Business Models of Organizations engaging with Urban Data Platforms

Two-staged, exploratory research to generate a business model framework and analyze as well as compare organizations in the context of Urban Data Platforms

MSc Business Information Management

Student Name: Rasmus Ramm

Student ID: 410570

Coach: Prof. Ting Li

Co-Reader: Dr. Tobias Brandt

Company Coach: Thomas Kruse

Date: 22.06.2019

RSM Erasmus University

Preface

Acknowledgement

I would like to thank prof. dr. Ting Li and dr. Tobias Brandt for your help throughout this project. The meetings with you were an invaluable guidance, always giving me a little push in the right direction, when I needed it. I would also like to thank Thomas Kruse for the practical insights and introducing me to the reality of Urban Data Platforms, when they used to be just a concept that I had read about. Further, I would like to thank all the participants for taking the time to take part in this research. Without your contribution my thesis would not have been possible.

Since this thesis also reflects the end of my academic journey, I would like to thank Jenny for always being there for me along my way and being my rock in turbulent waters. I would like to thank my parents Reinhard and Thekla for giving me all the support I could have ever wished for and enabling me to follow my dreams.

Executive Summary

Fueled by the rise of Internet of Things (IoT) devices, data for almost every aspect of urban life is collected in today's smart cities and the volume, as well as the domains from where data is collected, are increasing every day. This urban data gives organizations a unique chance to get insights about many aspects of urban life. To foster economic activities in the city, the usage of Urban Data Platforms (UDPs) is becoming more widely adopted among smart cities, encouraging the exchange of urban data between data suppliers and data users. In this role, engaging with a UDP allows organizations to either receive or share their urban data and create a new value proposition based on this engagement. Analyzing this value creation logic through a business model analysis is not yet well understood due to the lack of an appropriate framework. Other frameworks are either applied in a platform setting or an urban data setting, but no business model framework is suited for the urban data platform context of these organizations. This research fills this gap, by answering the research questions of (1) which dimensions need to be included in a UDP-engaging business model framework, (2) which business models are used by organizations and (3) how the business models differ.

This set of exploratory and inductive research questions was answered by adopting a two-staged, qualitative research design. First, a two-round Delphi study with 14 panelists was conducted to find dimensions for a business model framework. Second, the practical application of the framework was demonstrated while also answering the second and third research question by performing two case studies and comparing them.

The result of the Delphi study was a framework containing ten dimensions, five specifically targeted to describe the engagement of the organization to the UDP (Type of Engagement, Type of Data Exchanged, Type of Access, Degree of Interoperability, Native of UDP) and five to describe the operational aspects of the business model (Key Activity, Revenue Model, Partner Ecosystem, Offering, Target Customer) that were found based on group consensus. Utilizing the developed UDP-engaging business model framework to analyze and compare two cases, revealed two novel business models that are variations of preexisting business models, who could only be described by means of the dimensions included in the framework.

Three other findings are interesting to add to the body of literature about UDPs: (1) there appear to be different types of platforms regarding their willingness to enable UDP-engaging business models, (2) there can be more than one UDP in the context of one city and (3) there appear to be UDPs that are operated and governed by private organizations in a smart city context.

This thesis increases the empirical understanding of how the connection from UDPs to organizations generates new business models and provides a tool for systematic analysis.

Table of Contents

Abbreviations

UDP = Urban Data Platform

BM = Business Model

1. *Introduction*

In 2017, 91% of the population of the Netherlands lived in cities (Statista, 2019). While this fact is already astounding, this trend can be observed globally, with 68% of the world's population being predicted to live in urban areas by 2050, adding 2,5 billion inhabitants to cities starting today, which is as much as the entire world population 60 years ago (Worldometers, 2019). While this number is impressive, it is another statistic from the Netherlands, that explains why urbanization is seen as a "Mega Trend" and "Sustainable Cities" are one of the 17 most pressing sustainable development goals (United Nations, 2019). This statistic is that 20 out of the 35 largest Dutch cities originate from between the 11th and 14th century and are now being inhabited by more people than ever, in a city layout that originates from a time before Europeans knew that America existed (Dutch Government, 2019). To solve the challenges arising from urbanization, regarding transportation, waste management, and energy efficiency, to name a few areas, "Smart City" initiatives have developed in the last years. The lifeblood of smart cities is urban data, data that is collected regarding every aspect of life in a city (Gonfalonieri, 2018). This trend has been enabled by the Internet of Things (IoT), allowing a broad variety of devices to collect urban data (Goldsmith, 2014; Hashem et al., 2016). The real potential of this data is released by giving multiple parties access to this urban data via urban data platforms (UDP) (Barns, 2018). Urban data platforms are a relatively new phenomenon in academic literature and allow for urban data that is collected by public or private organizations to be shared with other public or private organizations. By utilizing this data to either improve their products/ service or generate new ones, they are contributing to a better life for the inhabitants of the city, while generating revenue for themselves (Barns, 2018). As such, they often represent a type of "private-public-partnerships" and connect multiple stakeholders by allowing for a large variety of data to be shared in real-time (Cheng, Longo, Cirillo, Bauer, & Kovacs, 2015). A systematic analysis of how these organizations are generating value propositions from the engagement with one or multiple UDPs is not possible today, due to a lack of an appropriate business model (BM) framework.

While there are frameworks for data-driven business models and even for urban data business models, none of these frameworks are suited to incorporate the engagement of a UDP used by an organization to generate a value proposition (Hartmann, Zaki, Feldman, & Neely, 2014; Mcloughlin, Maccani, & Donnellan, 2018). An applicable framework has to build on the business model logic of Fehrer et al. (2018) rooted in service-dominant logic, recognizing that to describe the business model of an organization in the context of a platform, aspects of other entities apart from the analyzed organization have to be considered. Using this co-creation business model logic, a business model framework of organizations engaging with UDPs should include dimensions to describe this engagement, which is not present in any of the related business model frameworks today.

Such a business model framework has the potential to advance the understanding of how value is created from urban data platforms which will enable researchers to explain this phenomenon scientifically and find business models that might be applicable in other contexts. As such the framework will also allow platform operators to understand how their platform is being used and by doing so find ways to increase their value proposition to increase engagement and foster economic growth in a smart city context. The organizations themselves can also increase their understanding of their business model to improve their strategic alignment. Furthermore, they can look at the business models of other players in the UDP ecosystem that could serve as a blueprint to them. At the same time, an organization considering engagement with a UDP but lacking a clear business model yet can use these business model blueprints as a starting point for an engagement.

This research tries to fill this research gap by developing a business model framework for organizations engaging with UDPs and testing its' real-life applicability by conducting two case studies, that in itself gives valuable insights into which business models are used in such a context and how they are different. This should give researchers and practitioners an analytical lens through with they can systematically analyze how organizations are generating value from UDP engagement and increase their understanding of this particular phenomenon. Such a framework will be applicable to the business model of an organization to produce a value proposition from an engagement with a UDP, which might be part of a larger overall company business model, or it could be the only business model used by an organization in case this value proposition is the only one produced by it.
To fill the aforementioned research gap, the following research questions will be answered through this research:

> **RQ1:** *Which dimensions can be used to analyze the business models of the organizations engaging with an Urban Data Platform in a business model framework?*

This question has the following sub-question:

RQ1.1: *What are the corresponding subdimensions of the main dimensions in the business model framework for organizations engaging with Urban Data Platforms?*

RQ2*: What business models are organizations engaging with an Urban Data Platform using?*

RQ3: *What are the differences and similarities between the business models of organizations engaging with Urban Data Platforms?*

Figure 1 shows the different research questions in a stylized relationship between a UDP and organizations engaging with the UDP yielding the conceptual model of this thesis.

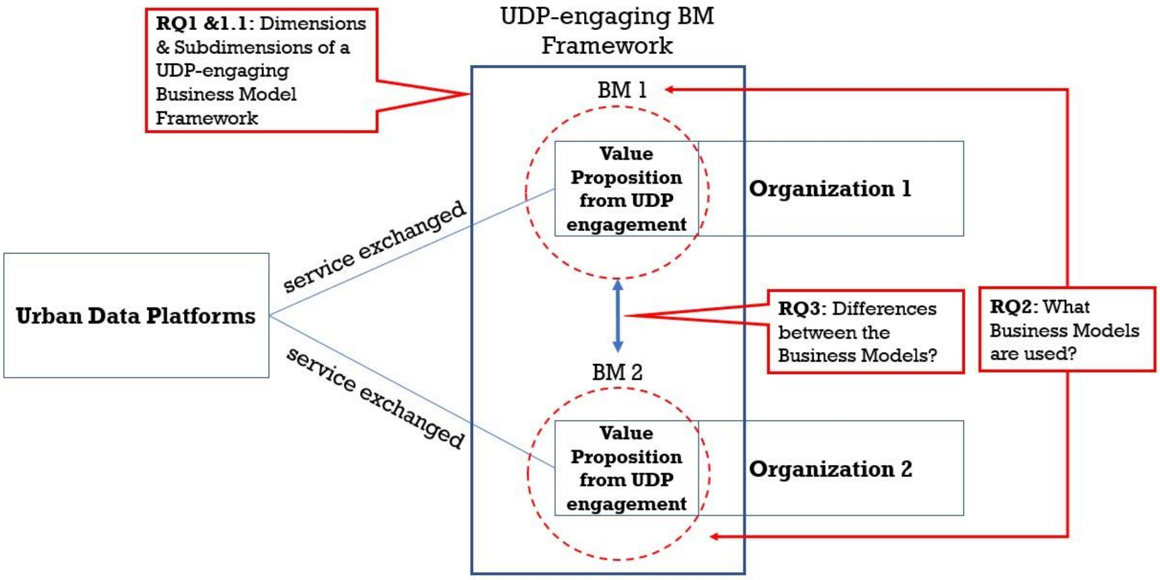


Figure 1. Conceptual Model

To address the research questions, an inductive, exploratory, qualitative research approach was chosen, since there is a lack of quantitative data available due to the novelty of this field of research. The research consists of two stages, a Delphi study with two rounds and an embedded comparative case study. First, the concept of Smart Cities, Urban Data, and Urban Data Platforms are introduced since they are essential foundations for the later framework development. The next section sheds light on the manifold research on business models, with a specific focus on data and technology-centric business models and their frameworks. Based on this review, dimensions for urban data business model framework are selected, validated, and adjusted using two rounds of Delphi research. In the next step, two case studies of companies engaging with an Urban Data Platform are conducted, to show the applicability of the previously developed framework and analyze their business model to generate an understanding of how the value proposition is created and compare the two business models in terms of similarities and differences (Yin, 2009).

2. *Literature Review*

This section gives an overview of the concept of smart cities and clarifies the importance of urban data for it. This is followed by a concise definition of urban data and an introduction to the platform concept and the role of platforms in a smart city ecosystem. This leads to the definition of urban data platforms and an elaborate description of its' features, which is required given the fact that there is no generally accepted definition of UDPs. Hence, the paragraph will describe what UDPs are considered to be for this thesis. This is followed by a section describing relevant business model literature. First, the term business model and business model framework are defined, succeeded by a literature review and definition of the ecosystem of the UDP-engaging business model framework developed in this thesis. The literature review secludes with an overview of the dimensions proposed to describe a business model from related business model frameworks and platform literature.

2.1.Smart Cities, Urban Data and Urban Data Platforms

2.1.1. Smart City Ecosystems

The concept of a "smart city" is the conceptual foundation of this thesis and has initially been proposed in 2008 by IBM, who delineate the focus of such a model on measurement, interconnection and intelligence, aiming to apply information technology systems to the toolbox of urban administration (Dirks, Keeling, & Dencik, 2009). A smart city governance model differs so much from the twentieth-century city that aspects such as the governance model and the frameworks themselves have to evolve (Arup, 2016). Over the years, the concept has become a new paradigm for public administration (Caragliu, del Bo, & Nijkamp, 2011). The growing popularity has led to a flood of different definitions of smart cities as can be seen by the research of Albino, Berardi, & Dangelico (2015) who identified 22 different definitions of smart cities that have emerged over the previous five years. From these definitions the one of Caragliu, del Bo, & Nijkamp (2011) will be used who define a smart city as focused on "investments in human and social capital and traditional (transport) and modern (ICT) communication infrastructure fuel sustainable economic growth and a high quality of life, with a wise management of natural resources, through participatory governance" (p.70). For the remainder of this thesis, the definition of Carguliu et al. (2011) will be adopted due to the clearly defined role of ICT, which is a crucial aspect used in this thesis. The goal of a smart city is commonly defined very broadly due to the magnitude of different initiatives that are collected under the smart city paradigm as enhancing the quality of life in the city (M Batty et al., 2012). As already indicated in this definition, ICT technology is influencing the different dimensions of the smart city, when data points are being collected at multiple points and stored (Hashem et al., 2016). There is no default "Smart City" but instead every smart city is different. However, there are some common components of the urban life that smart cities try to address that are similar between different cities (Albino et al., 2015). The most common areas that are addressed by smart cities in their effort to improve the lives of their citizens are the economy, education, e-democracy, logistics and infrastructure, efficiency and sustainability, as well as security (Lombardi, Giordano, Farouh, & Yousef, 2012). The different areas are addressed by a wide bouquet of smart city solutions that are driven by critical components of a smart city: technology, the people (providing creativity and diversity) and the institutions (providing governance and policy) (Nam & Pardo, 2011). An example of a smart city that is addressing many of these areas with different solutions is the German town of Friedrichshafen, who have developed approximately 14 different services until 2012, such as a mobile clinic system allowing remote monitoring of heart disease patients or a smart metering system, that provides the inhabitants instant access to their gas and electricity consumption (Hatzelhoffer, Humboldt, Lobeck, & Wiegandt, 2012). A commonality, shared by all of these services and most smart city services is that they are reliant on data that is collected via IoT devices and used smartly, as will be described in the next paragraph (Albino et al., 2015).

