart urbanism scholarship. Secondly, I describe how the oligopticon of control rooms are assembled in Santiago's public transport, detailing each of the partial visions of the city that compose the network. Thirdly, I revise the elements connecting these partial visions of the city, focusing on how the oligopticon holds together. Finally, I reflect on the generative role of control rooms as a workable response to the operational fragmentation of Transantiago.

4.2 Understanding control rooms: the smart city scholarship

Unsurprisingly, a significant amount of "smart urbanism" scholarship has analysed control rooms (Barns, 2017; Kitchin, 2017; Luque-Ayala & Marvin, 2016; Marvin & Luque-Ayala, 2017; Mattern, 2015). They are mainly framed as city infrastructures using real-time computational data feeds to transform urban governance and management into a situation of "perpetual present" (Kitchin, 2017), streamlining the smart city through the integration of multiple sources of data using sophisticated, *almost* real-time tools (i.e., dashboards and/or visualisations) for city management. Control rooms, accordingly, embody the ambition of a centralised big-data intensive management in the smart city (Wigley & Rose, 2020).

Control rooms can be traced far back in 20th-century history, usually as part of the ambitions of monitoring real-time data, such as Key Performance Indicators (KPIs), along with historical trends and data, all in one place. There are several imaginaries of control rooms widely present in western culture. These range from the classic NASA rooms where spaceships are launched and monitored to financial trading rooms where brokers "bet" in the stock market using real-time information, among other examples (Mattern, 2015).

Scholars have also focused on control rooms' security and surveillance side. Part of this work is motivated by questioning the effectiveness of centralised management forms of CCTV networks (Keval & Sasse, 2006; Rankin et al., 2012). This work has already flagged the figure of the control room analyst because CCTV networks, despite being designed to centralise decision-making, still rely on several on the spot decisions, both individual and collective, based on what is required according to a specific space-time context. Despite the efforts to standardize the internal dynamics in control rooms through detailed management protocols. Covering the architecture, design, and the organisational dynamics (Luff et al., 2000).

Increasingly, the nature of control rooms has expanded from CCTV surveillance to a more comprehensive approach toward "urban intelligence" (Mattern, 2014) based on integrating vast amounts of data and digital tools for urban governance. Despite enhancing the quality of cameras and software aiming to automate processes, however, the human component remains central to defining their operations, relying primarily upon individual responses and informal arrangements (G. J. D. Smith, 2004). Hence, several studies have indicated the role of internal organisational practices (Heath & Luff, 1991) as key to understanding how specific group dynamics produce different kinds of procedures, ultimately affecting decision-making based on the analysts' observational and cognitive capacities. From that perspective, CCTV surveillance is a collective practice and a collective work involving not only a material technical infrastructure, but also complex social relations, hierarchies, workplace cultures, all of which are essential for analysing how CCTV footage gets interpreted in control rooms—to the point that what happens in the street could be collectively re-performed using metaphors, talk, and even humour (Heebels & van Aalst, 2020). Ultimately, the CCTV control rooms work through collective problem-solving dynamics sustained on improvisation and experimentation to define what to do at a determined moment.

In Chile, the Cybersyn Project (also known as Synco) is a truly remarkable precedent (Medina, 2011). The project was a state management experiment developed during Salvador Allende's presidency (1970-1973), aiming to monitor key industries' performance based on updated data centrally. However, Cybersyn ended up being relegated by the end of Allende's period and then discarded after the *coup d'etat* and the subsequent dictatorship of Augusto Pinochet (1973-1989). Cybersyn is an early example of rationalising decision-making processes within the Chilean state through data-driven approaches, enabled by public-private collaborations with a strong technocratic focus.

As I mentioned in Chapter 2, the Rio Operations Centre (ROC) is one of the most iconic examples of a smart-city control room. According to McNeill (2015) the ROC represents the ambition of seeing the city as a "single-truth", an individual entity capable of objectifying and processing the plurality of visions and data flows unifying urban intelligence (Mattern, 2014, 2015a). However, as I argue in this chapter, control rooms in Santiago are different from the case of Rio and other cities, as they are complex and heterogenous network which operates at the same time individually and in multiplicity as part of the public transport operational management. In other words, it only exists as an ensemble through their individual entities operating in association with one another.

4.3 Assembling the *oligopticon*: control rooms in Santiago's public transport.

This section discusses the network of control rooms works in Santiago's Public Transport management and how data circulates within/amongst control rooms to enable traffic and fleet management for Transantiago. Accordingly, I describe and analyse the UOCT (Traffic Control Unit) cases, the CMB (Buses Monitoring Center), Santiago's Metro, and the private bus providers' units. I argue that, rather than a *panoptic* (Foucault, 1991b) vision of the city enacted in one centralised control room, public transport configures a decentralised network of several control rooms enacting an *oligoptic* (Latour & Hermant, 1998; Latour, 2005) vision of public transport. The latter redefines the power configuration attached to the notion of the *panopticon* characterised by a central structure in which a lot is rendered visible and can be seen from a vantage point where few resources are required, in terms of maximizing centralised control through minimum intervention (Foucault, 1991b). An oligoptic vision of public transport supposes something rather different, as Latour & Hermant (1998, p. 49) suggest when they refer to the *oligopticon* that observes Paris: "*every panopticon is an oligopticon: it sees little but what it does see, it sees well*". Thus, an oligoptic vision consists of enduring but narrow views enacting a unit only if connections between various oligoptica hold (Latour, 2005; p. 181).

One of Transantiago's main new features was to generate a public-private governance arrangement to provide transport services[41]. In Figure 10, I illustrate the various control rooms operating in Santiago's public transport. This network is divided into five responsibilities, including route speed inspection (Ministry of Transport route inspection division); the fleet management of the private bus operators; a public fleet management inspection unit located in the Ministry of Transport that oversees the actions of the private bus operators; traffic light management (UOCT); and the control room at Santiago's Metro. The primary and

[41] My perspective on public transport is wider than the public transport system including other actors like the UOCT (traffic lights).

most visible sources of data in every control room are: i) CCTV and ii) the operational data generated by every user boarding into the system using BIP cards and GPS tracking technology installed in/on buses. In every case, either observational or operational data management is created using software and some sort of protocol. However, as we see in this chapter, the problem-solving needs often require additional data resources in control rooms. In the same way, the available resources, such as the existing software, or the CCTV are overflowed by the problem-solving demands. So, despite the specificities of each control rooms and their data, the everyday problems can be messy and hard to anticipate.

Control Rooms in Transantiago

Organisation	Role	Responsibility	Number of Control rooms
Traffic Management Unit (UOCT)	Traffic lights management	Traffic lights of the entire city	1
Bus Monitoring Center (DTPM)	Transport management	Oversee third-party buses operated by Transantiago private bus providers	1
Private bus providers	Bus fleet management	Bus fleet management according to pre-established operational programmes	6*
Metro	Metro lines management	Metro lines operational management and surveillance	3**

*One control room for each service provider
** Metro has one main control room, one for the new lines and another one for the newest automated lines

Source: Personal elaboration

Figure 10 Control Rooms in Transantiago. Source: Own Elaboration

"The central control bus management office disappeared. Without it, there is no chance of a coordinated and integrated public transport system" (Former Ministry of Transport Public Presentation at SOCHITRAN, 2007). This statement was made

after almost a year of Transantiago’s implementation. The original design of Transantiago included a centralised control room for the system’s operational management. However, it was never implemented as such. Even more, a unified central room was seen as *a condition to* achieve an integrated transport system rather than *a consequence of* its integrated governance structure.

Instead, in Transantiago, each control room's decision-making domain varies depending on their specific operational requirements vis-à-vis public transport—atomizing the operational agency of each control room over the general operational management of the system. In other words, the configuration of control rooms in Transantiago is primarily a reflection of, and an operational response to, a previous operational fragmentation of Transantiago’s. However, I argue that, despite that perception of lack of coordination and integration of the system due to its fragmentation, the network of control rooms has been able to create a workable arrangement for transport management. In the following subsections I will describe each control room, focusing on their internal dynamics around data circulation.

4.3.1 The Traffic Control Unit (UOCT)

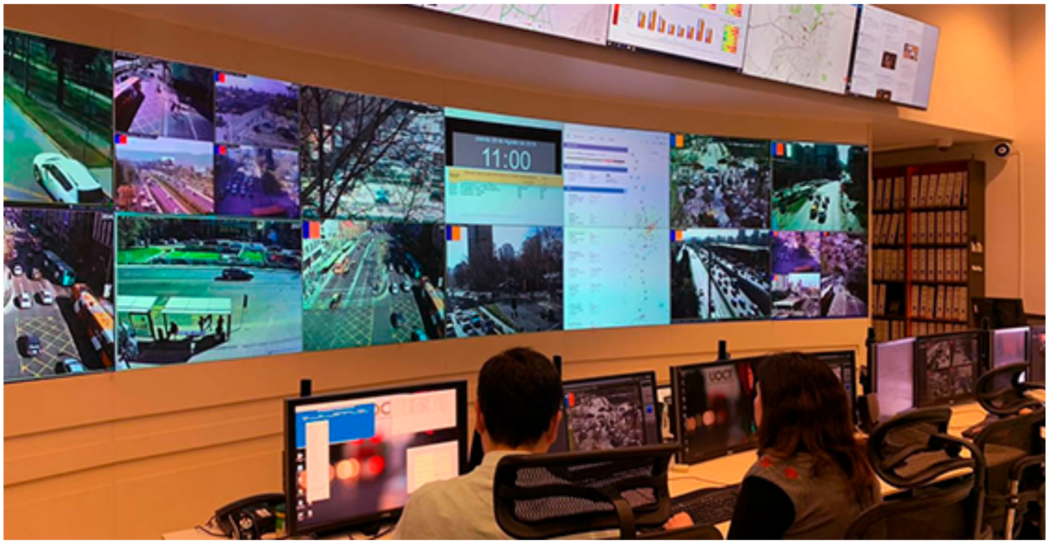

Figure 11 UOCT Control Room. Source: Subsecretary of Transport

The most iconic control room in Santiago's public transport was created in the mid-'90s, long before Transantiago, and is known locally as the Traffic Control Unit (UOCT in Figure 1). This control room was an early and significant attempt to deal with Santiago's fragmented municipal governance model. Accordingly, the UOCT's aims to integrate the coordination of the traffic light network of the city into a single operational management:

> *"When entering the UOCT main building, located in Providencia, one of Santiago's wealthiest municipalities, I noticed the highly securitised environment. There is no evidence of what happens in the building from the outside; even once getting access to the waiting room, I couldn't see anything happening in the control room. Only after a few interviews, and thanks to one of the Unit's leading officers, I was allowed to get into the central control room. During these visits, I was impressed by the internal architectural design. Almost every office of the highest hierarchies of the Unit was at the top of the building, and all had big windows from where the main control room could be seen. It looked like the main screens and dashboards located at the central TV wall were designed for the high-rank officers instead of the*

> *analysts, who are making real-time adjustments to the traffic lights based mostly on what they see at their desks rather than the main screens of the building. Also, the disciplining role of the design struck me, since literally, the analysts who were observing the city through the cameras and several other tools and resources were simultaneously in a permanent state of being supervised."*
>
> *(Personal ethnographic notes)*

My first impression of the control room at the UOCT relied on the visibility of the CCTV images and how the detailed observation of these images organised the work. The CCTV's primary role is to provide images for processing by the analysts who adjust the traffic lights based on what they see. Additionally, a secondary function of the images is security, and there is always a police officer present in the control room in case crime is detected by the cameras. At the same time, the internal organisational dynamics of the building are informed by the logic of panopticism, like the disciplinary scheme in which every analyst might be under the scrutiny of their managers even though the high-ranking officers are not directly "there" in the control room but in their offices—who conveniently have a direct view of what is happening in the control room.

As a public institution, the first achievement of the UOCT was creating an institutional commitment that integrated the management of traffic lights in all the municipalities of the city (38 in total). The mandate was straightforward: everyone understood that traffic lights required a coordinated operation, so the municipalities agreed with the Ministry of Transport to delegate the traffic lights management to a single operational unit. Despite this early agreement, generating an effective management model between the UOCT and the municipalities has been challenging mainly because the municipalities are continually pushing for more influence on how the UOCT should control their traffic lights.

The central technology of the UOCT is a CCTV network of nearly 300 cameras installed in traffic hotspots of the city. The cameras work 24/7, and there are people monitoring these at every hour – yet the UOCT control room works in full capacity during rush hours. The CCTV network extends and enables the control room's vision over the city's critical corners, where more significant traffic congestion is generated.

Internally, the UOCT control room is divided into three registers reflecting different arrangements for managing groups of traffic lights. The first group of lights is managed through what is internally called "dynamic control", which is operated through a semi-automated traffic light management software called SCOOT[42]. SCOOT feeds on traffic flow data coming from sensors encapsulated in the pavement, which then are processed by the software producing automatic adjustments to the traffic lights' timings. Although SCOOT was intended to become the standard for the entire city, the high costs of implementation and, above all, its costly repairs and laborious maintenance have limited the portion of traffic lights operating under SCOOT dynamic control. In 2010, 400 traffic lights were introduced under the SCOOT management, yet the proportion of dynamic control traffic lights has decreased since several sensors have been destroyed due to road reparations and not replaced afterwards. Today, most of the remaining lights managed by SCOOT are in areas of high-traffic congestion in the highest-income districts of the city, simply because these municipalities can afford their replacement and/or repair and maintenance.

[42] Software provided by Siemens Mobility division.

Figure 12. UOCT Analyst desk setup. Left screen shows the SCOOT software layup of dynamic control traffic management. Right screen shows specific CCTV images selected by the analyst. (Ignacio Pérez, participant observation, 2019).

Figure 12 shows the view from one traffic analyst desk in the UOCT control room. On the left screen, the map of the SCOOT software is shown in which red, blue and green represent different levels of traffic congestion. Then those images are compared with the CCTV images present on the right screen and the main TV wall.

A second group of traffic lights is managed at the UOCT. These traffic lights are handled through semi-automated software based on pre-programmed schedules adapted to the level of traffic congestion differentiating between days of the week and weekends. These constitute the most significant share of the total traffic lights in the city, and they operate through a combination of pre-defined operational programmes based on historical data modelling. Therefore, the operational programmes of these traffic lights vary depending on the corner, the time of day, and the day of the week.

These traffic lights rely on what is internally called “fine-tuning”. That is, the traffic analyst directly intervenes in traffic lights’ operational programmes when they determine it is required. So, if traffic congestion increases, an analyst will delay or shorten the light periods depending on what the analyst sees on the CCTV images. “Fine-tuning” is a shared practice in the control room, having been mentioned steadily during my visits as a way to put a name to what it is being done in the control room.

A third group of lights are managed by what is internally seen as a “less sophisticated” system, as an analyst at the UOCT mentioned. These lights are manually programmed on fixed schedules, no matter the day of the week or the time of day. Any alteration to the schedule depends on what the analysts observe during a time-specific frame; this is the old technology for managing traffic lights and usually deployed in some of the most deprived municipalities of the city.

At any rate, no matter how automated or sophisticated the arrangement for managing traffic lights is, the analysts’ agency is the most crucial element in the control room. “Having been there” is the most valued asset for an analyst, the situated experience of having been in the same situation several times so action can be undertaken according to that experience. These are learned techniques of observation that are specific to the UOCT analysts, techniques collectively expressed as *professional vision* (Goodwin, 1994), through which practitioners create meaning out of what they see (Vertesi, 2015). At the UOCT control room, the analysts are seen as the “experts” in their field thanks to the accumulated experience and the knowledge of the craft of managing traffic lights over time. However, the professional vision of UOCT analysts is an accomplishment of associations in which the analysts are one set of actants amongst many, including screens, software, CCTV, the UOCT building, and more.

No matter how precise and complex the CCTV coverage gets, the way images and additional data are processed depends on individual and collective ways of seeing. In other words, the traffic's organisational management is sustained by the analysts' ability to problematise determined situations through a perceptive synthesis of the data, adjusting the periodicity of traffic lights or getting in touch with other control rooms when the problem is out of their domain of action. This is made through individual and collective experimental problem-solving practices sustained by the analyst, as someone at the UOCT management said, *"who has been there before and, therefore, knows what to do"*, making his way of seeing almost uncontestable.

Although the UOCT is not formally part of Transantiago, I consider it as part of a more-than-institutional response enacted by control rooms on the problem of transport and institutional fragmentation.

4.3.2 Bus Monitoring Center (CMB)

A second control room is the Bus Monitoring Center (CMB). The CMB is located at the Public Transport Metropolitan Authority (DTPM) building —so it's formally part of Transantiago. Specifically, the CMB is responsible for overseeing the public bus network of Transantiago.

As I set out in Chapter 1, the DTPM aims to be Transantiago's central governance body, overseeing operations through its three modes of transport (buses, metro, and train). However, given its operational structure, the most significant part of DTPM's job is to oversee the private bus providers' (business units) contracts — this includes monitoring the fleet everyday key performance indicators (see chapter 6). Accordingly, the CMB observes the buses in operation through a mixture of CCTV images located in some predetermined traffic hotspots in the city and a fleet management software feeding on the GPS located at every single bus in operation.

The CMB has a sort of omnipotent vision of the bus providers, yet with limited powers as the operation of these buses is managed by each bus provider individually. Despite not being directly responsible for what is happening in the street with every bus in operation, the CMB and the other service providers of the system (buses, metro, and metro train) have mechanisms of coordination and collaboration in place. For example, the CMB has a landline that communicates directly with the Metro, which is used for severe service disruptions –like a closed metro station or heavy surface traffic congestion, both situations in which the passenger load from one mode of transport will mostly have to be absorbed by the other. Likewise, there are other ways of quick communication in place between CMB analysts and their colleagues working in other control rooms. That is the case of bus providers' control rooms which are normally paired up with individual analysts at the CMB which oversee specific business units and bus lines.

The CMB oversees the fleet management of the six existing private bus operators. Notably, they monitor the compliance with the "travel operational programmes" established contractually with bus providers for every bus line in operation. The accomplishment of the operational programmes is verified through the software *Sinóptico*, the main fleet management tool in operation within the system. Sinóptico produces a first level in which the data is synthesized at the CMB. It represents a basic need of the system, which is to compare operational programmes with what is actually happening during the trip. In that sense it is effective to identify if buses are working on schedule; however, in case they are not, it does not provide information about what is disrupting the service.

Sinóptico has been developed and maintained by SONDA, a CSP company that provides most of the public transport's digital technology.

> *"The problem of Sinoptico is that it is old, ugly, and does not represent what is happening in the city. To oversee public transport effectively, we need to see the full picture, not just the lines but the city. We need to know about other events that are simultaneously occurring in the city, like a protest or an accident. With this data, we can better understand when it is more appropriate to change a route or to request ground support from the police".* (CMB analyst Interview)

Despite the extended presence of Sinóptico, the software is widely criticized at the CMB (and beyond there, too) as it has several flaws and problems, as the analysts at the CMB repeatedly told me. Usually, it is mentioned as being outdated, old fashioned, and ugly (as the CMB analyst remarks). In some way, the software's lack of sophistication is not performing modern data visualizations which now are widely available. *"Why is not like Google maps or Waze?"*: these types of asseverations are normal at the CMB, and therefore the management has looked for software alternatives to Sinóptico.

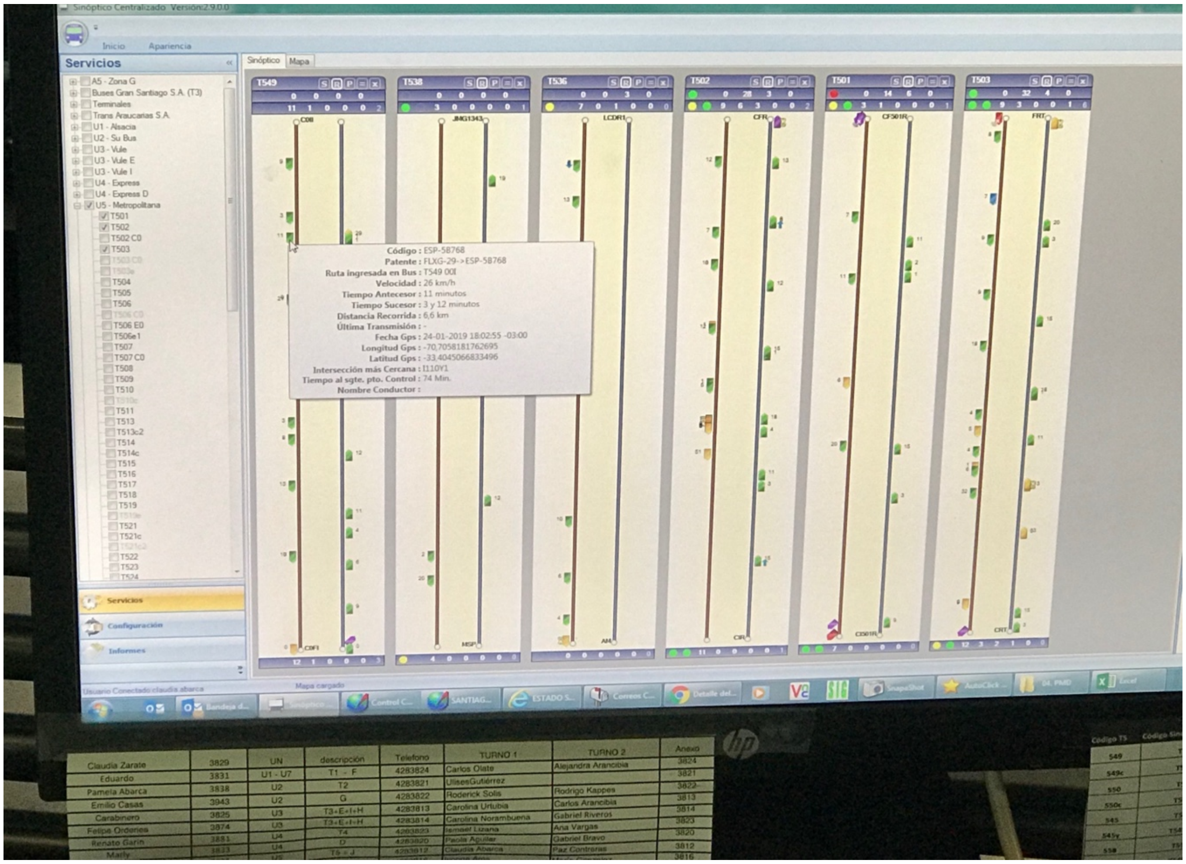

Figure 13 Sinóptico software displayed in an analyst computer. Each column represents a bus line operational programme and the current position of the bus—source: personal CMB control room visit.

The main problem of Sinóptico is that each bus line is seen as a separate column, but not in relation to the rest of the city (see Figure 13). This is problematic as bus speed disruptions are usually related to external unexpected factors.

> *We need a software not only telling us the status of a bus line, but that also shows what is happening in the rest of the city. For example, if a protest is happening in the city centre, we need to know that, not only as a reflection of buses slowing down their average speed but knowing at the same time what is really affecting the speed decrease, so we can take measures rapidly.* (CMB management interview)

Accordingly, the CMB management has looked for additional complementary software to fulfil the internal data needs not currently met by Sinóptico.

Consequently, new software was developed jointly with the French firm INRIA as an internal entrepreneurial effort of the CMB management.

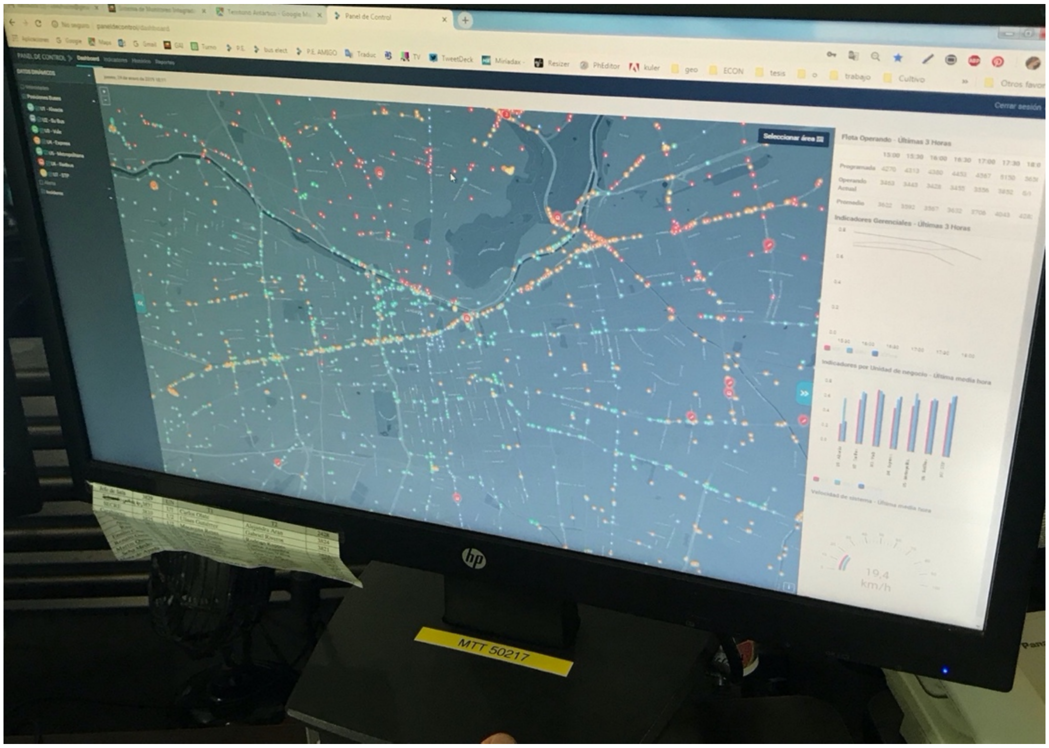

Figure 14 Inria's software layout. Every point represents a different bus; on the right side of the screen, a few graphs refer to average velocity and other similarities, which can be pinned depending to track bus services.

The new software (Figure 14), which does not have an official name, seeks to resolve the limitations of the synoptical vision by moving away from lines and towards moving points in the map. These points are positioned in relation to other hazards occurring in the city visualised jointly with essential real-time information like the average bus speed. Therefore, the new software responds to a specific spatial problem, providing additional spatial information to the preexisting operational GPS data. This allows the control room analysts to define potential solutions to the operational problems according to the specific situation happening in the city. For example, in case a riot, an accident or another disruption is affecting a particular bus route now they can visualise it on the map and act according to their capacities.

Now, does the partial view of CMB over the private bus network have any operational effect on keeping buses in the city in circulation? The answer is yes, but not in a straightforward way as the direct agency over the buses lies with the private providers. So, the improvements made by the new software in order to generate direct changes in the field need to be paired with relationships of trust between CMB operators and their counterparts working at the other control rooms. These institutional boundaries can be overburdened by the excess of information flowing from the CMB to the service providers; in that sense, not overcomplicating things using an additional software is a premise of the additional tool.

If we use the CMB as the point of observation of the whole oligoptic network, we can observe sequenced synthetical situations that have some level of pre-conditioning over the data circulation process. The process goes from a centripetal synthesis occurring within the CMB which sees how Sinóptico is overwhelmed by lack of spatial reference. After solving the internal requirement at the CMB, their role of overseeing the overall transport system can operate centrifugally over the rest of the control rooms, especially the bus providers, in order to make en route adjustments possible.

Ultimately, the way the CMB synthesizes the data from their partial position requires a different type of problem solving than the one needed at the control room at a bus provider. Even though their incentives are aligned, since both the public authority and the service provider ultimately want to optimize the bus performance and provide the best possible service, they synthesise the same data differently, resulting in a different data circulation.

Unlike the UOCT, the CCTV cameras across the city are not a significant source of data for the CMB analysts. They rely on the bus GPS data, which feeds into several software applications. Here, the type of synthesis differs since it is about visualizing the city beyond what is offered by Sinóptico and centrifugally generates an effective problem-solving system working along with the bus providers. In Figure 15, we observe a diagram of the synthetical process at the CMB.

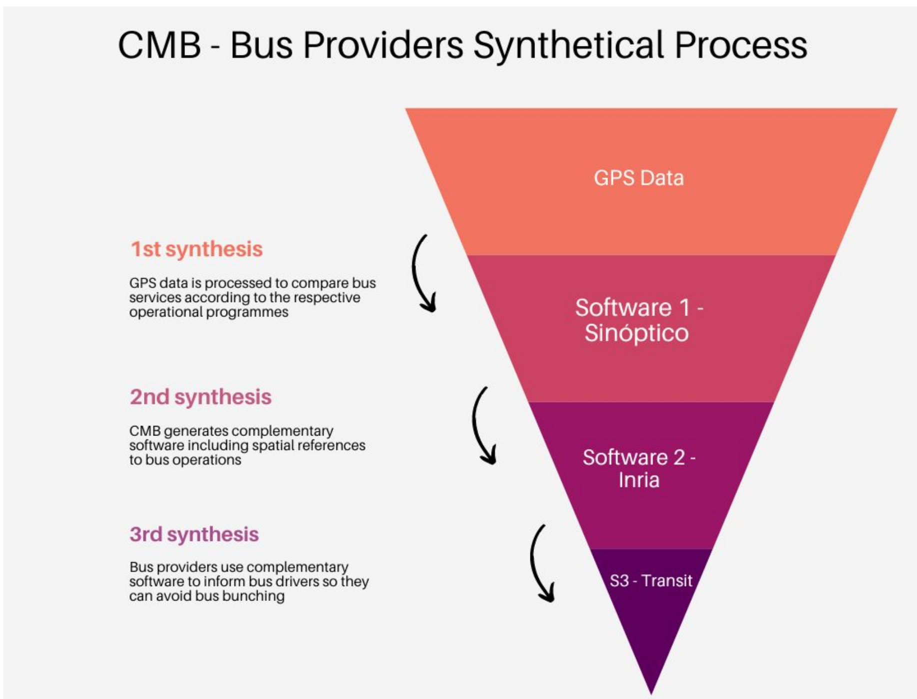

Figure 15 Summary of the CMB synthetical process of the GPS data feeding the different software used at the CMB and every bus provider.

4.3.3 Private bus providers

In this sub-section, I will concentrate on how bus providers resolve their internal data circulation problems to ensure bus fleet management according to their responsibilities and commitments with Transantiago.

As mentioned previously, the private bus providers operate another group of six control rooms enacting a particular vision of the city and public transport. Each of these control rooms are autonomously managed by each bus provider company (or business unit). As with the CMB, their main responsibility is to oversee the bus fleet according to the operational programmes. Therefore, Sinóptico is the central tool used at every business unit as it provides the comparison between the bus line operational programme and the current en route operation.

Sinóptico enacts a first moment of synthesis at every business unit control room yet falls short of effectively meeting the fleet management needs in terms of meeting their data circulation requirements. Thus, complementary software has been developed to tailor the data circulation needs, addressing two main issues: bus dispatching schedules and bus bunching. Bus dispatching schedules simply refer to acknowledging if buses are being dispatched according to a predetermined schedule. Bus bunching, instead, refers to keeping an adequate distance between bus during trips to avoid inefficiencies in travel schedule, or in other words, to avoid buses of a same line to travel very close to each other. Both issues are interrelated since bus dispatching can be adjusted in case bus bunching is occurring.

The software is designed to generate two informational outputs in a straightforward manner. Firstly, it creates a visualisation of the optimal dispatching time by adjusting schedules based on the real-time situation of buses, thereby enhancing their effectiveness. Secondly, it identifies the optimal driving speed to avoid bus bunching en route, which helps to keep buses distanced according to the operational programs. Unlike the development process at the CMB, this software presents itself as a business opportunity for bus providers. Since it is seen as a product that has the potential to transcend the operational needs of Transantiago's providers, leading to the development of an incipient market that can fulfill the business units' fleet management demands.

The new software, called Transit, was created by a start-up incubated within the transport engineering department at the Universidad Católica de Chile by experienced faculty members and former students working together in similar fashion to what is explained later in Chapter 5. Transit calculates bus distances and real-time speeds to inform bus drivers during the trip. All these calculations are made using the operational GPS data processed by algorithms and visualised for the bus drivers on tablets installed at every bus. According to what appears on the screens installed next to their driving seat, the drivers decide if they must accelerate or slow down to keep the optimal distance between buses. Similarly to the CMB, after solving the centripetal data circulation problem, there is a centrifugal problem to take care of as the agency over the bus speed lies with the bus driver, a different synthetic situation. Transit, therefore, extends the data circulation beyond the limits of the control rooms so that bus drivers can act directly over the speed without someone mediating the information transmission. However, the use of Transit monitors in the bus has not always been welcomed by bus drivers. According to an operations officer from a bus provider that is piloting the software, bus drivers often disconnect the screens since they do not like to receive orders because as someone in one of the control rooms said with some irony: *"no one else knows better how to drive a bus than they do themselves"*[43] .