2.1.2. Urban Data

Since data is the lifeblood of a smart city, there is a never-ending hunger of smart cities to collect data on many occasions in order to improve city life (Gonfalonieri, 2018). Examples of IoT data collection are the previously mentioned smart meters in Friedrichshafen or the smart lighting system in Amsterdam, that is collecting information about the energy consumption and brightness of the lights to drive predictive maintenance and reduced energy consumption (AmsterdamSmartCity, 2018; Hatzelhoffer et al., 2012). Technological advances regarding sensing technology and improved connectivity features will enable IoT devices to collect urban data in an increasingly more extensive range of applications increasing the amount of available urban data steadily (Lueth, 2018). All the different types of data that are collected within a city are summarized under the term ”Urban Data” (Wolff, Kortuem, & Cavero, 2015). There have been multiple definitions of the term “Urban Data" and a concise definition is of utmost importance due to its central role in this research. “Urban Big Data” is defined as a “massive amount of dynamic and static data generated from the subjects and objects including urban facilities, organizations and individuals, which have been collected and collated by city governments, public institutions, enterprises and individuals, using a new generation of information technologies” (Pan, Tian, Liu, Gu, & Hua, 2016, p. 172). This definition underlines the critical fact that the collection of urban data does not necessarily have to be done by a type of governmental institution. Data collection can also be done by the private sector or even citizens, who can then use this data for their benefit or engage in data monetization, sharing the data with interested parties, such as other companies or the city government in exchange for a reward (Pan et al., 2016). The authors propose that urban data has three features (hierarchy, integrity, and correlation) additional to the general 5 Vs (volume, velocity, variety, veracity and value), allowing for a more detailed description of data (Pan et al., 2016).

Another definition is presented by Wolff, Kortuem, & Cavero (2015) who define “Urban Data” as “data that informs about environmental, social and economic aspects of urban life” (p.3). With regards to the source of urban data, the authors add that it should be generated by the activities of the citizens of that particular city, but they do not define who collects the data (Wolff et al., 2015). Under their definition urban data can not only relate to multiple topics but also can be collected in real-time data streams, generating huge volumes of data over time and therefore quickly lead to “Big Data” (Wolff et al., 2015). To holistically define Urban Data for this thesis, aspects from both the definition of Pan et al. (2016) and Wolf et al. (2015) have to be combined to define Urban Data as “all data, of either static or dynamic type, being collected by the city, businesses or citizens concerning environmental, social and economic aspects of urban life”.

Since urban data is a type of big data, it can be described and differentiated using the four Vs of big data: volume, variety, velocity and veracity (IBM Analytics Hub, 2019; Kitchin, 2014). However, Mcloughlin et al. (2019) propose an even more refined description specifically for big data, consisting of the four Vs without volume and including a description of the domain, the data was collected from, the type of data (visual, auditory, numerical, etc.) and whether it is geospatial or not.

The main advantage of this type of big data from a city perspective is that it provides interested parties with detailed information about a multitude of events in the city, who can analyse the data and act accordingly and use this information to improve the quality of life in the city, as stated in the goal of a smart city (M Batty et al., 2012; Pan et al., 2016). Urban data does not only allow the city to analyze and improve its operations in the urban environment (Michael Batty, 2013; Foth, Choi, & Satchell, 2011), but at the same time is seen as a vital tool to be used as a new resource by businesses, fostering the economic development in the smart city ecosystem (Kitchin, 2014). Companies are often very interested in gaining access to this type of big data because it allows them to identify inefficiencies in daily life in the city or about the behavior of its' inhabitants, that can be used to improve their existing products or service or to generate a new offering based on urban data (Janssen, Charalabidis, & Zuiderwijk, 2012). While urban data offers many novel possibilities with regards to improving the lives of citizens, as well as fostering economic development, one has to consider the unique challenges that urban data bring with them when compared to "non-urban" big data, such as specific technical, socio-political, economic and ethnic challenges (Mcloughlin, Maccani, & Donnellan, 2019). Another issue from a city perspective is that a variety of different parties often collects urban data, and it is stored in "silos" that are not connected (Cheng et al., 2015).

To derive value for their citizens many cities (e.g. Hamburg, Copenhagen, and Helsinki) are giving businesses access to the data in the hope that they will generate public value by pursuing their business strategies. In this regard, the cities are using the extended enterprise approach to smart city governance, where city functions as a platform hub, providing the resources and infrastructure for the companies to increase the quality of life in the city, while simultaneously generating revenue (Visnjic, Neely, Cennamo, & Visnjic, 2016). A ubiquitous approach, how cities can give companies access to urban data and at the same time overcome the issue of unconnected data silos is via data platforms, as shall be explained in the next paragraph.

2.1.3. Platforms

The broadest definition of platforms describes them as interfaces between different suppliers and users to facilitate value-creating exchanges (Gawer, 2014; Rochet & Tirole, 2003). The following paragraphs will give an overview of different types of platforms and how their features set them apart from each other before introducing urban data platforms and placing them in the spectrum of platforms.

The first important distinction of general platforms is in two-sided and one-sided platforms. Two-sided ("multisided") platforms have at least two distinct groups of customers/users, where the members of one group necessitate a product or service produced by the other group (Evans, Hagiu, & Schmalensee, 2008). One-sided platforms lack one side on the spectrum. The nonexistence of the “supplier” side is often an indication of a new platform that has not yet attracted enough users to attract external developers to craft value-adding products or services (Tiwana, 2014). Nevertheless, there are also instances, when the end-customer side is not present, such as the case when SAP is providing an enterprise system to a company based on which the individual departments can build software solutions for their needs (Tiwana, 2014). The platforms described in this thesis can be assumed to be two-sided platforms as defined by Tiwana (2014).

The second distinction is between internal (“company-specific”) within one company and external platforms (“industry-wide”) that span across the boundaries of companies (Gawer & Cusumano, 2014). The focus of this thesis will be on external platforms which are commonly defined as products, services or technologies on which external innovators, that are operating in an innovative business ecosystem, can build their complementary products, services or technologies (Abbate, Cesaroni, Cinici, & Villari, 2018). Further, by tapping into the innovation capabilities of external parties, industry-wide platforms tend to facilitate the creation of complementary innovations and function as a technological foundation in the center of an innovative business ecosystem (Gawer & Cusumano, 2014). To establish itself at the center of a business ecosystem, platforms must convince other firms to use them. This is most commonly done by performing a function that is pivotal to a broader technological system and or solving a business problem for many participants in the industry (Gawer & Cusumano, 2014). While all of these factors are important to set an external platform apart from an internal one, the most important aspect is the potential creation of network effects also called “Metcalfe’s Law” (Gallaugher, 2018; Iyer, Lee, & Venkatraman, 2006). Gallaugher (2018) finds network effects to be present when the “value of a product or service increases as its number of users expand” (p.211) and puts forward the argument that network effects itself are the very promise, in terms of added value that participants gain, for any platform.

Within platform literature, there have been several streams of research identified that vary on their definition of a platform. The most relevant stream of platform literature, to which this thesis will try to contribute, defines a platform as a technological system and thereby finds multiple key-value contributors of platforms to companies engaging in them (Thomas, Autio, & Gann, 2014). The value created comes from product differentiation to a product broader than one product family, resulting in a managerial opportunity to increase operational efficiency, scale economies, market penetration and innovation (Krishnan & Gupta, 2001). Besides the internal aspects, the view of platforms as a technological system also incorporates direct and indirect network effects experienced by the participants, as well as the positive effects of creating a surrounding ecosystem and community, facilitated by the platform acting as a market intermediary (Thomas et al., 2014).

In the last decade, the word "platform" in the context of business models has witnessed a sharp increase in popularity. This increase is primarily due to technological advances that allow for the separation of service and product. Hence, even a normal product can function as a "rudimentary" platform with third-party providers offering services based on the product (Tiwana, 2014). The most sophisticated platforms are platforms that were able to build an ecosystem of users, producers, enablers, and suppliers around them (Tiwana, 2014).

2.1.4. Urban Data Platforms

Urban Data Platforms (UDPs) are used as a general term to summarize many efforts that a city or company takes with regard to the proliferation of urban data, breaking up the previously mentioned data silos, as well as private sector and citizen engagement (Accenture, 2016; Barns, 2018; Pettit, Lieske, & Jamal, 2017).

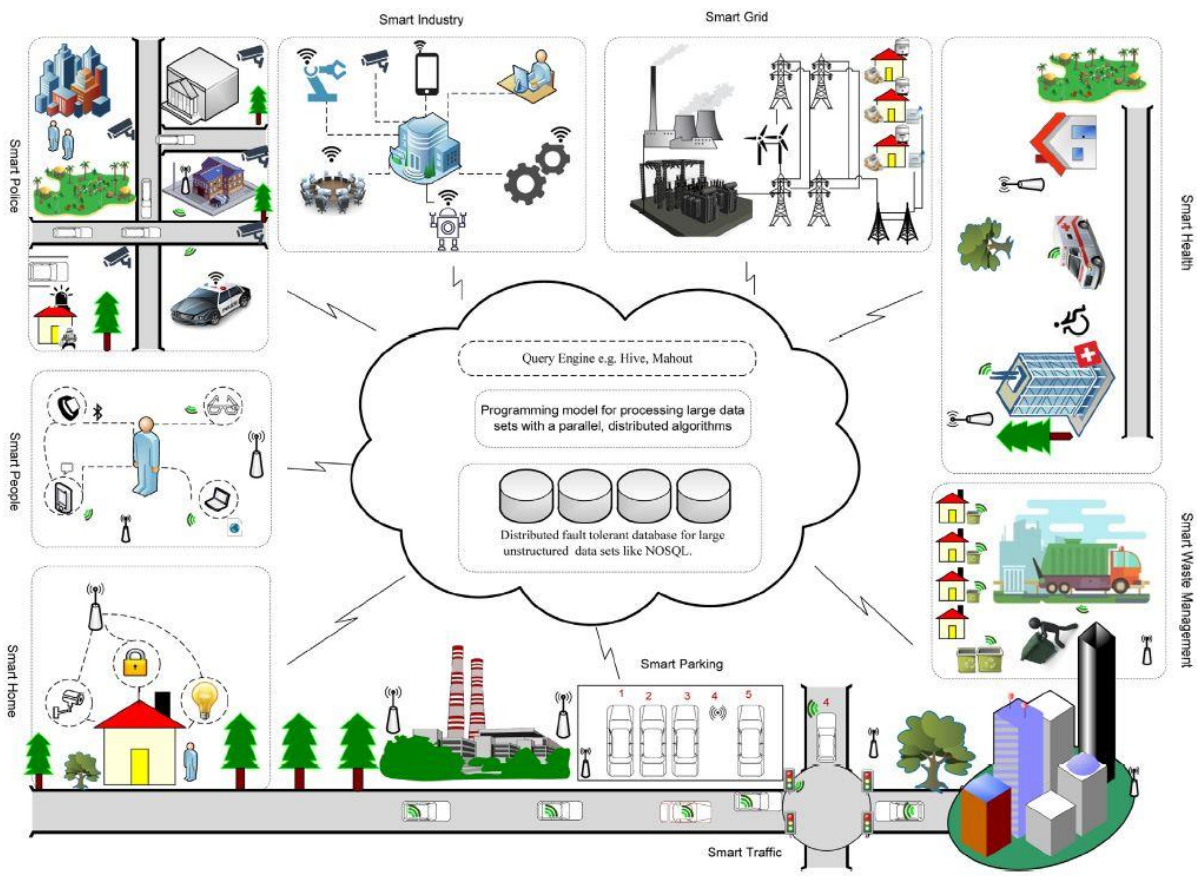


Figure 2. The role of big data on the different parts of a smart city. Adapted from "The role of big data in the smart city", by Hashem et al., 2016, *International Journal of Management*, 36, p. 750

As can be seen in Figure 2, the different players in a smart city ecosystem are sending or retrieving data that is stored in a cloud-based platform, that is a crucial enabler of multiple initiatives in a smart city. Figure 2 also nicely depicts how urban data is collected from many points within a city and can be stored at a central location so that different parties can access the data (Santana, Chaves, Gerosa, Kon, & Milojicic, 2016). Such a platform should be flexible to meet various customer requirements and connect data sources and applications (Cheng et al., 2015). This concept has been used by multiple cities already. The data exchange between the companies and the city can flow in both ways with the city giving data to the business or vice versa. Operations done by the platform, as well as the architecture can vary depending on the use case that the platform is built for (Cheng et al., 2015).

The type of data that is shared on such a platform can take multiple forms. One way of interaction is to exchange open data, which is publicly available, non-confidential, and downloadable free of charge (Zygiaris, 2013). Another type of exchange occurs for sensitive data that cannot be openly shared due to privacy concerns. Such data is either shared only on a per project basis with companies containing a predefined use case of the data or with a broader scope shared among after carefully selected companies that have to comply with security and privacy standards up front and are then free to use the data in the predefined boundaries (Zygiaris, 2013). The functionalities of the platform are assumed to be a connector between data suppliers and data users, by enabling a flow of urban data from the supplier to the user either free of charge or for a usage fee (Mcloughlin et al., 2019). Hence, these platforms are different to other types of platforms, due to the unique type of data that is exchanged over the platforms, leading to concerns regarding privacy and security, while giving access to unique data that could not be obtained elsewhere (Barns, 2018). These different characteristics also enable an ecosystem to grow around the platform that is different to the ones of other platforms, due to the unique characteristics of urban data and the smart city context (Abella, Ortiz-de-Urbina-Criado, & De-Pablos-Heredero, 2017).

Among the functional platforms are the ones from the city of Santander, Antwerp, Porto, and Utrecht (Cheng et al., 2015; Jorna, 2017). Other large cities have realized the positive impact on the smart city ecosystem of having an urban data platform and have pilot platforms up and running, such as the city of Rotterdam or Utrecht (van Osterhout & Cllclough, 2019). A conceptualization of the environment of an Urban Data Platform is represented in Figure 3 as envisioned by an EU-Initiative.

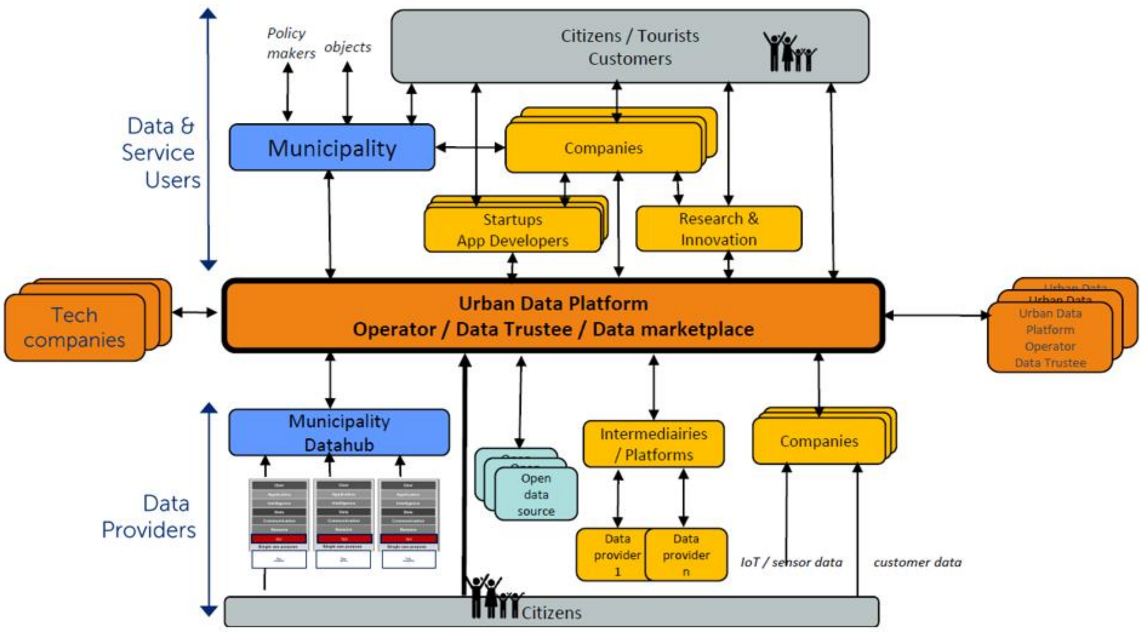


Figure 3. The Ecosystem of an Urban Data Platform. Adapted from "Urban data platforms – how public sector governance and triple bottom line business models create public value" by RUGGEDISED, 2019, p. 10

Figure 3 shows how companies or the municipality collect data at multiple points, by gathering the data either from IoT objects or from the customer directly by collecting information on usage data, for example, regarding waste, energy, and water (RUGGEDISED, 2019).

The sophistication and scope of UDPs concerning the capabilities of the platform varies (Barns, 2018). For example, the UDP in Rotterdam will be built as a limited two-sided market since it drives the interaction from two distinct groups (data suppliers and data users or app developers), but does not offer capabilities to allow for a two-sided market between app developers and citizens (RUGGEDISED, 2019; Tiwana, 2014). Yet, this should not be mistaken to be a software platform, since it is not an "operating environment or a database under which various smaller applications can be run" (Dictionary.com, 2019). It is much rather a distinct type of data platform that allows for the sharing of data with some services on top of the data (RUGGEDISED, 2019). There are however platforms, such as the UDP in Brno that offers a broad range of up to 80 applications on top of the data from the platform (Municipality Brno, 2019).

Regarding the relationship of the platform and the actors in its environment, three broad types of businesses can be identified regarding the function that they have in the context of a UDP as shown in Figure 4 (Schroeder, 2016).

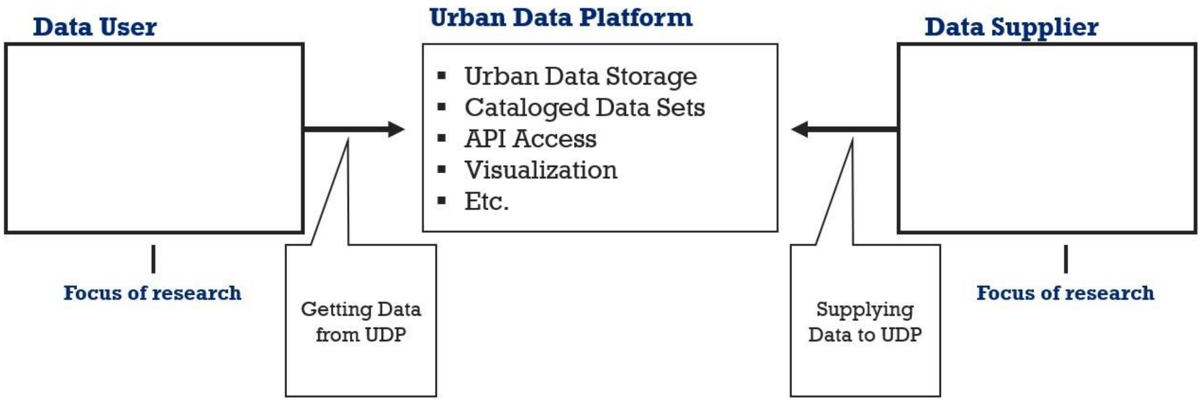


Figure 4. The Business-Ecosystem of an Urban Data Platform.

As a Data Supplier, the companies are supplying data to the platform, as a Data User, the companies are using the data from the UDP as an operator of the platforms the companies are responsible for providing the infrastructure and procedures to connect Data User and Data Supplier on an Urban Data Platform (Schroeder, 2016). The platform operator is often in the role of a service provider for the city since it is fulfilling a project based on guidelines from the municipality and are thus using a set of platform operator business models, that are not the scope of the following framework (Kuk & Janssen, 2011). Schroeder (2016) classifies this type of actor as a facilitator because he offers the infrastructure to facilitate the exchange of data. For the remainder of this thesis, the focus will be on the Data Supplier and Data User and to develop a business model framework for their operations and show how their business models are influenced by their affiliation with a UDP.

While the data supplier has the connection of a supplier to the UDP and hence sees the UDP as a customer for data monetization, the data user has different perspectives on a UDP (Woerner & Wixom, 2015). The data user can see a UDP either as a source of data assets, in which case the platform would offer a data-as-a-service offering to the data user, where he uses data assets provided by a third party, instead of generating the data on his own, to save time or because he is not able to do so (Vu, Pham, Truong, Dustdar, & Asal, 2012). On the other hand, the UDP could provide hosting capabilities for the service of the data user, in which case, the UDP offers a software platform to the data user (Tiwana, 2014).

While all UDPs try to increase the quality of life for the citizens, they can differ with regards to the target group (data users) towards which the platform is directed (Nam & Pardo, 2011; Neirotti, De Marco, Cagliano, Mangano, & Scorrano, 2014). Platforms might be targeted to foster economic growth and create opportunities for businesses to engage with the platforms to develop solutions that are both financially profitable and generate value for the citizens as per definition of the smart city (Caragliu et al., 2011; Cheng et al., 2015; Kloeckl, Senn, & Ratti, 2012). On the other hand, some of the platforms are built to inform citizens about the activities within the city to generate transparency and offer visualization tools to generate an overview of the operations within the city (Nam & Pardo, 2011; Neirotti et al., 2014). Finally, the most common target group of data consumers is the municipality themselves, when they use data that is collaborated in a UDP to analyze the activities within the city and improve their operations as the key provider of public services and infrastructure in a city (Hashem et al., 2016). This last type of platform is different from the other types of UDPs since it is an internal and one-sided platform, while the other described types of UDPs are external, two-sided platforms (Gawer & Cusumano, 2014; Tiwana, 2014).

By providing the data on UDPs or using the data from UDPs, there is a unique potential for actors to tap into new value generating activities and deploy novel and unique business models.

The next paragraph will provide a comprehensive overview of the literature that exists to build a framework to classify these different types of business models.

2.2. Business Models

The business model was chosen as a unit of analysis due to its central role in the value creation process and its role as the locus for innovation and differentiation between companies (Amit & Zott, 2001). There is no clear, broadly adopted definition of business models today (Kiel, Arnold, & Voigt, 2017). However, there seems to be an academic agreement that Business Models express value creation (Hossain, 2017). Therefore, a business model analysis of organizations engaging with a UDP shall be defined for this thesis as an "explanation of the value creation logic of an organization regarding an Urban Data Platform". This definition acknowledges the fact that this business model and the resulting business model framework will not explain the entire business model of an organization but the value proposition that it creates regarding a UDP. This might be the entire business model in the case of a start-up, but it might also be only a sub-business model that can then be aggregated to an overall business model. This logic is based on the findings of Casadeus-Masanell & Tarzijan (2012) that whenever a company has multiple sources of value, it will have multiple business models facing each value proposition. Thus, the business model of an organization that will be described will be the business model used by an organization to generate a value proposition from an engagement with one or multiple UDPs.

2.2.1. The Business Model Environment

The work of Wieland et al. (2017) states a need to generate a novel understanding of business models informed by service-dominant (S-D) logic. Generally, S-D logic provides an interpretation of markets and directs study toward networks and interdependencies between dynamic actors (Vargo & Lusch, 2016). S-D logic provides a theoretical lens for understanding the interactions of multiple actors in a broader network and platform ecosystem (Fehrer, Woratschek, & Brodie, 2018; Wieland, Hartmann, & Vargo, 2017). For this thesis, the business model logic of Fehrer et al. (2018) proposed for a platform context will be applied, being centered around the finding that "firms represent one important actor but do not alone suffice the study of business models in contemporary markets" (p.561). This logic is chosen to be used in this research, since the organizations engaging with UDPs are engaging in value co-creation given the fact that they are exchanging data with a UDP to produce a value proposition, showing the influence that the product or service received from the UDP has on the business model of the engaging organization. The proposed framework will therefore draw from S-D logic and applies its' logic of value co-creation to the concept of urban data platform-based business models, hence recognizing the influence of an Urban Data Platform on the business model of actors engaging with it and incorporate dimensions to describe the business model in terms of the engagement with the UDP.

To build a business model framework, it is essential first to characterize the context in which this framework is applicable. Within the business ecosystem, four factors influence the business model of the company as depicted in Figure 5 (Baghbadorani & Harandi, 2012). The suitable environment is depicted in Figure 5, and the business environment of a UDP can be reduced to two types Data User and Data Supplier as previously shown in Figure 4.