[43] This could be a trope of analysis by itself, yet I did not pursue it enough to included it more extensively in my dissertation. Historically, the transition to Transantiago has been marked by a lack of understanding of the bus drivers' culture. An indication of this is that some of the best performing bus operators are the ones that had previous experience as bus owners within the old system.

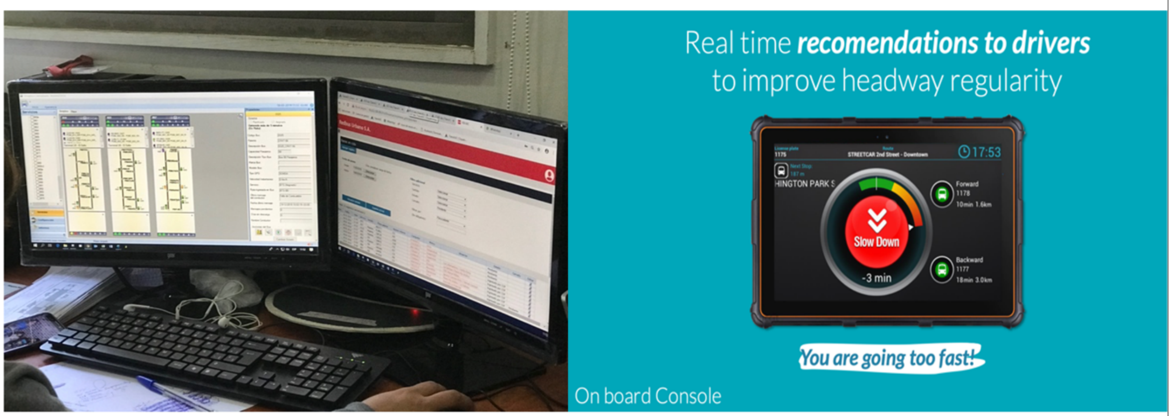

Figure 16. Two layouts of the Transit software. The left figure shows an analyst's desk with both Sinóptico and Transit software open, looking at the operational programmes on the left screen, and on the right screen, the KPIs (regularity, speed average, etc.) The image on the right is an example extracted from a brochure of the Transit software that shows the onboard console that updates real-time data for the drivers so they can adjust the driving speed to avoid bus bunching.

As seen in Figure 16, the bus providers control rooms represent a different way in which the city is observed, and the operational data is synthesized and circulated. The CMB and the bus operators have similar motivations, since both want to optimize bus operations, to provide the best possible service, and to fulfill the KPIs. Even more, arguably in both cases, they generate similar problem-solving strategies to cope with the limitations of Transantiago's Sinóptico software. However, in the case of bus providers, the software has different characteristics in order to take care of bus dispatching and bus bunching as problems within their direct domain of action. Further, they still understand that the new software, in this case Transit, needs to be directly and easily accessible to the drivers so they can make the speed adjustments on time. However, to ensure that drivers are making use of that data to drive at the optimal speed can still be challenging. Commonly they unplug the tablet in which the Transit data is shown because they just don't like to receive external orders either from the fleet management team or from a software. This last synthetical situation, the process in which the operational data enables the real-time average speed calculation to be displayed at the driver's seat, still requires additional work to generate an appropriate uptake from the bus drivers, considering the reluctancy of some drivers to receive orders. In this sense, it would be interesting to observe further what are the reasons to reject additional, and valuable, information. Especially if we consider that mechanisms to avoid bus bunching have been in place way before Transantiago, when the so called *sapos*[44] used to provide manual en route information at specific bus routes in exchange of a tip.

4.3.4 Santiago's Metro control room

Thus far, I have argued that Transantiago's control rooms circulate big data through distinct processes of synthesis. In the same way, I have described how the institutional fragmentation of these control rooms is solved through alternative forms of coordination and communication between control rooms. The final control room sub-case to be examined is Santiago's Metro. From this discussion, I will suggest that Santiago's Metro represents a different operational model compared to the rest of the control rooms already discussed. It marks a more structured and standardised form of control, which is consistent with the way Metro operates as a service less vulnerable to unexpected disruptions.

[44] As mentioned in the introduction, *sapos* (frogs) were widely known in Santiago as part of the previous transport system. These were informal workers placed in specific stops of a route who gave updated information to the bus drivers about the position of the other buses covering the same route, to avoid bus bunching.

Metro has one of the most sophisticated control rooms regarding data visualisation. In this control room, multiple Metro lines are visualised together. Several decisions on these lines are made in the same place to guarantee the operation of what one analyst described as: *"here we operate at maximum capacity, always with everything we can give and for this we need to have all the data at hand, in the same place"*. Accordingly, the control room is divided into several critical areas for the Metro's daily operations. In one place, the information on the trains' status operation is shown and analysed; in a different place in the control room, other analysts check regularity levels while analysing real-time key performance indicators.

Similarly, there is staff exclusively observing and acting on security cameras. This last element is distinctive to Metro since it has the most sophisticated CCTV network in the city, which, unlike the UOCT, is used exclusively for security purposes. Another difference is that, at the time of my fieldwork, these cameras were state-of-the-art technology fed with data to develop several proofs of concept for facial recognition software. As one of the managers in charge of Metro's Control room recognises (without elaborating too much):

> "*Safety for us is the most fundamental aspect, do not forget that Metro is more vulnerable to attacks than the rest of public transport. For example, our guards can use weapons, which is not common for the rest of the private guards. That is why the camera network is a fundamental asset for us; just as if there is someone with a health issue or any other complication, we must act quickly and very fine-tuned, following precise protocols to coordinate what we see in the control room with what happens underground. We know who to contact, and the staff in charge at the station knows precisely what to do according to our instructions*". (Interview Metro's COO)

When entering the control room, I noticed that everything looks well organised; different sections are occupied with various tasks: in one part, a group of analysts is observing the CCTV that shows sequenced images of every station and platform. On the other side, there is a red digital clock with a 5' chronometer ready to start at the front wall, which indicates that they only have 5-minutes to solve a problem so as not to disrupt the whole operation of the Metro's network. Another group observes a big wall with green and red dots signalling each line and station's current situation. The internal organisation and coordination between analysts became explicit when one of the Metro lines suddenly stopped during one of my visits, so the clock at the 5' counter started automatically. Everything started to move quickly to find a solution to whatever problem was happening to keep the optimal operation of the network. Everyone knew what to do when the counter started, so it did not look chaotic but efficient and active. During this visit, the person hosting me mentioned the protocols as "very relevant" to keep everything running smoothly and ensure high-quality service. In his own words: *"That is the most important characteristic to provide world-class service"*, which sounded like an attempt to distinguish the Metro from the rest of the public transport operators. These pre-established protocols have been written and implemented based on foreign standardised models benchmarking from a global Metro and ISO standards network. All these references, global networks, ISO, world-class service, are from my point of view efforts to insert Metro into wholly different geographies than the messy and difficult-to-control situations that are characteristic of Transantiago's street network. In some sense, the "world-class society" that Ureta's (Ureta, 2015) identified as the motto of Transantiago before its implementation, still remains in place at Metro's control room, but also internally across the organisation.

According to a senior operations manager: *"Here each person knows what to do, when, in what way, there is no room for improvisation. Everything seems to be protocolised, parameterised and standardised".* However, when I asked for the protocol books, they said they could not share them since it is "sensitive" information. Deciding not to share the protocols with me is certainly fair and surely well justified. Yet it denotes an aura of secrecy around the Metro that is worth reflecting on. In that sense, Metro's control room is embedded in a strongly hierarchical organisation, formally part of but fundamentally different to Transantiago, with locked-in formal and informal rules that have proven to be successful—as measured and induced by the 5-minute clock, which would simply not work in the same way at the CMB or at one of the bus providers control rooms.

Metro is an exception within Transantiago. First, although it is considered an essential part of the transport network, it is not directly subjected to DTPM's management. Since it is a public company, it has its own corporate governance structure, which is led by an executive president appointed directly by the president of the republic. However, it operates based on operational processes determined by themselves, there is in practice coordination with the rest of the system's actors (DTPM especially) yet from a position of autonomy. This point is important to understand how and why Metro operates according to different standards when compared with the rest of Transantiago. The performance observed at the control room exemplifies the differentiation from the rest of Transantiago. Everything that occurs in that room in some form indicates that things are under control, to the point that almost any fix could be done in less than five minutes.

In practice, the main point of coordination with the rest of the public transport is through the CMB and begins when there is a Metro station failure. When this happens, the surface bus transportation collapses because of the unexpected migration of underground travellers to the surface. When this occurs a designated person at Metro's control room gives immediate notice to the CMB to be prepared to receive an unusual demand for bus passengers. They do this through a landline call, only used to communicate between the CMB and the Metro control room. The way to solve the coordination and fragmentation of decision-making between control rooms does not depend on software, or sophisticated protocols, no matter how much these exist internally, but on a phone landline. Therefore, while there is strong coordination within the control room, there is less coordination with actors elsewhere, such as the CMB. The lack of integration reveals internal disputes and power asymmetries between the actors involved. It primarily reflects the (pre-existing) institutional setup and fragmentation in public transport. Some of my interviewees -though no one from Metro- pointed out that it is unlikely that Metro will be subjected to institutional power other than the Ministry of Transport under the current governance structure of the city. However, this could change with the election of the city's first metropolitan authority[45]; it will depend on this new institution's devolved powers, yet that is so far unclear.

4.3.5 Summary: the more-than-formal control room oligopticon

In sum (See Fig 17), control rooms in Santiago de Chile's public transport are organised into a networked and decentred structure *"where each place see very little, but it sees it well"* (Latour & Hermant, 1998). In this structure there are hierarchical relations in place. For example, the CMB is the ultimate responsible

[45] In April 2021, the first Regional Governor election will be celebrated; this elected body represents the first phase of a 3-stage decentralisation process (elected authority, power devolution, regional taxation). However, the whole process is now interrupted after the first phase after the initiation of a constitutional process consequence of the 18th of October of 2019 riots. It is expected that decentralisation and power devolution will be defined in, a potential, new constitution.

of the bus network, yet it does not operate the buses directly. Accordingly, it generates mechanisms to oversee the bus providers' network. One way to do this is to have determined analysts at the CMB paired up with specific bus providers. At the same time, bus providers' control rooms generate ways to transmit en route information to the bus drivers, using tools like Transit.

In the same way, there are non-dependent relations in place. For example, the UOCT has autonomy to define traffic lights operations, yet in case major disruptions are being observed at their control room, they normally inform the CMB and/or Metro as their services could be affected. Similarly, the CMB is coordinated with Metro's HQ control room, as they services are integrated so usually a disruption in one would affect the other. That is the case of a metro station closure, a phenomenon that became very common after the 2019 riots, which immediately would trigger a massive, unexpected, demand for bus trips. The opposite case could be a bus service strike or street closures, in which case the demand at Metro would immediately surge.

The oligopticon control rooms network in Transantiago (Fig 17) holds on to the partial visions that each of these places has and how they hold together, without following some of the typical smart city examples in which the control room enacts a single centralised structure integrating several data streams concurring in the city like in Dublin (Kitchin et al., 2016) or Rio de Janeiro (Luque-Ayala & Marvin, 2016). Neither does the control rooms network enact a "single-truth" of the city (McNeill, 2015). In Transantiago, control rooms sit in an overall context of urban fragmentation. In response, Transantiago generates an oligoptic control room structure assembling individual control rooms into a network. In this case, each control room is focused on concrete decisions depending on its role in maintaining a specific aspect of public transport, even if operations across rooms need to be coordinated in consistent ways.

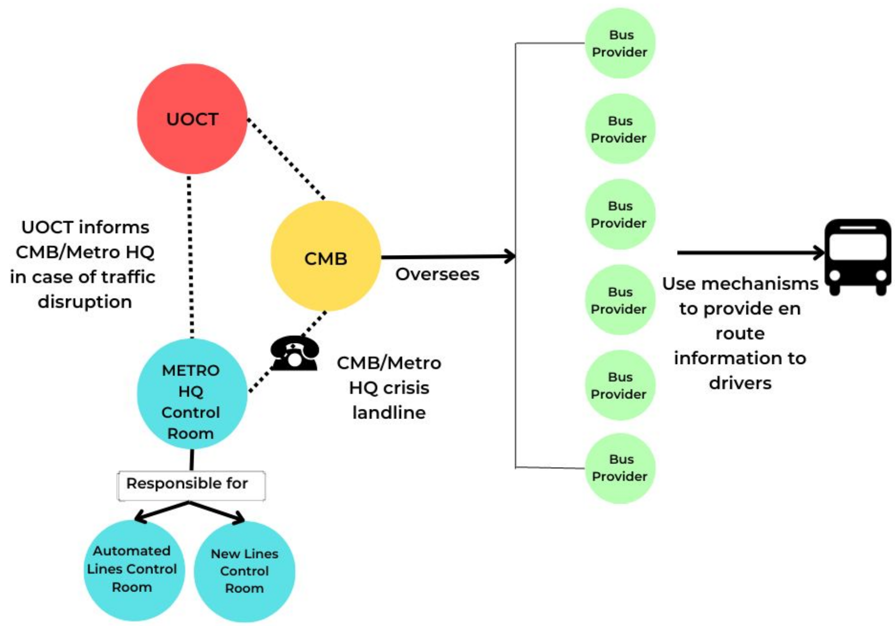

Figure 17 Control Room Oligoptic Network

4.4 Holding the oligopticon together.

In the previous section, I discussed how Transantiago configures control rooms as an oligopticon. Now, I will concentrate on some of the specific components that are making the network hold together. To produce durable connections is a challenging achievement, as these connections are contingent and subject to change. In fact, if a piece is modified, the whole oligopticon changes (Latour, 2005). In Transantiago's control rooms, there are several devices supporting the connections between control rooms beyond protocols and formal institutional transport governance.

To produce an oligoptic vision, the actors must be enrolled, aligned, and kept in line. Latour (1987, p. 128) refers to this process as "machination of forces", which ultimately is what sustains ANT as a method since it ensures that heterogeneous elements can be enrolled as a consistent unit. Undoing and redoing associations to sustain the control rooms network may involve pedestrian situations like sharing the same software or being connected through a mobile phone app. Similarly, it could depend on primary regulatory conditions, or specified enforcement mechanisms, which are more durable, as is the case with Sinóptico or KPI monitoring (more about this in chapter 6). Ultimately, if technology fails, or one component is modified, the vision changes.

In this section, I will focus on three elements that facilitate communication and coordination between control rooms. Firstly, I will discuss the role of control room analysts as the backbone of the internal operations of control rooms and as a conduit for communication and coordination among them. Secondly, I will refer to digital mapping visualisations as non-formal components that aid in data circulation in control rooms. Lastly, I will analyse the role of social media as an essential tool for disseminating information between control rooms and achieving coordination.

4.4.1 Control room analysts

Control room analysts play a substantial role in holding control rooms together, acting as *data bricoleurs*. The notion of bricolage has been previously used by Marvin and Luque-Ayala (2017) when referring to the construction of Urban OS, who note that *"the breadth of formal and informal digital urban applications* *currently constitut[es] a novel bricolage of hybrid informational ecologies"* (2017;86).

The role of control room analysts is crucial to ensuring data circulation within and between control rooms. They use everything at hand to leverage the available data for their specific decision-making domain. As seen during this chapter, the oligoptic network only works if its components hold together. By the connection of their partial visions, the network is constituted, and the control room analysts are crucial in achieving this.

When I started observing analysts in control rooms, one of my first impressions was that they were technical bureaucrats who defined *how* and *when* to act, taking account of the situation they are embedded in. Usually, they solve a situation they have already experienced before. I observed that these problem-solving actions are undertaken individually and collectively. Frequently analysts are seeking reassurance or comments from peers on the problem they are acting upon. In some form, the work analysts do as data bricoleurs enacts what Stengers calls a situation of *experimental togetherness* (2013;195). This is because analysts shape responses according to their individual experience, yet also by being embedded in a collective situation. Rather than following rigid procedures, they are participating in a collective dynamic of pragmatic learning of what works, when, and how.

The experimental capacity of the analysts coordinated within and between control rooms reveals habit and regularity rather than pure contingency. This is reflected in the following quote which points out the lack of structured zoning of the city at the UOCT when the analysts look at the cameras without a predefined order:

> *"This corner of the city is usually mine, even though the rest of the operators can see the same cameras. Also, they can "fine-tune" any*

> *lights if they want to, depending on what they are observing here. I normally look here every day, so I already know what to do and when. We don't have divisions of the city or zones in which each of us is concentrated; however, we normally know where to look, when and how to act, all of us coordinated".* (UOCT analyst interview)

Thus, each operator has developed an interest in specific critical nodes of the city, knowing what to look at, when, and –more importantly– how to act in coordination with everyone's habits. For example, they have routinised practices according to the day of the week it is and according to the time of the year - the first Monday in March when children return to school after summer is very different from a rainy winter Monday in August, when several roads are flooded. Likewise, they know the limits of their observation since they understand that there are things not revealed by the cameras, so they must look elsewhere to know what to do. Accordingly, they use "whatever helps", from checking out the state of traffic lights on SCOOT, looking at Waze, or checking the institutional Twitter. In short, their expertise is defined by a pragmatic experience of experimentation and problem-solving.

Ultimately, the analyst is an actor whose main attribute is their experience and habits. Their main force is to have been repeatedly in a situation requiring a consistent response, lining up habit with problematisation. Since the regularity of actions do not neglect the possibility of these to change depending on the specific problem (Bridge, 2020). Because, ultimately, acting habitually refers to *"the embodied, acquired, thought-imbued sensitivity to the negotiation of practical situations"* (Dewey (1922) in Barnett and Bridge, 2016, p.1197).

4.4.2 Digital mapping apps

In this sub-section I will focus on the use of mapping visualization tools and digital mapping apps in control rooms. As mentioned in the previous sub-section, the bricolage work of analysts involves finding solutions using whatever tools are at hand. Thus, now I will discuss specifically the use of mapping visualistion tools and apps in the oligopticon. I argue that these are useful tools used by analysts to find solutions and to keep responses aligned across Transantiago's control rooms.

During one of my visits to the UOCT control room, I noticed that a couple of new screens installed on the main TV wall showed a map with several flags and an average speed heatmap. When I asked about this change, the people at the UOCT told me that it was a new dashboard called the Waze-o-meter made available by platform company Waze owing to a recently signed memorandum of understanding (MoU). Waze is a crowdsourced digital mapping app which updates the state of traffic in real time, based on the information provided by their own users. Based on my observation, the product provided by Waze was a tool identifying the real-time status of major traffic hotspots in the city. The tool establishes the degree of traffic congestion in the city from the aggregated analysis of the traffic status of more than 200 critical nodes in the city and the average speed of traffic in several streets in the town using the GPS data from their users.

In practice no one cares much about the Waze-o-meter, yet Waze remains essential for the UOCT and for the rest of the control rooms as well. On one of my visits, I asked an analyst how important Waze was for their everyday observation; the answer was: *"It is essential since, thanks to Waze, I can optimise the way I observe the CCTV images because I know upfront up if something is happening because it is flagged in the app map. Then I just corroborate it in the camera images"*. However, when I asked about the Waze-o-meter, the answer was less clear about its utility, it looked more as a "potentially" helpful tool, but not essential as it is to have the platform opened when observing the CCTV images.

The use of Waze is widespread among the various control rooms, particularly those related to bus operations. This is because Waze facilitates the identification of events occurring throughout the city, acting as a complementary tool to others like Sinóptico. Also, Waze serves a similar role to the complementary and unnamed mapping tool developed at the CMB, which situates bus operations on the map in relation to other ongoing situations (See Section 4.3.2).

The capacity to anticipate incidents is a shared benefit recognised between control rooms. Like Waze, other mapping tools are in permanent use in control rooms; relevant cases are Google maps, and the platform MOOVIT. For example, at the UOCT, an analyst could simultaneously use Google Maps and Waze on separate screens while being informed about an accident that requires some specific action at the traffic lights thanks to a message or by being tagged on Twitter. In the case of the CMB, the situation was similar; in addition to the software for internal use, Sinóptico and the map generated by Inria, the analysts were also looking at Google Maps and Waze, simultaneously. These platforms are sensibly different depending on the developer, the intended users, the data they rely on, and their business models, so they align differently depending on the context.

These resources are superficially seen only as a "tool" among many others (direct messages, emails, phone calls, etc.). Their use is embedded in a solution-oriented situation that defines the analysts' role as real-time problem solvers in Transantiago. It also affects how the network of control rooms is configured since it is a typical mediation occurring in every control room, similarly to Sinóptico. Waze, Google Maps and other similar digital mapping tools do not offer neutral representations of the city. Each app relies on their capacity to gather, process, and represent spatial data according to the platform configuration, that involves specific code and algorithms to corporate interests and business models.

Further research is required to analyse in detail how digital mapping platforms are performing a certain type of city which potentially could affect decision-making in Transantiago and beyond. For now, I flag the importance of seeing these tools as off-the-book resources shared by control rooms, fulfilling common spatial representations of Transantiago in relation to the multiple situations occurring which could potentially affect transport management.

4.4.3 Social media: Whatsapp and Twitter

Additionally, I decided to discuss the use of Whatsapp and Twitter in control rooms as they were widely used by analysts to do their everyday work.

4.4.3.1 WhatsApp

Whatsapp is a social media messaging app service which can be used either through smartphones and/or web browser. Whatsapp is the predominant way by which operators communicate between control rooms, and an important resource to receive information of traffic disruptions and similar issues happening in the city. Therefore, WhatsApp has a double function in the control room. First, as a tool for coordination and communication, therefore playing an essential role for problem-solving. Second, as a tool to receive information from the outside world, connecting the control room analysts with informants reporting from the city situations that might require attention.

WhatsApp is used in control rooms to exchange quick messages, especially, when necessary, to prevent disruptions, share relevant information to solve an issue, to confirm a determined situation in the city, etc. The app is not part of any protocol or operational manual yet is exceptionally relevant to keep communication between analysts from the different control rooms. For example, when a traffic light is not working well, the analyst at the UOCT will send a WhatsApp message to another analyst at the CMB to inform them that something is happening at a specific point in the city to anticipate potential traffic disruptions. In the same way, if an analyst at the CMB observes that a particular bus service is not working according to schedule, it would be normal to send a Whatsapp text to the bus providers contact point to checking out what is wrong.

> *"I am in a WhatsApp group with the ministry [of Transport], the subsecretary, the intendent, the DTPM, all the relevant authorities of the city. When something is wrong in Metro, something that could generate a disruption, this is best way to communicate it. Also, ONEMI is part of this group, so if anything becomes more complicated the first step is to call the transport crisis committee through Whatsapp, and then to define how urgent is to meet.* (Santiago's Metro Executive)

WhatsApp is also used to manage crisis situations at a higher hierarchical level. I became aware of a WhatsApp group between Santiago's leading transport authorities, including the Ministry and the Secretary of Transport, the president, the CEO, and the COO of Metro, the DTPM CEO, and the UOCT CEO, among others. Despite Whatsapp not being an "official" tool, as it is recognised during some interviews, it is of wide use even for situations that could potentially raise questions of security. In that sense, it is recognised that this could generate some privacy issues yet is not seen as a major problem. At the end of the day, Whatsapp is seen as a practical tool, of daily use by everyone, so any potential risk is balanced with its handiness and usefulness.

A last use of WhatsApp I found interesting is related to the management of control rooms during lockdown due to COVID-19, more specifically at the UOCT. According to one UOCT staff, most control room interactions were taking place on a WhatsApp group known as "The control room" because of the quarantine and the subsequent office closure. In other words, the UOCT managed to move the control room to each analyst's home, and Whatsapp was essential to enable this.

The conversations and shared problematisations concerning the "fine-tuning" process occur on the platform rather than in person in the control room. This last situation suggests that the control room itself is more of an abstract idea of coordination. Rather than a physical space with state-of-the-art technologies, as in practice, the screens and cameras can be mobilised using a WhatsApp group chat. This situation has undoubtedly been forced by COVID-19. Arguably, the critical aspect refers to how to respond to a new problem to keep everything working as it should, in this case, using Whatsapp. Yet is not clear if and how the physical dynamics observed at the control room could be replicated, replaced, or transformed by the virtual presence.

4.3.3.2 Twitter

Twitter is also extensively used in control rooms, mainly to get information "from the ground" about the transport situation in the city. Twitter is a social media platform that operates as a microblogging and social networking service. It has a wide variety of uses in control rooms. First, it is a handy tool to provide messages to users on the status of the service. That is normally done through institutional accounts, that would be the most formal use of the platform. At the same time, Twitter is helpful to receive updates directly from the transport users. For example, users often tag Transantiago or the responsible bus provider account to inform that a particular bus line is late on schedule, or if anything else is happening. Accordingly, part of the work at the control room concentrated on monitoring social media, as responding to Twitter tags or direct messages, or to inform to the public of major disruptions when observed at the control room.

Control room analysts usually have Twitter opened on their computers or phones; however, they use Twitter more a as confirmatory tool of information they already have received, rather than as a primary source. The monitoring of social media normally is handled by community managers hired specifically for these purposes, and in case something relevant is observed, they communicate the information to the analysts. In that sense, Twitter, and social media in general, create an additional interaction, and synthesis in the data circulation process, as non-technical workers distill information before sharing it to the control room analysts who then decide what to do with it.

As seen, social media and messaging apps are widely present and in constant use in control rooms. Despite not necessarily being official tools, their usage is widely accepted with no major concerns about privacy and security. Both cases demonstrate how the oligopticon is held together through human communicative practices that are facilitated by specific social media platforms.

4.5 Conclusion

In this chapter, I have discussed the role of control rooms in the constitution of a data dispositif in Santiago's Public Transport. I also analysed control rooms as enmeshed in a shared sequence of coordinated problematisations regarding the challenge of making data circulate *within* and *between* control rooms. Accordingly, I have argued that Transantiago's management is an effect of the interaction and coordination of control rooms configuring an oligoptic network of connected partial units in charge of a particular domain of action. Accordingly, the governance of public transport observed from the perspective of control rooms becomes a consequence of shared practices, habits, and ways to problematise and synthesise the urban data collectively between and within the organisations composing the oligoptic network.

Control rooms are not purely replicating the institutional fragmentation. Instead, the oligoptic configuration is an adaptive response to an institutional environment that in some ways is inhospitable to the strategic operational function of making Transantiago work. The network created by control rooms then is by itself a workable arrangement responding to the shared operational need of mutual coordination. In other words, working together is, ultimately, the best way each control room can fulfill their individual responsibilities with the system.

Additionally, control rooms in Santiago's Public Transport are a manifestation of an unwritten arrangement that, despite all the challenges, ends up working. One of the characteristics of that arrangement is the coordination achieved between control rooms to keep public transport circulating. In one of my interviews, the Transport Sub-Secretary[46], when I asked him if a new metropolitan authority with powers over transport, would help coordinate public transport more efficiently, responded: *"In the case of public transport in Santiago, we have already an arrangement that works. So, we hope that a new authority will not have power over it or at least will not change the hierarchies because it has been tough to achieve"*.

Then, I discussed the particularities each of the control rooms composing the oligoptic network. In each case, different synthetical situations emerged in concordance to their internal operational needs. At every case, data circulation is a result of experimental practices characterised by pragmatic dynamics of mutual learning. The role of control room analysts in that sense is crucial, since they creatively find solutions to emergent problems, that over time become more

[46] The Ministry of Transport is led by a Minister who is the most important authority assuming a political role as a member of the president's cabinet. The second authority is the sub-secretary who is also designated by the president yet concentrated in operational sectoral activities rather than in political discussion.

regular, and part of the structured organisational practices. However, even though regularity is achieved out of the need of finding solutions to problems in traffic management, none of these become structured enough to be part of a manual of a specific protocol.

The exception to the above state of affairs is Santiago's Metro which has a completely different management order, much more protocolised and standardised, than the control rooms focusing on overground transport and traffic operations. The type of disruptions and failures experienced at Metro are more regular and less affected by unexpected situations. This allows Metro operations to be more structured, better optimised and less dependent on experimental problem-solving action. As seen, that has important effects on the internal culture of Metro which sees itself as more professional and reliable service providera compared to the rest of Transantiago's providers. I think this specific point on Metro's culture should be closely observed in the future, especially when the institutional design of Transantiago is revised, and potentially changed.

The last part of the chapter focuses on how the oligopticon holds together. Here I describe first the role of control room analysts as the bricoleurs capable to integrated multiple data sources to solve emergent problematic situations. In the same way, I briefly discuss how analysts at different control rooms generate ties between one another, not necessarily formal, becoming an essential cement to facilitate communication and to activate collaborative problem-solving across Transantiago.

Subsequently, I discussed the role of digital mapping and social media apps as tools of pervasive presence in control rooms which are deeply influential to keep the oligopticon holding together. The use of anticipatory measures to keep track either by "fine-tuning" traffic lights or flagging an incident from the CMB to one of the bus providers, thanks to what is captured in Waze, are examples in which urban platforms are influencing public transport management. Social media apps, especially WhatsApp and Twitter, are playing a complementary role as easy-to-use communication channels to coordinate actions within and between control rooms when a shared problem arises. In the same way, especially Twitter has become a sensible tool to rapidly flag situations of concern for the public, but also, to connect with users through tags and direct messages, generating a reciprocal form of communication for transport management. All these tools are additional ways by which data is synthesized in each control room, again, with the strategic focus on problem solving so Transantiago can work according to what is operationally planned.

5. Problematisation II: Expertise, knowledge boundaries, and transport engineers in big data circulation

5.1 Introduction

In this chapter, I will go further to analyse the data dispositif by exploring the role of *experts* and *expertise* in the data circulation process in Santiago de Chile's public transport. My focus in this chapter will be centred on the relationship between specific forms of expertise influencing Transantiago as a system, focusing specifically on its role determining the trajectories of data circulation in time. In that sense, it is distinct from the discussion of analysts in control rooms because it concentrates on the strategies and arrangements made between transport engineering academics and the public transport bureaucracy to enable data circulation across the system.

Accordingly, I analyse the overarching role of transport engineers who appear in almost every association of the network, assuming a wide variety of roles, supported by their technical capacities and the high legitimisation of the discipline of transport engineering. As noted in chapter 2, I approach transport engineers as an enclosed *epistemic community* of technical experts (Haas, 1992). For this purpose, I consider epistemic communities as groups configured around shared technical expertise, capable of building a common frame of values and objectives, as well as shared notions of validity, and joint policy enterprises often strategically focused on helping decision-makers to identify and deploy solutions to solve problems (Haas, 1992). The power and legitimacy of epistemic communities, in this case transport engineers, is sustained by their capacity to enact boundary work (Gieryn, 1983). This is, the way how transport engineers demarcate their practical domain of expertise to differentiate themselves from other forms of expertise, or non-experts. Boundary work is an important resource that translates into "strategic practical action" (Gieryn, 1999, p. 23) for the purpose of establishing epistemic authority (Lamont & Molnár, 2002). If successful, boundary work can turn into stable knowledge group practices, or in other words, it can enact a distinctive form of epistemic culture (Knorr-Cetina, 1999). In this chapter, I will show how transport engineers take advantage of big data in Transantiago to solidify their influence as transport experts. They do this by remaking their own practice so they can enlarge boundary work demarcation, and ultimately enacting their domain specific knowledge into an epistemic culture.

Transport engineers, who are mostly, but not exclusively, middle-aged men from two of the country's most prestigious universities, are present at every step of the way in public transport governance and management, including data circulation. Transport engineers are everywhere in public transport; they fill the different divisions at the UOCT and DTPM such as planning, infrastructure, and new units like the Data team, which I will cover later in the chapter. In the same way, they have prominent presence as part of the service provision side of public transport, including the private bus providers, Santiago's Metro, and in the technological provision side. Transport engineers are also critical for providing transport consultancy services to the MTT and DTPM, either as academics or as private technical consultants.