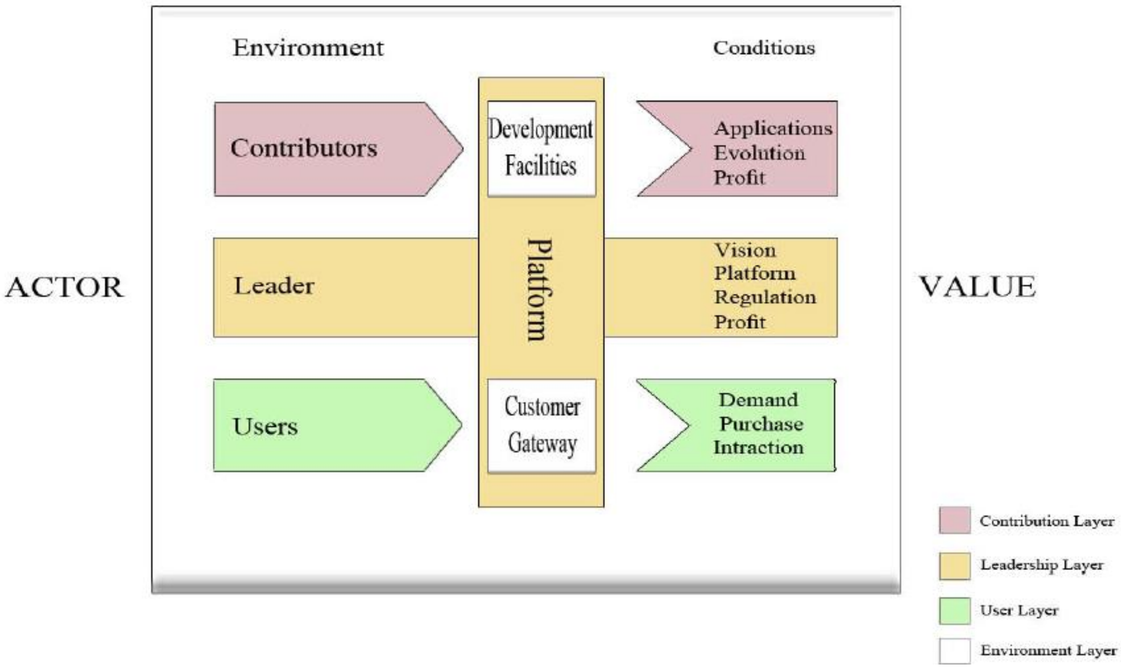


Figure 5. The business ecosystem conceptual model. Adapted from "A Conceptual Model for Business Ecosystem and Implications for Future Research", by M. Baghbadirani & A. Harandi, 2012, *International Proceedings of Economics Development and Research,* 67, p. 15

The different actors of a business ecosystem in a platform context contain: the platform, the businesses that contribute to the platform, the users of the products and services that the businesses build and the environment (including general economic and societal influences) (Baghbadorani & Harandi, 2012). To avoid unnecessary complexity of the business model framework, the focus will be on the relationship between the platform and the businesses assuming that the other two components remain constant. Therefore, the influence of the platform on the business models of the actors engaging with it will be represented in the newly developed business model framework as proposed by S-D logic (Fehrer et al., 2018).

To be able to have a meaningful comparison of start-ups, governmental agencies, as well as established companies engaging with a UDP, the unit of analysis for established companies and government, will be the business model regarding the value proposition of the organization enabled by the connection to the UDP. According to Casadeus-Masanell & Tarzijan (2012) whenever a company has two district sources of value (which can be assumed for established companies in this study since they are generating value from urban data per definition), a second business model is indispensable. Bertini & Tavassoli (2015) make the argument that it is possible within one business unit to have separated business models on a project level that are comparable to the models of an entire company.

To develop a framework of business models of companies engaging with a UDP, it is important to look at different aspects that these companies share to define the environment in which they operate and the different factors that are important to describe a business model under such conditions (Fielt, 2013). Companies engaging with Urban Data Platforms operate in a very diverse environment and are subject to multiple dimensions that influence their business model. The most prominent ones are summarized in Figure 6.

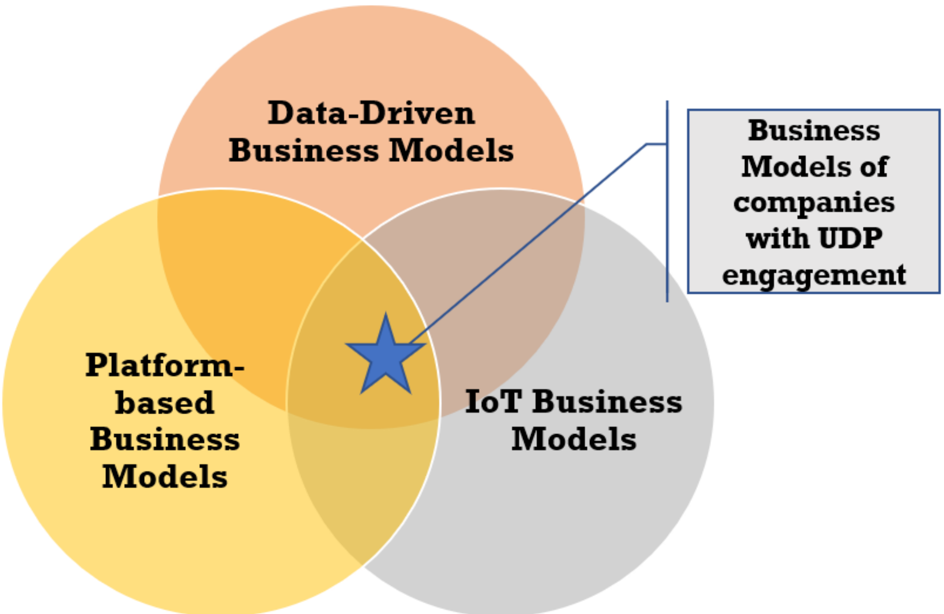


Figure 6. Environment of Urban Data Platform Business Models

The first domain is the one of Data-Driven business models, which is applicable since one of the key resources used by an applicable company must be data, due to their direct interaction with a UDP. Using this as a starting point, the businesses can be analyzed using the data-driven business model framework developed by Hartmann et al. (2014). At the same time the companies use functions of the UDP, and the platform, therefore, has an influence on how the companies generate value propositions, allowing for an analysis of the business models from the platform-based business model domain (El Sawy & Pereira, 2013; Tiwana, 2014). With regards to this dimension, the VISOR platform-based business model framework from El Sawy & Pereira (2013) provides an insightful set of dimensions along which to analyze businesses engaging with a platform. The third dimension from which the business models of companies engaging with UDPs could be analyzed is the IoT business models, since the companies are using data from IoT devices either directly or indirectly (via the platform) and perform activities based on this data, similar to the definition of IoT Business Models from the literature (Turber, vom Brocke, Gassmann, & Fleisch, 2014).

2.2.2. Theoretical Positioning of the Business Model Framework

There are several frameworks for business models that are proposed in the literature, all with a different focus on specific actors and different dimensions among which they classify the actors into business models. The research streams that are relevant with regards to classify the business models of companies engaging with UDPs is shown in Figure 7.

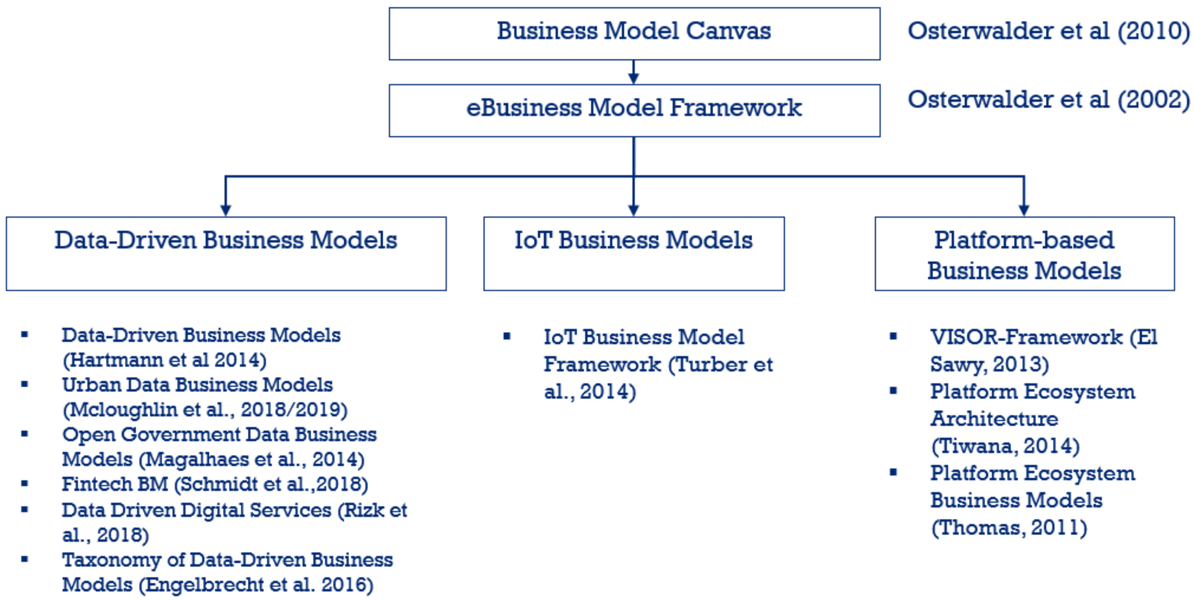


Figure 7. Applicable business model framework literature streams

Coming from the general Business Model Canvas classification that can be applied to any type of business to analyze its business model, Osterwalder also provides a more specialized framework of eBusiness models (Osterwalder & Pigneur, 2002, 2010). This e-Business model research stream can be spilt again into three sub-streams that are equal to the context in which the focus businesses of this study operate: Data-Driven Business Models, IoT Business Models and Platform-based Business Models as described in section 2.2.1. In each of these streams, there have been several publications on different frameworks, all of which can be loosely applied to the focus companies of this research.

From a thematical point of view, there were some business model frameworks, that are to a certain degree applicable to businesses engaging with UDPs. These four frameworks and the business models that they propose, as well as the dimensions used to analyze them, are shown in Table 1.

Publication Title & Author	**Business Models Identified**	**Dimensions in Business Model Framework**
Big Data Business Models (Schroeder, 2016)	▪ Informing Business Decisions ▪ Data Brokers ▪ Data analytics as a service ▪ Consultancy and advertisement ▪ Tools providers	▪ No specific framework used ▪ Focus on the key activities performed on big data
Data-Driven Business Models (Hartmann et al., 2014)	▪ Free data collector and aggregator ▪ Analytics as a service ▪ Data generation and analysis ▪ Free data knowledge discovery ▪ Data aggregation as a service ▪ Multi-source data mash-up and analysis	▪ Data Source ▪ Key Activity ▪ Offering ▪ Target Customer ▪ Revenue Model ▪ Specific Cost Advantage
Data-Driven Digital Services (Rizk, Bergvall-Kåreborn, & Elragal, 2018)	▪ Data acquisition ▪ Data exploitation ▪ Insights utilization ▪ Service interaction	▪ Utilization and flow of data ▪ Analytics capabilities
Urban Data Business Models (Mcloughlin et al., 2019)	▪ Sensing as a Service ▪ Prescriptive insights as a product ▪ Analytics as a service ▪ Recognition as a service ▪ Automated service interaction model ▪ Crowdsourcing community platform	▪ Key Resources ▪ Key Activities ▪ Target Customers ▪ Revenue Models ▪ Cost Structure

Table 1. Related Business Models and the Frameworks used for classifying

Different business model frameworks allow for the classification of different business models that are found to be a mutually exclusive and collectively exhaustive list of all possible business models within the given context. One more aspect that is relevant in the discussion of business models is the classification along the big data value chain, that can also be used for open government data as shown in Table 2 (Klievink, Romijn, Cunningham, & de Bruijn, 2017; Ubaldi, 2013).

Stage on the data value chain	Big Data Activities
Collection	▪ Collect, annotate ▪ Acquire, record ▪ Generate ▪ Choose ▪ Sense
Combination	▪ Extract, clean, prepare, process ▪ Combine ▪ Organize ▪ Store ▪ Integrate, represent
Analytics	▪ Analyze, model
Use	▪ Initiate ▪ Deploy ▪ Make decisions ▪ Apply, produce insight ▪ Evaluation

Table 2. Government Data Value Chain. Adapted from "Big data in the public sector: Uncertainties and readiness" by B.Klievink, B. Romijn, S. Cunningham & H. de Bruijn, 2017, *Information System Frontiers*, 19 (2), p. 27

This type of classification is not applying a multidimensional business model framework to analyze the business model, but is solely examining the key data related activities and can, therefore, be potentially included in a broader business model framework (Klievink et al., 2017).

Due to the new emergence of the business model logic proposed by Fehrer et al. (2018) to include aspects of the platform with which an organization is engaging as part of the business model, only a very limited number of dimensions in the existing body of applicable business model literature included dimensions to describe the platform engagement. To fill this gap, platform and platform business model literature was analyzed, to find suitable dimensions. Table 3 summarizes the different dimensions that were mentioned by different authors in the respectively applicable research streams, as well as including dimensions how the engagement of an organization and a platform can be described, based on an analysis of platform literature.

Dimension	Description	Mentioned by
Data Source/Type	Data sources and types used as key resources	(Hartmann et al., 2014) (Rizk et al., 2018) (Schmidt, Drews, & Schirmer, 2018) (Engelbrecht, Gerlach, & Widjaja, 2016) (Gawer & Cusumano, 2014) (Barns, 2018)
Key Resource	Distinguish between more resources used for value proposition such as software, hardware and data	(Mcloughlin et al., 2018)
Key Activity	Activities performed to produce and deliver its value proposition	(Hartmann et al., 2014) (Mcloughlin et al., 2018) (Schmidt et al., 2018) (Arup, 2016) (Cheng et al., 2015) (Klievink et al., 2017) (Ubaldi, 2013)
Value Proposition/Offering	Expression of the experience a customer will have from the supplier's creation	(Hartmann et al., 2014) (Magalhaes, Roseira, & Manley, 2014) (Schmidt et al., 2018) (Turber et al., 2014) (El Sawy & Pereira, 2013) (Ubaldi, 2013)
Target Customer	At whom is the value proposition targeted	(Hartmann et al., 2014) (Mcloughlin et al., 2018) (Schmidt et al., 2018) (Turber et al., 2014) (Engelbrecht et al., 2016)
Revenue Model	Revenue streams from the value proposition	(Hartmann et al., 2014) (Mcloughlin et al., 2018) (Schmidt et al., 2018) (Turber et al., 2014) (El Sawy & Pereira, 2013)*
Cost	Costs incurred to generate the value proposition	(Hartmann et al., 2014) (Mcloughlin et al., 2018) (Schmidt et al., 2018) (El Sawy & Pereira, 2013)*
Business Model Openness	Degree to which the focal firm depends on one or a few partners to create the value proposition	(Magalhaes et al., 2014)
Open Government Data Centrality	Degree to which acquired data is central to the company's business model	(Magalhaes et al., 2014)

Insights Utilization	How are the generated insights utilized in the value proposition	(Rizk et al., 2018)
Data Exploitation	Processing and analytical activities employed on data to add value	(Rizk et al., 2018)
Service Interaction	Modes and technologies used for interaction with the value proposition	(Rizk et al., 2018)
Technological Effort	Amount of technological effort required to provide a value proposition	(Engelbrecht et al., 2016)
Value Chain	Value chain needed to deliver the value proposition	(Turber et al., 2014) (Ubaldi, 2013)
(Service) Platform	Technical architecture or assets that allows to provide a value proposition via a platform	(El Sawy & Pereira, 2013) (Barns, 2018) (Lopez et al., 2012) (Cheng et al., 2015) (Costa & Santos, 2016) (Arup, 2016) (Thomas et al., 2014) (Gawer & Cusumano, 2014)
Organizing Model	Answers the question of: How does the enterprise or a set of partners organize business processes, value chains and partner relationships to generate a value proposition	(El Sawy & Pereira, 2013)
Interface	Interface used by the customer to experience the value proposition	(El Sawy & Pereira, 2013)
Public Value Created	Weighting environmental benefits vs cost and social benefits vs cost	(Meijer & Bolívar, 2016) (Papi, Bigoni, Bracci, & Deidda Gagliardo, 2018)
Type of Access	How the company has access to the data that they use	(Barns, 2018) (Lopez et al., 2012) (Costa & Santos, 2016) (Magalhaes et al., 2014) (Thomas et al., 2014) (Gawer & Cusumano, 2014) (Ubaldi, 2013)
Interoperability	Number of platforms the company engages with	(Lopez et al., 2012) (Cheng et al., 2015) (Costa & Santos, 2016) (FIWARE, 2019) (Ubaldi, 2013)

**El Sawy & Pereira combine Revenue Model and Cost in one dimension in their framework*

Table 3. Overview of dimensions used in related business model framework research

3. *Methodology*

This section shall explain the methodology that was chosen to answer the research questions. The methods chosen will be explained and evaluated regarding their validity, reliability, and limitations and consequently the implications that these methods have on the findings. The unit of analysis is therefore, the business model of organizations engaging with UDPs in its real-life environment. To enable a structural description of the unit of analysis first, a business model framework for the unit of analysis has to be created and validated after which a case study will analyze the unit of analysis in more detail.

To answer the research question, two empirical studies were conducted: a Delphi study to develop and validate a framework of business models of organizations engaging with UDPs and a case study to demonstrate the validity in terms of the practical application of the framework and to find differences between business models of organizations engaging with a UDP.

3.1 Research Design

The topic of the business models of organizations engaging with UDPs is still very conceptually new due to the early stage of the development of UDPs. Due to the poor understanding of the concept of the business models of organizations engaging with UDPs, exploration is the most appropriate research method (Stebbins, 2011). In the paradigm of exploratory research, a qualitative approach was chosen since there are not enough quantitative factors that could be used to answer the research questions (Creswell, 2007).

To answer the exploratory research question, using qualitative methods, following grounded theory, a Delphi study was chosen to develop a framework based on rigorous literature review and expert opinion (Okoli & Pawlowski, 2004; Strauss & Corbin, 1997). Following a two-staged Delphi research, the practical applicability of the developed framework will be validated in the next research stage using case studies (Strategic Highway Research Program, 2013). Further, a cross-case study analysis was conducted to compare the two cases in a qualitative manner and delineate differences between them, following the dimensions of the business model framework developed in the previous two rounds of the Delphi methodology. This case study has two purposes in the structure of this research. First, following analytical induction, the framework can be validated if the application of the framework reveals that one can describe the business models holistically using the previously developed business model framework. Second, the analysis of the business models of the organizations and the comparison will be stand-alone results of two types of business models that can be found from organizations engaging with UDPs.

This thesis follows a two-staged exploratory research design with two exploratory research methodologies. By using this staged research design, the validity of the qualitative research findings from the Delphi study is increased and the practical relevance of the business model framework is demonstrated, as shown by Ifenthaler & Widanapathirana (2014). Nambisan, Agarwal, & Tanniru (1999) use a very similar research design when they use a Delphi method to first find a taxonomy which is then later tested with case studies as field research in a staged design. The resulting staged research design with a two-round Delphi method as the first stage and case studies as the second stage is depicted in Figure 8.

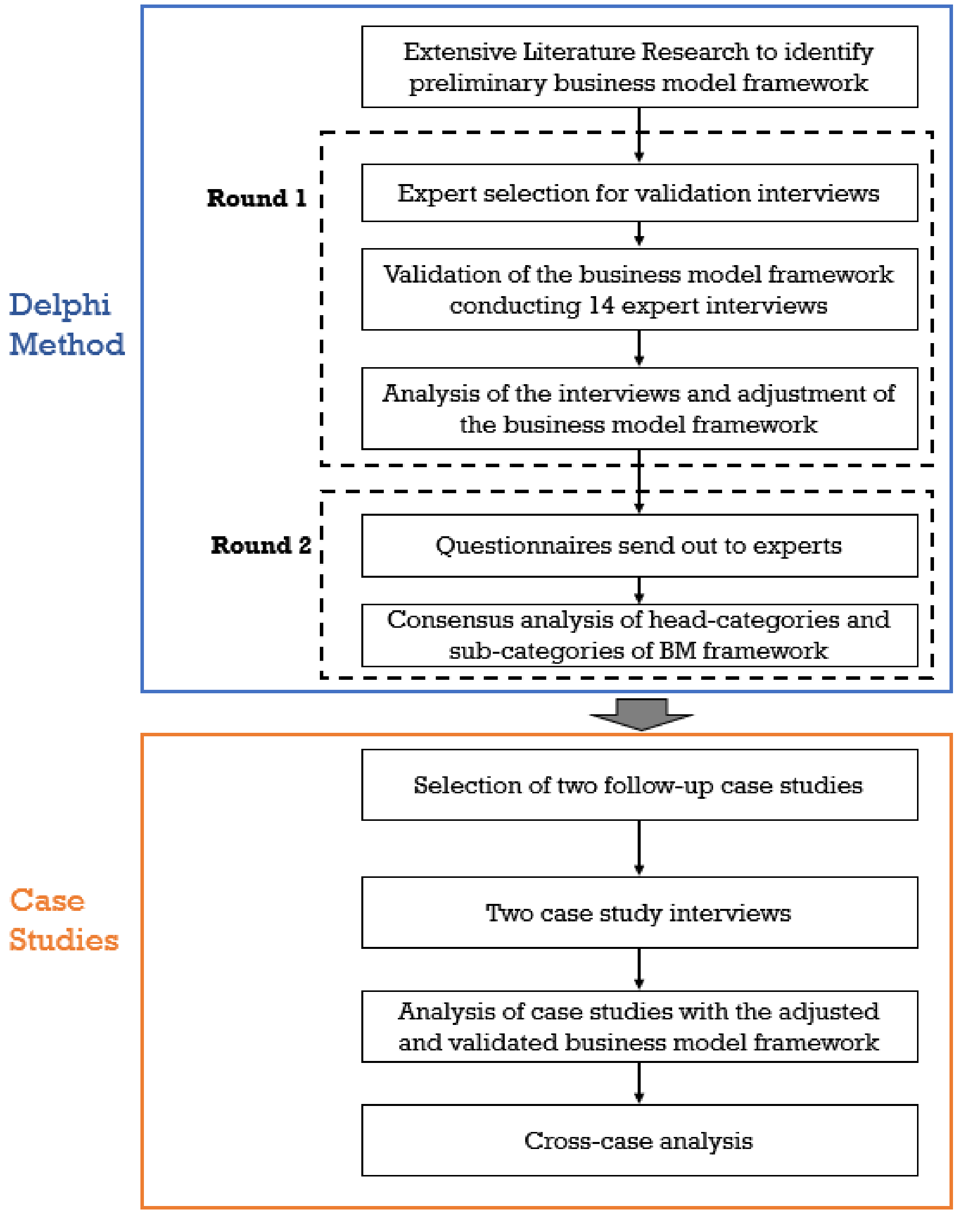


Figure 8. Research Process Overview

3.1.1. Quality Standards

Since this is a qualitative study, several considerations have to be kept in mind to ensure that quality standards are adhered. Schwandt, Lincoln, & Guba (2007) identify four different factors that must be regarded during qualitative research. To ensure a high quality of this research, these factors were considered and led to the choice of the research methods and staged design shown in Figure 5. The following standards from Schwandt et al. (2007) were incorporated:

Credibility refers to the degree to which the findings of qualitative research represent the views and perceptions of the panelists (Schwandt et al., 2007). The main threat to credibility is the influence of the researcher while conducting the interviews and analysis. The influence of this was reduced by clarifying unclear statements during the interviews. Further, the interview transcripts were sent to the panelists to check if they correctly reflected their opinions. Moreover, the research process will be described in much detail to clarify the influence of the researcher. Additionally, including a comparably large number of panelists causes higher credibility and reduces the threat of extreme opinions influencing the consensus process (Skulmoski & Hartman, 2007). Finally, by staging the research process and including case studies another set of findings was introduced to limit the influence of the researcher further.

Transferability refers to the extent to which the findings can be transferred into another research context (Schwandt et al., 2007). The focus of this study was to include diverse experts to avoid over-focus on one country or one UDP because there is a high variation of UDPs between cities. This fact was ensured by the panel selection criteria stated in section 3.2.1. Additionally, the research context was very clearly defined by conducting an extensive literature review to specify the business model framework and the context in which it is applicable. Finally, by including case studies from different cities, transferability will be shown by applying the framework to these cases.

Confirmability in qualitative research refers to the aspect of neutrality and defines that the findings shall be constructed by the panelist’s opinions and not by the researcher. Regarding the main dimensions, this standard is adhered since the respondents clearly stated their opinion and the framework was adjusted using consensus, so no personal opinion was involved. Regarding, the analysis of themes for the main dimensions and the corresponding sub-dimensions, the researcher was involved in the construction applicable themes. However, this process was documented rigorously to ensure the confirmability of the findings. Finally, by applying the framework to two companies in the case studies, confirmability is increased since a practical application of the constructs is shown.