The prevalence of transport engineers within the variety of actors involved in Transantiago is neither new nor surprising. It is not the objective of this chapter to provide a complete description of the role of transport engineers in public transport as a system[47], since they cover spaces beyond the purpose of my analysis. Instead, I will concentrate on the role of transport engineers *vis à vis* the data dispositif and the data circulation process, working with/from Transantiago's bureaucracy, and more specifically, the DTPM. Describing the strategies undertaken by transport experts to validate and influence the transport bureaucracy, I unfold how they perform their group identities depending on the emerging challenges/problems and the required solutions. I observe that transport engineers in that field preside over other forms of expertise as the predominant group, by redefining their group boundaries according to the emerging demands of digital technologies and big data circulation itself.

Transport engineers are part of a historical trajectory of science-policy interactions between and within the Chilean State supported by a technocracy that has had a crucial role in developing a "modern" State rationality in Chile. Beyond the particularities of public transport, engineers have played an increasingly relevant role in the industrialisation strategy promoted by the Chilean State since the 1930s and created the National Corporation of Production Promotion (CORFO) (Silva, 2006).

The role of engineers has been critical to develop sizeable public infrastructure projects, public housing, transport, and working directly with State management. They form part of a particular type of non-elite middle-class technocracy, usually connected to civil services and "republican" institutions, such as public universities and public schools. Over the years, technocrats (including engineers) have become more directly embedded in formal partisan politics, which is a characteristic of the Chilean technocracy, since rather than replacing politics with

[47] Ureta (2015) offers a detailed account of transport engineers' participation in the conception and early implementation of Transantiago from an STS perspective.

technical work, technocrats have worked within the traditional political structures. Silva (2010) names this type of technocrat as *technopolitician* because of their direct involvement in the political field by following the codes of partisan politics (Silva, 2010). After Pinochet's dictatorship, experts' role mutated from being non-political role and revolving around offering technical advice to a partisan one because of direct involvement in the configuration of the centre-left governments of "La Concertación"[48]. During that period (1990s and 2000s), a new generation of experts helped to recover and transition towards a new democracy providing a robust development roadmap that led to the accelerated economic development and modernisation of the country[49]. Many of these experts came back to the country after long periods of exile, in which many of them had obtained high-level degrees from some of the most prestigious universities in the world. This new generation of experts, or technopoliticians, is likewise characterised by their outstanding qualifications and topic-specific high-level credentials and by a profound understanding of partisan politics. During La Concertación, they have been involved in the production of political programmes, direct partisan activity, fulfilling political and technical roles in sectoral ministries, and even as candidates for elected political roles.

Transantiago is a product of this new regime of technocrats, representing an extensive public infrastructure that embodies a *modern* vision of the future. In the words of Ricardo Lagos, the ex-president (2000-2006) who designed the new

[48] Centre-left coalition that remained in power for four consecutive governments after the dictatorship. It emerged from the group configured to regain power through a revocatory referendum to in 1988 putting an end to 17 years of dictatorship.

[49] The post-dictatorship period in Chile is characterised by the coexistence of rapid economic growth, including massive poverty reduction, yet with timid reductions on inequality, which has led to an ambivalent evaluation of the period as successful but at the same time, essentially conservative in terms of dealing with social inequality.

transport system, Transantiago would transform Chile into a "world-class society" (Ureta, 2015).

In this chapter, I will concentrate on transport engineers as a sub-group of experts working in public transport, and specifically structuring the data circulation process. Engineers play a critical role in designing, planning, and executing the new transport system with a nuanced capacity to blend technical expertise with a deep understanding of the political structures in place.

Accordingly, I start the chapter analysing how transport engineers enact an epistemic community providing technical support in public transport. There, I describe the role of transport engineers in Transantiago's implementation crisis, specifying how they managed to stay technically predominant in the system despite their responsibility in the crisis. Then, I define what makes a transport engineer a member of the epistemic community, focusing on academic credentials and community building associations, including rites of passage and dynamics of internal hierarchical ordering. Next, I concentrate on how the transport engineers manage to keep their predominant role with the emergence of big data, and how they redefine technical demarcation practices enacting boundary work, and as consequence enabling data circulation. Finally, I reflect on the role of transport engineers, and technical knowledge in general, in the way big data has been implemented, developed, and ramified across Transantiago.

5.2 Enacting the transport engineer's epistemic community

In this section, I will discuss the role of transport engineers in the data circulation process in Santiago's public transport and how they became the most predominant group of experts across Transantiago. With this, I am not arguing that transport engineers are the only epistemic community or discipline relevant to the public transport sector providing technical and or expert advice. Arguably, within government technocracy, other groups and disciplines also significantly influence the policymaking process providing technical knowledge and expert advice. That is the case with lawyers translating policies into formal law projects and developing regulatory frameworks, for example.[50] Also, especially from the Pinochet's (see: Valdés, 1995) dictatorship, the role of the economists[51] became widely significant within the State apparatus, developing policies with a clear neoliberal orientation (Silva, 1995, 2010). However, with that precaution made, I found that the effectiveness of transport engineers to engage with the data circulation process in Transantiago makes them the predominant expert group. Hence this chapter focusses on them.

5.1.1 Experts and Transantiago's implementation crisis

The modernisation of public transport after the design and implementation of Transantiago was a decisive moment in which the trajectories of the different concerned experts were defined. The initial chaos generated by the combination of failures in the first phase of the implementation of Transantiago (2007-2010) heavily eroded the relationships between transport experts, bureaucrats, and politicians. This last point was mentioned several times by my interviews and discussions with transport-related specialists revealing that, despite the time that

[50] Indeed, the triggering initial condition for the data dispositif constitution was the public property of the operational data. Which is something that was formally included by the lawyers in charge of generating the first batch of contracts in Transantiago.

[51] During the Pinochet dictatorship the figure of the economist as a policy expert emerged with force in contraposition to politicians, as actors disposed of ideology only mobilised by the facts and their expert neutrality. However, now we know that itself was a strategy of the regime for the instauration of a radical neoliberal experiment. That ideological project has had an enormous effect in the conception of the State affecting key policy processes such as the development of public infrastructure and the provision of public services (including public transport). See: (Harvey, 2007; Valdés, 1995)

has passed, the changes in the system, the contract alterations (see chapter 6), and the overall objective performance improvements, there are still reminiscences of mistrust between the concerned professional actors working across Transantiago. Accordingly, since its implementation in 2007, the trajectory of the system is one of rebuilding trust and confidence across experts, bureaucrats, and specialists to generate a productive collaboration between the transport authorities and the experts within, and beyond the transport bureaucracy.

The initial period of "crisis"[52] in Transantiago can be seen as a shared experience of trauma. It was characterised by an ambience of mutual blaming, often publicly, between and amongst experts, politicians, and bus and technology providers regarding who was responsible for the failure of Transantiago. The crisis of Transantiago drew massive public attention resenting the public evaluation of the entering government of Michelle Bachelet. Naturally, the public directed the responsibility onto the political authorities for what had happened. However, internally among the actors involved in the public transport, there were mixed views about what happened, how it happened and who was responsible of the early problems of Transantiago.

> "*Transantiago's was a surgery conducted without anesthesia. The scale of the project and the high political ambitions behind it collided with the reality of what we could implement as a country at that moment. There was chaos, crossed incentives in tension with each other and major implementation failures. There were economists making calculations of what was financially affordable, lawyers preparing contracts without knowing much about the financial incentives, and engineers proposing, impossible, costly designs based on their transport demand models. It was a problem of coordination and knowing what and who was right and what wasn't." (Former Ministry of Transport (2010-2014) Interview)*

[52] See Ureta, 2015 p.23

Accordingly, the starting point of Transantiago's implementation crisis is marked both by mistrust and by a situation of radical epistemic uncertainty in which the determination of responsibilities and the difficulties of establishing what really went wrong from a technical point of view were two sides of the same coin. It was symptomatic of the technocratic arrangement between politics and experts to try to mutually blame each other for being ultimately responsible of the chaos. The quotation, also, is explicit in revealing how difficult it was to implement a large-scale public service, in terms of overseeing the technical components of it, including design, legal procedures, financial structure, operations and management.

Throughout this chapter, I argue that transport engineers, despite being seen as directly responsible of a significant part of the implementation crisis, managed to fortify their relevance as an epistemic community in the ministry of Transport and Transantiago.

One of the most significant and publicly known examples of the responsibility of transport engineers is the case of the transport demand miscalculation. The transport authorities hired a well-known local transport engineering consultancy firm to project the new bus fleet based on transport demand modelling. Yet, the initial calculations did not fit with the estimated budget established by the Ministry of Finance. So, the finance authorities demanded that the models' parameters be adapted to stay aligned with the available budget. The consultants made the subsequent adjustments to "recalibrate" their models using a new set of parameters, changing the total amount of required buses to operate the system. The consequences were disastrous since the new models underestimated the total bus fleet provision offer by at least 2,000 buses of the total available daily bus fleet[53], producing a significant collapse in the bus provision. On top of the service shortage other problems were synchronically affecting the system, as was the case of the lack of GPS information for monitoring the services and problems like lack of drivers, among other unprecedented situations (Muñoz et al., 2009).

Naturally, transport engineers have traditionally been connected to the transport policy and planning process. For instance, they were heavily involved in the immediate previous history of Transantiago, specifically on the development of the PTUS[54] —guideline document for a new transport system for the 2000-2010 period which served as baseline document for the design of Transantiago. According to Ureta (2015), the PTUS was the materialisation of more than four decades of transport engineering work. With Transantiago transport engineers' capacity to influence the policy making process dramatically increased.

Along with the initial crisis of Transantiago, the "nature" of the Ministry of Transport changed. Before and during the system implementation, the Ministry was a "normative" ministry. As one of my interviewees explained:

> *"Before [Transantiago] The Ministry of Transport was a normative ministry. They gave permits, concessions, contracts, they oversaw contractual commitments, drafted laws, etc. It was managed by a few lawyers that knew a bit of transport. But no one really was a transport expert, so the ministry was not ready to operate since they didn't have the technical muscle to do it. That changed progressively after the initial collapse of Transantiago, and now it's a completely different ministry, with a clear transport technical orientation".*

[53] The initial transport models estimated approximately a total fleet of 6,500 buses for the whole city, yet after budgeting complains made by the finance authorities these models were recalculated adjusting parameters estimating approximately 4,500 buses (Ureta, 2015, 2017). However, by the end of the first year of implementation (2007), the authorities decided to increment the bus fleet to 6,400 units (Muñoz et al., 2009)

[54] Plan de Transporte Urbano de Santiago (2000-2010)

My interviewee distinguishes "normative" as opposed to technical. In other words, he sees the previous "normative" nature of the Ministry of Transport basically as a legal predominance of the ministry function, focusing on contracts, compliance, bidding structuring, etc. In contrast, with Transantiago the Ministry of Transport became "technical", that is, it became a policy and project-oriented ministry focused on the technical enablement of public transport managed with transport engineers in control. This change on the "nature" of the ministry was also critical to augment the influence of transport engineers on the transport bureaucracy from a technical perspective. In other words, the response of the authority to the technical problems during the early implementation of Transantiago was to give even more importance to the Transport experts. I identify this particularity of the period as a critical process to understand the increased predominance of transport engineers in Transantiago, and the Ministry of Transport, despite being at the centre of the failures of the new system.

The relevance of transport engineers has often been self-perceived as mild, with interviewees claiming that the engineering community was a group that had not been taken seriously enough to achieve better results in public transport:

> *"It is like everything was defined into one contract where you can find the engineers, the economists, the lawyers, the technology providers, etc. Then, in different moments, each of these groups have tried to dominate the discussion about what we should do to improve public transport. The economists said that the problem was that the contracts did not include the appropriate economic incentives because lawyers made them. Lawyers said that the economists didn't know how to transform their ideas into real projects, Sonda also was blamed by the government for not delivering properly, and so forth. We engineers have been somehow cornered in our field. Part of what we have learned is that we need to understand the different variables to improve public transport, the big picture. We as engineers need to play that role, of understanding the role of each of the elements in*

every aspect of public transport, and to assemble the pieces to make it work." (Former DTPM planning division transport engineer)

The quotation illustrates the self-perception of engineers as a group that understands transport in a fuller and more complex form than other professional groups, beyond the boundaries of transport engineering. Implicit in the quotation is the critique that they have not played the role they think they should have over the years, which contrasts with the fact that they have been part of the development of public transport in almost every possible aspect. However, they believe that they have been cornered by other groups of experts and professional groups and have not been considered in the policymaking process with sufficient attention.

These critical views of the consideration of transport engineers in public transport are replicated in academia. A well-reputed academic at the transport engineering department at the Universidad Católica mentioned: *"My work has been more recognised and useful for policymaking in several other countries, in Europe and the US, but, sadly, not in Chile. I guess no one is a prophet in their land".* This perception is in tension with this same academic's roles as a technical advisor at the Ministry of Transport during different political administrations, in several capacities[55]. A second element I observe in the quotation is the self-perception of transport engineering as playing a God trick[56], in which the transport engineer is the only one in a position to claim what is valid and required knowledge regarding

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[55] I decided to not give specific details on the roles to keep the person anonymous.

[56] Donna Haraway (1988) describes how performing "the god trick" is enabled by "a perverse capacity […] to distance the knowing subject from everybody and everything in the interests of unfettered power" (581). The "god trick" is about enacting "a conquering gaze from nowhere". The vision (as a metaphor) that Haraway proposes is embodied, partial, and accountable/answerable for what one sees and how one organises what one sees: "Vision is *always* a question of the power to see – and perhaps of the violence implicit in our visualising practices. With whose blood were my eyes crafted?" (585) (cited in Rogowska-Stangret, 2018).

public transport. In this case, the God trick is seen as a strength from the point of view of the researcher, which contrasts with the way it's seen by Haraway's. Therefore, I argue that the role of transport engineers is constituted as much more than modelling transport demand or giving topic-specific technical advice, despite the perception that engineers have of being cornered "only" as technical observers of the policymaking process. Their role goes beyond the technical expertise but is deeply rooted in political savviness, as they understand how to navigate across boundaries within the political landscape. In other words, the sensation of being left out is probably more sustained by how their technical advice has been considered and used by the authorities rather than their absence in critical policy making situations.

The responsibility assigned to experts during the initial Transantiago crisis did not lead to a replacement of the predominant technical visions regarding public transport. In fact, it reinforced transport engineers' predominance, through direct involvement in the policy process either from academia, the transport bureaucracy, or the private sector.

5.1.2 Who is the transport engineer?

How did transport engineers manage to build a solid epistemic community to stay on top of public transport? especially after the emergence of big data, which required new technical and practical skills to enable its circulation.

Transport engineers rely on different sources of legitimacy to build up their group relevance as an epistemic community. These sources of legitimacy operate as ways to generate, reproduce, reinforce, and demarcate the role of transport engineers between the ecology of experts in public transport. These operations are the ways in which *boundary work* (Gieryn, 1983) is enacted to establish group demarcation, that is, to define who, why, and how determined individuals or groups can or cannot get involved in technical discussions.

The first source of that legitimacy is academic credentialism, which takes the minimum form of having been formally instructed as a "proper" engineer in an academic institution, and hopefully, but not exclusively, as a transport engineer. I say minimum because not every degree in engineering or transport engineering is equally important; the university conferring those degrees is similarly or perhaps even more important. Accordingly, the role that the Universidad Católica and the Universidad de Chile have as the most prestigious universities in the country, both located in Santiago de Chile and usually the first pick for local elite education, is relevant. Similarly, their engineering faculties offer careers with high entry requirements and are highly reputed in several sub-areas of the discipline (Villalobos et al., 2020). Transport engineers in both faculties represent a small portion of the total number of graduates, but they are recognised as a top-level academic community. Something observed in my fieldwork is the predominance of both faculties as the primary sources of professionals for the different institutions involved in public transport. It is very common to see engineers of different ages and career stages in a wide variety of technical roles beyond the specifics of transport planning, in management, operations, finances, research and, even, in marketing-related roles. The capacity of these engineering faculties to provide professionals to the public sector, academia, private consultancy practices, private bus providers, and technology providers, among others, is highly effective. Although other engineering faculties offer transport engineering in Santiago and other regions in the country, those at the Universidad Católica and the Universidad de Chile are by far the most prestigious and, consequently, are more effective in providing highly regarded professionals for the job market.

On a different level, the role of professional societies is critical to build, sustain, reinforce, and internally organise hierarchies of the transport engineering epistemic community. That is the case of the Chilean Society of Transport Engineering (SOCHITRAN). This professional society founded in 1982 unites transport engineers from academia, the public sector, consultants, and other specialists. This exclusive group is internally configured by different memberships organised by type of involvement and professional and academic merits. On the limited list of active members, there are people like the current and former Ministers and Sub-Secretaries of Transport, as well as renowned local academics, transport consultants, and long-time public servants, among others. To become a SOCHITRAN member, the society has its rites of passage, which include procedures such as being referred by at least three current members and submitting a formal application. The application is then evaluated by the sitting board which accepts, or not, the new member. Once membership is granted, it is expected that the new member will give an inaugural lecture to the rest of the active SOCHITRAN. The welcoming ceremony is the official way by which new members are received as part of the SOCHITRAN community —but is also a practice that allows new members to expose their work, as well as to get feedback and to get some sense of the internal dynamics and hierarchies in place.

SOCHITRAN also organises internal meetings and seminars, inviting national and international experts to give presentations to its members and to generate knowledge exchange networks. At the same time, influencing public discussion is one of the main preoccupations of SOCHITRAN; accordingly, they generate policy documents, technical minutes, academic papers, op-eds, and columns to circulate their ideas and visions in the media. Further, every other year the society organises the Chilean Congress of Transport Engineering, where most of the members present scientific papers based on their current research in the plenary and panel sessions. It is the mission of SOCHITRAN to generate, stimulate, promote, coordinate, and disseminate initiatives that help develop research in transport engineering. Likewise, part of the society's mission is to promote the application of new technologies in the public transport sector at a national level (SOCHITRAN, 2021). SOCHITRAN, represents a specialised community of transport experts that is vitally engaged in producing quality research and policy inputs for the development of public transport in Chile. Likewise, it is an institution where hierarchies are performed and strengthened. It is a way to organise the epistemic community, through a wide variety of practices and actions, rites of access and passage, a wide variety of events, networking, and knowledge exchange activities.

At the same time, SOCHITRAN is a group where familiarity and bonds are created and fortified, which are then expressed in the development of group policy agendas, enrolment strategies, and means to disseminate knowledge and their interests. Ultimately SOCHITRAN creates a practical framework, a sort of rationale, to delve effectively into the policymaking processes and, more extensively, into the constitution and development of the local public transport apparatus. Accordingly, SOCHITRAN is able to participate in and influence public transport discussions and policies through a highly legitimate technical position. Additionally, and more importantly, it expands and reinforces the influence of its members beyond its organisational boundaries given that the internal hierarchies produced at SOCHITRAN remain relevant outside the organisation.

Therefore, I argue that the epistemic community of transport engineers primarily relies on specific educational credentials, and on the participation and membership of groups of exclusive access. I argue that these sources of legitimacy, first, generate a baseline of technical certification to get involved in the epistemic community and, second, consolidate a network capable of defining cohesive agendas, strengthening internal group ties, as well as ordering hierarchies within the group based on membership, selection, and recognition criteria. At the same time, I argue that the hierarchies made at organisations like SOCHITRAN can operate beyond the professional society's limits. Accordingly, I argue that the effectiveness of transport engineers to influence the public transport apparatus, including the way by which data circulates, is sustained by permanent efforts of group demarcation, internal structuration, and solidification of their epistemic community. Also, by the willingness of others to be persuaded by the technical claims of transport engineers.

In the next section, I will focus on how the emergence of big data has been helpful to enlarge their domain of influence; or in other words, how boundary work makes transport engineers even more relevant in public transport and the data dispositif.

5.2 Undoing and redoing transport engineering with big data

As mentioned in the introduction of the dissertation, technology provision is one of the most significant innovations of the Transantiago. Yet, as we also know, one of the problems of the initial collapse in the implementation of Transantiago was directly related to technology. These problems permanently affected the reputation of the complementary services providers, who are responsible for providing and maintaining the technological provision of the system, including all the variety of data-related services, including collection, software provision, reporting, storage, etc. How transport engineers managed to take advantage of the new technologies, and its problems, to enhance and solidify their technical influence in Transantiago? In this sub-section, I focus on this question to analyse the influence of transport engineers, as epistemic community, in the data circulation process, SONDA is the leading technology provider of the system, and arguably, one of the most affected in terms of reputation after the implementation failures. During the first week of implementation of Transantiago in February 2007, arguably none of the new technological features worked as expected. This is the case with the recently introduced smart card validation terminals used for payment, so none of the users were charged for transport use during the first week. Also, during the first 6 months, GPS services did not work, affecting the implementation of the new fleet management system and massively disturbing the bus operations. In the words of one of my interviewees, *"Let's not forget that during the first six months, we were completely blind to what was happening because the GPS systems failed, so no daily operational data was available."* By no means were the complementary services providers exempted from the chaos and the lack of trust between the different actors involved in the implementation of the new system.

The fragile position of the technology providers after the massive failures became an opportunity for transport engineers. The technology provision was already negotiated and structured by contracts between the Ministry of Transport and the complementary service providers establishing the detailed technology provision, data services and responsibilities. However, that did not prevent other groups of experts thinking about new ways to develop further potential uses and trajectories of the new technology, including, of course, the operational data. The development of the software ADATRAP enacts that involvement of transport engineering experts to develop further big data throughout the transport system:

> *"It all started at the engineering department of the Universidad de Chile when a group of people discovered this opportunity in the new contracts, right when Transantiago started in 2007. It was something quite unexpected, but as we were all the time seeking for new approaches to produce research outputs, it also made sense that we were the people called to find and develop these new opportunities in*

terms of using the data. Thanks to this is that ADATRAP really exists." (Former Planning Division Manager DTPM)

As we observe in the quotation, at an early stage, a group of engineers at the Universidad de Chile foresaw the usefulness of the emerging data on the new transport system. Therefore, extensive experimentation started after this preliminary account of the opportunity of making use of the data, mobilising its circulation towards new unknown trajectories in public transport. Despite not having a complete understanding of what the requirements were, there was an idea, one at the core of engineering practice, of doing something "useful" with it beyond academic interest. Yet, the transport engineers at the Universidad de Chile saw an opportunity to obtain more data inputs for their academic[57] purposes.

These triggering circumstances or early problematisations of the data circulation processes were neither anecdotical nor purely intuitive, as some of the same individuals directly involved often recognise. Contrary to what is said, these triggering events are entrenched in, and are a consequence of, a context of an existing epistemic community of transport engineers already influential within the transport policymaking process. Transport engineers' expertise is in effect the ability to problematise big data circulation in Transantiago, effectively.

To make data circulate and, therefore, to increase and expand its presence, throughout Transantiago, is at the same time a result of the influence of a pre-existing community of transport engineers, and an opportunity to solidify their position as transport experts through data circulation. Yet, to stay on top of the new requirements of big data, transport engineers produce ways to bridge the

[57] Some of the academic publications based on this data are: Amaya et al., 2018; Bucknell et al., 2017; Byon et al., 2018; Cortés et al., 2011; Gschwender et al., 2016; Munizaga et al., 2012, 2014; Munizaga et al., 2017; Munizaga & Palma, 2012; Tirachini, 2013.

emerging knowledge and skills gaps to work with big data, keeping boundary work in place. That is, to demarcate the boundaries of technical expertise to determine who can participate in the data circulation process.

Before detailing these challenges, I first want to focus on how I experienced boundary work and expert demarcation in the field. During my interviews with transport engineers, I often perceived an implicit questioning of my status as transport researcher, as I recognise in chapter 3, this situation has marked my whole research project. Frequently I felt an implicit assumption from part of my interviewees, when they were transport engineers, that I was not familiar with basic technical terms such as an origin-destination matrix, or a discrete choice model. Often, my interviewees stopped in the middle of their answers to explain to me some of the technical terminology they were using, assuming I was not aware of their meaning. This personal experience is illustrative of the argument made before about technical demarcation and boundary work. The patronised way to convey transport technicalities reflects an extended practice of transport engineers' community[58] vis-à-vis other transport researchers not belonging to their epistemic community. Ultimately, these practices neglect other types of knowledges that are different from the ones that the engineers define as valid, which I argue is a strategy to reinforce engineers boundary work in public transport and the data dispositif. An example of this comes from an interview with a local transport engineering academic:

> *"Getting the appropriate data to estimate models, being rigorous, and representing populations is difficult. We put a lot of work into building simulations and producing trustable inputs for policymaking. Other transport specialists, even former academics, have become high-ranked government officials in public transport, we expect them, and*

[58] Despite some encouraging changes in the new generation of scholars who seemed to be more open to seek inter/transdisciplinary collaborations. See for example (Jiron & Carrasco, 2020)

> *they normally do, to use the evidence we have provided. The problem is that not all the research, and not all the evidence is equally useful. For example, there are well-intentioned academics that produce methodologically limited studies, including small samples that do not represent anything more than that small group, using non-probabilistic methods. Because, if you follow a small group of, I don't know, 10 or 12 people, no matter how intensively, that does not represent anything else than that group, and that is not enough to inform policies." (Transport engineering academic)*

The quotation makes clear the perception of a well-established transport engineer in academia about "other" transport researchers and "other" engineers that have turned into public authorities. Now that the latter are part of the government, they have "sacrificed" the rigour they used to have as academics, basing their decision making on an inappropriate use of the data. The comment on the scholar "*that follows smaller groups of people*" signals something similar: it draws a boundary between a particular type of transport knowledge (his) that is epistemologically of valuable transport research, as qualitative work belonging to a less-relevant discipline like sociology or anthropology. Moreover, such work is not even qualified as transport research but as a different discipline; from this perspective, the term "transport" by itself is used to demarcate boundary work.

In this case, although implicitly, I knew the person the academic was referring to. Even though the person has a PhD (not in engineering) from a prestigious international university and has published their research on transport peer-reviewed journals, although not in the top tier journals for transport engineers, the fact is that their research is qualitatively less important than the one he and his peers do; it refers to something "else" than proper transport research. At the same time, the "other" researcher is not an engineer, or a member of SOCHITRAN, nor any other equivalent society; rather, they undertake qualitative ethnographic research using "other methods" that are not "sufficiently" valid to inform policies, beyond what he and the epistemic community understand as valid or valuable. In his definition of transport research, those approaches are less acceptable than those produced by him and his colleagues[59], because the knowledge produced is epistemologically different and cannot be evaluated under their vision of an "appropriate" form of transport research that is useful for informing policies.

The relevance of the situation resides in the capacity of a certain type of knowledge to become "the" transport knowledge. Ureta (2015) illustrates another example of this when identifies the enactment of Transantiago's users because of transport modelling, as "made up" by a determined form of origin-destination calculation. The way transport engineers demarcate their position regarding the production of valid knowledge, ultimately, enacts a relation of power across disciplines. An academic that feels in position to define what is transport research and what is not, knows that he can make that claim based on its position as an academic within the broader academic landscape, for example if he is backed by a tenure-track position at his university. But also, he is aware of its position of privilege within his epistemic community, as holding the credentials that define himself as someone relevant in the transport community, so that claim becomes

[59] Consistent with this is a comment made by another transport engineer in one of my interviews in which he dismissed the value of the book published by Sebastián Ureta, a sociologist and local academic who published an STS analysis of the early years of Transantiago, which I have cited thoroughly during my work. About it one transport engineering academic said: "That book is entirely wrong, unfortunately he never understood [signalling the author] how the transport system was made, how a transport system even work. His interpretation of the facts is partial, and not entirely rigorous".

the claim of the group, not only his. Boundary work operates here reinforcing both an individual and a group epistemic position of authority.

Ultimately, this is an example of how boundary work demarcation operates in practice, making distinctions between disciplines, types of expertise and individual professionals, defining exclusions patterns of specific people and knowledges.

Now, let's return to the involvement of transport engineers in the data circulation process. As we already know, transport engineers effectively capitalized their technical role over the newly created big data early when Transantiago started. However, staying on top of the requirements and emerging problems of data circulation made transport engineers to undo and redo their own discipline to avoid losing their position of privilege in public transport.

This process represents the engineers' capacity to problematise the data dispositif and act upon the emerging new requirements for data circulation, acting upon their own professional practices. These responses have been aligned with a group awareness of the necessity to generate new skills, produce new configurations, and to rearticulate pre-existing ones, making new demarcations between other disciplines and specialists.

Typically, there are two types of knowledge involved in the dominance of the transport engineering community: knowledge about a specific topic or object (i.e., public transport, mobility more generally, etc.); or knowledge, as know-how, as transport related technical expertise. Based on these two broad differentiations they generate ways to resist, confront, and keep things under their control through specific practices and techniques. Transport engineers fit in the second category because what they do, even if it's focused on an academic output, always has some type of practical orientation. However, these differentiations are not part of the ways transport engineers talk about their own craft; nor are they present in their public statements about public transport.

Interdisciplinary work and collaborative practices are present in the transport engineering lexicon. However, these references are vague, operating more as checks to make, as a minimum form of epistemic correctness, rather than a sustained effort to cross disciplinary boundaries. This is exemplified by the way transport engineers understand interdisciplinary collaboration working with Transantiago big data.

> "*In that [ADATRAP] project I worked with computer engineers. Computer science engineers to be more precise, which are the ones that we produce in our engineering department. That was a collaborative work, where each is adding some value from their discipline, and learning from each other's discipline. That was interdisciplinary work." (Transport engineering academic)*

In this case, interdisciplinary work is within the engineering discipline, and even more, within the same engineering department. The collaboration is justified by their disciplinary interests rather than influenced by a genuine effort to integrate other visions into the data circulation process, as we know, ADATRAP is ultimately a precious tool for transport engineering technical work. In contrast, when it is a case of integrating visions and technical skills from other disciplines, when the utility of the collaboration is less clear, the positive attitude towards interdisciplinary work changes.

> *"At the DTPM they have geographers working with GIS tools, but here we don't have them. We work well with 'basic tools', as the techies like to call them, since they are quite elemental tools. What we need really is to process, integrate, to visualise, those big volumes of data".*

Here, the same interviewee refers to 'basic tools' to indicate GIS tools, which are widely used to make spatial quantitative analyses by geographers. In this case, since the tool is considered basic, and thus easy to use, there is no interdisciplinary work because the transport engineers don't see the value of integrating the geographer's perspective since they know how to work with their tools. One theme, of course, is the limited consideration of geographers as merely GIS operators, which probably could be matter of another dissertation on its own. Another theme, referring to disciplinary demarcation, is the way they assimilate other disciplines' practices to their toolkits —which is a case of enlarging disciplinary boundaries rather than promoting interdisciplinary collaborations.

In sum, transport engineers have capitalized on data circulation as an opportunity, in different ways, to learn new skills, to assimilate others, and to enlarge boundary work rather than to work with transport specialists from other disciplines. Despite some valuable efforts to form collaborations across disciplines between transport engineers and other transport specialists, like geographers, anthropologists and urban planners. However, these are still timid and mostly peripheral to the data circulation process.

In the next three subsections, I will concentrate on the boundary-spanning (Levina & Vaast, 2005; Williams, 2002) efforts made by the transport engineering community to maximise their role of influence in the data dispositif. As mentioned, boundary spanners are either individuals, collective groups, or organisations who are capable to build inter/cross organisational knowledge practices influencing groups beyond their own community of practice.

5.2.1 La Mesa de Velocidades

La Mesa de Velocidades[60] is a first example of these practical efforts for cross-boundary collaboration between transport engineer academics and the Ministry of Transport. La Mesa de Velocidades is project that firstly involves the creation of an executive board formed by DTPM representatives, other regional government offices like MOP, Metro, UOCT, and academics from PUC. The board was created as an executive platform to fast-track adjustments in Transantiago's everyday operations based on the operational data. It was created as part of a consultancy[61] work commissioned by the DTPM to CEDEUS[62], a research centre affiliated to PUC.

The main objective of the project was to create a multi-stakeholder body to: *"coordinate and to align the institutions involved in the implementation of the measures required to improve the velocities of the public transport system, and therefore, the overall performance"* (Pontificia Universidad Católica de Chile, 2017, p. 17). Formally, la Mesa de Velocidades included a group of CEDEUS transport engineers and several public transport divisions including DTPM (acting as the main counterpart too), SEREMI MTT (Regional Secretary of Transport), UOCT, among other transport-related divisions. However, depending on the required actions to solve the bus speed problems, or bottlenecks, other

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[60] Translated in English would be something like "Public Transport Speed Improvement Executive Board".