Dependability indicates that the decisions and influences on the analysis were traceable and that the findings were consistent (Schwandt et al., 2007). Again, this standard was adhered by providing transcripts of the interviews for the Delphi process and the case studies, as well as providing the summaries of the questionnaires in the second Delphi round. Further, the research process was well described and decisions that were taken were justified and documented.

3.2.Delphi Method

As shown in Figure 8, the first stage of the research is conducted using the Delphi method. First mentioned in 1950, the Delphi method is most applicable to novel fields of study that are still developing and hence quickly changing (Ouariachi, Olvera-Lobo, & Gutiérrez-Pérez, 2018). As mentioned by Okoli & Pawlowski (2004), Delphi is an excellent tool to conduct exploratory research for IT-related topics, due to its comparably high rigor from using a staged research process and qualitative as well as quantitative measures. In this research, a multimodal Delphi methodology was used, containing both qualitative and quantitative elements.

To overcome the issue that there might be little useable quantitative evidence of a novel phenomenon, Delphi research utilizes the wisdom of a panel of individual experts, who iterate their answers over multiple rounds, until a consensus is achieved (Brady, 2015). After an initial literature review to develop an initial framework, the experts share their opinion on a certain matter independently from each other (Brady, 2015). The researcher summarizes the opinion and adjusts the framework if needed, and the process is repeated with the adjusted framework, until one of two things occurs: either consensus is achieved, when a predefined percentage of experts agrees on the framework, or until a predefined number of iterations has been reached (Fletcher & Marchildon, 2014). Therefore, the Delphi method tries to achieve consensus or near-consensus of the experts on the item that is evaluated (Fletcher & Marchildon, 2014). For this research consensus on the main dimensions was defined as an agreement between the panel experts on a rating of a particular item within a specific round. The common measure of 75% was selected as the minimum percentage of agreement, following the logic of Murry & Hammons (1995). For the subdimensions, during the first round, a qualitative measurement of consensus was utilized as suggested by Lunsford & Fussell (1993) to allow for a broader idea generation in this stage. Another advantage of the Delphi method is that it allows for high flexibility regarding the process design and by using interviews even allows for valid findings created in just one round (Okoli & Pawlowski, 2004; Skulmoski & Hartman, 2007).

As established by the frequently used guide from Okoli and Pawlowski (2004), Delphi methodology can either be used to forecast a scenario and identify issues or to develop a concept or framework. This thesis will utilize the Delphi method to do the latter and develop a framework for business models for organizations engaging with UDPs. Using this methodology for framework development is common and has been done in multiple studies such as the work of Tigelaar, Dolmans, Wolfhagen, & van der Vleuten (2004) because multiple rounds of Delphi ensure a higher validity than for example interviews. The rounds in Delphi research deviate between two and three, depending on the resources available (time and money) and the complexity of the topic to reach consensus (Mozuni & Jonas, 2018). Due to the limited time available for this research, the number of rounds of the Delphi method was set ex-ante to be two rounds which is expected to be no limitation to the research due to this being a very prevalent number of rounds to lead to consensus or near-consensus (Skulmoski & Hartman, 2007). Although there are many variations of the Delphi method they commonly share three characteristics that were also adhered in this research that generate distinct advantages of this method compared to the widespread technique of focus group interviews (Moore, Lingstone, & Turoff, 1977):

- *Anonymity and structured communication.* Participants give their true opinion about the matter without feeling effects of social pressure reducing the threat of group thinking
- *Iteration*. Since there are multiple rounds, the participants can change their opinion and give feedback on the ideas of other participants, leading to increased external validity
- *Aggregation between the rounds*. There can be qualitative or quantitative aggregations of the data at the end of the round to show group consensus, giving the developed propositions stronger support than what would be possible using individual expert interviews. This gives experts the chance to consider the ideas of other panelists and act accordingly, to increase the validity compared to expert interviews.

All these principles were adhered during this research by centralizing the communication to the researcher and ensuring anonymity among participants. Further, the research conducted quantitative and qualitative aggregation and consensus measurements to ensure that the different options of the experts were aggregated into a group option that could be iterated. The structure of the adapted Delphi method is shown in Figure 9.

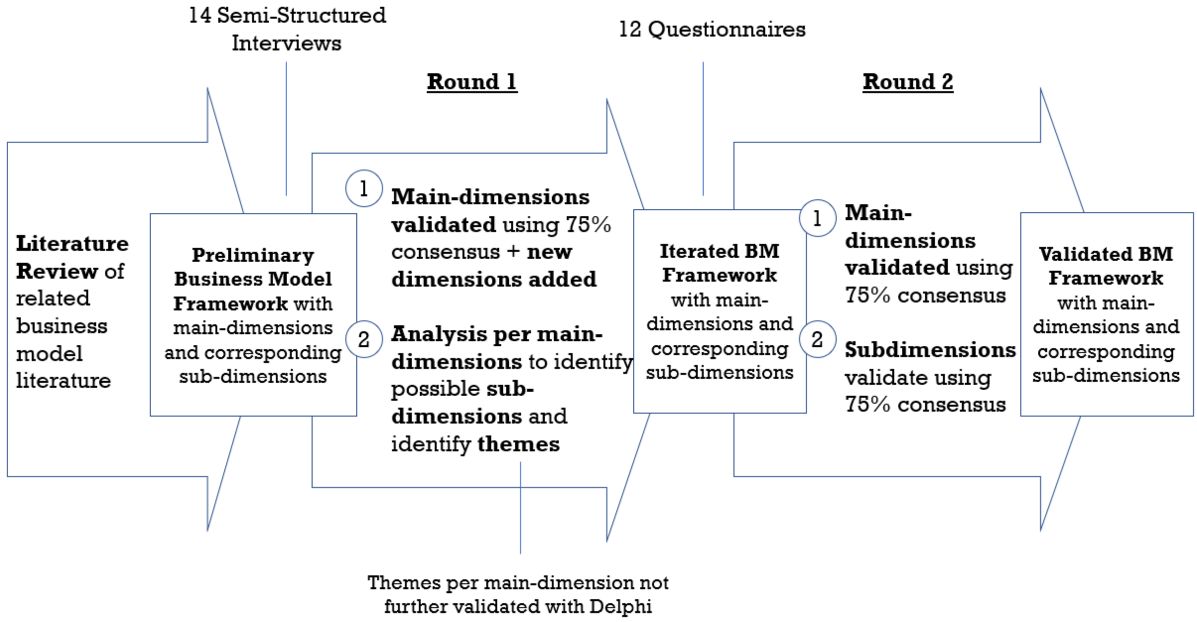


Figure 9. Delphi Research Process

3.2.1. Panel Selection

Selecting the panel members is a critical stage in the Delphi research process since the opinions of these experts are the basis for the findings of this process (Brady, 2015). Adler & Ziglio (1996) propose the most important factors for the expert selection in the Delphi technique to be i) knowledge about the issue under investigation; ii) capacity and willingness to participate; and iii) effective communication skills. Hence, a purposive sampling technique is required to find experts with the ability to answer the questions of the research (Fink, 2015). The criteria for the experts were the following:

1.) The expert must possess extensive knowledge in the field of UDPs
2.) The expert must be involved in the development or maintenance of UDPs
3.) The expert must have an overview of the business models of the organizations engaged to the UDP and its’ operational environment
4.) The UDP to which the expert is affiliated must operational with at least a pilot of the platform

Another criterion that was taken into consideration during the selection was the internationalization aspect and focus on experts from different cities (different platforms), to allow for better generalizability (Okoli & Pawlowski, 2004). Following these criteria, a short-list was constructed, containing 24 potential experts qualified to participate in the research that were contacted. 14 experts from 11 different platforms/cities and 7 different countries agreed to take part in the research and are shown with their characteristics in Table 4.

Expert ID	Sector	Country	Organization
E1	Public	Netherlands	City of Rotterdam
E2	Public	Netherlands	City of Rotterdam
E3	Private	Netherlands	Civity (Utrecht)
E4	Private	Netherlands	Atos (Eindhoven)
E5	Private	Netherlands	ESRI (Utrecht & others)
E6	Private	Netherlands	Future Insight (Rotterdam & others)
E7	Private	Netherlands	CGI (Groningen & others)
E8	Public	Germany	City of Hamburg
E9	Public	Germany	City of Munich
E10	Public	Poland	City of Warsaw
E11	Public	France	City of Nice
E12	Public	Czech Republic	City of Brno
E13	Public	Denmark	City of Copenhagen
E14	Private	Finland	Former COSS (Helsinki)

Table 4. Expert participants for the Delphi Method

Generally, the larger the sample of experts in Delphi studies, the better for the quality of the findings due to reduced group error (Skulmoski & Hartman, 2007). However, after a certain size, the process becomes very cumbersome which is why the sweet spot for panel size in Delphi studies was found to be between 10 to 18 individuals in the first round (Okoli & Pawlowski, 2004). Since it can be expected that some panelists drop out during the research process due to the time-consuming nature of Delphi research, the minimum number for any subsequent rounds of experts was set to be 7. This number was found by Dalkey, cited in Linstone (1985, p. 635) to be the minimum number of experts to be included in a Delphi study. As the research process showed, the number of experts did drop during the interviews, but only to 10 experts ensuring adherence to the established quality standards.

3.2.2. Building of the initial Framework and Interview Guide

The structure of a standard Delphi study has a preselection of the dimensions for the framework by the researcher as a first step, that often requires an extensive literature review focused on the validity of the generated construct (Brady, 2015). This step was rigorously carried out, where the different main and sub-dimensions of the framework were selected after an extensive literature review, following the logic of Fielt (2013) regarding which factors must be part of a business model framework while incorporating the influence of the UDP in the framework at the same time. This first building of the framework is, due to the highly explorative nature, very prone to bias since the decision alone rested with the researcher (Saldaña, 2013). However, this is a standard procedure during the Delphi method and the following two rounds, during which the framework was iterated and adapted according to the opinions of experts, minimize this initial bias (Van Urk & Grant, 2016). Based on this preliminary framework, an interview guide for semi-structured interviews was developed using the 10 step manual for developing interview guides by the Harvard Faculty of Sociology (2013) see Appendix 1.

3.2.3. Round 1

During the first round of the Delphi research semi-structured interviews were conducted, since they allow for a broader gathering of expert opinions than questionnaires and are commonly used in IT related business model framework building as shown by Dijkman, Sprenkels, Peeters, & Janssen (2015). The first round took place to iterate the framework with the panel of experts using interviews. This is a deviation from the standard Delphi process that commonly uses questionnaires to get the experts opinion (Brady, 2015; Mozuni & Jonas, 2018; Okoli & Pawlowski, 2004). This deviation was done since the open-ended nature of many of the questions posed in this research required a broader spectrum of input from the experts on themes regarding the main dimensions that could only be generated by interviews. However, such an adaptation is not uncommon in Delphi research and was previously utilized by multiple studies by Fletcher & Marchildon (2014) and mentioned to be valid among others by the frequently cited papers of Dalkey & Helmer (1963) or Rayens & Hahn (2000).

Data collection

The data in round one was collected in 14 semi-structured interviews conducted via Skype from the 30th of April 2019 until the 10th of Mai 2019. Every interview was conducted for one hour, except for one interviewee who had to leave after 30 minutes.

The interviews were conducted according to an interview protocol to ensure guidance and comparability of the interviews, without limiting the answers of the interviewee. Before the interview, all participants received a presentation regarding the scope of the research, as well as the preliminary business model framework to ensure their informedness. Further, conducting the interview via Skype provide that the researcher was able to share the presentation during the interview so that the panelist could visualize constructs easier to increase expert understanding and increase the quality of the findings obtained. All participants agreed to have the interviews recorded to allow for an in-depth analysis. To ensure that the participants could freely speak their opinion without having to fear any negative consequences, the anonymity of the participants was ensured and the interviews anonymized. This was done by only showing the statements made by the panelist by their expert ID, as shown in Table 4 (Harvard Faculty of Sociology, 2013). To further increase the credibility of the interviews, the transcripts were sent to the panelist for correction if needed (Schwandt et al., 2007). No issues were reported back to the researcher regarding this.

Analysis

For the analysis of round 1 all interviews were transcribed following the proposal of Bailey (2008) to ensure that the content was presented one to one and ensure trustworthiness (example transcript see Appendix 2). On top of that, filler words were removed, since the way the experts expressed their opinion was not the focus on this study.

The next step was the coding of the interviews and analysis to revise the preliminary framework and validate dimensions that needed no revision (Okoli & Pawlowski, 2004). The coding was done in Atlas.ti by using anchor codes according to the different main dimensions of the business model framework and one for additional dimensions to ensure that a structured analysis to answer the research question was possible (Saldaña, 2013). The analysis was done in a two-step approach, as can be seen in Figure 9. For the interview to be considered during the analysis stage, the panelists had to state their opinion regarding all the main dimensions and had to agree to foresee a usage of the UDP by different organizations.

First, the consensus regarding the main dimensions was analyzed. This was done by utilizing content analysis to derive the opinion from every expert regarding the main dimension (identifiable by the anchor codes) and to classify them as "agree" or "disagree", as proposed by von der Gracht (2012). The consensus was measured by the proportion of the respondents who agreed to keep a main dimension in the framework as done, amongst others, by Rådestad et al. (2013) and Seagle & Iverson (2002). Then the 75% agreement measure of consensus was applied and all dimensions that had less than 75% "agree" opinions from the expert panelist were excluded from further research. In the same step, content analysis was performed to find frequently mentioned new dimensions to be included in the framework. The most frequently mentioned ones were examined for applicability regarding the context of the business model framework that was set and included if they were deemed to be plausible.

Second, for each of the remaining main domains and the added main domains, themes, to describe which sub-dimensions are deemed possible, were created from the interviews. This part of the research was of highly exploratory and qualitative nature and was rooted in grounded theory (Strauss & Corbin, 1997). Following the structure of Saldaña (2013), a two-cycle coding strategy was used. The first cycle was coded using “Themeing”, finding themes identifying “what a unit of data is about and or what it means” (Saldaña, 2013, p. 175). The second cycle of coding was done using “axial” coding to find “categories discerned from the first coding cycle” (Saldaña, 2013, p. 218). The resulting categories and themes were then ordered by the anchor codes to describe the expert’s opinions regarding a main dimension and their opinion on its consequent sub-dimensions. Table 5 includes an example of how themes and thus the findings from the interviews were generated following the aforementioned methodology using the example of the main dimension “Type of Data Exchanged” with the anchor code “DT” indicating by how many different respondents the themes were mentioned in the brackets after the theme.

Anchor Code	1st Order (Themeing)	2nd Order (Axial Coding)
DT	DT: Yes (10)	Agreement to keep main dimension Type of Data Exchanged in Framework
DT	DT: aggregated data example (3)	
DT	DT: aggregated data will have smaller size and be cheaper and easier to download (1)	
DT	DT: only raw data at the moment (1)	
DT	DT: privacy issue with raw data (1)	
DT	DT: raw and aggregated both wanted (1)	Raw vs. Aggregated Data as a new subdimension
DT	DT: raw data example (2)	
DT	DT: Raw data versus aggregated data (5)	
DT	DT: Reasoning why raw vs. aggregated (1)	
DT	DT: receive raw data (1)	
DT	DT: Domain is interesting (3)	Domain valid subdimension
DT	DT: AI learning needs historical data (2)	
DT	DT: predictive analytics = historical data need (1)	Different Key activities depending on velocity
DT	DT: predictive analytics needs both velocity types (2)	
DT	DT: Historic and real-time data available (4)	
DT	DT: real-time example (2)	
DT	DT: real-time for decision making (1)	
DT	DT: real-time less often but coming (1)	Velocity valid subdimension
DT	DT: real-time most wanted (1)	
DT	DT: real-time vs historic makes sense (2)	
DT	DT: Old Type No (4)	Remove definition of data type with textual, visual, etc.

DT	DT: Variability is valid (4)	Variability valid subdimension
DT	DT: variability difference example (2)	
DT	DT: difference open vs closed data (5)	Subdimension of Open vs Closed needed
DT	DT: closed data paid (2)	Closed data free vs paid
DT	DT: closed data free (3)	
DT	DT: Barter examples	Include barter as option for subdimension of closed
DT	DT: multiple data types per company possible (2)	Multiple data types for one company

Table 5. Coding Table Example for "Type of Data Exchanged"

Each of the 1st order coding units referred back to a statement made by one or more panelists during the interviews. The themes identified in the axial coding were then used for analysis and are presented in the findings section.

The analysis of the main dimensions with the identified themes was excluded in the next round because it would have been very time consuming to check if the themes find an agreement for the experts in a questionnaire. Nevertheless, these themes can already be viewed as relevant findings due to the fact that they were derived from 14 interviews, which is a valid sample size for grounded theory building (Creswell, 2007). This method has been used to find themes for IT related business model frameworks already with a sample size of 11 in the work of Dijkman et al. (2015).

The end of round 1 resulted in an iterated BM framework that was validated and iterated again in round 2 of the Delphi study.

3.2.4. Round 2

Following the standard Delphi procedure in this step, the revised framework was shown to the experts again and their consensus was measured using questionnaires (Okoli & Pawlowski, 2004).

Data Collection

Questionnaires were chosen in this round since two rounds of interviews generally result in lower response rates of the panelist due to the more time-consuming participation. Another reason to use questionnaires was that only the main dimensions and their subdimensions were evaluated again due to the strict time schedule of the study (Ouariachi et al., 2018). The questionnaire was ordered by main dimensions, asking participants to agree or disagree on a five-point Likert scale (1=strongly agree, 2= agree, 3=neutral, 4=disagree, 5=strongly disagree) as done by Rådestad et al. (2013) on the main dimensions and the subdimensions. To avoid skewed results of the subdimensions, the panelists could only give their vote on the subdimensions if they agreed (1 or 2 on the Likert scale) with the main dimension to which the subdimensions belonged. With this practice, it was ensured that there was no downvoting of the subdimensions in case a panelist did not agree with the main dimension. Therefore, the votes of the subdimensions represent the opinions of the panelists who agree that the overall dimension should be kept in the framework, so given that the main dimension should be included in the overall framework, the votes show whether the subdimension is a possible type of the main dimension. The final questionnaire (example question see Appendix 5) was uploaded to Qualtrics to enable data collection online and was available from the 27th of Mai 2019 till the 2nd of June 2019. After which the data collection was stopped due to time constraints. During this time 10 panelist responded and had their answers recorded meaning that two respondents dropped out. However, 10 panelists are still a valid group size in Delphi research in well above the minimum threshold of 7 (Linstone, 1985).

Analysis

The five-point Likert scale was then trichotomized to a three-point Liker scale with "strongly agree" and "agree" being representing totally agree and "disagree" and "strongly disagree" representing totally disagree, while neutral remained neutral. Such a reduction for analysis purposes is commonly used in quantitative consensus measurement in Delphi studies shown in the work of Rådestad et al. (2013) or Mcilfatrick & Keeney (2003). This combination of agreement measurement with the trichotomization of the Likert scale follows the Delphi design used by Seagle & Iverson (2002). The responses of the participants were analyzed using the percentage of overall agreement and all dimensions and subdimensions that were below the consensus threshold of 75% were dropped (von der Gracht, 2012).

After this iteration, the Delphi study was ended, keeping the dimensions that had reached consensus in the business model framework, allowing it to be regarded as scientifically validated (Moore et al., 1977).

3.3. Follow-Up Case Studies (Second Stage)

To validate the developed business model even further and to gain insights into the different business models of organizations engaging with a UDP, in the second stage of the staged research, two case studies were conducted. Completing these case studies helped to validate the framework further, while at the same time answering the research questions regarding which business models are used and how are they different. To do so, two exploratory case studies were conducted to compare one phenomenon; the business model and engagement of an organization to a UDP in different situations. A case study is a suitable research methodology when the researcher wants to investigate something unique special or interesting and can be about processes, organizations or institutions (Yin, 2009). For this research this methodology was chosen due to its ability to position organizations in their social and real-life context and since there is no need to generalize, but to research a specific phenomenon such as the business model of organizations engaging with UDPs in the case of this research (Phondej, Kittisarn, & Neck, 2011). The unit of analysis for the case studies was chosen to be the business model of organizations that engage with UDPs. The design of the case study was chosen to be a multiple case study, as this type of case study produces evidence that is more compelling and the study itself is regarded as more robust, increasing the external validity of the case studies (Yin, 2009). The focus of the individual cases was selected to be embedded, where the researcher examines some aspects of the cases (organizations) to be analyzed as opposed to holistic where the entire organization must be described as a whole (Yin, 2009). This design was chosen since it allows to focus on the unit of analysis specifically and is most commonly chosen in multiple case studies, as a holistic study would require too much time and effort in a setting with multiple cases (Yin, 2009). By using a multiple, embedded case study design, this research aims to describe the business models with the previously developed framework in two different situations and analyze the differences between the two case studies.

3.3.1. Selection of the Cases

In the first step of the case studies, two organizations to be analyzed using the business model framework were selected. It was a key requirement that these companies are engaged with a UDP in any of the applicable settings mentioned in the literature review (Section 2.3.1). Further, insights during the first round of the Delphi methodology revealed different types of cases that are commonly seen in the environment of a UDP. Depending on these types, two different case studies were selected.

3.3.2. Data Collection

For the data collection phase, an interview was conducted with someone from each organization who was knowledgeable about the connection of the organization to a UDP. This interview was extended by incorporating publicly available information to perform triangulation as proposed by Yin (2009). By performing triangulation and using multiple sources of evidence, the construct validity of the case study can be increased (Yin, 2009). Following the gathering of data from public sources, two semi-structured interviews with top level-executives (once the CEO and in the other case with the CIO) were performed following a case study protocol to increase the validity of the research as proposed by Yin (2009) (Appendix 6). The first interview was conducted via Skype, while the second interview was conducted face to face in Amsterdam. Both interview partners agreed to have the interview recorded for later analysis.

3.3.3. Case Analysis

The data analysis was performed in a structured way, using a case study protocol (Yin, 2009). The interviews were recorded and transcribed to enable a structured analysis. Each case study represents one organization engaging with a UDP, and for each organization the dimensions of a business model were described and analyzed for each company respectively, by following the themes mentioned by the interviewees for each dimension. The statements of the interviewees are ordered according to the dimensions of the business model framework and cross-case analysis was conducted to find patterns between different types of business. To analyze the cases a pattern matching technique was used to compare the pattern of the different organizational scores along the dimensions of the business model framework that in their entirety allow for a business model comparison (Veal, 2005). To achieve this cross-case synthesis was performed based on the dimensions of the previously developed UDP-engaging BM framework. As such, the BM framework serves as a tool to systematically asses the differences between the two business models along its dimensions as proposed by Yin (2009).

The following section shows the findings of the two Delphi rounds, followed by a discussion of the Delphi study, which is followed by a section containing the findings of the case studies, proceeded by the discussion of the case study findings.

4. *Delphi Study (First Stage)*

This section describes the process of the Delphi study. It starts with the derivation of the main and sub-dimensions of the preliminary business model framework, followed by reporting the findings of the two Delphi rounds separately and ending with a discussion of the findings of the Delphi study in light of the current body of literature.

4.1.Deriving the Initial Model

The business model of a company describes the value logic of an organization by focusing on how it captures and creates customer value in terms of a product or service (Fielt, 2013). The goal of any business model framework is to enable a systematic analysis and comparison of different companies and their respective business models (Brownlow, Zaki, Neely, & Urmetzer, 2015). The framework shall, therefore, contain a set of possible attributes for every business model dimension to comprehensively describe any business model of companies engaging with UDPs. This subparagraph describes the creation of the initial business model framework building on the literature review on business models in section 2.2.2 using the criteria from section 3.2.2.

From the body of literature, the Data-Driven Business Model (DDBM) framework by Hartmann et al. (2014) was chosen as the basis of the analysis of business models in an urban data context. This framework contains six different dimensions, along which companies are classified to analyze their business model (Hartmann et al., 2014).

According to Fielt (2013) a business model framework must contain at least four dimensions that address the customer, value proposition, organizational architecture, and economics. Hence during the selection of the elements for the first iteration of a business model framework for companies engaging with UDPs, these four high-level dimensions were used as guidelines for the selection of the dimensions to be included. Further, following the S-D business model logic of Fehrer at al. (2018) and show the influence of the urban data platform on the business models of the organizations engaging with it, half of the dimensions are focused on capturing the nature of the engagement with the UDP.

To fully capture the business model of actors engaging with a UDP, ten main dimensions with the first five more focused towards incorporating the aforementioned UDP impact and five containing more operational dimensions were selected based on the dimensions identified by previous research in Table 3. The preliminary business model framework is shown in Figure 10.