[61] The consultancy project name was "Asesoría para Mejoras Operativas y de Participación Ciudadana para el Sistema de Transporte Público de Santiago", "Operational and citizen participation assessment to improve the public transport system of Santiago de Chile" in English. The project was developed between April 2015 and April 2017 (Pontificia Universidad Católica de Chile, 2017)

[62] Centro de Desarrollo Urbano Sustentable which translated in English would be Urban Sustainable Development Centre.

institutions could be brought to the table, like a private bus provider or a specific municipality. The proposed model was suggested by CEDEUS as part of a wider consultancy project to improve Transantiago, and this specific component was particularly related to the improvement of average bus speeds by solving bottlenecks, effectively working with the DTPM from within. Part of the project involved sending a group of recently graduated transport engineers from PUC/CEDEUS to work at the DTPM offices.

> *" If we wanted to improve the bus provision indicators, we needed to have our engineers there working at the DTPM, not just the Ministry of Transport engineers alone. So, when we proposed the project, we budgeted the inclusion of some of our top students to be there working at their offices. They were going every day, working with the data to identify where the average bus speed was lower, see why it was lower, and hopefully find a quick and cost-effective solution. The idea was also to interact with the DTPM engineers to find out how to solve these bottlenecks, together, fast, with quick and efficient field interventions." (CEDEUS/PUC academic).*

CEDEUS strategy involved creating a practical methodology to convert acute data analysis into effective field solutions to traffic bottlenecks.

> *"Part of our role was to mediate between the actors. To produce quick and cost-effective solutions to, we needed to understand who was responsible for making the adjustments happen to solve the bottlenecks. We didn't want to open long-term conversations about costly and large changes. We wanted to go to the field based on our analysis of the data, to check what was generating the bottleneck, and see how to fix it. If we needed to adjust a traffic light for example, we called the UOCT and asked to make the change. Making that call from the DTPM surely was more effective if we made it ourselves". (CEDEUS/PUC academic)*

CEDEUS engineers, along with DTPM, decided to prioritise specific bus traffic bottlenecks located at strategic points of traffic based on the data. Their idea was to act directly on what was disrupting traffic, and on bus speed, in the field. To do so, they created an efficient model to get in touch with the public organisation to make the adjustments rapidly; in the end, this was a way to put their technical advice into practice.

CEDEUS engineers were conscious of the limitations of their domain of action as experts. Yet, they manage to create a collaborative scheme with the transport authorities precisely because they understood that the solution was beyond its powers. In practice, they wanted to bring their expert advise to the field mediating potential interventions with the responsible public authorities. Ultimately, this strategy exposes the capacity of transport engineering academics to mobilise their agendas inside the State's bureaucracy without compromising their situation as academics. To achieve this, they figured out a method to use their networks with the public sector, without leaving their day-to-day academic positions. Rather, they managed to position their collaborators as their "eyes and ears" in the DTPM offices. From the point of view of academics, this was the best way to maximise the effectiveness of their technical input to deal with the traffic bottlenecks problem.

The assessment of CEDEUS to the MTT and the DTPM go beyond the work of La Mesa de Velocidades. Also, it included presentations, technical minutes, and policy documents to improve public transport in a wide variety of areas. Additionally, they coordinated knowledge exchange activities, such as meetings with international transport authorities and academics, to promote policy collaborations (with cities like Rio de Janeiro or Curitiba). Furthermore, CEDEUS engineers benchmarked models of transport governance, with the case of Transport for London constantly repeated as an example to be followed by Santiago. Additionally, academic outputs have been published in academic transport journals, co-authored by CEDEUS academics and transport engineers at the Ministry of Transport[63].

Despite the intention of CEDEUS to extend the project to further stages, the new transport authorities, which arrived in 2018 after the election of the right-wing government of Sebastian Piñera, decided to finish the project. According to people involved in the collaboration, the new authorities saw the project as part of the "previous administration". CEDEUS failed to keep the project alive, despite claiming political neutrality in their technical work, the new authorities linked them to the previous centre-left administration. Perhaps the trade-off of generating a cross-boundary methodology to work with/in Transantiago is that CEDEUS work was "unfairly labelled as partisan", as someone from CEDEUS complained in one of the interviews.

Nonetheless, the methodology created by CEDEUS enacts an innovative approach to the traditional analysis of operational data to assess operational bus fleet management. In practice, this methodology was a way to combine the quantitative analysis with field action, including an efficient framework to coordinate cross-sectoral solutions. Based on the mixed approach, la mesa de velocidades, and more specifically the executive team composed by DTPM and CEDEUS, could coordinate cost-effective interventions more efficiently.

At the same time, the experience was a strategy set by transport engineers academics to mobilise boundary work across the MTT and the DTPM. Maximising their influence as experts acknowledging the limitations of not having the ultimate

[63] See for example: (Bucknell et al., 2017) "Identifying and Visualizing Congestion Bottlenecks with Automated Vehicle Location Systems: Application to Transantiago, Chile"

responsibility to produce quick field interventions to enhance bus operations effectively. In other words, the way transport engineers problematise the operational bus data makes them look to alternative arrangements to provide solutions to these problems; this differs from their traditional ways of interacting with the authorities, adding a direct involvement component in the relationship between external technical advice and the authorities.

5.2.2 The Heterogeneous Engineer

Another example in which boundary work operates, along with boundary spanning is the case of Pedro[64], who I called "The Heterogeneous Engineer". In this case, this is one specific person who can mobilise expertise both ways between academia and the transport bureaucracy. To span the boundaries between academia and the public transport bureaucracy is seen as a crucial capacity to enable data circulation in Transantiago. The case of Pedro represents another way by which transport engineers influence data circulation keeping boundary-work demarcation in place, through specific individuals and/or organisations that bridge academic and bureaucratic knowledge.

Pedro, The Heterogenous Engineer, has been involved in the data circulation process from the early days of Transantiago, initially from one of the main transport engineering departments. Since then, he has worked in Transantiago in several management and technical roles. Today, he shares responsibilities as a part-time academic and as a part-time advisor at the DTPM transport planning division, a double function which he has decided to pursue. In several interviews he is mentioned as "the man to talk with" if I wanted to know more about big data

[64] Pedro is a fictitious name which I decided to use to protect the identity of one of my informants.

in public transport. Accordingly, he has been recognised as a "bridge" between the transport academic community and the transport specialists working at the DTPM. He is a transport academic, holding a PhD in transport engineering from a prestigious European university; he is also a senior member of SOCHITRAN and a part-time lecturer in a top transport engineering department, and he has co-authored academic publications with well-known transport engineers from the Universidad de Chile and the Universidad Católica. Along with his academic work, he has served in various capacities working part-time at the MTT and the DTPM, and in several governments of different political sectors.

About his role, one academic said in an interview:

> *"His role has been so important in so many ways. Because he was involved in the university developing the ADATRAP software while he had his eyes on the government as an advisor, he could fully identify what was needed from the transport authorities, in what format, etc. He also helped to build a technical data muscle within the transport authority that now is our formal counterpart, people who know what to do with the data. Also, he has helped to generate joint applications for grants and leverage public funds for our software to be developed at different stages. He has been involved in testing our ideas practically within the transport bureaucracy and forming people there to make sense of our work to make the data useful." (Transport engineering academic)*

Pedro is still playing a double role in the transport engineering faculty and at the DTPM. In the faculty, he teaches public transport, as well as supervising dissertations and publishing academic papers. At the same time, he works at the DTPM: here, he has been key to embedding big data into the everyday practice at the organisation and promoting an organisational culture to enable big data in processes beyond bus operations – both by working on the challenges to making it that happen, that is, identifying organisational bottlenecks as skills, incentives, objectives, and by promoting its benefits to the authorities. Consequently, given his early involvement in ADATRAP, he has been a fierce advocate of the software, playing a significant role to generate the conditions to make it sustainable in time by ensuring funding, the political buy-in, and developing organisational skills and capacities to make the most of its outputs.

Pedro understood early on that the best way to influence public transport was to formally be part of both worlds, acknowledging that this was the best route to connect technical and political expertise to policy decisions – possibly at the cost of sacrificing his success both as academic and as a public servant. *"To do that requires an important amount of altruism"*, as an academic colleague suggested, referring to the importance of Pedro's at the DTPM, but also acknowledging the potential costs of his decision for his academic career.

However, his role has been decisive for making data circulate over the years in Transantiago, helping to produce a "virtuous cycle" between academia and the public sector, as another academic named it. As seen with la Mesa de Velocidades, academics know that to influence the transport bureaucracy decisions requires strategic action and innovative cross-boundary arrangements. The heterogeneous engineer personifies this problem-solving situation. He does it by focusing on boundary work, that is, by finding the ways to keep the influence of transport engineering technical capacity within the transport bureaucracy, without abandoning his position as an academic.

Accordingly, the heterogeneous engineer operates as a boundary-spanner between academia and the public transport bureaucracy to mobilise technical engineering knowledge, as well as to deepen intra/inter-organisational trust, reciprocal access, and communication channels between both worlds. As mentioned earlier in Chapter 1, public policies are "wicked issues" (Williams, 2002); that is, complex and cross-boundary in nature. Therefore, the focus of the organisational action needs to move from a preoccupation with intra-organisational imperatives to a commitment to the building of inter-organisational capacity. In the same way, these policies require a common language that reflects familiarity, interconnections and interdependencies between organisations (Williams, 2002, p. 105). In this case, the public sector as it is the ultimate responsible of an appropriate service delivery, and academia as a providing technical expertise advice.

5.2.3 The Data Team

A final example of boundary work demarcation and boundary spanning is the creation of the "Data Team": first as a group within the DTPM planning division working on big data, and then as a separate unit working for the whole organisation. The unit is an organisational response to the increasing skill development challenge to make more and better use of the operational big data across Transantiago. Therefore, it emerges along with, and as a response to, projects like ADATRAP, and the data circulation process in general.

The emergence of the team is tightly connected with Pedro's vision of how to make the most of ADATRAP in Transantiago. Early on, he saw in ADATRAP a way of converting DTPM and Transantiago in general as more data-oriented organisations. However, it also meant that to take the most ADATRAP opportunities, and from similar digital technologies, would require strong organisational skills in big data manipulation. These organisational skills would help to level up DTPM in at least three ways. First, as a more literate counterpart vis-à-vis external technology partners, for example, to solidify its relationship with organisations like SONDA thanks to a better understanding of the rapidly emerging digital technologies and big data related to public transport. Second, to work more and better with the available data for transport planning, mainly enabled through the development and improvements of the ADATRAP software. Third, to interpret the data needs of Transantiago and DTPM more rigorously and to transform these needs into opportunities for new developments (software, analytics, reporting, etc.)

The data team is formed of a group of transport engineers with solid training in data science methods and proven skills working with big data for and beyond public transport analysis. The data team provides technical support developing big data-related tools, making experimental analyses to support Transantiago's operations from DTPM. They also work as technical counterparts to external technology providers to be sure that the DTPM demands are met. For example, they have regular meetings with the ADATRAP at the Universidad de Chile, to oversee the progress of the software and the new requirements, and to test ideas together. In the same way, they are in permanent contact with SONDA following-up the appropriate technological provision of the system established on the CSP contracts. There is a shared vision amongst academics, practitioners and even by the technology providers like SONDA, that most of the technology problems of Transantiago were consequence of the lack of technical understanding of digital technologies by the transport authorities. Therefore, the data team is an organisational response to that technical knowledge gap to balance relationships between Transantiago and technology third parties. More of this is analysed in chapter six when I refer to contracts.

In the conclusion of this chapter, I will refer more extensively to the relationship between boundaries and the ways in which the transport engineering community establish, reinforce, and enlarges its epistemic dominance of the data dispositif.

5.3 Conclusion

In this chapter, I have analysed how experts and expertise influence big data circulation in Transantiago. More specifically, I focused on transport engineers as the main expert epistemic community influencing the data circulation process. Accordingly, I have described how they dealt with the initial implementation Transantiago legitimacy crisis, which counter-intuitively ended up reinforcing their technical role despite their work being directly responsible of some of the early problems of Transantiago. In the same way, I described and analysed how transport engineers use boundary work to enlarge and solidify their position as the most dominant expert group despite the challenges presented by big data circulation to their discipline.

In this chapter, we observed that the emergence of big data helped transport engineers to keep abreast of public transport, reinforcing and enlarging its technical boundaries as epistemic community. Moreso, I argue that this predominance goes further than the provision of technical support, but it becomes the prevalent epistemic culture, in the data dispositif, and in Transantiago.

Transport engineers creatively and effectively enact the capacity to *"answer questions that no one asked them"* (Latour, 1996, p. 32). This capacity is strengthened by the way in which transport engineers perceive themselves as neutral technical experts defining and defending technological fixes using their neutrality as a principle of the community. However, transport engineers know how to blend major social questions, which in politics are expressed in programmes, political agendas, and by the ability to convert "proper" technological questions into a single, non-partisan discourse (Latour, 1996). In the case of transport engineers in Santiago's public transport, I argue that they are knowledgeable of political dynamics and the specificities of transport bureaucracy to influence these structures, without sacrificing their “aura” of technical objectivity as a technically infused professional discipline.

Transport engineers’ influence on the transport policy process is neither new nor surprising. It started long before Transantiago and still prevails today. My argument in this chapter is that transport engineers had to put a lot of effort into remaining and prevailing in the policy process beyond their technical role. The findings presented here support the idea that transport engineers are much more than just technical advisers or top-down technocrats who attempt to impose technical work by replacing politics. Instead, they are a type of technopolitician, yet in slightly different terms to those identified by Silva (2006, 2010), where experts directly got involved in partisan structures. The case of transport engineers, as epistemic community, is a more nuanced, distant form partisan politics, ultimately, more technocratic than the technopolitican. However, despite the technocratic orientation, transport engineers still enact an acute understanding of the dynamics of the transport bureaucracy, and consequently acknowledging the importance to get directly involved within these structures if they want to remain effective as predominant technical advisers.

Accordingly, transport engineers effectively consolidate themselves as an epistemic community by demarcating the boundaries of its discipline/group, reinforcing the constitution of transport engineering as a professional practice that is qualitatively different from others (Abbott, 1988). In other words, by differentiating themselves as experts through boundary work, establishing what type of knowledge is valid to enable data circulation, and who is able to participate in that process as a technical expert.

To become part of the community, and to be someone important within that community, is linked to at least two specific sources of legitimacy. First, academic credentialism, as the community is heavily sustained on the provision of people who had their degrees from two of the most prestigious academic institutions of the country (especially the Pontificia Universidad Católica de Chile and Universidad de Chile). Secondly, becoming part of professional associations like the Chilean Society of Transport Engineering (SOCHITRAN), which defines inter-institutional hierarchies through internal rites of passage. So, becoming part of the epistemic community requires individuals, as the baseline, to be a transport engineer; then, to have a degree from a prestigious university; and finally, to become a member of SOCHITRAN. This process helps to delineate boundary demarcation, defining "who" is able to become a transport engineer; and, to define "who is who" within the community. This last point is essential to structure hierarchies within transport engineers' community, which then are extensive to interorganizational relations around the data circulation process.

Boundary work (Gieryn, 1983) is the way in which transport engineers demarcate their technical role from other transport specialists. As I describe thoroughly in chapter 2, boundary work denotes specific operations by which a technical group is capable of demarcating disciplinary borders between those who have the legitimacy and competency to participate in specific domains of decision-making and those who do not. Whether engaged in building professional communities or asserting their autonomy against external controls, transport engineers use a variety of boundary-defining strategies to establish who is *in* and who is *out* of relevant peer groups and networks of prestige authority (Jasanoff, 2009, p. 34). In the case of Transantiago and the data dispositif, transport engineers have become *obligatory passage points*[65] for most policy discussions in public

[65] Bruno Latour identified engineers as obligatory passage points in the ARAMIS transport development project (Latour, 1996). In the next chapter, I use the term with a slightly different emphasis focusing on specific devices which stabilise big data circulation in Transantiago.

transport, limiting the participation of other scientific disciplines and registers of knowledge, by making themselves the baseline discipline to participate in any decision. This is also accomplished through boundary spanning strategies which allow transport engineers to get direct involvement in the transport bureaucracy to define how big data is circulated.

Correspondingly, transport engineers have, over time, constructed an extended epistemic community that overflows the boundaries of transport engineering as a technical practice. In doing so, transport engineers as a community are able to enact an epistemic culture (Knorr-Cetina, 1999), since they proved to be effective on building endurable and epistemically relevant arrangements to varnish their vision of public transport as the only possible expert knowledge in Transantiago.

6. Problematisation III: Obligatory Passage Points

6.1 Introduction

As we have seen so far, the trajectories of data circulation are marked by problems, and these problems trigger novel arrangements to mobilise solutions producing new pathways by which data circulation is enabled. In chapters 4 and 5, I have focused on two overarching problematisations: the problem of control room fragmentation and the problem of expertise demarcation. In both cases, I inquired into the ways data circulation is made possible by a process where the dispositif is disarranged and rearranged to make data circulate across Transantiago.

In this chapter, I focus on a different problem. In fact, more than a problem, I refer rather to a specific form of problem-solving; these are called *obligatory passage points (OPPs)* (Akrich et al., 2006; Callon, 1984b; Law & Callon, 1988). I have already introduced OPPs in chapter 2 in more detail, linked to the classic ANT notion of *translation* (Callon, 1984). However, I will reiterate some of its most relevant features to explain how I am using them to analyse data circulation in public transport.

I consider translation a strategy to enrol actors when shared problematisations emerge between actors involved in the data circulation process. Translation, then, is the process by which an arrangement is made between actors, making up a network. The dispositif, as I have mentioned, is always subject to change, to be once again problematised according to a specific point of rupture, and in doing so, to be source of new translations, producing new arrangements, and potentially bringing new actors into play, in order to make these arrangements more durable over time. Ultimately, the process of translation leads to a "blackbox", taking the form of a material or non-material arrangement that is so taken for granted that it no longer needs to be reconsidered, at least temporarily (Michael, 2016). The process of translation operates to rebalance power relations, mobilizing diverse, and potentially divergent, types of interests related to the ways in which data could/should circulate in Transantiago. The obligatory passage point (OPP) therefore emerges as what is unavoidable within a certain problem, which is always shared between the actors wanting to make data to circulate. Hence, OPPs congregate actors in relation to a mutual concern; in this case, in relation to the data dispositif and the possibilities by which data circulates. To identify what is unavoidable, an obligatory point of passage allows problems to line up solutions, mobilizing diverse actors towards making new arrangements, and consequently, defining the way by which data circulates. In Callon's words (1984: 206), "*[an obligatory passage point] designates the device by which a set of interrelated roles is defined and attributed to actors who accept them".* So, they become enrolled on a mutual path. In other words, *"if consensus is achieved, each entity's manoeuvre margins will then be tightly delimited"* (Callon, 1984:213). This last point is central to my interpretation of the concept. It refers to how the actors intend to solve the lack of convergence in their agendas by finding a device to move forward, enacted as an obligatory passage point to allow data to circulate in Transantiago.

Accordingly, this chapter pays particular attention to a series of obligatory passage points that emerged to make big data circulate in Transantiago, structuring its trajectories supported by the alignment of actors with divergent incentives and/or interests in Transantiago. I structure the chapter into three sections, each of which focusses on specific OPPs: ADATRAP; Origin-Destination Matrices; destination matrices; Contracts and KPI's. First, I discuss the central role of the software ADATRAP to structure, and trigger, the expansive use of big data in Transantiago beyond its original purposes. Second, I describe the role of origin-destination matrices to structuring big data for transport modelling, remaining unavoidable despite the challenges of data abundance. Third, I analyse the role of contracts between MTT and DTPM with their providers, specifically private bus companies and complementary service providers. In this case, contracts keep a balance between expectations and incentives amongst the authorities and its providers, in turn creating an enforcement scheme that is at the same time rigid, so it stabilizes expectations between actors, but also flexible enough to adapt the service provision to technological change. Also in this section, I refer to the way in which the relationship between DTPM and its providers is numerically organised through KPIs. Specifically, I discuss how data circulation has allowed the redefining of indicators that shape the incentives of the system and impact the overall performance of Transantiago. In this sense, indicators change along with the ways in which data circulates more extensively across Transantiago. Finally, I reflect on the role of obligatory passage points as way to produce endurable arrangements to enable data circulation, black boxing key operational processes of Transantiago to stabilize the overall management and performance of the system.

6.2 First obligatory passage point: ADATRAP

In this section, I will discuss the role of the ADATRAP software as an obligatory passage point in Transantiago. Specifically, I will focus on two overarching situations. First, I focus on how ADATRAP translates big data as an operational component of the system to data circulation beyond the limits of the system operations. In other words, thanks to ADATRAP, big data became much more than an input to calculate bus payments and to monitor fleet operations. I argue that the centrality of ADATRAP allowed big data to circulate in unimagined ways and places at the DTPM, and beyond.

As mentioned previously, a decisive moment in the history of big data in Transantiago was when the first contracts were designed and signed between the MTT and the diversity of service providers of the new system. This included private bus companies and complementary service providers which would oversee the technology provision of the system. It also comprised the development of a new data infrastructure composed by an online GPS tracking service, and data generated from every BIP card transaction. These contracts established the type of data to be generated in the system, how it was meant to be used, and more importantly, who the owner of that data will be. The latter acts as a triggering condition to understand the data circulation in Transantiago since, thanks to that specific contractual indication, the data generated would be subjected to the Law Nº20.285 “Sobre el acceso a la información pública”, which regulates the ways by which public data can be accessible for anyone. Without this contractual definition, ADATRAP would possibly never have existed, as some people involved in the development of the software recognised during my interviews. In the same way, this contractual term also allowed a wide diversity of software to use the operational data of Transantiago, that is the case of ADATRAP but also of other developments such as TRANSIT which is mentioned in chapter 4.

The public ownership of Transantiago’s[66] data is more the exception than the rule. There are at least two examples within the transport sector in which the data is neither public nor explicitly accessible when the data is generated by a third party

[66] Chile has a distinctive model of public-private-partnerships in several areas. Commonly, ownership, and therefore the access to the data generated as part of the service provision, does not belong to the State but to the service providers.

within a private-public-partnership (PPP). That is the case of urban highways in Santiago, infrastructure that generates data of every vehicle that passes by free-flow toll gates with Automatic Vehicle Identification (AVI); this data is stored and processed by each of the private concessionaries, and it is only vaguely known how they make use of it. Therefore, the data is fragmented, handled by every provider, and underused by the public authority. In case anyone wants to get access to the toll data, the best way to do it is to talk directly to the toll companies, which then need to issue a permit by the relevant authority to share the data. External developments using the toll data are scarce; a notable exception is a car crash prediction model which is sourced by a portion of toll data provided by one tolling company. Using the data, a group of transport researchers built the "Autopista Segura" ("Safe Highway") software and have published academic research on the topic (i.e., Basso et al., 2018).

Another case is the mobile phone network data. The way the Chilean State delegates mobile phones network spectrums to private communications companies have a similar ownership problem, also leading to difficult access and fragmentation. Each phone company owns the data generated by the connections of individuals using the networks, which ultimately creates traffic flows of their users' data. Transport researchers and practitioners identified the data as incredibly valuable since it reflects origin-destination traces of mobile phone users, which indeed could be even more precise than the estimations made by BIP card transactions. If the data was centralised by the public authority, as in Transantiago, the possibilities of making something similar to ADATRAP could have led to an even more precise tool for travel behaviour analysis and transport demand modelling (Graells-Garrido & Peña-Araya, 2020). Some of the potential gains of the mobile phone data are the volume and granularity, especially considering that there are more than 26 million mobile phones in the country

(Subtel, 2019), an impressive figure considering that the total country population is 18 million. The COVID-19 pandemic crisis has helped reveal the usefulness of the mobile phone data for travel behaviour analysis, given that the aggregated mobility data was used to indicate quarantine compliance (Carranza et al., 2020; Pappalardo et al., 2020). However, the mobility data was made available only by a few different mobile phone companies separately, so each analysis was limited to each company's users. The reports were prepared thanks to joint projects and an academic institution responsible for the data analysis, and in each case without direct involvement of the transport authorities.

In Transantiago the situation is entirely different, since the initial consideration of public ownership of the data created a path dependency allowing the data dispositive to emerge and develop.

> *"The data availability is stipulated in the first contracts [of Transantiago]. Without this, no ADATRAP would have been possible really. In the contracts It is established that the data can be used in broad terms, defining it as State property. Definition that responds to a long-term strategic vision. I imagine that people involved in contract design consciously made that effort as they believed this was a very concrete need. Probably without imagining the full richness, even that now it looks like something obvious! well, it was not at the time. Therefore, the first step to extract the value of the system's data is that it is not the private service providers' property, which is the case of the mobile phones and the urban highways". (DTPM planning division assessor)*

As we know now, the inclusion of the "data clause" in the early contracts was not just out of luck or a random occurrence of the people designing the contracts before Transantiago was launched. First, there were some vague introductory ideas about automated passenger counters and smart card transactions in the "Plan de Transporte Urbano de Santiago", the planning document which served as a baseline to Transantiago's design (Bustos et al., 2000). Second, and much more importantly, was the influence of the transport engineering community as already analysed in the previous chapter. So, technology, and more specifically the transition towards a data-intensive system, were already part of the discussions taken during those days in the early 2000's.

However, including new technologies to produce new sources of operational data was not enough to consolidate a "virtuous cycle" (remembering what a transport academic mentioned in Chapter 5) on how to make the most of the data to improve the system. After the regulatory clearance, the next step was making big data essential for the system beyond payments and fleet management.

As stated by a member of the Transport Planning Unit at the DTPM which stated that public ownership was only a first step in the data circulation process:

> *"Public ownership was only the first step. Then we needed to make the data available for third parties, to make more with it. However, this wasn't really a thing in Transantiago when it started. That internal buy-in changed when a few unexpected uses of the data happened. "In 2008/2009, the government developed a "bus-waiting prediction tool" hiring a technology company using online GPS data. (…) This tool remained open as a "test" website without being launched to the public. However, someone randomly found the website and that person generated a mobile SMS app using the data stored on that website. The chief's first reaction at the DTPM was funny since he immediately said: "we need to close the website", so the authority blocked the website. However, later, someone at the MTT said: "why don't we make this information public? So, the approach dramatically changed. The transport authorities agreed with the mobile phone companies to make a massive SMS alert service available based on the app made by this unidentified person. That is a wonderful example of the power of making the data available for the public and a virtuous*

cycles arise consequently". (DTPM transport planning unit advisor interview)

Progressively, the transport authorities began to understand the real opportunities of the new data. In this case, the online GPS data was used by an anonymous person who found access to the data located in an unfinished website. The unexpected use of the data helped to generate buy-in among the Transantiago authorities towards making the operational data for third-party use. This random development did not progress any further, yet it created a new atmosphere around the potential benefits of using the GPS data. This development ended up working as a proof of concept, reinforcing the idea that more could be done with the new operational data generated within the system.

However, neither the “data clause” nor the preliminary proofs of concept of what can be done with the operational big data were enough to ensure a consistent buy-in of the transport authorities. In parallel with the regulatory clearance and the disposition of making the data available to the public, novel software developments helped the data to circulate. Although the wide variety of products generated using the GPS online services of Transantiago through the API[67], one software prevailed over the rest: the ADATRAP. As I explained in Chapter 1, ADATRAP is a software created to analyse the smart card transanctional data and the GPS data of Transantiago’s operations to optimize origin-destination analysis and fleet management.

"A second example, following the same line of the case of the open website and the SMS app, is ADATRAP. Before Transantiago started, we already knew that every bus would have an integrated GPS device and that the payment would be made using a smart card. Then, a group of engineering professors from the Universidad de Chile approached

[67] Application Programming Interphase. It is a way to communicate more two or more computers.

the Ministry of Transport and said: "you know, this is a beneficial data source for transport data analysis". So, access to the data was granted by the MTT to the university, and several prototypes were made. ADATRAP allows us to have detailed and updated data of each travel feeding on smart card transactions and GPS data. It gives us data about the number of people waiting at the bus stop and the origin-destination of the users. The software generates info on every trip made on public transport. After more than ten years, we have made several other incremental developments, especially related to transport demand modelling." (DTPM planning division advisor)

The increasing interest of the transport authorities to do more with the data was well capitalized by transport engineers developing the software ADATRAP. The software was a consequence of the initial opportunity seen by the transport engineers to make use of Transantiago's operational data. ADATRAP, during the first years of Transantiago was a peripheral effort, mostly academic, to innovate developing software to optimize the use of the operational big data of the system. At the time it was not of major significance in Transantiago but, given that ADATRAP was neither a cost for Transantiago, it was seen as potentially useful. So, when the authorities became aware of, and were more attracted to explore, the alternate uses of the operational data —the base of what to do, with what people, and concrete cases of what was possible to achieve, was already in place within the system.

Through a gradual and highly experimental process since then, ADATRAP has become an OPP channeling the efforts to do more with the operational big data generated in Transantiago. Seen now, it is recognised by some of my interviewees that ADATRAP was not necessarily the most cost-effective software to make the operational data circulate in Transantiago, especially if we compare it with a wide variety of software solutions existing today in the market. However, at the time, it was seen as the best course of action to follow, and now it is just too costly to migrate to a different tool. In that sense, ADATRAP is much more than an unavoidable tool at the DTPM; over time it induced organisational changes (like the creation of the Data Team), it solidified inter-institutional relations between the DTPM and Universidad de Chile, as well as evolving into a more user-friendly software and incorporating additional data analysis and data visualization tools which did not required major technical expertise to be handled.

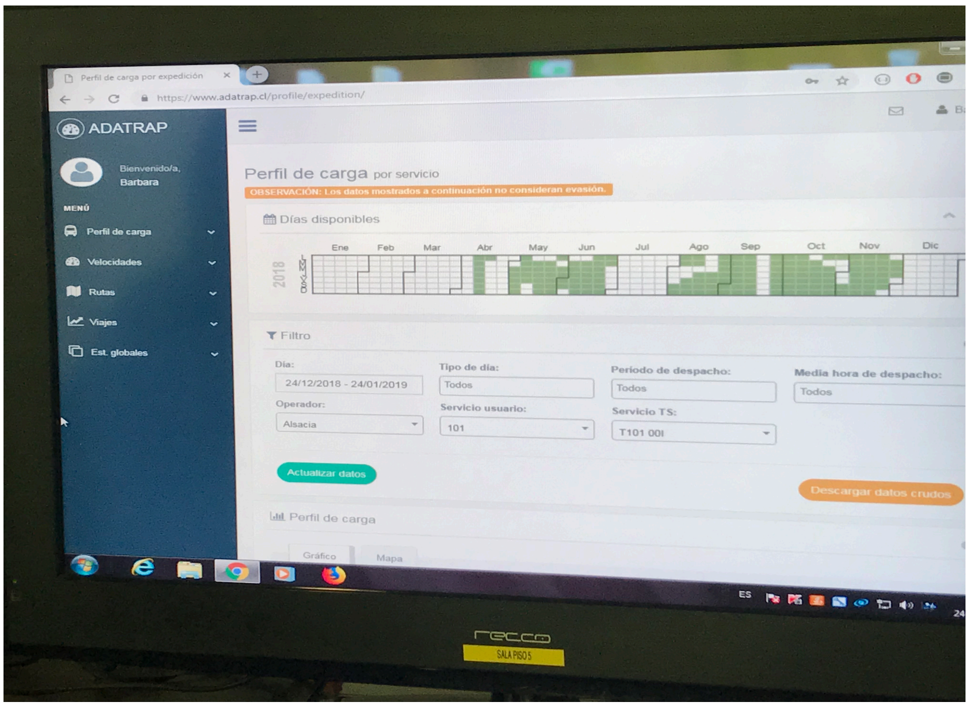

Figure 18 ADATRAP layout showing a visualisation of the charging profile by service of one line of Transantiago's buses. The photo was taken at the DTPM offices at an analyst desk, with permission, during one of my visits.

Figure 19 ADATRAP layout showing a speed matrix. Photo taken, with permission, during one of my visits at the DTPM.

Consequently, ADATRAP is the shared point by which all the rest of the discussion on "how to" make the data circulate through software is stabilised. ADATRAP is the main route for the transport system's data to circulate, and most of the further innovations are made within ADATRAP; as the project leader at the Universidad de Chile mentioned in an interview: *"ADATRAP is now everywhere. After all these years, now almost every process in Transantiago is somehow linked to ADATRAP"*. In other words, ADATRAP becomes the OPP that stabilises big data circulation in Transantiago, converting data circulation into a process that can take unexpected forms beyond its original purposes.

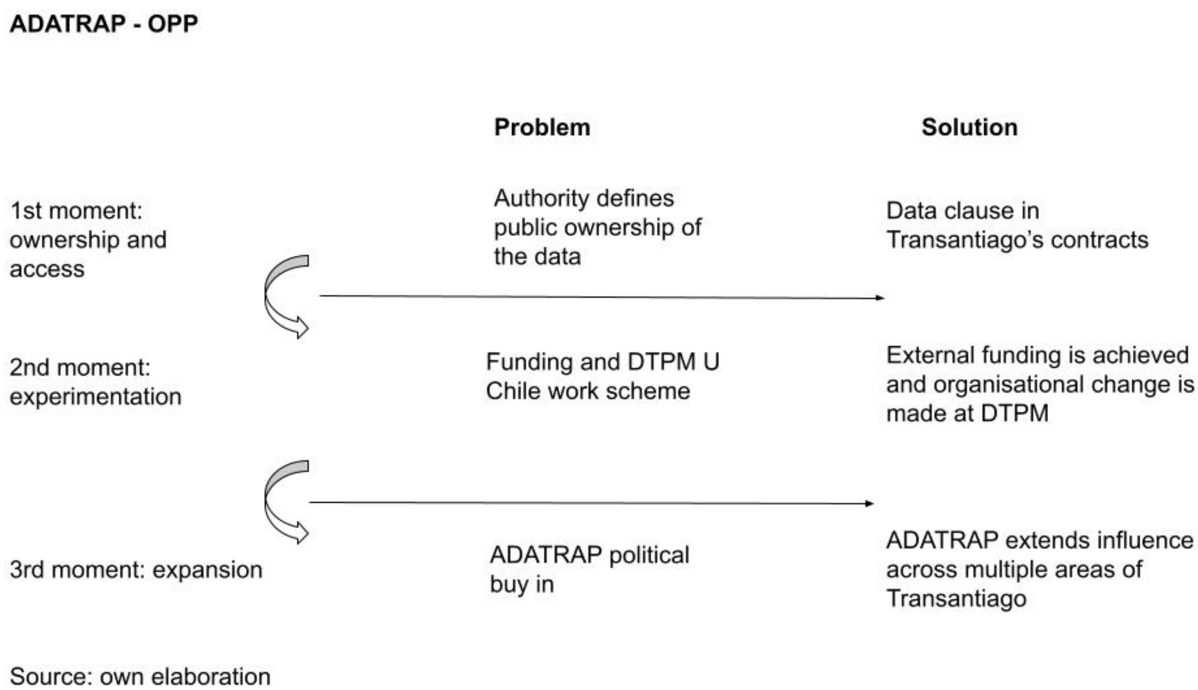

Figure 20. ADATRAP Obligatory Passage Point process.

I identify three moments in which the access to the data progresses towards broader circulation (Figure 20). The first moment refers to the inclusion of explicit clauses of data ownership in the early Transantiago's contracts. A second moment is marked by the generation of a collaboration framework between the engineers at the DTPM and the Department of Engineering at the Universidad de Chile, securing funding and a governance model to develop an appropriate tool/software to analyse Transantiago's operational data. The third is when the ADATRAP software gets the buy-in of the MTT and DTPM authorities since it proves its usefulness across Transantiago's management.

The case of ADATRAP reveals how the usefulness of big data must be worked out over the years through legal, technical, organisational and political operations. In that sense, ADATRAP became the unavoidable way by which the operational big data has been circulated across the system after a process of experimentation and learning between transport authorities and the Universidad de Chile's engineers. Today, as it has been mentioned already, ADATRAP permeates almost every single space of Transantiago, shaping the system operational management as well as the internal organisational structure.

6.3 Second Obligatory Passage Point: The origin-destination matrix.

In this section I concentrate on a different OPP: the origin-destination matrix. Origin destination-matrices (OD Matrix) are essential tools for transport planning, especially for the estimation of transport demand-models and travel forecasting. They are one of the main inputs, if not the main input, of ADATRAP —it's not an exaggeration to say that ADATRAP relies on its capacity to generate these matrices.

Well-known across the transport research community is the origin-destination matrix, which in simple terms denotes the origin and the destination of the observed mobility in a particular place. In other words, an empty origin-destination matrix represents all possible combinations of origins and destinations; filled, it represents the distribution of the observed origin-destination combination over all possible combinations. Ureta (2015, 2017) states that origin-destination data is an essential input for transport modelling in Santiago de Chile, and therefore has enormous relevance across the planning and management of the system, especially when the data is available. The origin-destination data configures an ontology of what public transport is, in which everything is analysed through the origin-destination framework (Ureta, 2015).

The origin-destination ontology has had a massive influence on transport planning as a discipline and as a policy-making practice which the lack of data has historically guided, so the abundance of big data generates a momentary situation of uncertainty that requires finding a new common output to make the data circulate. In this section, therefore, I analyse the operations by which origin destination matrices remained obligatory passage points for the circulation of big data in Transantiago.

Table 3
Aggregated OD matrix March 2009.

	North	West	East	Center	South	South-East	D_j
North	157,950	36,389	51,489	78,906	22,988	18,087	**365,810**
West	34,164	294,670	116,217	162,561	37,041	30,525	**675,177**
East	49,382	112,436	317,606	173,157	70,812	150,056	**873,450**
Center	74,593	167,516	160,132	171,932	103,127	96,399	**773,700**
South	22,222	34,877	73,977	104,116	189,216	54,216	**478,624**
South-East	18,379	30,450	158,839	97,234	55,614	250,057	**610,572**
O_i	**356,690**	**676,338**	**878,261**	**787,906**	**478,798**	**599,339**	**3777,333**

Table 4
Aggregated OD matrix June 2010.

	North	West	East	Center	South	South–East	D_j
North	176,291	38,976	57,360	86,022	24,671	20,565	**403,885**
West	37,568	313,822	131,083	176,402	38,491	33,571	**730,937**
East	52,693	120,714	349,172	187,507	71,893	160,822	**942,799**
Center	84,344	178,518	168,284	176,849	106,518	100,024	**814,538**
South	24,658	37,350	83,124	113,291	194,636	56,133	**509,192**
South–East	20,115	33,326	170,041	104,565	56,563	255,868	**640,478**
O_i	**395,668**	**722,707**	**959,064**	**844,636**	**492,772**	**626,982**	**4041,830**

Figure 21 [table 3 and 4]; an example of an origin-destination matrix generated through the data extracted from the ADATRAP software for March 2009 and June 2010 (Munizaga & Palma, 2012).

Transport engineering research, and transport planning especially, is historically based on quantitative data analysis. In the same way, the capacity to anticipate potential scenarios through travel forecasting tools like travel demand models are seen as the holy grail for the planning practice (Boyce & Williams, 2015). This is confirmed by most of my interviewees who mentioned these devices constantly during the interviews. As in other quantitative approaches, the challenge of dealing with the scarcity of data is solved by using inferential statistics and representative agents. The drive to represent *the whole by parts of the whole* through techniques of representative sampling in the 19th century marked a break from the tradition of generating descriptive data from smaller communities (Desrosières, 1998). Fast-forwarding, big data today generates a similar break to the one presented by the emergence of statistical methods. However, the question now is about handling the abundance of data without affecting the challenge of representing the population, without sacrificing the rigour of statistical methods. The break presents the challenge "to do more" with the excess rather than dealing with the challenges of not having enough data. Big data results from reconfiguring pre-existing organisational and regulatory conditions (Ollion, 2015), specialized technical skills, and advanced computational power (Batty, 2018). These changes in techniques have not necessarily triggered a more comprehensive process of reflective thought and action about the transport engineering practice. Instead, it has been marked by a sort of "Leopardism"[68] where everything changes as a strategy to keep things equal.

The rise of big data redefines the problem of how to make data circulate using accurate statistical methods that lead to reliable travel forecasting. The problem now refers to the capacity of structuring and manipulating the abundance of data in a consistent and accessible manner. Currently, working with big data is posited more as manipulation skills, that is, highly advanced computational and coding skills and not necessarily more sophisticated statistical methods. Thus, instead of representing a significant shift in terms of accuracy and robustness, working with big data is massively marked by the capacity of certain spokespersons (i.e. boundary spanners) to influence the concerned publics on the reliability of big data over what previously existed. In that sense, producing an artificial antagonism

[68] Following the literary example of Lampedusa's book Il Gatopardo, which often is used as a reference denoting the need of "changing everything, so nothing changes at all".

between big and small or abundance and scarcity becomes a strategy of some of these spokespersons to validate their positions (Kitchin, 2014b). Differently, in the case of Transantiago, the public "selling" of big data opportunities has been driven mostly by transport experts and transport academics, so it has been less motivated by business opportunities and more by an interest in producing more inputs leading to enhance Transantiago as a system.

Before ADATRAP, the "old" form of data was generated through the "Encuesta Origen Destino de Viajes" (Origin Destination Survey in English), based on face-to-face surveys, which was conducted by SECTRA at the MTT. This survey had two goals i) to collect detailed information about the trips made in Santiago and from the people who make those trips, and ii) to satisfy the requirements of information for the strategic transport demand modelling for the city (SECTRA, 2014). The information provided by this survey was then used to produce OD Matrices.

As any other survey, it represented a "snapshot" of the everyday travel of Santiago in one specific moment. Moreover, the data collection and data analysis process were costly and difficult. As such these surveys could only be updated every 10 years. To become representative of Santiago's population it required a specific large sample comprising around 60.000 households from a total population of 7.112.808[69]. So, the opportunity that ADATRAP provided is attractive as it could generate similar origin-destination data in shorter periods of time and at a lesser cost. However, there were, at least, two limitations. The first was the lack of valuable socio-demographic data, which face-to-face surveys provides and big data does not (Schwanen, 2017). The second, and probably more important, is the

[69] See: https://www.gobiernosantiago.cl/datos-geograficos/

question of statistical rigour. The problem of the abundance of data of ADATRAP had a significant issue, the data collected from every BIP card transaction only counts when a person is entering the bus, but not when that same person alights.

> *"We use algorithms to estimate where the people descend based on the next Bip! Card transaction. Based on that calculation, we can estimate with 80% precision where a person alights from a bus. That is the first strong algorithm. Then, we build a sequence based on each additional time a person gets into a bus, when a new transaction is made, and then when they descend, on and off, which bus line, etc. After this, we can start building the origin-destination matrix. Origin-destination matrices are the main input for transport planning, so if we get to reconstruct a person's travel trajectory, we can build the origin-destination matrix, which's crucial. There's a process there; a different algorithm collates the previous stages to then be allowed to say: "ok, these are the stages of a trip[70]". (ADATRAP software engineer interview)*

ADATRAP transforms the new digital data into a format that is compatible with the origin-destination logic according to which information on trips used for modelling purposes has traditionally been organised. In that sense, it is a complement of traditional surveying but not a replacement, since an 80% level of precision to estimate destination is not robust enough to adequately inform transport planning practice. ADATRAP uses the online availability of the BIP card transactions and the GPS data to calculate bus speeds, real-time estimations of passenger load profiles (or *perfiles de carga* in Spanish), among other automated calculations. In that sequence, algorithmic processes act as cumulative calculations, generating the origin-destination outputs. Following the quotation,

[70] A trip can be composed of several stages. Considering that the main limitation, from an operational data perspective, is that a user does not have to validate the Bip card when is descending that bus so that information must be estimated as a proxy of the last validation. To see more details please refer to (Gschwender et al., 2016; Munizaga & Palma, 2012)

we observe that algorithms are necessary forms of data manipulation that help structure data, impute missing data, and make automated calculations crucial to generating the origin-destination matrices. In practical terms, these algorithms work as components of ADATRAP, feeding on a daily average of 11 million GPS data observations (Basso et al., 2020) and close to 4.5 million daily contactless Bip! Card transactions on an average weekday in the city (Gschwender et al., 2016).

> *"We really understood that this was something of a different scale when we noticed that the EXCEL spreadsheet was not enough to analyse the massive amount of data, so we had to move towards proper databases" (DTPM planning division engineer)*

Computational capacity is an additional challenge in the process of converting big data into an OD Matrix. By "proper databases", the engineer was referring to SQL databases which were beyond their computational skills. SQL[71] is a popular database language that the older and more experienced DTPM engineers did not manage well, creating an additional technical challenge to sort out. Databases needed to be legible. In practice, the legibility of the data is more important than the abundance of the data, so, at some point, not being able to produce legible models with the data could be a problem. In this case, the abundance problem was resolved by translating the SQL database into a workable format, adjusting the smart card and GPS data processed by ADATRAP into an OD matrix.

Similarly, the preponderance of workable formats, such as MS Excel, expresses how more experienced transport researchers and specialists retain their positions of expertise in the data circulation process over other groups—usually corresponding to transport engineers with lower seniority at the DTPM or in

[71] Structured Query Language, programming language used to communicate with a database.

academia who can work in both formats, but more importantly, to translate it into the format of their superiors. That is tightly connected with the way the transport engineering community is internally organised in terms of seniority and hierarchies. Consequently, the OD matrix works as an obligatory passage point (OPP) because it sets the momentary state of certainty required by all the transport engineers to work on the transport models.

In this section, I have covered how OD matrices have remained as obligatory passage points in the data circulation process despite the changes of periodicity, volume, format, and skills of the new data. The prevalence of OD matrices as an unavoidable point is remarkably connected to the role of transport engineering in the data circulation process. As I argue in the beginning of the section, the origin-destination matrix enacts a logic, a way of seeing the world, an ontology of mobility that is essential for the transport engineering community. Therefore, any changes and potential opportunities that big data could generate are only possible if they are able to pass the filter of the OD Matrix. Otherwise, the data generated in the system would have remained, or in other words, the data circulation process would have taken an entirely different route. As seen, OD Matrices have been used in transport modelling before big data and ADATRAP, in that sense, the case of Transantiago is how these devices have remained central for the practice when the data becomes abundant rather than scarce, and ADATRAP has been essential to make that possible.

6.4 Third Obligatory Passage Point: Contracts and KPIs

In this section, I discuss contracts and KPIs as obligatory passage points enabling data to circulate. In this case, the OPP structures relationships between the public transport authority (enacted in the Ministry of Transport and the DTPM) and the private service providers and their relevance in the data circulation process –

which ultimately is translated into a measurable form. However, I distinguish between two types of contractual relationships. In the first part of the section, I refer specifically to the challenge of designing contracts between Transantiago public authorities and the complementary service providers, which are responsible for the digital technology provision of the system. In the second part of this section, I focus on the contracts between the authority and the privates bus service providers, the so-called business units of Transantiago. Here, the discussion moves towards the way in which data circulation has redefined key performance indicators over time, as a consequence of the “virtuous cycle” of ADATRAP. In both cases, I argue that data circulation has challenged the rigidness of contracts and KPIs triggering changes that have, ultimately, influenced the overall system’s performance.

In their own way, contracts and KPIs are OPPs working to regulate expectations, responsibilities, and incentives between Transantiago and their providers. They are also part of an operation of translation, as different actors, with their own visions and interests are required to black box an operational framework to become indisputable for Transantiago to function.

Briefly, we can recall that there are two categories of contracts depending on the public procurements of specific services: i) operational (private buses, metro), and ii) complementary services (technology). These categories are a simplification of the wider ecology of contracts in place to regulate relations within Transantiago. Here, I will discuss specifically how contracts regulate expectations between the actors involved in the data circulation process, producing stable arrangements within a certain rigid legal framework yet remaining open to change.

6.4.1 Technology provision, information asymmetries, and evolutive maintenance.

> *"Probably, one of the most significant changes from the previous system ("micros amarillas" – see Chapter 1) to Transantiago is related to the technology provision and the embeddedness of data in the core of the management of the system through the complementary services contracts. We need something different, based on new operational contracts aligned with an appropriate technological provision based on world-class standards" (Interview DTPM IT officer).*

Contracts are a different domain in which an OPP has been used to enable big data circulation. These legal devices enact several roles in defining *what* is possible to do by structuring and performing relationships between the actors involved in the process of data circulation. Before Transantiago, digital technologies were completely absent from public transport — it was only after the first group of contracts were signed that digital technologies became part of the core of public transport when the system was launched in February 2007. As we know, Transantiago introduced the so-called complementary services -the digital technologies- which was a major innovation of the new system, including new actors and associations, service providers, a whole new set of interdependent infrastructures requiring specific attention, software, data, new skills, organisational changes, and so forth. Accordingly, contracts have played a pivotal role in the way those associations have been imagined, and structured, while as regulatory devices they have had to remain flexible enough to introduce changes, especially considering the speed of new technological developments.

> *"Probably the main problem was that the people that negotiated the first contracts did not know what to ask in terms of data provision, and probably SONDA took advantage of that. Because it was clear that they could have provided more from the beginning, yet we didn't*

know what to ask until after the system was running." (DTPM former planning officer interview)

"I was not directly involved at the time when these contracts were designed, but my experience as close observer of the whole process from academia allows me to think that SONDA could have done much more that what they did as the main technology provider of the system". (Transport engineering academic)

Most interviewees expressed concerns regarding the effectiveness of the technological provision contracts to meet the transport system requirements, especially when the first batch of contracts were designed and assigned. Contracts are necessary to structure relationships, set the technical specifications, and to delimitate the technical services expected from the complementary services providers, everything commonly agreed and established on paper. However, setting up contracts that complied with what was really needed by the transport authority has not been easy at all, especially in relation to the digital technologies and its providers. However, this is something that has changed over time, making the information gaps between the transport authority and their contractors smaller.

The alignment of expectations between DTPM and the complementary service providers is not as straightforward as just stablishing roles, duties, and responsibilities in contractual terms. Instead, it oscillates between the legal rigidness of the contract and the requirement of flexibility to introduce changes to the provision without necessarily change the whole contracting process. In other words, the process in which data circulation has proliferated has challenged the contractual agreements, so over the years, the actors have managed to create a way to deal with technological change without renegotiating the whole batch of technology provision. Balancing the expectations between the rigidness of the law and the flexibility of technological innovation has been a complex and iterative process in Transantiago:

> "*There is a problem with the design [of the complementary services contracts]. In 2012 we renegotiated the contract with Sonda, defining their work as a service. That allowed us to subcontract part of the provision to deal with the obsolescence. That helped to catching up with the rapidly changing technological landscape, however, the main issue has been to know what we can really need beyond what is offered by the technology companies." (Former DTPM director)*

Let us for a moment remember that, after some years of chaotic operations during the first presidency of Sebastián Piñera (2010-2014), most of the contracts were renegotiated. The principle that motivated these changes was to improve the performance of the system based on the readjustments of the incentives for the service providers. In the case of the CSP, the contractual changes determined more flexibility regarding the potential, unexpected and unforeseen technology innovations. In the same way, it opened the possibility of sub-contracting technology to deconcentrate part of the provision. This is for example the case of the collaboration subscribed with INRIA to develop a complementary tool to the Sinóptico provided by SONDA, seen in chapter 4.

Most interviewees and several other analysts and policymakers agreed on how difficult it has been to stabilise the system's operation through long-term contracts for various reasons. Notably, the contracts are legal devices that shape and direct the public transport system as a unified system based on multiple individual sub-contracts, establishing the rules and requirements that regulate the relationship between the public sector and private providers. They set critical regulatory elements such as the ownership of the data generated in the system, or the software license developed for those purposes.

Contracts translate the expectations of the Ministry of Transport and the complementary service providers by delimiting roles and mobilising the enrolment strategies operationalised in the text. The Ministry of Transport has made significant progress in clarifying their expectations regarding the technology provision indicated in the contracts, to make it flexible enough to catch up with the emerging technologies more efficiently. This was made possible after years of accumulated experience working with the new data at the DTPM, which has been possible thanks to internal rearrangements such as skills development, new units, and internal areas, along with the increasing internal relevance of ADATRAP, as seen previously in this chapter. That is the case, for example, with the data team analysed in chapter 5. Ultimately, these groups enacted more than an internal need to do more with the data and acted as technical groups capable of acting as counterparts to other technical groups such as SONDA, or any other potential technology provider.

SONDA has responded to the problem of bridging the informational gaps of their services towards the transport authorities. For them, more than making a critical analysis of their role as a provider, this means focusing on simplifying the narrative of 23 contractually established services to Transantiago. To communicate those, SONDA grouped their services in two types: *payment management* and *operational* data services. The latter are generally referred to as the GPS online service[72] and include the data generated by GPS tracking and smart card transactions. Further, SONDA has created an additional narrative strategy to cope with the problem of technology obsolescence; that is, the idea of *evolutionary maintenance.* SONDA has coined the notion to delimit the

[72] It is common within the public transport system to talk about the "online service", which is the access point to the GPS data open to every bus provider and other third parties interested in generating software or apps using the online GPS data.

responsibilities of the company vis-à-vis the Ministry of Transport and the DTPM. The idea responds to the problem of adjusting the contracts depending on the emerging new requirements that the authority has technology-wise:

> *"The 2013 contracts have differences to the previous versions. One of them includes the evolutionary maintenance service. Therefore, we should modify a system with an incremental methodology. We start from a problem to a solution in various steps, following a process like the AGILE methodology for software development. We also know what the adequate service levels are that we are expected to provide; for example, the contract includes the possibility of errors in the software development and the chance to make further corrections" (SONDA Executive Interview).*

Therefore, the possibilities of making new requests, or amending errors in software development, adjusting criteria in the formatting of the database, asking for clarification in data processing, or providing additional access to the online data to external users (such as academics or external developers) are all processes linked to the evolutionary maintenance service. In the same way, the analogy to recognizable AGILE[73] methodology, a widely known software development methodology, creates an atmosphere of certitude beyond the unexpected ways the technology provision, and the data circulation process can take.

As seen in this section, contracts are legal devices that are crucial to defining the trajectories that the data circulation can take throughout the dispositif. The most important characteristic is their malleable function as they are flexible enough to realign and enrol the public authorities and the service providers in different

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[73] Agile methodologies and practices emerged as an attempt to more formally and explicitly embrace higher rates of change in software requirements and customer expectations (Williams, 2010, p. 1)

periods. The role of translation, in this case, is manifested by precise formulations that support the provision of the complementary services provider's services (i.e., Sonda) without necessarily explaining in detail each of the contract components, in short, the simplification of the narrative. That process is characterised by selecting key concepts, like the last example of *evolutive maintenance*, which operates as an obligatory passage point shared by Sonda as the key complementary services provider and the DTPM representing the transport authority. Consequently, *evolutive maintenance* has served to realign their expectations on the services required by the transport authority and the ones offered and provided by Sonda. This means that *evolutive maintenance* is a different kind of obligatory passage point. It represents a narrative operation to make things stable, it resides on using a particular term that enable changes within a rigid contractual framework. It is more subtle and less present in the data circulation process, but not for that matter less relevant. However, *evolutive maintenance* is the last link to negotiations that started early before the implementation of Transantiago in 2007, in which expectations between the authority and Sonda have been at stake requiring adjustments in terms of the skills, the organisational structure and the narrative of what was expected and what is provided.

6.4.2 Key Performance Indicators

> *"When Transantiago started the incentives were incorrectly conceived. Because they did not direct the operation of the private providers to deliver a better service for the users. Once we started to generate more detailed data and understand that data, we could generate a new order of incentives to provide a more effective and efficient service. So, access to massive and more detailed data gave us new opportunities to generate new relevant questions that we could not have known otherwise. All of which was afterwards*

> *incorporated into the new contracts". (Former DTPM planning division manager).*

Now, a different way in which contracts operate in Transantiago are the bus provision contracts. Setting up performance indicators that are suitable to produce efficient incentives to enhance the service provision from the side of the bus providers is another way contracts have emerged as a problem in the data circulation process. The appearance and expansion of big data through developments like ADATRAP have had massive effect on the redefinition of contracts between Transantiago and its bus providers, as well as in the development of new KPIs, generating new financial incentives for the operators. In other words, data circulation transformed the possibilities of evaluating the system's performance according to new KPIs, redefining the existing incentives scheme between Transantiago and its service providers, specifically the bus fleet provision and operations. In the case of the bus service provision, the KPIs represent a different form of OPP –one that is contractually established, yet which interacts differently with the data circulation process.

The indicators produced within public transportation are crucial for translating the contractual terms into measurable, detailed, and transparent key performance indicators (KPI). These calculations are essential elements of the data dispositif. KPIs numerically organise how the Ministry of Transport and their third-private parties (i.e., private bus providers) interact through a complex system of measurements and quantifiable indicators. Accordingly, they are included in the contracts between the Ministry of Transport and the bus service providers. Transantiago predominantly uses quantitative KPIs to analyse the system operations on an everyday basis, but also over longer periods of time. Further, KPIs are used to evaluate bus providers' performance, to set up provider incentives through different mechanisms which could lead to operational fines, or even to the unilateral cancellation of a specific bus service due to performance reasons (Hurtubia & Leonhardt, 2021). Likewise, KPIs are capable of quantitatively tracking down performance, in contrast to other non-quantitative forms of evaluation and comparison.

The discussion on indicators is tightly connected to generating the appropriate incentives to keep public transport circulating efficiently in the city. For example, a former transport authority mentioned that the early KPI were so draconian that they were ultimately unenforceable, because otherwise it would have led to the bankruptcy of every bus provider.

In the introduction Chapter (section 1.2.3), I give a detailed overview of the main KPIs along with the changes established in the new contracts in 2012. As a refresher, the main changes in the contract renegotiation between Transantiago and the private bus providers rested on redefining the operational incentives through a risk transfer from the regulator towards the providers. Contracts include fines and revenue deductions from the service providers in case of poor service delivery. The main KPIs for operational purposes are:

i) The Average Seating Time Compliance Index (ICPH), which is calculated as the number of buses operating every half-hour multiplied by their total capacity, divided by the theoretical figure indicated in the operating programme (Gómez-Lobo & Briones, 2014).
ii) The Bus Frequency Compliance Index (ICF), which is a monthly indicator that measures the number of buses that each bus operator has on its

routes and compares it with the number of buses planned in the operational programmes[74].

iii) Bus Regularity Compliance Index (ICR), which registers the average difference in the time intervals between the actual services and the intervals between scheduled services according to the operational programme. It is based in the coefficient of variation (CV) of the headways observed in a period of service. This indicator is relevant since it operationalises one of the most mentioned elements related to the quality of the service: the user waiting times (Andrade, 2017).

These indicators work as *conventions of equivalence* (Desrosières, 2001) reducing the data's complexity into mathematical calculations shared and accepted by the transport authority and the service providers, generating agreement on the performance required by the transport authority. As I could determine through the interviews, these agreements could be summarized into the following sequence:

i) The indicators and fines are negotiated (and potentially agreed upon) between the public authority and the private service providers;
ii) the acceptance of those indicators and the establishment of a transparent verification mechanisms, and consequently the possibility of asking for further clarifications;
iii) and hence, the *normalisation* of those indicators.

This process reveals how the transport authorities seek to measure and enforce the bus providers' performance quantitively. However, the process itself has been

[74] These programmes are designed by the bus operators and validated by the transport authority. They define the routes of the buses and are then used to compare the projected performance in relation to what actually happened.

matter of dispute and critiques. It has led to changes, as seen, over extensive periods of time to redefine indicators and incentives. Also, it has been subjected to questioning by the operators who did not necessarily agree on the calculations and the fines imposed. On that point, a high-level executive at SONDA recognised:

> *"During the first years of the system, we had some issues with some of the bus operators that disputed our calculations, but these trust problems have been resolved over time. We had to use much time explaining the data and our calculations to the public authority and then to the bus service providers. Nevertheless, it was crucial to do it thoroughly to generate basic trust with our clients, which is what supports our work". (Interview SONDA executive).*

The process by which these indicators and fines became obligatory passage points was not exempt from troubles and challenges.

> *"I remember enormous challenges dealing with the data because we did not know how to make the calculations to pay the providers, following what was stipulated in the contracts. The contracts said: "the variable "time of the bus trip'"; and then we had to calculate the difference between the operational programme and what was the reality. Then we had the interval between the buses to get the regularity index and then explain how to make the calculation. But how the hell would I get that data? The contracts assumed that the data was available as something magical. Nevertheless, which data was valuable? Which was not? The process in which you end with a number that works according to what is said in the contract is quite unclear, primarily because of the technical criteria to determine how to make the calculations and which data is required to calculate that final indicator result. There was much room to select things that would result in different numbers, affecting the payments or producing fines to the service providers. So, it was far from an automatic process or a question of pure technology. There was a naive divorce between knowing where the data was and what to do afterwards to prepare it to make it useful without harming anyone." (Former DTPM planning division analyst)*

To define a KPI in a contract was insufficient to determine how those will be calculated. By any means, these indicators are presented as trustable, yet, following the last two quotations, they are still subject to manipulation. Their efficacy relies on the stability provided by the process in which they are agreed as per a convention of equivalence, getting established in formal contractual form, and become black boxed as a calculation by a trusted third party, as well as being enforceable through a form of pecuniary punishment.

The normalisation of these indicators, or how they become a convention of equivalence, is crucial to the system's general management because it structures the relationship between the Ministry of Transport and the bus service providers. Accordingly, indicators are unavoidable for overseeing the operational management of the system, yet they can be different, and most certainly will be different, depending on the need to restructure relations and incentives of the bus providers.

After the 2012 contract re-negotiations, additional indicator issues emerged. For example, the need to grasp the users' evaluation became relevant because of the limitations of the prevalent KPIs (ICPH, ICF, ICR) that do not include users' perception and overall satisfaction with the service.

> *"One of our challenges is to measure what needs to be measured to capture the system's improvements. As in other places globally, we expect to use more big data to generate a better service based on more detailed and real-time information. We also expect to illustrate the system's performance by capturing the needs and concerns of the population. We think that we have made impressive progress in understanding how the system works, and based on that, we know that the system objectively is better than in the past. However, for some unknown reason, those improvements aren't reflected on user's perception". (Secretary of Transport interview)*

There is a difference between “what” is measured and “how” it is measured. Indeed, authorities seem more preoccupied with “how” to quantify Transantiago (tools, data, software, KPI’s etc.) yet not sufficiently with “what” needs to be measured, beyond quantitative KPI’s. In other words, the way Transantiago is measured is still locked-in within the transport engineering ontology disregarding relevant aspects of the service performance beyond efficiency, regularity, waiting times and optimization. At the same time, the authority makes a parallel with international benchmarking, probably large cities in the global north, as happened often in my interviews. How the system is measured is aligned with the predominant epistemic culture in Transantiago, following the argument made in chapter 5. However, the predominant epistemic culture is less effective in determining alternative subjective measures that reflect the authorities’ interests.

The authorities in response sought to explore what and how to quantify Transantiago’s performance, differently. The introduction of the “mystery passenger” or the implementation of user satisfaction surveys are examples of efforts to include users’ experience and qualitative data. These complementary indicators are inputs to quantify the “ranking of service provision” by the comparative analysis of the different performance indicators (including the ICF, ICR and qualitative indicators) amongst the bus service providers. Systematic poor evaluation based on the ranking can lead to hard measures, which was the case of the early contract termination of one of the biggest bus providers (Alsacia) in 2018. The provider’s early termination was a significant milestone in Transantiago; before that, no one really believed it was feasible to remove a provider given their size and potential aggregated negative effect on the bus provision. Despite the notable impact of alternative KPIs, Transantiago’s operation is still based mostly on “quantitative” KPIs such as the ICPH, ICF, and ICR. The latter is closely connected with the epistemic culture prevalent in Transantiago, as seen in chapter 5. By this, I am saying that it is more likely that indicators focusing on user experiences and subjectivities are seen as soft and vague, as less objective, and rigorous, by Transantiago's specialists.

In this section, I have analysed contracts and KPI's together as usually operate in tandem. Both OPPs fulfil a similar function in the data circulation: that is, to structure, regulate, and to order mutual expectations regarding service provision. The idea that a contract or a KPI is unavoidable to mobilise data circulation is fairly obvious—the public sector and private providers normally use contracts to structure how they will work together, including enforcement mechanisms such as penalties, fines, and early contract cancellations. However, despite the obduracy and rigidness of contracts, they are prone to change over time. More importantly, in this section I have shown how contracts and KPI's are overflown by data circulation, so ultimately, the changes are a consequence of the increased influence of big data in Transantiago over the years.

6.5 Conclusion

In this chapter, I have discussed three obligatory passage points operating in the transport data dispositif. As seen, an OPP emerge in moments of uncertainty, when different actors need to converge in order to achieve or maintain data circulation. Therefore, OPPs play a significant role in providing stability to the data dispositif, and to Transantiago as a system.

The three OPPs addressed in this chapter (ADATRAP, OD-Matrices, and Contracts and KPIs) have a common feature: in every case, they enact an operation to balance the continuities and discontinuities of the data circulation process. For example, ADATRAP works as a tool to enable data circulation in a context where new operational data appeared, yet without knowing to what extent the new data would be useful to Transantiago. ADATRAP did not start as an OPP, but became one, after a lot of hard work. For example, it involved early contractual decisions aligned with transparency laws and a regulatory framework which allowed the new data to become accessible. At the same time, ADATRAP required multiple other operations to become OPP. These include cross-institutional collaboration between academia and the Ministry of Transport to build the new software, to ensure funding, to generate proofs of concept that can demonstrate its usefulness to higher-ranked authorities, among other actions. Also, ADATRAP as OPP is tightly connected to OD Matrices, which is another OPP. Ultimately, the endurance of ADATRAP depends on its capacity to provide OD Matrices, to respect that format.

Then, contracts and KPIs also enact OPPs that provide stability to the heterogenous associations involved in the data circulation, trying to provide order, to determine responsibilities, commitments and mechanisms of control and punishment, where necessary. However, even its rigidness, the dynamics and expansion of the data circulation in Transantiago have stressed contracts and KPIs to the point that they also needed to change; that is, to redefine and rearrange its components, including new associations, so they became effective as tools to legally and operationally structure relationships and expectations between the transport authorities and its service providers.

Ultimately, OPPs demonstrate that a heterogenous ensemble such as a dispositif is possible, it can work and make things work. In that sense, data circulation is not only possible, but also effective in terms of enabling Transantiago as a system. Yet, at the same time, it demonstrates that stability is fragile: it relies on specific operations, experimental and uncertain associations, on individuals' creativity, aligned with devices like contracts, on finding problems and endurable solutions.

7. Conclusions

This dissertation unravels the intricate journey of big data circulation in Transantiago, highlighting that the subtle balance of this achievement is continuously shaped and reshaped by the way that big data circulates, and what it does in that process.

In this work, I delve into the complex interplay between human and non-human actors as they form a data dispositif, shaped by the problems of data circulation and their subsequent solutions. Through this exploration, I uncover a network of unexpected connections between materialities, knowledge groups, expert practices, and obligatory passage points, all contributing to the data circulation and configuration of the data dispositif in Transantiago. This work seeks to highlight the complex tapestry of big data in Transantiago by symmetrically examining the people, institutions, companies, devices, contracts, regulations, techniques, practices, and cultures that facilitate data circulation within Santiago's public transport system. Emphasising *"gets to,"* I assert that data circulation is neither guaranteed nor finalised, but rather a continuously evolving outcome of a dynamic network of relations, configurations, and agencies. Accordingly, big data in Transantiago is a precarious, yet noteworthy accomplishment that ultimately redefines what public transport is in Santiago de Chile.

In this final chapter, I underscore the conclusions and contributions of my dissertation, delving into the empirically grounded interconnections between smart cities, big data, and public transport in Santiago de Chile. Accordingly, I structure the chapter by outlining the main conclusions and contributions of my research, drawing on my findings. In the first section, I focus on the relationship between smart cities and urban big data in Latin America. In the second section, I explore the theoretical and methodological implications of data dispositifs as a suitable approach for studying and unpacking big data. The third and fourth sections address the two main empirical contributions of my work, specifically, the role of experts, expertise, and knowledge production, as well as the emerging arrangements, configurations, and their relationship with urban and transport governance. The final section envisions the outlook for future research on urban big data in Latin America and globally.

7.1 Smart cities and big data in a Latin-American city.

Much of the work on smart cities is more or less connected to the potential opportunities that data-infused "solutions" present for addressing urban challenges, and urban management in particular. In response, an important amount of the scholarship on smart cities has criticised the "technological fixes" of the previous approaches, developing what now is called "critical smart urbanism" (Luque-Ayala & Marvin, 2015; Marvin et al., 2016). Initially centring the analysis on corporate storytelling (Hollands, 2015; Sadowski & Bendor, 2019; Söderström et al., 2014), neoliberal expansion (Cardullo & Kitchin, 2019; Datta, 2015b; Jirón et al., 2021; Sadowski, 2019), and the political economy of the smart cities as techno-political project (Aurigi & Odendaal, 2021; Klauser et al., 2014; Krivý, 2018; Smith & Martín, 2021; Vanolo, 2014), the discussion has increasingly moved towards the implications of big data for urban processes beyond smart city projects and policies (Bannister & O'Sullivan, 2021; Barns, 2021; Baykurt & Raetzsch, 2020; Coletta et al., 2019; Luque-Ayala & Marvin, 2016, 2020), including an important amount of work on platform urbanism (Barns, 2018, 2020; Blok et al., 2018; Hodson, 2021; Rose et al., 2020). My dissertation contributes to that direction as it posits the analysis of big data as part of a larger urban service beyond the mainstream programmes and accounts of the smart city.

The self-congratulatory narratives surrounding big data, primarily advanced by big-tech companies, and eagerly endorsed by international organisations and governments, portray an oversimplified account of big data effortlessly navigating communities of practice and urban spaces, informing decision-making processes—a depiction that is ultimately inadequate. My work aligns, then, with scholarship already identifying the need to critically analyse how big data and urban management enmesh together more effectively (Barns, 2021; Batty, 2016; Blok et al., 2018; Courmont, 2015; Kitchin et al., 2017; Kitchin & Moore-Cherry, 2020; Luque-Ayala & Marvin, 2020; Sadowski & Maalsen, 2020; Söderström & Mermet, 2020). However, at the same time, it emancipates from these notwistanding relevant critiques, as it focuses on the complex and generative data itself.

Transantiago is not usually mentioned either as an example of "smartness" or as a practical case of big data implementation in a public service. Instead, it was seen as old, not innovative, and chaotic, rather than a case of experimentation on how to make big data to work and circulate. Farias and Widmer (2018, p. 44) suggest that if we really want to find cases in which digital technologies are permeating urban infrastructures, we need to look beyond the "unbearable" mainstream smart city policy discourse and frameworks so we can find the "ordinary smart city". Even more, to looking out "elsewhere" also opens possibilities to identify alternative smart city projects, less obsessed on the technological fixes and more concentrated on leveraging a knowledge-intensive smart urbanism (McFarlane & Söderström, 2017). Therefore, my thesis contributes towards illustrating more examples of the ordinary smart city in Latin America as an alternative knowledge-intensive project beyond the predominance of the corporate storytelling which often characterises smart city programmes and strategies.

In conclusion, this study has significantly contributed to understanding the role of urban big data in a Latin American city. By narrating the introduction, implementation, and development process of big data within a transport system in a Latin American capital, this research provides valuable insights for other Southern and Latin American geographies engaged in designing or implementing new transport systems. Instead of offering a set of rules, a mobile policy framework, or a list of "best practices," this work serves as an empirical example of incorporating big data into a large urban infrastructure in a city like Santiago de Chile. Which is also valuable from a "south-south" urban perspective and also highlights the intricacies of implementing urban big data on a global scale.

7.2 Dispositifs, Problematisations, and data circulation.

A key conclusion and axial theoretical-methodological contribution of my work is the conceptualisation of the data dispositif, the generative role of problematisations, and the suitability of following the data as a method for empirically grounding big data circulation in Transantiago. This research simultaneously contributes to constructing a framework for studying big data as a heterogeneous, unfinished dispositif, characterized by data circulation and its consequential actions, aligning with approaches that view data as a relational, complex process in constant development (Gabrys, 2016; Gitelman, 2013; Kitchin, 2014b; Ruppert et al., 2017; Shelton, 2017). Theoretically, the data dispositif bears similarities to other critical approaches to the studies of big data, which have depicted the phenomena as complex, relational, non-commonsensical, mobile, and sustained by infrastructural interdependencies (Barns et al., 2017; Bates et al., 2016; Kitchin, 2014b). In that effort, Kitchin (2014) identifies a predetermined list of apparatuses and elements as constituting a data assemblage, as characteristics that could be established beforehand.

However, Transantiago's case reinforces the idea of using dispositifs rather than assemblages in various ways. First, from a data dispositif perspective, it may be inadequate to prefigure a list of apparatuses and their corresponding elements as something that could be anticipated. While data assemblage focuses on the convergence of material components, techniques, and practices, the data dispositif approach emphasizes the interplay between human and non-human actors, as well as the complex power relations and agencies that contribute to data circulation. The dispositif perspective may argue that data assemblage does not adequately address the broader sociopolitical context and negotiations that shape data practices. The emergence of a diversity of technical processes, provoking arrangements, and re-arrangements between pre-existing groups of transport engineers, policymakers, and providers, in order to incorporate big data into their processes, exemplifies this. Similarly, the generation and use of obligatory passage points as mechanisms for problem-solving and actor coordination provide stability and have facilitated the circulation of big data while simultaneously emerging with the dynamics shaping the data dispositif. Ultimately, anticipating the actors involved, their configurations, and strategies to prevail in the process of making data circulate is hardly possible, differing from Kitchin's suggestions.

A second consideration highlights the focus on problematisations characterising the data dispositif, underlining their generative role in shaping data practices and configurations. In contrast, the data assemblage concept might not explicitly underscore how problematisations contribute to the formation and transformation of data practices across technical actors or the configuration of novel arrangements for coordinating these practices within and between various groups involved in Transantiago. In the Transantiago case, big data circulation is neither smooth nor problem-free, demanding considerable work, improvisation, creativity, and experimentation to generate new alternatives and possibilities for data to circulate. For instance, the oligoptic control rooms network, the way transport engineers negotiate and mobilise technical work, and the emergence of OPPs are all experimental forms through which data has circulated. These forms, which could have differed in the past and may evolve in the future, emphasise the dynamic and relational nature of the data dispositif, acknowledging the contingent and experimental aspects of data circulation. I am not saying with this that experimentation is replacing rulebooks and standards in Transantiago. Instead, I am arguing that experimentation and improvisation operate when these protocols lose their usefulness and effectiveness, so alternative problem-solving is required to keep data circulating. Therefore, data circulation is performed balancing these ambivalences, enacting processes of collective experimentation occurring based on the ambition that at some point things will become regular, and that the achieved regularity will improve the service delivery. Obligatory passage points, in this sense, represent material examples by which regularity and endurance are achieved, beyond management protocols (although still through widely known and much more important devices such as contracts).

Accordingly, the data dispositif perspective offers significant critical force, suggesting that future challenges may create opportunities for novel solutions, contesting established power relations and agencies in play. More specifically, it foregrounds the power dynamics, relations, and agencies that drive data circulation and shape its outcomes. Thus, my research not only contributes to understanding what big data does but also explores its potential, without providing causal representations or definitive solutions. Despite big data's opacity, particularly in large urban infrastructures like Transantiago, the data dispositif approach highlights possibilities for manoeuvring and transformation, stressing change and adaptation potential. The data dispositif takes form in these problematic situations as an effect of acute practices, arrangements, and governing techniques between various actors and forces, capturing the complexity and contingency of relations composing big data while acknowledging the constant interplay between human and non-human actors, power relations, and the ongoing accomplishment of data circulation through problem-solving.

This leads to a third consideration, which connects to the previous discussion and highlights the intrinsic dynamism of the data dispositif, differentiating it from the data assemblage concept. While data assemblage may be perceived as a relatively static, prefigured configuration of elements, the data dispositif approach accentuates the continuous change and precarious nature of data circulation. Which suggests that the assemblage perspective may not capture the full complexity and fluidity of data circulation. In the context of Transantiago, the dynamism of the big data dispositif is exemplified by the constant adaptation and reconfiguration of data practices in response to emerging challenges, such as the development of new software targeting specific requirements of a private provider, the renegotiation of contracts based on novel data coming from ADATRP, or the integration of alternative data from platforms and apps. These examples demonstrate the fluidity of relations and the continuous interplay between human and non-human actors, power dynamics, and the ongoing and accomplishment of data circulation within the data dispositif, further emphasising its importance as a conceptual tool for understanding the complexity and contingency of big data circulation.

Transantiago delineates how a process of sociotechnical change depends on the capacity to solve problems through experimental operations that are almost impossible to anticipate. That is, ultimately, a way of dealing creatively with the uncertainty of sociotechnical change, offering an alternative regarding the rampant technological-solutionism discourse present nowadays in smart urbanism initiatives. In that sense, not knowing if a determined data-related project will be successful is an enabler for, rather than impediment to, sociotechnical change. Let's say, for example, the usefulness of ADATRAP was much more uncertain when it was conceived; however, it enabled a way of doing things differently through experimentation that ultimately triggered a virtuous cycle regarding the implementation of big data in Transantiago. In that case, the uncertainty of ADATRAP led to undoing and redoing the way big data was circulated and used in Transantiago beyond the initial expectations.

An additional contribution of the dispositif approach is methodological. The data dispositif approach has settled the ground to explore the particularities, dynamism, and complexity of big data in Transantiago. However, it did not necessarily provide a framework to operationalise that approach into an exploratory methodology capable of capturing its richness and complexity. In that regard, the role of problematisation, which ultimately is generative of new arrangements and associations, aligns with the contigent associations proposed in the ANT approach. Moreover, the special attention on following the actors, has proven to be an effective tool when revisited as following the data.

The main reason is that this approach allowed me to sequentially problematise my own case, starting from the smart city but quickly moving towards big data as the main topic of interest. In this sense, taking an initial exploratory time to find the most appropriate case of big data circulation, beyond the smart city programmes and policies, was essential. Also, the combination of data collection tools, particularly ethnography and in-depth interviews, proved to be an effective resource for devising the ways in which big data is circulated in Transantiago. The use of these tools ultimately proved useful in tracking down the associations shaping the data dispositif and the emerging problems influencing its circulation.

The dispositif approach and the "follow the data" methodology, as demonstrated in the case of Transantiago, hold potential for broader applicability and utility across various contexts beyond this specific instance. By closely examining the circulation of big data and the networks it traverses, I consider that urban researchers can gain valuable insights into the complexities, associations, and dynamics that shape the implementation of big data within urban infrastructures and other large-scale urban services and systems.

7.3 Transport engineers, data bricoleurs and the heterogeneous configuration of knowledge.

Building on the previous sections discussing the data dispositif approach, I will draw conclusions about the role of experts, expertise and the problem of knowledge in Transantiago. A core element that emerged from my research, constitutive of the data dispositif and transversal to every empirical chapter, is the relevance of technical practices, experts, and their relationship urban knowledge. One significant conclusion of my work is that big data has challenged traditional ways of knowledge production in Transantiago, leading to its transformation to meet new technical and disciplinary requirements that enable big data circulation within the system. Concurrently, this process has revealed how data circulation relies on a diverse array of actors and knowledges, which sometimes remain concealed within the opaque and complex dynamics of the transport system.

The significance of expertise, experts, and the way knowledge takes part on the data dispositif operates various ways. First, as I thoroughly analyse in chapter 5, as how transport engineers have remained as the most prevalent epistemic community with the emergence of big data in Transantiago. However, my work also exposes alternative actors and practices to the predominance of transport engineers in the composition of the data dispositif, that not necessarily are identified on the mainstream groups of experts in Transantiago.

The influence of transport engineers as the dominant group in public transport is neither new nor surprising. Indeed, their decisive role as experts in Transantiago has noted already by Ureta (2015, 2017), who analysed the role of transport engineers during the early days of the system and identified them as the most significant technical group during its inception.

However, the implementation of big data in Transantiago and its circulation in the formation of a big data dispositif represent a distinct way in which transport engineers can influence the transport system. In the first place, transport engineers as a technical group resist taking responsibility for the chaotic initial implementation of Transantiago. Despite their technical responsibility for the system's design—including widely remembered failures such as the initial estimation of travel demand modelling—they remained the predominant expert group providing technical advice within the system. Instead of being replaced, the new requirements that emerged alongside the implementation of big data helped to further solidify their influence on the transport policy-making process in the system.

Therefore, transport engineers in Transantiago have successfully maintained and solidified their epistemic authority through *boundary work* (Gieryn, 1983). That is the way by which transport engineers demarcate themselves as experts, establishing boundaries in relation to other expert groups acting as a resource that translates into "strategic practical action" (Gieryn, 1999, p. 23) for the purpose of establishing the epistemic authority of transport engineers in the data dispositif and Transantiago in general. Whether they are engaged in building professional communities or asserting their autonomy against external controls, transport engineers use a variety of boundary-defining strategies to establish who is *in* and who is *out* of relevant peer groups and networks of prestige authority (Jasanoff, 2009, p. 34). Employing the three genres of boundary work—expulsion, expansion, and protection of autonomy (Lamont & Molnár, 2002)—transport engineers create disciplinary borders that define who has the legitimacy and competency to participate in specific domains of decision-making. This is achieved through various mechanisms, such as obtaining specific academic credentials, joining professional associations, and integrating topic-specific knowledge from other groups while framing it as interdisciplinary collaboration.

A crucial ability of transport engineers is to anticipate and to structuring discussions on the "what" and the "how" of big data circulation. In other words, as Latour (1996, p. 32) emphasises, transport engineers have the ability "to make questions that no one asked them", that allows the epistemic community to direct the discussion according to their terms and technical domain. But in the same way, it demonstrates how boundary work operates as demarcating the professional autonomy of transport engineers amongst the wide ecology of actors involved in Transantiago's operations. The effectiveness of transport engineers safeguarding their professional autonomy also denotes a deep understanding of the politics in which technical expertise is embedded, without sacrificing their aura of technical neutrality.

An important conclusion of my work, however, is that despite the prevalence and explicit presence of transport engineers as epistemic group and culture shaping up the dispositif, there are other less visible groups that are equally important to constitute the dispositif enabling data circulation in Transantiago.

An illustrative example is the case of control room analysts, whom I define as data bricoleurs. These analysts play a vital role in the day-to-day operations of

Transantiago, primarily resolving situations to ensure that the system operates according to operational KPIs, and the specific objectives of each actor involved in providing adequate service. Although the importance of data analysts in the system is essential, it is much less visible and prominent in the mainstream technical practices enabling big data. Similarly, the practical knowledge of analysts relies on their ability to determine what to do and when, based on specific problems requiring attention. In this sense, their technical skills involve a deep understanding of the transport system, their role in the operational network, and the available resources, which they adeptly integrate into their decision-making process. Their knowledge relies much less on the support of an epistemic community, their mechanisms of legitimacy and reinforcement, and much more on their ability to coordinate things amongst peer and with others across the dispositif. The situated experience of having spent enough time in the control room, is what determines their legitimacy as experts in their craft. Therefore, the ability of crafting the bricolage is much less determined by academic and epistemic group credentials, and much more bi the seniority acquired thanks to the experience of having been there before. This distinct type of knowledge plays a crucial role in the data dispositif, complementing the expertise represented by transport engineers.

Despite the importance of analysts in enabling data circulation and ensuring the smooth operation of Transantiago, their role remains peripheral in the network of knowledge relations across the transport system. Nonetheless, it is difficult to envision how the role of analysts could potentially be transformed to increase their visibility and relevance as a legitimate expert group, from the point of view of the predominant epistemic groups in the system. As we have seen, the mechanisms by which experts work and knowledge is created and validated extend far beyond the technicalities and practicalities of enabling data circulation.

They involve a wide variety of group practices, which ultimately translate into a dominant transport engineering epistemic culture.

A final conclusion regarding the cross-cutting issue of expertise, and knowledge in the circulation of big data in Transantiago refers to the future possibilities of the transport engineering culture of expanding their horizons of epistemic predominance towards a more heterogeneous practice. Because, at the end of the day, the predominance of transport engineers across the dispositif is defined by the capacity of their own practice of changing according to the new requirements imposed by big data circulation. In the same way, their influence is equally sustained on technical expertise as on their capacity of understanding the political landscape in which they are situated as expert groups. In other words, the existing boundaries between groups are hard to span, yet the system only works, and data only can circulate, thanks to the permeability of these boundaries. The very success of transport engineers of influencing the system is determined by their ability of spanning these boundaries, as the case of the heterogenous engineer well illustrates through its capacity to navigate the machineries of the political landscape to enable data circulation.

There is, however, room to reconsider the role of experts and expertise in the production of knowledge in Transantiago, even when considering the established epistemic culture of transport engineers. The concept of the heterogeneous engineer offers guidance, suggesting that the transport engineering community could redefine their disciplinary boundaries to create a more diverse engineering practice. Take, for example, the individual case of Pedro, the heterogeneous engineer, who knows what to do, how, and when, not solely because of his engineering credentials, but also because he is a practical sociologist (Law & Callon, 1988). Which means that he is aware of the conditions (social, political, technical) in which he is immersed as a transport expert; and of the practical side of things ("how to make things happen"), which is largely how engineers are idealised as problem-solvers. That requires more than transport engineers unidirectionally acting as boundary-spanners, to mobilise their interests and knowledges across the variety of groups involved Transantiago. It really entails a more comprehensive change on how to deal with knowledge production more pragmatically in terms of how to achieve interdisciplinarity and to open the field to a less hegemonic and homogenised type of transport expertise in Transantiago, but also more broadly as how transport engineers conceive themselves as epistemic group in relation to other groups and disciplines.

7.4 Arrangements, configurations and governing techniques.

An additional overarching conclusion, albeit slightly more peripheral than the question of expertise and knowledge production in the dispositif, concerns the configuration of the data dispositif as a fragile yet effective achievement in terms of ensuring big data circulation to meet the operational requirements of the system.

Consider the example of transport fragmentation, a cross-cutting characteristic of Transantiago as a system. As previously described, Transantiago faces two concurrent and partly overlapping issues: the institutional fragmentation of the city and that of Transantiago itself. While there is public consensus among mainstream transport community members—including academics, politicians, and providers—that a new metropolitan organisation is needed for more efficient governance, Transantiago has managed to configure a governance arrangement over the years to address fragmentation, making the system work and even improve over time. Hence, it can be said that Transantiago, as a dispositif, has responded to the problem of fragmentation by generating novel arrangements and configurations according to its operational requirements.

In the same way, big data circulation in Transantiago offers further insight into understanding how the system has dealt with the problem of institutional fragmentation from an operational standpoint. This is exemplified through the case of control rooms and the formation of an oligoptic network for the operational fleet management of the system, which was developed in response to a pre-existing problem of institutional fragmentation.

To "dominate the vision" of the city as a whole, Latour and Hermant (1998) argue, requires that the points of observation become small yet networked. Transantiago's control rooms exemplify this, as they operate as compact units, dissecting specific details of the everyday operation while concurrently configuring a coherent network. The control room analyst plays a pivotal role in facilitating data circulation and promoting effective coordination, combining their expertise with the ability to manage the system's complexity. This illustrates two key aspects: firstly, the capacity to perceive unity amidst fragmentation, thus enabling a comprehensive view and allowing the system to function; secondly, a unique form of knowledge rooted in the analyst's accumulated experience, marked by their ability to experiment and improvise rather than rigidly adhering to standardised protocols and rulebooks.

Likewise, an additional conclusion relates to the role of OPP's as mechanisms to provide coordination and stability to configure enabling data circulation in Transantiago. As such, OPPs represent durable yet fragile arrangements that resolve problems while being subject to change.

OPPs are achievements of the data dispositif, resulting from hard work and power-laden negotiations to balance expectations, responsibilities, and rights among actors. In cases such as ADATRAP and contracts and KPIs, these OPPs have emerged after periods of uncertainty and disagreement, with involved actors having to translate their ideas and objectives into a common framework, often adhering to the positions of others to maintain data circulation. Origin-Destination Matrices, on the other hand, have a longer trajectory of usage in transport engineering, making them an enduring device even before the advent of big data in Transantiago. The endurance of OD Matrices has been maintained by adapting their pre-existing format to accommodate big data circulation. OPPs demonstrate the mutual dependence between data circulation and the arrangements and configurations enabling it. On one hand, OPPs provide stability for big data circulation in Transantiago; on the other, the circulation overflows OPPs, requiring space for adaptation and change to remain in place.

Ultimately, the data dispositif's ability to generate effective arrangements and configurations for data circulation holds significant implications for transport and urban governance. The governance arrangements forged in Transantiago, despite the system's inherent fragmentation, have successfully accommodated big data circulation, which in turn has led to improved system performance and coordination. This highlights the importance of understanding and leveraging the data dispositif in addressing complex urban challenges and designing more efficient governance structures. By harnessing the strengths of the data dispositif, including the role of OPPs and the expertise of control room analysts, transport specialists and policymakers can better navigate the complexities of institutional fragmentation, ultimately resulting in more effective governance and enhanced urban services. Embracing this perspective can be crucial for the future development of Transantiago and other metropolitan systems, as it offers valuable insights into the intricate relationship between data circulation, governance techniques, and the ongoing evolution of urban infrastructures.

7.5 Outlook into the future

In the last section of my conclusions, I will concentrate on two streams of reflection regarding future avenues of research. In the first part, I will provide some details of the limitations of my work, expressed specifically through themes that emerged from my work but that I decided to either exclude from or discuss without enough detail in my research. In the second part, I will discuss the future of the research on the topic of digital cities and public transport and provide ideas about what to focus on and how to do it.

7.5.1 Limitations and further research about big data in Transantiago.

As I discuss in chapter three, an important element of the ANT approach taken to do this research, enacted in the following the data methodology, is to build up a consistent narrative of a case knowing that the network built could have taken alternative forms. Accordingly, the main challenge and limitation of my conceptual proposal was to determine the course of action once a particular problem around data circulation was found, which is itself a moment of uncertainty. My own capacity to determine where to go next is probably the main limitation of this work. The ramifications and trajectories of data circulation in Transantiago are determined by the underlaying partialities and biases of how I have problematised the topic of big data in Santiago's public transport. This means that several relevant questions around data circulation in Transantiago have been sidelined. In practical terms, it also implies that both the case of data circulation in Transantiago, and the issues of fragmentation (chapter 4), expertise (chapter 5) and obligatory passage points (chapter 6) emerged as "problems" based on my own interpretation of its significance vis-à-vis other situations that could eventually be included in the analysis.

In that sense, there are relevant research streams that could, and should, be analysed in further work to keep producing comprehensive knowledge about big data in Transantiago.

A first consideration is temporal. My fieldwork and most of my data collection process was undertaken between the last quarter of 2018 and 2019. During that period there were ongoing policy agendas which led me to take significant decisions regarding my project. A first one was the ongoing changes on Santiago's public transport, agenda pushed by Sebastián Piñera's second presidency. When I was doing my fieldwork, the president declared that Transantiago would be replaced by a completely new system called "Red Movilidad". As we know, Transantiago did not have a good public evaluation despite steady performance improvements, so making changes or even replacing it was an easy sell for any government. The renovation started with a total rebranding of the system, including painting the buses of a different colour, as well as a media campaign mostly centred on highlighting a new fleet of electric buses. In parallel, new contracts would be designed to open a new tender including the bus service provision and the technological provision. However, the latter were postponed so no big changes were made at the time. That is why I also decided to stick to Transantiago rather than Red, since, despite the changes, people still refer to it as Transantiago. Now, the public tenders are out, and the system should start increasingly changing, amongst the main changes there will be a separation between operations and bus provision, meaning that who owns the buses will not also be operating them. This will make it easier to change operators in case of poor performance. In the same way, the complementary services provision should change, in this case there are fewer certainties about what is going to change and who will run these changes. I left out of the analysis some references to these changes made by officers at the DTPM in charge of designing the new tenders; in these conversations they mentioned that for the technology provision they were expecting the best providers in the world, pointing out that SONDA was not good enough to lead this new era of the RED system. However, right after these conversations, SONDA's contracts were extended for two more years instead to opening the public tender out. However, in August 2022, the new Ministry of Transport of Gabriel Boric, Juan Carlos Muñoz, which is a former transport engineering professor at Universidad Católica, launched the new digital transfromtion strategy for Santiago's public transport. The strategy was presented in an event made at Colegio de Ingenieros de Chile (Chilean Society of Engineers). There, the ministry provided details on the roadmap to transform the digital provision of the system, including a renovation of the fleet management services, improvements in the ticketing services (BIP Card), and the addition of a vast fleet of electric buses. During the event, the new DTPM CEO said: "We want to have a new world class fleet management system", shockingly resonating with Transantiago's early days before its implementation.[75]

I consider that further research should be undertaken when these changes started to happen in order to track down how the changes of the new system are balanced with the previously existing technologies in place. Certainly, big data is likely to be influencing the new contracts' design. In the same way, interesting new opportunities are likely to emerge to keep following big data in Santiago's public transport.

[75] See: https://www.red.cl/red-comunica/47421/

Another consideration is political. For future research on Transantiago, this has a double dimension. In the first place, further research must be undertaken according to the changes in the political cycles. Starting in 2006 with the first mandate of Michelle Bachelet, Chile has been characterised as oscillating between party coalitions at every presidential election[76]. This situation affects policies and institutions since, at every change of presidency, policies and programmes change severely. In the same way, Chile doesn't have a structured civil service, meaning that with every new government most of the workforce, including technical roles, change. Accordingly, it is important to identify how these changes affect the ways in which longstanding policy processes, such as the implementation of big data in Transantiago, remain in place, and how these are affected by changes in political cycles.

A second political dimension refers to the social revolt that occurred on the 18th of October 2019, which has had massive political and social effects in the country. The revolt started with a transport-related issue; after a 30-peso[77] increase in Transantiago's fare, high school students began protests jumping the Metro's turnstiles, claiming: "it is not 30 pesos, but 30 years". After that, massive protests demanding social changes spread across the city and around the country, pushing the government to the verge of collapse. At the time I had recently arrived back in Oxford after my fieldwork; the massive implications of the revolt compelled me to consider make changes into my analysis. Yet, after a careful revision of my data and a thorough discussion with my supervisors, I decided not to investigate

[76] Chile's presidential election system does not allow a subsequent re-election. Therefore, during this period both the centre-left Michelle Bachelet (2006-2010 / 2014-2018) and centre-right Sebastián Piñera (2010-2014 / 2018-2022) have led the country twice in non-subsequent re-elections. Now, the recently elected president Gabriel Boric represents a shift towards a leftist government representing the Apruebo Dignidad coalition.

[77] 30 CLP is equivalent to 0,029 GBP (08th September 2022).

the issues further. Hence, I think there is room for further research that integrates data circulation in Transantiago, for example, in relation to how fares are decided through what is called the "Panel de expertos de Transantiago" (Transantiago's expert panel). The panel is defined as a technical and autonomous body in charge of making fare adjustments in Transantiago, applying an automatic mathematical formula defined by law[78]. I consider it relevant to explore in more detail how institutions like the expertanpanel are shaped by data circulation. If we follow the example of other institutional and organisational changes related to big data circulation in Transantiago (i.e., contracts, KPIs, Data Team), it might be worth generating evidence about how other institutions are changing or resisting change according to how data circulates in Transantiago.

7.5.2 Further avenues of research on big data, cities, and transport.

My research is an effort to problematise differently the recent and prolific tradition of smart cities research happening in a wide variety of fields, including geography, urban studies, STS, among other disciplines. As I argue in my research, smart city research has not focused enough on the ways in which the related data-infused projects unfold in specific contexts. In the same way, it has not focused enough on big data itself as the unit of analysis, and even less as the unit of observation, of the emerging smart city projects, policy, and discourse agenda. I think that these two shortages are extensively problematised and discussed in my research, yet much further work is required in order to understand how big data and cities are enmeshed, and therefore, changing together.

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[78] The expert panel was created, and it has their functions delimited in the Supreme Decret № 140, of 2009, of the Ministry of Transport and Telecommunications. Source: http://www.paneldeexpertostarifas.cl/quees.php

I think that it would be useful to sustain the cross and interdisciplinary efforts to connect a wide variety of disciplines working on cities, big data and sociotechnical change. In that sense, it would be of great benefit to rethink the very same smart city projects through the lenses of Science and Technology Studies (Blok, 2016; Farías & Bender, 2009; Lury, 2020; Michael & Wilkie, 2020; Vertesi & Ribes, 2019), Information Studies (Ford, 2014; Kallinikos, 2011a, 2011b; Tanweer et al., 2016), and Organisational Studies (Carlile, 2004; Kallinikos, 2004; Orlikowski et al., 2016; Reay et al., 2019). A shared interest of these disciplines is the focus on processes and interactions concerning technological projects. There is ample room to reconsiderate the spatial concerns of Geography and Urban Studies using an interdisciplinary approach in dialogue with these and other disciplines. Specially to critically cover the processes in which data is made to circulate, that is, to be integrated into infrastructures, institutions, organisations, to transform the way decisions are made in cities. As seen in my work, making organisational adjustments, involving the development of new skills and interdisciplinary collaborations are only a portion of the critical points to stay abreast on the opportunities that big data provides to urban management. Therefore, the connection with disciplines that have been focusing on the organisational and institutional aspects of big data-for years-to make it work in cities is a crucial aspect to continue investigating.

A third point, also illustrated in my work, is that the relationship between big data and the city is not necessarily attached to the smart city. This also opens opportunities for much further research focusing on the relationship of big data and cities. A starting point of my work is attention to the "ordinary smart city" (Farías & Widmer, 2018), as a strategy to find big data beyond the smart city discourse and projects—this is a strategy that could be taken much further. Since, the excessive focus on the smart city programmes, and the more established mainstream smart city agendas has left behind initiatives developing big data in cities. As I mentioned before, the amount of research about the smart city is globally vast in terms of quantity, yet there is still much room to analyse "actually existing smart urbanism" from the perspective of big data circulation. I think this has special relevance now that the smart city discourse has moved towards ideas around Artificial Intelligence, Machine Learning, Digital Twins, Autonomous Vehicles, to name just a few data-infused projects. Recent research on platform urbanism (Barns, 2017, 2020; Blok et al., 2018; Hodson, 2021; Offenhuber, 2019; Rose et al., 2020; Smith & Martín, 2021; Söderström & Mermet, 2020; Stehlin et al., 2020; Wilmott, 2021) has focused on the effects of big data unpacking digital platforms. However, I think that there is still much room to unpack other infrastructures in place that have already enabled big data as a key operational component, not necessarily labelled as "smart". Just a name a few, developments on key urban services such as waste management, urban logistics, water, and energy provision, along with CCTV networks, and alternative citizen-led initiatives operating at a smaller scale. Getting a grip of the already existing initiatives, beyond the smart city programmes would be of great benefit to understand better how cities and big data are mutually shaping each other.

A final suggestion for further research on big data and cities relates to the geographical focus. Although some relevant efforts have been undertaken to challenge the northern hegemony of the critical smart city research (see: (Anand, 2021; Datta, 2015b, 2015a, 2018, 2019; Irazábal & Jirón, 2021; Jirón et al., 2021; Luque-Ayala & Marvin, 2016; Odendaal, 2016; Offenhuber & Schechtner, 2018; Tironi, 2019; Tironi & Valderrama, 2017), there is still massive space to undertake more detailed research focusing on cities in the global south. More specifically, in Latin America, there are smart city projects happening everywhere, whether from local initiatives, global corporate efforts such as the Smarter Cities Challenge, or consultancy initiatives from companies like Deloitte. Likewise, multilateral agencies like the Interamerican Development Bank (IADB)[79] are funding a wide variety of smart city projects in places like Uruguay, Perú, Panamá, Puerto Rico, Guatemala. México, Guyana, and even in more remote places like Easter Island. This is a starting point, because much more is to be grasped if we take the route beyond these initiatives, challenging the dominant smart city discourse to focus on the ordinary smart city, as I have suggested during my research.

[79] See more examples at: https://www.iadb.org/en/urban-development-and-housing/idb-citieslab#:~:text=The%20IDB%20Cities%20Laboratory%20is,Latin%20America%20and%20the%20Caribbean.

References

Abbott, A. (1988). *The system of professions: An essay on the division of expert labor.*

Akrich, M., Callon, M., & Latour, B. (2006). *Sociologie de la traduction—Textes fondateurs*.

Albino, V., Berardi, U., & Dangelico, R. M. (2015). Smart Cities: Definitions, Dimensions, Performance, and Initiatives. *Journal of Urban Technology*, *22*(1), 3–21. https://doi.org/10.1080/10630732.2014.942092

Amaya, M., Cruzat, R., & Munizaga, M. A. (2018). Estimating the residence zone of frequent public transport users to make travel pattern and time use analysis. *Journal of Transport Geography*, *66*, 330–339. Scopus. https://doi.org/10.1016/j.jtrangeo.2017.10.017

Anand, P. B. (2021). Assessing smart city projects and their implications for public policy in the Global South. *Contemporary Social Science*, *16*(2), 199–212. https://doi.org/10.1080/21582041.2020.1720794

Anderson, B. (2010). Preemption, precaution, preparedness: Anticipatory action and future geographies. *Progress in Human Geography*, *34*(6), 777–798. https://doi.org/10.1177/0309132510362600

Anderson, B., & McFarlane, C. (2011). Assemblage and geography. *Area*, *43*(2), 124–127.

Anderson, C. (2008). The End of Theory_ The Data Deluge Makes the Scientific Method Obsolete. *Wired Magazine*, *16.07*, 3.

Andrade, M. (2017). *Usos y Gestión de Información en Transantiago*. Universidad de Chile.

Anthopoulos, L. G. (2015). Understanding the Smart City Domain: A Literature Review. In M. P. Rodríguez-Bolívar (Ed.), *Transforming City Governments for Successful Smart Cities* (pp. 9–21). Springer International Publishing. https://doi.org/10.1007/978-3-319-03167-5_2

Aradau, C., & Blanke, T. (2010). Governing circulation: A critique of the biopolitics of security. In *Security and Global Governmentality* (pp. 56–70). Routledge.

Aradau, C., & Blanke, T. (2015). The (Big) Data-security assemblage: Knowledge and critique. *Big Data & Society*, *2*(2), 205395171560906. https://doi.org/10.1177/2053951715609066

Ash, J., Kitchin, R., & Leszczynski, A. (2018a). Digital turn, digital geographies? *Progress in Human Geography*, *42*(1), 25–43. https://doi.org/10.1177/0309132516664800

Ash, J., Kitchin, R., & Leszczynski, A. (2018b). *Digital Geographies*. SAGE.

Ashton, P., Weber, R., & Zook, M. (2017). The cloud, the crowd, and the city: How new data practices reconfigure urban governance? *Big Data & Society*, *4*(1), 2053951717706718. https://doi.org/10.1177/2053951717706718

Aurigi, A., & Odendaal, N. (2021). From "Smart in the Box" to "Smart in the City": Rethinking the Socially Sustainable Smart City in Context. *Journal of Urban Technology*, *28*(1–2), 55–70. https://doi.org/10.1080/10630732.2019.1704203

Bacchi, C. (2012). Why Study Problematizations? Making Politics Visible. *Open Journal of Political Science*, *02*(01), 1–8. https://doi.org/10.4236/ojps.2012.21001

Bannister, J., & O'Sullivan, A. (2021). Big Data in the city. *Urban Studies*, 00420980211014124. https://doi.org/10.1177/00420980211014124

Barnett, C. (2015). On Problematisation. *Non Site*, *6*.

Barnett, C., & Bridge, G. (2016). The Situations of Urban Inquiry: Thinking Problematically about the City: The Situations of Urban Inquiry. *International Journal of Urban and Regional Research*, *40*(6), 1186–1204. https://doi.org/10.1111/1468-2427.12452

Barns, S. (2017). Smart cities and urban data platforms: Designing interfaces for smart governance. *City, Culture and Society*. https://doi.org/10.1016/j.ccs.2017.09.006

Barns, S. (2018). Smart cities and urban data platforms: Designing interfaces for smart governance. *City, Culture and Society*, *12*, 5–12. https://doi.org/10.1016/j.ccs.2017.09.006

Barns, S. (2020a). *Platform Urbanism: Negotiating Platform Ecosystems in Connected Cities*. Springer Singapore. https://doi.org/10.1007/978-981-32-9725-8

Barns, S. (2020b). *Platform Urbanism: Negotiating Platform Ecosystems in Connected Cities*. Springer Singapore. https://doi.org/10.1007/978-981-32-9725-8

Barns, S. (2021). Out of the loop? On the radical and the routine in urban big data. *Urban Studies*, 00420980211014026. https://doi.org/10.1177/00420980211014026

Barns, S., Cosgrave, E., Acuto, M., & Mcneill, D. (2017). Digital Infrastructures and Urban Governance. *Urban Policy and Research*, *35*(1), 20–31. https://doi.org/10.1080/08111146.2016.1235032

Basso, F., Basso, L. J., Bravo, F., & Pezoa, R. (2018). Real-time crash prediction in an urban expressway using disaggregated data. *Transportation Research Part C: Emerging Technologies*, *86*, 202–219. https://doi.org/10.1016/j.trc.2017.11.014

Basso, F., Frez, J., Martínez, L., Pezoa, R., & Varas, M. (2020). Accessibility to opportunities based on public transport gps-monitored data: The case of Santiago, Chile. *Travel Behaviour and Society*, *21*, 140–153. https://doi.org/10.1016/j.tbs.2020.06.004

Bates, J., Lin, Y.-W., & Goodale, P. (2016). Data journeys: Capturing the socio-material constitution of data objects and flows. *Big Data & Society*, *3*(2), 205395171665450. https://doi.org/10.1177/2053951716654502

Batty, M. (2013a). *The new science of cities*. MIT press.

Batty, M. (2013b). Big data, smart cities and city planning. *Dialogues in Human Geography*, *3*(3), 274–279. https://doi.org/10.1177/2043820613513390

Batty, M. (2016). Big Data and the City. *Built Environment*, *42*(3), 321–337. https://doi.org/10.2148/benv.42.3.321

Batty, M. (2018). Data about Cities. In *Data and the City* (pp. 31–43).

Batty, M., Axhausen, K. W., Giannotti, F., Pozdnoukhov, A., Bazzani, A., Wachowicz, M., Ouzounis, G., & Portugali, Y. (2012). Smart cities of the future. *The European Physical Journal Special Topics*, *214*(1), 481–518. https://doi.org/10.1140/epjst/e2012-01703-3

Baykurt, B., & Raetzsch, C. (2020). What smartness does in the smart city: From visions to policy. *Convergence*, *26*(4), 775–789. https://doi.org/10.1177/1354856520913405

Beer, D. (2016). How should we do the history of Big Data? *Big Data & Society*, *3*(1), 2053951716646135. https://doi.org/10.1177/2053951716646135

Beltrán, P., Gschwender, A., & Palma, C. (2013). The impact of compliance measures on the operation of a bus system: The case of Transantiago. *Research in Transportation Economics*, *39*(1), 79–89.

Beltrán, P., & Palma, C. (2012). Transantiago, su evolución operacional desde el diseño original. *Trabajo Presentado En El XVII Congreso Panamericano de Ingenería de Tránsito, Transporte y Logística*, *24*.

Bijker, W. E., Hughes, T. P., & Pinch, T. (Eds.). (2012). *The social construction of technological systems: New directions in the sociology and history of technology* (Anniversary ed). MIT Press.

Bissell, D. (2021). Encountering automation: Redefining bodies through stories of technological change. *Environment and Planning D: Society and Space*, *39*(2), 366–384. https://doi.org/10.1177/0263775820963128

Blackstone Jr, J. H., & Cox, J. F. (2005). APICS: The association for operations management. *APICS Dictionary,*.

Blok, A. (2016). *Urban Cosmopolitics: Agencements, assemblies, atmospheres* (1st ed.). Routledge. https://doi.org/10.4324/9781315748177

Blok, A., Courmont, A., Hoyng, R., Marquet, C., Minor, K., Nold, C., & Young, M. (2018). Data Platforms and Cities. *TECNOSCIENZA: Italian Journal of Science & Technology Studies*, *8*(2), 175–220.

Boltanski, L., & Thévenot, L. (1999). The sociology of critical capacity. *European Journal of Social Theory*, *2*(3), 359–377.

Bowker, G. C., & Star, S. L. (1999). *Sorting things out: Classification and its consequences*. MIT Press.

Boyce, D. E., & Williams, H. C. W. L. (2015). *Forecasting Urban Travel: Past, Present and Future*. Edward Elgar Publishing.

Boyd, D., & Crawford, K. (2012). Critical questions for big data: Provocations for a cultural, technological, and scholarly phenomenon. *Information Communication and Society*, *15*(5), 662–679. https://doi.org/10.1080/1369118X.2012.678878

Bridge, G. (2020). Habit, experience and environment: A pragmatist perspective. *Environment and Planning D: Society and Space*, *38*(2), 345–363. https://doi.org/10.1177/0263775819882715

Briones, I. (2009). Transantiago: Un problema de información. *Estudios Públicos*, *116*.

Bucknell, C., Schmidt, A., Cruz, D., & Muñoz, J. C. (2017). Identifying and Visualizing Congestion Bottlenecks with Automated Vehicle Location Systems: Application to Transantiago, Chile. *Transportation Research Record*, *2649*(1), 61–70. https://doi.org/10.3141/2649-07

Burns, R., Fast, V., Levenda, A., & Miller, B. (2021). Smart cities: Between worlding and provincialising. *Urban Studies*, *58*(3), 461–470. https://doi.org/10.1177/0042098020975982

Bussolini, J. (2010). What is a Dispositive? *Foucault Studies*, *10*, 85–107.

Bustos, E. A., Díaz, G. C., Tagle, S. G., & Mateluna, S. S. (2000). *POLITICA Y PLAN DE TRANSPORTE URBANO PARA SANTIAGO 2000—2010*. 109.

Byon, Y.-J., Cortés, C. E., Jeong, Y.-S., Martínez, F. J., Munizaga, M. A., & Zúñiga, M. (2018). Bunching and Headway Adherence Approach to Public Transport with GPS. *International Journal of Civil Engineering*, *16*(6), 647–658. https://doi.org/10.1007/s40999-017-0153-3

Callon, M. (1984a). Some Elements of a Sociology of Translation: Domestication of the Scallops and the Fishermen of St Brieuc Bay. *The Sociological Review*, *32*(1_suppl), 196–233. https://doi.org/10.1111/j.1467-954X.1984.tb00113.x

Callon, M. (1984b). Some Elements of a Sociology of Translation: Domestication of the Scallops and the Fishermen of St Brieuc Bay. *The Sociological Review*, *32*(1_suppl), 196–233. https://doi.org/10.1111/j.1467-954X.1984.tb00113.x

Callon, M. (1987). Society in the making: The study of technology as a tool for sociological analysis. *The Social Construction of Technological Systems: New Directions in* *the Sociology and History of Technology*, 83–103.

Callon, M., & Latour, B. (1981). Unscrewing the big Leviathan: How actors macro-structure reality and how sociologists help them to do so. *Advances in Social Theory and Methodology: Toward an Integration of Micro-and Macro-Sociologies*, *1*.

Cardullo, P. (2021). Provincialising smart cities. *City*, *25*(3–4), 553–555. https://doi.org/10.1080/13604813.2021.1939970

Cardullo, P., & Kitchin, R. (2019). Smart urbanism and smart citizenship: The neoliberal logic of 'citizen-focused' smart cities in Europe. *Environment and Planning C: Politics and Space*, *37*(5), 813–830. https://doi.org/10.1177/0263774X18806508

Carlile, P. R. (2004). Transferring, Translating, and Transforming: An Integrative Framework for Managing Knowledge Across Boundaries. *Organization Science*, *15*(5), 555–568. https://doi.org/10.1287/orsc.1040.0094

Carranza, A., Goic, M., Lara, E., Olivares, M., Weintraub, G. Y., Covarrubia, J., Escobedo, C., Jara, N., & Basso, L. J. (2020). The social divide of social distancing: Lockdowns in santiago during the covid-19 pandemic. *Available at SSRN 3691373*.

Castells, M. (2002). Local and global: Cities in the network society. *Tijdschrift Voor Economische En Sociale Geografie*, *93*(5), 548–558.

Castelnovo, W., Misuraca, G., & Savoldelli, A. (2016). Smart Cities Governance: The Need for a Holistic Approach to Assessing Urban Participatory Policy Making. *Social Science Computer Review*, *34*(6), 724–739. https://doi.org/10.1177/0894439315611103

Charnock, G., March, H., & Ribera-Fumaz, R. (2021). From smart to rebel city? Worlding, provincialising and the Barcelona Model. *Urban Studies*, *58*(3), 581–600. https://doi.org/10.1177/0042098019872119

Coletta, C., Evans, L., Heaphy, L., & Kitchin, R. (2018). *Creating Smart Cities*. Routledge.

Coletta, C., Heaphy, L., & Kitchin, R. (2019). From the accidental to articulated smart city: The creation and work of 'Smart Dublin'. *European Urban and Regional Studies*, *26*(4), 349–364. https://doi.org/10.1177/0969776418785214

Coletta, C., & Kitchin, R. (2017). Algorhythmic governance: Regulating the 'heartbeat' of a city using the Internet of Things. *Big Data & Society*, *4*(2), 205395171774241. https://doi.org/10.1177/2053951717742418

Cortés, C. E., Gibson, J., Gschwender, A., Munizaga, M., & Zúñiga, M. (2011). Commercial bus speed diagnosis based on GPS-monitored data. *Transportation Research Part C: Emerging Technologies*, *19*(4), 695–707. https://doi.org/10.1016/j.trc.2010.12.008

Courmont, A. (2015). Open data et recomposition du gouvernement urbain: De la donnée comme instrument à la donnée comme enjeu politique. *Informations sociales*, *n° 191*(5),

40. https://doi.org/10.3917/inso.191.0040

Cowley, R., & Caprotti, F. (2018). Smart city as anti-planning in the UK. *Environment and Planning D: Society and Space*, 026377581878750. https://doi.org/10.1177/0263775818787506

Crampton, J. W., Graham, M., Poorthuis, A., Shelton, T., Stephens, M., Wilson, M. W., & Zook, M. (2013). Beyond the geotag: Situating 'big data' and leveraging the potential of the geoweb. *Cartography and Geographic Information Science*, *40*(2), 130–139. https://doi.org/10.1080/15230406.2013.777137

Dalton, C. M., Taylor, L., & Thatcher (alphabetical), J. (2016). Critical Data Studies: A dialog on data and space. *Big Data & Society*, *3*(1), 205395171664834. https://doi.org/10.1177/2053951716648346

Dameri, R. P., & Benevolo, C. (2016). Governing Smart Cities: An Empirical Analysis. *Social Science Computer Review*, *34*(6), 693–707. https://doi.org/10.1177/0894439315611093

Datta, A. (2015a). A 100 smart cities, a 100 utopias. *Dialogues in Human Geography*, *5*(1), 49–53. https://doi.org/10.1177/2043820614565750

Datta, A. (2015b). New urban utopias of postcolonial India: 'Entrepreneurial urbanization' in Dholera smart city, Gujarat. *Dialogues in Human Geography*, *5*(1), 3–22. https://doi.org/10.1177/2043820614565748

Datta, A. (2018). The digital turn in postcolonial urbanism: Smart citizenship in the making of India's 100 smart cities. *Transactions of the Institute of British Geographers*. https://doi.org/10.1111/tran.12225

Datta, A. (2019). Postcolonial urban futures: Imagining and governing India's smart urban age. *Environment and Planning D: Society and Space*, *37*(3), 393–410. https://doi.org/10.1177/0263775818800721

Datta, A., & Odendaal, N. (2019). Smart cities and the banality of power. *Environment and Planning D: Society and Space*, *37*(3), 387–392. https://doi.org/10.1177/0263775819841765

David Beer. (2016). *Metric Power*. Palgrave Macmillan.

De Gregorio, J. (2017). *Transantiago: Una licitación que abre oportunidades*. Espacio Público.

de Waal, M. (2017). A city is not a galaxy: Understanding the city through urban data. In *Data and the City* (pp. 17–30). Routledge.

Deleuze, G. (2006). What Is a Dispositif? In *Two regimes of madness: Texts and interviews 1975-1995* (p. 415). Semiotext(e) ; Distributed by MIT Press.

Desrosières, A. (1998). *The politics of large numbers: A history of statistical reasoning*. Harvard University Press.

Desrosières, A. (2001). Entre réalisme métrologique et conventions d'équivalence: Les ambiguïtés de la sociologie quantitative. *Genèses*, *43*, 112–127. JSTOR.

Dwyer, A. (2019). *Malware ecologies: A politics of cybersecurity*.

Edwards, P. N., Mayernik, M. S., Batcheller, A. L., Bowker, G. C., & Borgman, C. L. (2011). Science friction: Data, metadata, and collaboration. *Social Studies of Science*, *41*(5), 667–690. https://doi.org/10.1177/0306312711413314

Espejo, R. (2014). Cybernetics of Governance: The Cybersyn Project 1971–1973. In G. S. Metcalf (Ed.), *Social Systems and Design* (pp. 71–90). Springer Japan. https://doi.org/10.1007/978-4-431-54478-4_3

Farías, I., & Bender, T. (2009). *Urban Assemblages: How Actor-Network Theory Changes Urban Studies*. Taylor & Francis Group. http://ebookcentral.proquest.com/lib/oxford/detail.action?docID=1020217

Farias, I., Roberts, C., & Blok, A. (Eds.). (2020). *The Routledge companion to actor-network theory*. Routledge, Taylor & Francis Group.

Farías, I., & Widmer, S. (2018). How Calculated Users, Professional Citizens, Technology Companies and City Administrations Engage in a More-than-digital Politics. *TECNOSCIENZA: Italian Journal of Science & Technology Studies*, 18.

Figueroa, O., & Orellana, A. (2007). Transantiago: Gobernabilidad e institucionalidad. *EURE (Santiago)*, *33*(100), 165–171.

Ford, H. (2014). Big Data and Small: Collaborations between ethnographers and data scientists. *Big Data & Society*, *1*(2), 2053951714544337. https://doi.org/10.1177/2053951714544337

Foucault, M. (1980). *Power/knowledge: Selected interviews and other writings, 1972-1977* (1st American ed). Pantheon Books.

Foucault, M. (1984). *Polemics, Politics and Problematizations: An interview conducted by Paul Rabinow in May 1984* [Interview]. https://foucault.info/documents/foucault.interview/

Foucault, M. (1988). *The History of Sexuality vol.2: The Use of Pleasure* (1st Vintage Books ed). Vintage Books.

Foucault, M. (1991a). *The Foucault effect: Studies in governmentality*. University of Chicago Press.

Foucault, M. (1991b). *Discipline and Punish: The Birth of the Prison* (A. Sheridan, Trans.; New Ed edition). Penguin.

Foucault, M. (1996). *Foucault Live: Collected Interviews, 1961–1984* (S. Lotringer, Ed.; L. Hochroth & J. Johnston, Trans.). Semiotext(e).

Foucault, M. (2007). *Security, territory, population: Lectures at the Collège de France, 1977-78*. Springer.

Foucault, M. (2008). *The birth of biopolitics: Lectures at the Collège de France, 1978-79*. Palgrave Macmillan.

Foucault, M., Burchell, G., Gordon, C., & Miller, P. (Eds.). (1991). *The Foucault effect: Studies in governmentality: with two lectures by and an interview with Michel Foucault*. University of Chicago Press.

Foucault, M., & Rabinow, P. (1984). *The Foucault reader* (1st ed). Pantheon Books.

Gabrys, J. (2014). Programming Environments: Environmentality and Citizen Sensing in the Smart City. *Environment and Planning D: Society and Space*, *32*(1), 30–48. https://doi.org/10.1068/d16812

Gabrys, J. (2016). Practicing, materialising and contesting environmental data. *Big Data & Society*, *3*(2), 205395171667339. https://doi.org/10.1177/2053951716673391

Gabrys, J. (2019). Sensors and Sensing Practices: Reworking Experience across Entities, Environments, and Technologies. *Science, Technology, & Human Values*, *44*(5), 723–736. https://doi.org/10.1177/0162243919860211

Garland, D. (2014). What is a "history of the present"? On Foucault's genealogies and their critical preconditions. *Punishment & Society*, *16*(4), 365–384. https://doi.org/10.1177/1462474514541711

Gekker, A., & Hind, S. (2020). Infrastructural surveillance. *New Media & Society*, *22*(8), 1414–1436. https://doi.org/10.1177/1461444819879426

Gieryn, T. (1999). Cultural boundaries of science: Credibility on the line University of Chicago Press. *Chicago IL*.

Gieryn, T. F. (1983). Boundary-Work and the Demarcation of Science from Non-Science: Strains and Interests in Professional Ideologies of Scientists. *American Sociological Review*, *48*(6), 781–795. https://doi.org/10.2307/2095325

Gitelman, L. (Ed.). (2013). *'Raw data' is an oxymoron*. The MIT Press.

Gómez-Lobo, A. (2012). The ups and downs of a public transport reform: The case of Transantiago. *Serie Documentos de Trabajo SDT354, Universidad de Chile, Departamento de Economía, Santiago, Chile*.

Gómez-Lobo, A., & Briones, J. (2014). Incentives in Bus Concession Contracts: A Review of Several Experiences in Latin America. *Transport Reviews*, *34*(2), 246–265.

https://doi.org/10.1080/01441647.2014.895451

Goodwin, C. (1994). Professional Vision. *American Anthropologist*, *96*(3), 606–633. https://doi.org/10.1525/aa.1994.96.3.02a00100

Graells-Garrido, E., & Peña-Araya, V. (2020). Toward An Interdisciplinary Methodology to Solve New (Old) Transportation Problems. *ArXiv:2002.08956 [Cs]*. http://arxiv.org/abs/2002.08956

Graham, S. (2000a). Constructing premium network spaces: Reflections on infrastructure networks and contemporary urban development. *International Journal of Urban and Regional Research*, *24*(1), 183–200. https://doi.org/10.1111/1468-2427.00242

Graham, S. (2000b). Introduction: Cities and Infrastructure. *International Journal of Urban and Regional Research*, *24*(1), 114–119. https://doi.org/10.1111/1468-2427.00238

Graham, S. (2004). *The cybercities reader*. Routledge.

Graham, S. D. N. (2005). Software-sorted geographies. *Progress in Human Geography*, *29*(5), 562–580. https://doi.org/10.1191/0309132505ph568oa

Graham, S., & Marvin, S. (2001). *Splintering urbanism: Networked infrastructures, technological mobilities and the urban condition*. Routledge.

Graham, S., & Wood, D. (2003). Digitizing Surveillance: Categorization, Space, Inequality. *Critical Social Policy*, *23*(2), 227–248. https://doi.org/10.1177/0261018303023002006

Granovetter, M. S. (1973). The Strength of Weak Ties. *American Journal of Sociology*, *78*(6), 1360–1380. https://doi.org/10.1086/225469

Greenfield, A. (2013). *Against the smart city (The city is here for you to use)*. Verso.

Gschwender, A., Munizaga, M., & Simonetti, C. (2016). Using smart card and GPS data for policy and planning: The case of Transantiago. *Research in Transportation Economics*, *59*, 242–249. https://doi.org/10.1016/j.retrec.2016.05.004

Haas, P. M. (1992). Introduction: Epistemic Communities and International Policy Coordination. *International Organization*, *46*(1), 1–35. JSTOR.

Hacking, I. (1990). *The taming of chance*. Cambridge University Press.

Hacking, I. (1991). How should we do the history of statistics? *The Foucault Effect: Studies in Governmentality*.

Haraway, D. (1988). Situated Knowledges: The Science Question in Feminism and the Privilege of Partial Perspective. *Feminist Studies*, *14*(3), 575–599. https://doi.org/10.2307/3178066

Harvey, D. (2007). *A Brief History of Neoliberalism*. OUP Oxford.

Heaphy, L. (2019). Data ratcheting and data-driven organisational change in transport. *Big Data & Society*, *6*(2), 2053951719867359. https://doi.org/10.1177/2053951719867359

Heath, C., & Luff, P. (1991). Collaborative Activity and Technological Design: Task Coordination in London Underground Control Rooms. In L. Bannon, M. Robinson, & K. Schmidt (Eds.), *Proceedings of the Second European Conference on Computer-Supported Cooperative Work ECSCW '91* (pp. 65–80). Springer Netherlands. https://doi.org/10.1007/978-94-011-3506-1_5

Heebels, B., & Aalst, I. van. (2020). Surveillance in Practice: Operators' Collective Interpretation of CCTV Images. *Surveillance & Society*, *18*(3), 312–327. https://doi.org/10.24908/ss.v18i3.13916

Hennion, A., & Muecke, S. (2016). From ANT to Pragmatism: A Journey with Bruno Latour at the CSI. *New Literary History*, *47*(2–3), 289–308. https://doi.org/10.1353/nlh.2016.0015

Hidalgo, D., & Graftieaux, P. (2008). Planning and implementation issues of a large scale transit modernization plan: The case of Transantiago, Chile. *Transportation Research Board, 87th Annual Meeting, Washington*.

Hodson, M. (Ed.). (2021). *Urban platforms and the future city: Transformations in infrastructure, governance, knowledge and everyday life* (First edition). Routledge, Taylor & Francis Group.

Hodson, M., Kasmire, J., Mckmeckin, A., Stehlin, J., & Ward, K. (Eds.). (2021). *Urban platforms and the future city: Transformations in infrastructure, governance, knowledge and everyday life* (First edition). Routledge, Taylor & Francis Group.

Hollands, R. G. (2008). Will the real smart city please stand up?: Intelligent, progressive or entrepreneurial? *City*, *12*(3), 303–320. https://doi.org/10.1080/13604810802479126

Hollands, R. G. (2015). Critical interventions into the corporate smart city. *Cambridge Journal of Regions, Economy and Society*, *8*(1), 61–77. https://doi.org/10.1093/cjres/rsu011

Hopkins, D., & Schwanen, T. (2021). Talking about automated vehicles: What do levels of automation do? *Technology in Society*, *64*, 101488. https://doi.org/10.1016/j.techsoc.2020.101488

Hurtubia, R., & Leonhardt, J. (2021). *The Experience of Reforming Bus Concessions in Santiago de Chile*. ITFOECD Discussion paper.

IBM Watson. (2016, September 17). *The 5 V's of big data*. Watson Health Perspectives. https://www.ibm.com/blogs/watson-health/the-5-vs-of-big-data/

INE. (2017). *Censo nacional de población y vivienda*. http://resultados.censo2017.cl/Region?R=R13

Irazábal, C., & Jirón, P. (2021). Latin American smart cities: Between worlding infatuation and crawling provincialising. *Urban Studies*, *58*(3), 507–534. https://doi.org/10.1177/0042098020945201

Jasanoff, S. (2009). *The fifth branch: Science advisers as policymakers*. Harvard University Press.

Jasanoff, S. (2017). Virtual, visible, and actionable: Data assemblages and the sightlines of justice. *Big Data & Society*, *4*(2), 2053951717724477. https://doi.org/10.1177/2053951717724477

Jirón Martínez, P. (2009). *Prácticas de movilidad cotidiana urbana: Un análisis para revelar desigualdades en la ciudad*.

Jiron, P., & Carrasco, J. A. (2020). Understanding daily mobility strategies through ethnographic, time use, and social network lenses. *Sustainability*, *12*(1), 312.

Jirón, P., Imilán, W. A., Lange, C., & Mansilla, P. (2021). Placebo urban interventions: Observing Smart City narratives in Santiago de Chile. *Urban Studies*, *58*(3), 601–620. https://doi.org/10.1177/0042098020943426

Kallinikos, J. (2004). The Social Foundations of the Bureaucratic Order. *Organization*, *11*(1), 13–36. https://doi.org/10.1177/1350508404039657

Kallinikos, J. (2011a). Technology as Object of Social Enquiry. In *Governing through Technology* (pp. 1–11). Palgrave Macmillan, London. https://doi.org/10.1057/9780230295148_1

Kallinikos, J. (2011b). Unpacking Information Packages: Rationalization and Governance. In *Governing through Technology* (pp. 46–62). Palgrave Macmillan, London. https://doi.org/10.1057/9780230295148_4

Keval, H. U., & Sasse, M. A. (2006). Man or a Gorilla? Performance Issues with CCTV Technology in Security Control Rooms. *16th World Congress on Ergonomics Conference, International Ergonomics Association*, 10–14.

Kitchin, R. (2013). Big data and human geography: Opportunities, challenges and risks. *Dialogues in Human Geography*, *3*(3), 262–267. https://doi.org/10.1177/2043820613513388

Kitchin, R. (2014a). *The data revolution: Big data, open data, data infrastructures and their consequences*. Sage.

Kitchin, R. (2014b). Big Data, new epistemologies and paradigm shifts. *Big Data & Society*, *1*(1), 205395171452848. https://doi.org/10.1177/2053951714528481

Kitchin, R. (2014c). *The Data Revolution* (1 edition). Sage Publications Ltd.

Kitchin, R. (2015). Making sense of smart cities: Addressing present shortcomings. *Cambridge Journal of Regions, Economy and Society*, *8*(1), 131–136. https://doi.org/10.1093/cjres/rsu027

Kitchin, R. (2017). The Realtimeness of Smart Cities. *TECNOSCIENZA: Italian Journal of Science & Technology Studies*, *8*(2), 24.

Kitchin, R. (2021). *The Data Revolution: A critical analysis of big data, open data and data infrastructures*. Sage.

Kitchin, R., Coletta, C., Evans, L., Heaphy, L., & Donncha, D. M. (2019). Smart cities, algorithmic technocracy and new urban technocrats. In *Planning and Knowledge: How New Forms of Technocracy Are Shaping Contemporary Cities* (p. 8). Bristol University Press.

Kitchin, R., & Dodge, M. (2011). *Code/Space: Software and Everyday Life*. https://doi.org/10.7551/mitpress/9780262042482.001.0001

Kitchin, R., & Lauriault, T. P. (2014). *Towards critical data studies: Charting and unpacking data assemblages and their work*.

Kitchin, R., Lauriault, T. P., & McArdle, G. (2015). Urban indicators and dashboards: Epistemology, contradictions and power/knowledge. *Regional Studies, Regional Science*, *2*(1), 43–45. https://doi.org/10.1080/21681376.2014.991485

Kitchin, R., Lauriault, T. P., & McArdle, G. (Eds.). (2017). *Data and the city*. Routledge, an imprint of the Taylor & Francis Group.

Kitchin, R., Maalsen, S., & McArdle, G. (2016). The praxis and politics of building urban dashboards. *Geoforum*, *77*, 93–101. https://doi.org/10.1016/j.geoforum.2016.10.006

Kitchin, R., & McArdle, G. (2016). What makes Big Data, Big Data? Exploring the ontological characteristics of 26 datasets. *Big Data & Society*, *3*(1), 2053951716631130. https://doi.org/10.1177/2053951716631130

Kitchin, R., & Moore-Cherry, N. (2020). Fragmented governance, the urban data ecosystem and smart city-regions: The case of Metropolitan Boston. *Regional Studies*, 1–11. https://doi.org/10.1080/00343404.2020.1735627

Kitchin, R., & Stehle, S. (2021). Can Smart City Data be Used to Create New Official Statistics? *Journal of Official Statistics*, *37*(1), 121–147.

Klauser, F., Paasche, T., & Söderström, O. (2014). Michel Foucault and the Smart City: Power Dynamics Inherent in Contemporary Governing through Code. *Environment and Planning D: Society and Space*, *32*(5), 869–885. https://doi.org/10.1068/d13041p

Knoblauch, H., & Löw, M. (2017). On the Spatial Re-Figuration of the Social World. *Sociologica*, *2*, 0–0. https://doi.org/10.2383/88197

Knorr-Cetina, K. (1999). *Epistemic cultures: How the sciences make knowledge*. Harvard University Press.

Knorr-Cetina, K. (2009a). The Synthetic Situation: Interactionism for a Global World. *Symbolic Interaction*, *32*(1), 61–87. https://doi.org/10.1525/si.2009.32.1.61

Knorr-Cetina, K. (2009b). The Synthetic Situation: Interactionism for a Global World. *Symbolic Interaction*, *32*(1), 61–87. https://doi.org/10.1525/si.2009.32.1.61

Koopman, C. (2013). *Genealogy as critique: Foucault and the problems of modernity*. Indiana University Press.

Koopman, C. (2018). Problematization in Foucault's Genealogy and Deleuze's Symptomatology. *Angelaki*, *23*(2), 187–204. https://doi.org/10.1080/0969725X.2018.1451583

Krivý, M. (2018). Towards a critique of cybernetic urbanism: The smart city and the society of control. *Planning Theory*, *17*(1), 8–30. https://doi.org/10.1177/1473095216645631

Lamont, M., & Molnár, V. (2002). The Study of Boundaries in the Social Sciences. *Annual Review of Sociology*, *28*, 167–195.

Lampland, M., & Star, S. L. (2009). *Standards and their stories: How quantifying, classifying, and formalizing practices shape everyday life*. Cornell University Press.

Larraín-Videla, C., Muñoz, J.-C., & Briones, J. (2022). Gobernanza del transporte en áreas metropolitanas: Revisión crítica y análisis para Santiago de Chile. *Revista EURE - Revista de Estudios Urbano Regionales*, *48*(145), Article 145. http://www.eure.cl/index.php/eure/article/view/EURE.48.145.14

Latour, B. (1987). *Science in action: How to follow scientists and engineers through society*. Harvard university press.

Latour, B. (1990). Technology is Society Made Durable. *The Sociological Review*, *38*(1_suppl), 103–131. https://doi.org/10.1111/j.1467-954X.1990.tb03350.x

Latour, B. (1993). *We have never been modern*. Harvard University Press.

Latour, B. (1996). *Aramis, or the love of technology* (4. printing). Harvard Univ. Press.

Latour, B. (2004). Why has critique run out of steam? From matters of fact to matters of concern. *Critical Inquiry*, *30*(2), 225–248.

Latour, B. (2005). *Reassembling the social: An introduction to actor-network-theory*. Oxford University Press.

Latour, B. (2010). An Attempt at a 'Compositionist Manifesto'. *New Literary History*, *41*(3), 471–490.

Latour, B. (2013). *An inquiry into modes of existence: An anthropology of the moderns*. Harvard University Press.

Latour, B., & Hermant, E. (1998). *Paris: Ville Invisible*. http://www.bruno-latour.fr/sites/default/files/downloads/viii_paris-city-gb.pdf

Latour, B., Hermant, E., & Shannon, S. (1998). *Paris ville invisible*. La Découverte Paris.

Latour, B., & Woolgar, S. (1986). *Laboratory Life: The Construction of Scientific Facts*. Princeton University Press.

Law, J. (1987a). On the Social Explanation of Technical Change: The Case of the Portuguese Maritime Expansion. *Technology and Culture*, *28*(2), 227–252. https://doi.org/10.2307/3105566

Law, J. (1987b). The Structure of Sociotechnical Engineering—A Review of the New Sociology of Technology. *The Sociological Review*, *35*(2), 404–425. https://doi.org/10.1111/j.1467-954X.1987.tb00015.x

Law, J. (1997). Traduction/trahison: Notes on ANT. Department of Sociology, Lancaster University. *Online at: Http://Www. Lancaster. Ac. Uk/Sociology/Stslaw2. Html*.

Law, J. (2002). Aircraft stories. In *Aircraft Stories*. Duke University Press.

Law, J. (2009). Seeing like a survey. *Cultural Sociology*, *3*(2), 239–256.

Law, J., Bijker, W. E., Hughes, T. P., & Pinch, T. (2012). Technology and heterogeneous engineering: The case of Portuguese expansion. *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology*, 105–127.

Law, J., & Callon, M. (1988). Engineering and Sociology in a Military Aircraft Project: A Network Analysis of Technological Change. *Social Problems*, *35*(3), 284–297.

Law, J., & Urry, J. (2004). Enacting the social. *Economy and Society*, *33*(3), 390–410. https://doi.org/10.1080/0308514042000225716

Lehuedé, S. (2021). *Governing data in modernity/coloniality: Astronomy data in the Atacama Desert and the struggle for collective autonomy*. London School of Economics and Political Science.

Leigh-Star, S. (1999). The Ethnography of Infrastructure. *American Behavioral Scientist*, *43*(3), 377–391. https://doi.org/10.1177/00027649921955326

Lemke, T. (2019). *Foucault's Analysis of Modern Governmentality. A Critique of Political Reason.* Verso.

Leszczynski, A. (2016). Speculative futures: Cities, data, and governance beyond smart urbanism. *Environment and Planning A: Economy and Space*, *48*(9), 1691–1708. https://doi.org/10.1177/0308518X16651445

Levina, N., & Vaast, E. (2005a). The Emergence of Boundary Spanning Competence in Practice: Implications for Implementation and Use of Information Systems. *MIS Quarterly*, *29*(2), 335–363. https://doi.org/10.2307/25148682

Levina, N., & Vaast, E. (2005b). *The Emergence of Boundary Spanning Competence in Practice: Implications for Information Systems' Implementation and Use*. 50.

Lim, Y., Edelenbos, J., & Gianoli, A. (2019). Identifying the results of smart city development: Findings from systematic literature review. *Cities*, *95*, 102397. https://doi.org/10.1016/j.cities.2019.102397

Lock, O., Bednarz, T., Leao, S. Z., & Pettit, C. (2020). A review and reframing of participatory urban dashboards. *City, Culture and Society*, *20*, 100294. https://doi.org/10.1016/j.ccs.2019.100294

Luff, P., Heath, C., & Jirotka, M. (2000). Surveying the scene: Technologies for everyday awareness and monitoring in control rooms. *Interacting with Computers*, *13*(2), 193–228. https://doi.org/10.1016/S0953-5438(00)00038-2

Luque-Ayala, A., & Marvin, S. (2015). Developing a critical understanding of smart urbanism? *Urban Studies*, *52*(12), 2105–2116. https://doi.org/10.1177/0042098015577319

Luque-Ayala, A., & Marvin, S. (2016a). The maintenance of urban circulation: An operational logic of infrastructural control. *Environment and Planning D: Society and Space*, *34*(2), 191–208. https://doi.org/10.1177/0263775815611422

Luque-Ayala, A., & Marvin, S. (2016b). The maintenance of urban circulation: An operational logic of infrastructural control. *Environment and Planning D: Society and Space*, *34*(2), 191–208. https://doi.org/10.1177/0263775815611422

Luque-Ayala, A., & Marvin, S. (2020a). *Urban operating systems: Producing the computational city*. http://mitpress.mit.edu/9780262539814

Luque-Ayala, A., & Marvin, S. (2020b). *Urban Operating Systems: Producing the Computational City*. https://doi.org/10.7551/mitpress/10869.001.0001

Lury, C. (2020). *Problem spaces: How and why methodology matters*. Polity Press.

Mackenzie, A. (2017). *Machine Learners: Archaeology of a Data Practice*. MIT Press.

Marcus, G. E. (1995). Ethnography in/of the World System: The Emergence of Multi-Sited Ethnography. *Annual Review of Anthropology*, *24*(1), 95–117. https://doi.org/10.1146/annurev.an.24.100195.000523

Marres, N. (2019). As ANT is getting undone, can Pragmatism help us re-do it? In *The Routledge Companion to Actor-Network Theory* (pp. 112–120). Routledge.

Marvin, S., & Luque-Ayala, A. (2017a). Urban Operating Systems: Diagramming the City:

Urban Operating Systems. *International Journal of Urban and Regional Research*, *41*(1), 84–103. https://doi.org/10.1111/1468-2427.12479

Marvin, S., & Luque-Ayala, A. (2017b). Urban Operating Systems: Diagramming the City: Urban Operating Systems. *International Journal of Urban and Regional Research*, *41*(1), 84–103. https://doi.org/10.1111/1468-2427.12479

Marvin, S., & Luque-Ayala, A. (2017). Urban Operating Systems: Diagramming the City. *International Journal of Urban and Regional Research*, *41*(1), 84–103. https://doi.org/10.1111/1468-2427.12479

Marvin, S., Luque-Ayala, A., & McFarlane, C. (Eds.). (2016a). *Smart urbanism: Utopian vision or false dawn?* Routledge, Taylor & Francis Group.

Marvin, S., Luque-Ayala, A., & McFarlane, C. (Eds.). (2016b). *Smart urbanism: Utopian vision or false dawn?* Routledge, Taylor & Francis Group.

Mattern, S. (2014). Interfacing Urban Intelligence. *Places Journal*. https://doi.org/10.22269/140428

Mattern, S. (2015a). Mission control: A history of the urban dashboard. *Places Journal*.

Mattern, S. (2015b). Mission Control: A History of the Urban Dashboard. *Places Journal*. https://doi.org/10.22269/150309

Mattern, S. (2017). A City Is Not a Computer. *Places Journal*.

Mattern, S. C. (2017). *Code + clay... data + dirt: Five thousand years of urban media*. University of Minnesota Press.

McFarlane, C. (2011). Assemblage and critical urbanism. *City*, *15*(2), 204–224. https://doi.org/10.1080/13604813.2011.568715

McFarlane, C., & Anderson, B. (2011). Thinking with assemblage. *Area*, *43*(2), 162–164.

McFarlane, C., & Söderström, O. (2017a). On alternative smart cities. *City*, *21*(3–4), 312–328. https://doi.org/10.1080/13604813.2017.1327166

McFarlane, C., & Söderström, O. (2017b). On alternative smart cities: From a technology-intensive to a knowledge-intensive smart urbanism. *City*, *21*(3–4), 312–328. https://doi.org/10.1080/13604813.2017.1327166

McNeill, D. (2015). IBM and the visual formation of Smart Cities. In *Smart Urbanism: Utopian vision or false dawn?* (pp. 34–55). Routledge, Taylor & Francis Group.

Medina, E. (2011). *Cybernetic Revolutionaries_ Technology and Politics in Allende's Chile*. MIT Press.

Meier, R. L. (1962). *A communications theory of urban growth*. Joint Center for Urban

Studies of the Massachusetts Institute of Technology ….

Meijer, A., & Bolívar, M. P. R. (2016). Governing the smart city: A review of the literature on smart urban governance. *International Review of Administrative Sciences*, *82*(2), 392–408. https://doi.org/10.1177/0020852314564308

Michael, M. (2016). *Actor network theory: Trials, trails and translations* (1st edition). SAGE Ltd.

Michael, M., & Wilkie, A. (2020). Speculative Research. In *The Palgrave Encyclopedia of the Possible* (pp. 1–8). Springer International Publishing. https://doi.org/10.1007/978-3-319-98390-5_118-1

Mignolo, W. D. (2009). Epistemic Disobedience, Independent Thought and Decolonial Freedom. *Theory, Culture & Society*, *26*(7–8), 159–181. https://doi.org/10.1177/0263276409349275

Mignolo, W. D. (2011). *The Darker Side of Western Modernity. Global Futures, Decolonial Options* (Duke University Press).

Mladenovic, M. (2021). Mobility as a Service. In *International Encyclopedia of Transportation*. Elsevier.

Mouton, M., & Burns, R. (2021). (Digital) neo-colonialism in the smart city. *Regional Studies*, 1–12. https://doi.org/10.1080/00343404.2021.1915974

Müller, M. (2015). Assemblages and Actor-networks: Rethinking Socio-material Power, Politics and Space. *Geography Compass*, *9*(1), 27–41. https://doi.org/10.1111/gec3.12192

Munizaga, M. A., Núñez, C., & Gschwender, A. (2017). Smart card data for wider transport system evaluation. In *Public Transport Planning with Smart Card Data* (pp. 163–179). Scopus. https://doi.org/10.1201/9781315370408

Munizaga, M. A., & Palma, C. (2012). Estimation of a disaggregate multimodal public transport Origin–Destination matrix from passive smartcard data from Santiago, Chile. *Transportation Research Part C: Emerging Technologies*, *24*, 9–18. https://doi.org/10.1016/j.trc.2012.01.007

Munizaga, M., Beltrán, P., Cortés, C. E., Gschwender, A., Ibarra, R., Palma, C., Ortega, M., & Zúñiga, M. (2012). Obtención de Información Valiosa a partir de Datos de Transantiago. *Ingeniería de Transporte*, *16*(2). https://ingenieriadetransporte.org/ojs/index.php/sochitran/article/view/131

Munizaga, M., Devillaine, F., Navarrete, C., & Silva, D. (2014). Validating travel behavior estimated from smartcard data. *Transportation Research Part C: Emerging Technologies*, *44*, 70–79.

Muñoz, J. C., Batarce, M., & Hidalgo, D. (2014). Transantiago, five years after its launch.

Research in Transportation Economics, *48*, 184–193. https://doi.org/10.1016/j.retrec.2014.09.041

Muñoz, J. C., de Dios Ortuzar, J., & Gschwender, A. (2016). Transantiago: The fall and rise of a radical public transport intervention. In *Travel Demand Management and Road User Pricing* (pp. 171–192). Routledge.

Muñoz, J. C., & Gschwender, A. (2008). Transantiago: A tale of two cities. *Research in Transportation Economics*, *22*(1), 45–53. https://doi.org/10.1016/j.retrec.2008.05.010

Muñoz, J., Ortúzar, J. de D., & Gschwender, A. (2009). Transantiago: The Fall and Rise of a Radical Public Transport Intervention. *Travel Demand Management and Road User Pricing: Success, Failure and Feasibility*.

Nochur, K. S., & Allen, T. J. (1992). Do nominated boundary spanners become effective technological gatekeepers? (Technology transfer). *IEEE Transactions on Engineering Management*, *39*(3), 265–269. https://doi.org/10.1109/17.156560

Odendaal, N. (2016). Getting Smart About Smart Cities: Beyond the Rhetoric. *Smart Urbanism. Utopian Vision or False Dawn*, 71–87.

OECD. (2009). *OECD Territorial Reviews: Chile 2009 (Spanish version)*. Ministry of the Interior, Chile.

OECD. (2017). *Gaps and Governance Standards of Public Infrastructure in Chile: Infrastructure Governance Review*. OECD. https://doi.org/10.1787/9789264278875-en

Offenhuber, D. (2019). The platform and the bricoleur—Improvisation and smart city initiatives in Indonesia. *Environment and Planning B: Urban Analytics and City Science*, *46*(8), 1565–1580. https://doi.org/10.1177/2399808319865749

Offenhuber, D., & Ratti, C. (2014). *Decoding the city: Urbanism in the age of big data*. Birkhäuser.

Offenhuber, D., & Schechtner, K. (2018). Improstructure—An improvisational perspective on smart infrastructure governance. *Cities*, *72*, 329–338. https://doi.org/10.1016/j.cities.2017.09.017

Olavarría-Gambi, M. (2020). Policy Failure Revisited: Conceptual Implications From the Chilean Case of Transantiago. *Administration & Society*, *52*(5), 690–717. https://doi.org/10.1177/0095399718786878

Ollion, É. (2015). L'abondance et ses revers. Big data, open data et recherches sur les questions sociales. *Informations sociales*, *n° 191*(5), 70. https://doi.org/10.3917/inso.191.0070

Orlikowski, W. J., Walsham, G., Jones, M. R., & DeGross, J. I. (2016). *Information Technology and Changes in Organizational Work*. Springer.

Pappalardo, L., Cornacchia, G., Navarro, V., Bravo, L., & Ferres, L. (2020). A dataset to assess mobility changes in Chile following local quarantines. *ArXiv Preprint ArXiv:2011.12162*.

Picon, A. (2018). Urban Infrastructure, Imagination and Politics: From the Networked Metropolis to the Smart City. *International Journal of Urban and Regional Research*, *42*(2), 263–275. https://doi.org/10.1111/1468-2427.12527

Pink, S., Fors, V., & Glöss, M. (2018). The contingent futures of the mobile present: Automation as possibility. *Mobilities*, *13*(5), 615–631. https://doi.org/10.1080/17450101.2018.1436672

Pontificia Universidad Católica de Chile. (2017). *Inforime Final Asesoría para Mejoras Operativas y de Participación Ciudadana para el Sistema de Transporte Público de Santiago".*

Quijano, A. (1999). COLONIALIDAD DEL PODER, CULTURA Y CONOCIMIENTO EN AMÉRICA LATINA. *Dispositio*, *24*(51), 137–148.

Rabinow, P. (2003). *Anthropos today: Reflections on modern equipment*. Princeton Univ. Press.

Rabinow, P. (2011). Dewey and Foucault: What's the Problem? *Foucault Studies*, *11*, 11. https://doi.org/10.22439/fs.v0i11.3202

Rankin, S., Cohen, N., Maclennan-Brown, K., & Sage, K. (2012). CCTV Operator Performance Benchmarking. *2012 IEEE International Carnahan Conference on Security Technology (ICCST)*, 325–330. https://doi.org/10.1109/CCST.2012.6393580

Reay, T., Zilber, T. B., Langley, A., & Tsoukas, H. (2019). *Institutions and organizations: A process view*. Oxford University Press.

Robinson, J. (2006). *Ordinary cities: Between modernity and development*. Routledge.

Rogowska-Stangret, M. (2018). Situated Knowledges. *The New Materialist Almanac*.

Rose, G. (2016). Rethinking the geographies of cultural 'objects' through digital technologies: Interface, network and friction. *Progress in Human Geography*, *40*(3), 334–351. https://doi.org/10.1177/0309132515580493

Rose, G. (2017). Posthuman Agency in the Digitally Mediated City: Exteriorization, Individuation, Reinvention. *Annals of the American Association of Geographers*, *107*(4), 779–793. https://doi.org/10.1080/24694452.2016.1270195

Rose, G., Raghuram, P., Watson, S., & Wigley, E. (2020a). Platform urbanism, smartphone applications and valuing data in a smart city. *Transactions of the Institute of British Geographers*, *n/a*(n/a). https://doi.org/10.1111/tran.12400

Rose, G., Raghuram, P., Watson, S., & Wigley, E. (2020b). Platform urbanism, smartphone applications and valuing data in a smart city. *Transactions of the Institute of British Geographers*, tran.12400. https://doi.org/10.1111/tran.12400

Roy, A. (2009). Strangely Familiar: Planning and the Worlds of Insurgence and Informality. *Planning Theory*, *8*(1), 7–11. https://doi.org/10.1177/1473095208099294

Ruppert, E., Isin, E., & Bigo, D. (2017). Data politics. *Big Data & Society*, *4*(2), 205395171771774. https://doi.org/10.1177/2053951717717749

Sadowski, J. (2019). When data is capital: Datafication, accumulation, and extraction. *Big Data & Society*, *6*(1), 2053951718820549. https://doi.org/10.1177/2053951718820549

Sadowski, J., & Bendor, R. (2019). Selling Smartness: Corporate Narratives and the Smart City as a Sociotechnical Imaginary. *Science, Technology, & Human Values*, *44*(3), 540–563. https://doi.org/10.1177/0162243918806061

Sadowski, J., & Maalsen, S. (2020). Modes of making smart cities: Or, practices of variegated smart urbanism. *Telematics and Informatics*, 101449. https://doi.org/10.1016/j.tele.2020.101449

Savransky, M. (2021). Problems All the Way Down. *Theory, Culture & Society*, *38*(2), 3–23. https://doi.org/10.1177/0263276420966389

Schwanen, T. (2017). Geographies of transport II: Reconciling the general and the particular. *Progress in Human Geography*, *41*(3), 355–364. https://doi.org/10.1177/0309132516628259

Schwanen, T. (2022). Information Technology and Mobility. In *International Encyclopedia of Geography* (pp. 1–4). John Wiley & Sons, Ltd. https://doi.org/10.1002/9781118786352.wbieg0403.pub3

Scott, J. C. (2008). *Seeing like a state*. yale university Press.

Seaver, N. (2017). Algorithms as culture: Some tactics for the ethnography of algorithmic systems. *Big Data & Society*, *4*(2), 205395171773810. https://doi.org/10.1177/2053951717738104

SECTRA. (2000). *PLAN DE TRANSPORTE URBANO SANTIAGO 2000—2006—Resumen Ejecutivo*. http://coaliciontransportejusto.wdfiles.com/local--files/wiki:biblioteca/PTUS_resumen_ejecutivo.pdf

SECTRA. (2014). *Actualización y recolección de información del sistema de transporte urbano, IX Etapa: Encuesta Origen Destino Santiago 2012. Encuesta origen destino de viajes 2012 (Documento Difusión)*.

Shelton, T. (2017). The urban geographical imagination in the age of Big Data. *Big Data &*

Society, *4*(1), 205395171666512. https://doi.org/10.1177/2053951716665129

Shelton, T., Zook, M., & Wiig, A. (2015a). The ‘actually existing smart city’. *Cambridge Journal of Regions, Economy and Society*, *8*(1), 13–25. https://doi.org/10.1093/cjres/rsu026

Shelton, T., Zook, M., & Wiig, A. (2015b). The ‘actually existing smart city’. *Cambridge Journal of Regions, Economy and Society*, *8*(1), 13–25. https://doi.org/10.1093/cjres/rsu026

Silva, P. (1995). Empresarios, neoliberalismo y transición democrática en Chile. *Revista Mexicana de Sociología*, *57*(4), 3–25. https://doi.org/10.2307/3540903

Silva, P. (2006). LOS TECNÓCRATAS Y LA POLÍTICA EN CHILE: PASADO Y PRESENTE. *Revista de Ciencia Política (Santiago)*, *26*(2), 175–190. https://doi.org/10.4067/S0718-090X2006000200010

Silva, P. (2010). *En el nombre de la razón: Tecnócratas y política en Chile*. Ediciones Universidad Diego Portales.

Smith, A., & Martín, P. P. (2021). Going Beyond the Smart City? Implementing Technopolitical Platforms for Urban Democracy in Madrid and Barcelona. *Journal of Urban Technology*, *28*(1–2), 311–330. https://doi.org/10.1080/10630732.2020.1786337

Smith, G. J. D. (2004). Behind the Screens: Examining Constructions of Deviance and Informal Practices among CCTV Control Room Operators in the UK. *Surveillance & Society*, *2*(2/3). https://doi.org/10.24908/ss.v2i2/3.3384

Söderström, O., & Mermet, A.-C. (2020). When Airbnb Sits in the Control Room: Platform Urbanism as Actually Existing Smart Urbanism in Reykjavík. *Frontiers in Sustainable Cities*, *2*. https://doi.org/10.3389/frsc.2020.00015

Söderström, O., Paasche, T., & Klauser, F. (2014a). Smart cities as corporate storytelling. *City*, *18*(3), 307–320. https://doi.org/10.1080/13604813.2014.906716

Söderström, O., Paasche, T., & Klauser, F. (2014b). Smart cities as corporate storytelling. *City*, *18*(3), 307–320. https://doi.org/10.1080/13604813.2014.906716

Sovacool, B. K., & Hess, D. J. (2017). Ordering theories: Typologies and conceptual frameworks for sociotechnical change. *Social Studies of Science*, *47*(5), 703–750. https://doi.org/10.1177/0306312717709363

Srnicek, N. (2016). *Platform Capitalism*. Polity.

Stehlin, J., Hodson, M., & McMeekin, A. (2020). Platform mobilities and the production of urban space: Toward a typology of platformization trajectories. *Environment and Planning A: Economy and Space*, *52*(7), 1250–1268. https://doi.org/10.1177/0308518X19896801

Stengers, I. (2018). The challenge of ontological politics. *A World of Many Worlds*, 83–111.

Strathern, M. (2005). *Partial connections*. Rowman Altamira.

Strathern, M. (2018). Infrastructures in and of ethnography. *Anuac*, *7*(2), Article 2. https://doi.org/10.7340/anuac2239-625X-3519

Straube, T. (2016). Stacked spaces: Mapping digital infrastructures. *Big Data & Society*, *3*(2), 205395171664245. https://doi.org/10.1177/2053951716642456

Straube, T. (2017). Situating data infrastructures. In *Data and the City*. Routledge.

Subtel. (2019, October 18). *Usuarios de Internet móvil consumen 10 GB en promedio al mes y número de teléfonos móviles sube a 26 millones*. Subsecretaría de Telecomunicaciones de Chile. https://www.subtel.gob.cl/usuarios-de-internet-movil-consumen-10-gb-en-promedio-al-mes-y-numero-de-telefonos-moviles-sube-a-26-millones/

Tanweer, A., Fiore-Gartland, B., & Aragon, C. (2016). Impediment to insight to innovation: Understanding data assemblages through the breakdown–repair process. *Information, Communication & Society*, *19*(6), 736–752. https://doi.org/10.1080/1369118X.2016.1153125

Thatcher, J., & Dalton, C. (2017). Data provenance and possibility: Thoughts towards a provenance schema for urban data. In *Data and the City*. Routledge.

Thrift, N. (2005). *Knowing capitalism*. Sage.

Thrift, N., & French, S. (2002). The automatic production of space. *Transactions of the Institute of British Geographers*, *27*(3), 309–335. https://doi.org/10.1111/1475-5661.00057

Tijoux Merino, M. E., & Córdova Rivera, M. G. (2015). Racismo en Chile: Colonialismo, nacionalismo, capitalismo. *Polis (Santiago)*, *14*(42), 7–13. https://doi.org/10.4067/S0718-65682015000300001

Tirachini, A. (2013). Estimation of travel time and the benefits of upgrading the fare payment technology in urban bus services. *Transportation Research Part C: Emerging Technologies*, *30*, 239–256. https://doi.org/10.1016/j.trc.2011.11.007

Tironi, M. (2019). Experimentando con lo urbano: Políticas, discursos y prácticas de la ciudad inteligente y la datificación. *Athenea Digital. Revista de pensamiento e investigación social*, *19*(2), Article 2. https://doi.org/10.5565/rev/athenea.2366

Tironi, M., & Valderrama, M. (2017). Unpacking a citizen self-tracking device: Smartness and idiocy in the accumulation of cycling mobility data. *Environment and Planning D: Society and Space*, 026377581774478. https://doi.org/10.1177/0263775817744781

Townsend, A. M. (2013). *Smart cities: Big data, civic hackers, and the quest for a new utopia*. WW Norton & Company.

Ugarte, S. (Forthcoming). Racialized Positionalities: Ethnographic Responsibility and the

Anthropology of Racism and White Supremacy. In *Anthropology and Responsibility* (edited by M. Fumanti, C. Lynteris, and M. Demian). Routledge.

UN Habitat. (2022). *Goblal Review of Smart City Governance Practices*. https://unhabitat.org/sites/default/files/2022/11/grscgp_design_final8.pdf

Uprichard, E. (2013). Focus: Big data, little questions? *Discover Society*, *1*.

Ureta, S. (2014). Normalizing Transantiago: On the challenges (and limits) of repairing infrastructures. *Social Studies of Science*, *44*(3), 368–392. https://doi.org/10.1177/0306312714523855

Ureta, S. (2015). *Assembling policy: Transantiago, human devices, and the dream of a world-class society*. MIT Press.

Ureta, S. (2017). *Transantiago: O el fallido ensamblaje de una sociedad de clase mundial*. Ediciones Universidad Alberto Hurtado.

Valdés, J. G. (1995). *Pinochet's economists: The Chicago school of Economics in Chile*. Cambridge University Press.

Vanolo, A. (2014). Smartmentality: The Smart City as Disciplinary Strategy. *Urban Studies*, *51*(5), 883–898. https://doi.org/10.1177/0042098013494427

Vertesi, J. (2015). *Seeing Like a Rover: How Robots, Teams, and Images Craft Knowledge of Mars*. University of Chicago Press. https://doi.org/10.7208/chicago/9780226156019.001.0001

Vertesi, J., & Ribes, D. (Eds.). (2019a). *DigitalSTS: A field guide for science & technology studies*. Princeton University Press.

Vertesi, J., & Ribes, D. (2019b). *Digital STS. A field guide for science and technology studies.* Princeton University Press. https://press.princeton.edu/books/hardcover/9780691187075/digitalsts

Villalobos, C., Quaresma, M. L., & Franetovic, G. (2020). Mapeando a la élite en las universidades chilenas. Un análisis cuantitativo-multidimensional. *Revista Española de Sociología*, *29*(3), Article 3. https://doi.org/10.22325/fes/res.2020.33

Webber, M. M. (1965). The roles of intelligence systems in urban-systems planning. *Journal of the American Institute of Planners*, *31*(4), 289–296.

Webber, M. M. (2016). *Explorations into urban structure*. University of Pennsylvania Press.

What is UX Research? (n.d.). The Interaction Design Foundation. Retrieved 19 July 2022, from https://www.interaction-design.org/literature/topics/ux-research

Wigley, E., & Rose, G. (2020). Will the real smart city please make itself visible? In *The*

Routledge Companion to Smart Cities (pp. 301–311). Routledge.

Williams, L. (2010). Agile Software Development Methodologies and Practices. In M. V. Zelkowitz (Ed.), *Advances in Computers* (Vol. 80, pp. 1–44). Elsevier. https://doi.org/10.1016/S0065-2458(10)80001-4

Williams, P. (2002). The Competent Boundary Spanner. *Public Administration*, *80*(1), 103–124. https://doi.org/10.1111/1467-9299.00296

Williamson, B. (2017). Computing brains: Learning algorithms and neurocomputation in the smart city. *Information, Communication & Society*, *20*(1). https://doi.org/10.1080/1369118X.2016.1181194

Wilmott, C. (2021). From Panopticons to the Partial. Digital and Blockchain Mapping in Platform Urbanism. In *Urban Platforms and the Future of City* (pp. 191–206). Routledge, Taylor & Francis Group.

Winthereik, B. R. (2019). Is ANT's radical empiricism ethnographic? In *The Routledge Companion to Actor-Network Theory* (pp. 24–33). Routledge.

Yonego, J. T. (2014, July 23). Data Is the New Oil of the Digital Economy. *Wired*. https://www.wired.com/insights/2014/07/data-new-oil-digital-economy/