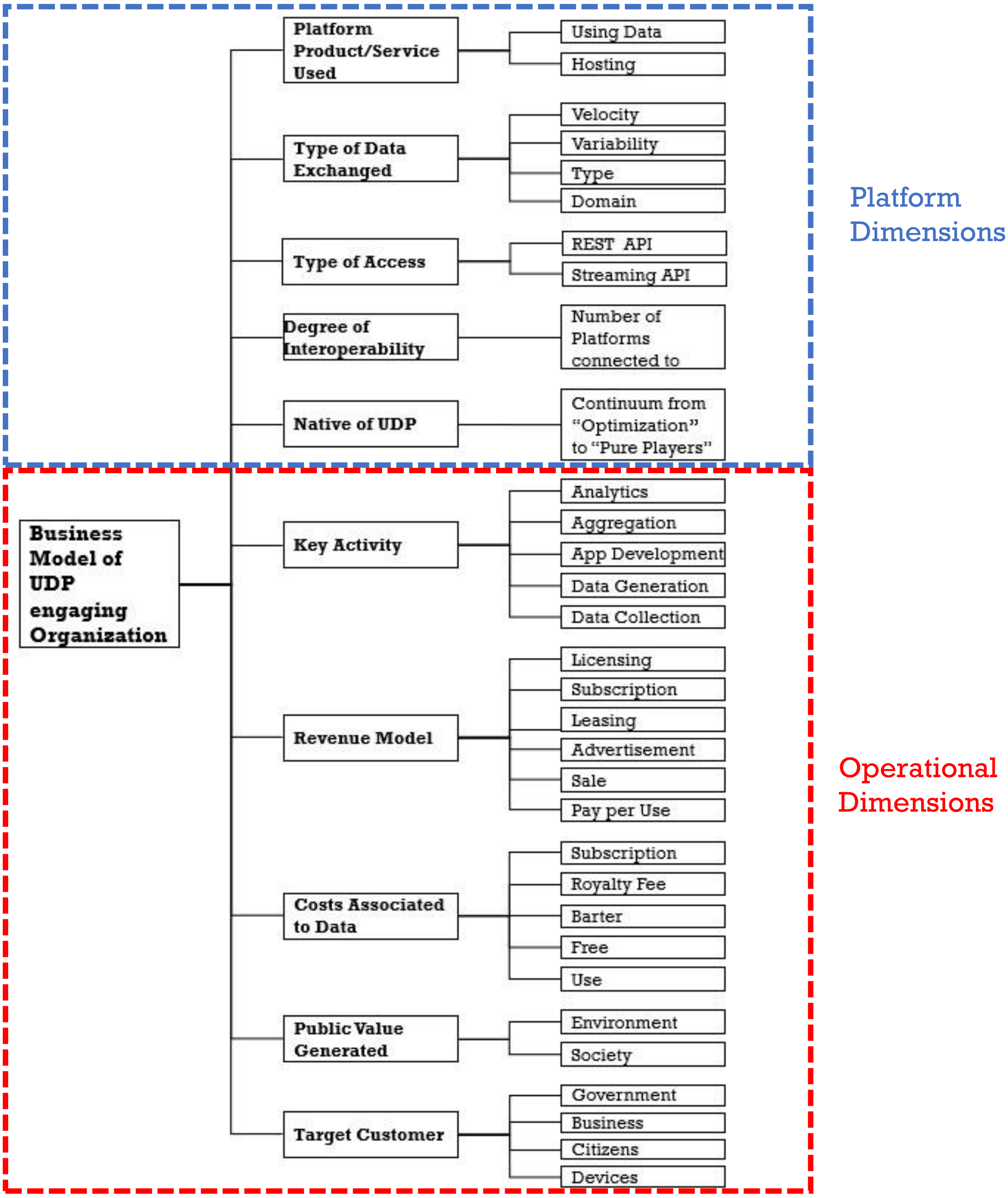


Figure 10. Preliminary Urban Data Business Model Framework

4.1.1. Main Dimensions

Platform Dimensions

The first dimension is "Platform Product/Service used". This was evolved from (Service) Platform used. El Sawy & Pereira (2013) acknowledge the effect of different services used on the business models, where the separation is made between buying data from the platform or using hosting capabilities of a UDP to host a service on the UDP.

The second platform dimension “Type of Data Exchanged” influences the business model since different types of data allow for different types of activities to be performed based on them, as acknowledge by Hartmann et al. (2014) in their Data-Driven Business Model (DDBM). The different subdimensions to describe the types of data are from big data literature describing the 5 Vs and from the Data-Driven Business Model framework and Urban Data classification literature by Pan et al. (2016) (Hartmann et al., 2014; IBM Analytics Hub, 2019; Pan et al., 2016). From the 4 Vs Volume and Veracity were dropped due to limited applicability in a UDP context. This is due to the fact that the UDP dictates the volume of the date and relatively constant across different platforms and veracity being less important since the data is coming from a platform where the government takes over at least a governing part and ensures a high degree of certainty of the data (Mcloughlin et al., 2018; Pan et al., 2016).

The third platform dimension “Type of Access” is related to the type of data exchanged, since several data types can only be exchanged using certain types of access. However, this is not a one to one relationship, and the same type of data can be exchanged using different types of access. The different types of access (REST and Streaming API) that are deemed possible were mainly derived from publications about cities that already operate an urban data platform, namely Singapore, London and Santander (Arup, 2016; Cheng et al., 2015; Kloeckl et al., 2012; Ubaldi, 2013; Zygiaris, 2013).

The fourth platform dimension “Degree of interoperability” describes to how many different UDPs the actor was connected and was consistently mentioned as an important differentiator of businesses in urban data platform literature (even in different reference models that were developed such as FIWARE and QuerioCity) and urban data literature (FIWARE, 2019; Lopez et al., 2012; Pan et al., 2016; Ubaldi, 2013). The more platforms an actor is connected to, the higher its requirements are with regards to interoperability and hence the more city or platform specific the offering of him will be.

“Native to UDP” as the fifth platform dimensions is derived from the “business model openness” dimensions used in the business model framework for open government data by Magalhaes et al. (2014). This describes a continuum between “better business through open data”, when an actor is using open data only to improve an existing value offering and “open data pure players”, when the value proposition of the actor is highly dependent on open data and could not produce the offering without it (Magalhaes et al., 2014). The dimension was adopted into a UDP context, by replacing open data with urban data platform in the definition and included since it allows for the separation of business models on another dimensions. "Urban Data Platform Pure Players" will be more reliant on a UDP and might exhibit different characteristics to balance out this increase in risk compared to "Better Business through UDP Players".

Operational Dimensions

The sixth dimension included is "key activities", describing the key activities performed regarding the UDP. This dimension is mentioned in almost all relevant business model framework literature, such as DDBM, IoT Business Model Classification, Fintech Business Models, Urban Data Business Models and even the Business Model Canvas (BMC) (Hartmann et al., 2014; Mcloughlin et al., 2018; Osterwalder & Pigneur, 2010; Schmidt et al., 2018; Turber et al., 2014). The different subdimensions were derived from the DDBM, where some could be excluded due to the specific context of a UDP environment. Additionally, to being a very important facto to classify the business model of an organization, these classifications also allow the business to be classified along the (open) government data value chain (Klievink et al., 2017).

As a seventh dimension, the "revenue model" of the actor was incorporated in the preliminary framework. Comparable to the "key activity" this dimension is part of all influential business model frameworks (IoT, Fintech, Data-Driven, Urban Data, BMC) and also of the platform-specific VISOR Framework (El Sawy & Pereira, 2013; Hartmann et al., 2014; Mcloughlin et al., 2018; Osterwalder & Pigneur, 2010; Schmidt et al., 2018; Turber et al., 2014). The revenue model describes how the company is generating revenue streams from the value proposition and has the subtypes licensing, subscription, leasing, sale, usage and advertisement (when the company is offering the product or service for free and generates income based on advertisement as part of the value proposition) (Hartmann et al., 2014).

The eight dimension is the costs associated to UDP. Like the previous two dimensions, costs are part of all relevant business model frameworks and have been adapted to represent how the company must pay for the data that they receive from a UDP. Companies can incur costs that are linked to the revenue models of the data supplier side in the UDP environment, that can be described using the revenue models for big data monetization, as well as the subtype free, since urban data is in many cases open data (Lokitz, 2018; Pan et al., 2016). A model whose existence has not been shown yet but is assumed to be relevant in a UDP context is “barter”. In this subtype, the data supplier supplies data to the data consumer in exchange for a non-monetary product or service, such as an analysis that the consumer provides for the supplier. Another reason to engage in barter can be that the consumer decides to share his data with the supplier in exchange, swapping the roles of data supplier and consumer (Humphrey & Hugh-Jones, 1992).

The ninth dimension is “public value” and is important in light of the goal of smart city initiatives to generate public value with their activities and increase the quality of life for the citizens (Caragliu et al., 2011). The public value shall capture whether the connection of the actor to the UDP is generating more public value than causing public costs. Hence the costs and benefits are compared to each other in the subdimensions of Environment and Society as proposed by Papi et al. (2018) to separate the business models that are in line with the overall goals of smart city initiatives form the ones that might be focus on private value generation and public cost (Papi et al., 2018).

Incorporating the “Target Customer” as the tenth dimension is important since the type of end customer has an influence on multiple considerations of the business model of a company and are a key aspect of the value proposition that the company produces (Osterwalder & Pigneur, 2010). The offering of actors might be targeted as governments, businesses, citizens or devices that are a separate sub-form of businesses since they require a different type of value proposition (El Sawy & Pereira, 2013; Hartmann et al., 2014).

Due to the definition of the analysis of a business model of organizations engaging with a UDP, as an explanation of the value creation logic of an organization regarding a UDP, the value proposition itself is not part of the preliminary business model framework, since it can be assumed to logically flow from the other higher level dimensions of the framework as propose by Mcloughlin et al. (2018).

4.2. Findings of Round 1

This section outlines the findings of the first round of the Delphi study, by reporting the findings of the analysis done in Atlas.ti of the 14 transcripts of the interviews with the panelists. First, the consensus on the 10 main dimensions is reported and new main dimensions to be included are described. In the following subsection, the most important themes per main dimensions are described and the possible subdimensions are mentioned. Finally, this section contains a subparagraph on other findings that were discovered during the analysis of the interviews that were found to be an addition to the current body of literature. The other findings and the themes per main dimension were excluded from the following Delphi round and can be viewed as stand-alone findings based on 14 expert interviews found using grounded theory and content analysis.

Before the panelists were asked to give their opinion on the main dimensions of the business model framework, it was checked if they agree that a UDP might be interesting to use for private and public organizations, so that there will be a new value proposition developed and hence a new business model will emerge that can be analyzed. 13 out of the 14 interviewees agreed that this was the case and the platforms that they were currently developing were either already taking measures to actively engage organizations to use the UDP or planning to do so in the future. For example, E2 mentioned, "*since I'm working in urban platform development, the main focus for me is on how it can support businesses and communicate with parties outside the municipality*" showing the importance that UDPs will have regarding new business models. Only participant E9 disagreed with this statement saying, "*if we (as the UDP) just share a lot of data, there might be competitors using it and taking the business away from the Stadtwerke*". The city of Munich has the city-owned for-profit organization "Stadtwerke" that were fulfilling many of the value creation tasks that other cities tried to achieve by opening their UDP up to the outside. E9 further explained, "*we are offering bike sharing services via the Stadtwerke and we don't want to share their operating data with other companies that will compete with them*". Therefore, it has to be noted that, while even Munich shared some urban data, there are different types of cities with different types of agendas regarding UDPs. While the interview with E9 provided some very interesting other findings, it was excluded from the business model framework dimensions, since there was no intention to enable new business models by opening the UDP up. The same occurred to interview E13, where not all questions could be asked due to the limited time of the interviewee available who had to leave after 30 minutes. Both interviews are included in a following result section about other findings regarding the context of UDPs.

4.2.1. Findings of the Main Dimensions and Overall Framework

The remaining 12 interviews were first analyzed regarding their agreement to the main dimensions. To get the opinion of the experts regarding the ten main dimensions, the interview guide included closed-ended questions that the respondents had to answer to give their opinion on the main dimensions. The aggregate findings are shown in Table 6.

		Panelist Opinion	
		Total Agreement	**% Agreement**
Main Dimensions	**Platform Service Used**	3	25%
	Type of Data Exchanged	11	92%
	Type of Access	9	75%
	Degree of Interoperability	9	75%
	Native of UDP	9	75%
	Key Activities	10	83%
	Revenue Model	9	75%
	Costs associated to Data	8	67%
	Public Value	6	50%
	Target Customer	10	83%
	Overall Framework Valid	11	92%

Table 6. Overview of Panelist Opinion First Round

The table shows the findings of an Excel analysis of the measure of the percentage of agreement. 11 out of 12 respondents (92%) agreed with that the preliminary business model framework is a valid tool to analyze the business models of organizations engaging with UDPs, which is an agreement with the overall structure of the framework. Therefore, consensus regarding the inclusion of operational, as well as platform dimensions. Statements made by E5, E10 and E11 were in support of this, pointing out the validity of incorporating platform dimensions in a business model framework – E11 "*What I like is that you included platform aspects as well here. I think this has an influence on the business model and should be included in such a framework*"; E5 "*how they work with us as a platform and what we can offer to them has an influence on the business model that they use when they work with a UDP*".

Regarding the main dimensions, three out of the original ten dimensions did not reach consensus. There was one platform dimension removed due to failure to reach consensus, as well as two operational dimensions.

Removed dimensions

Further elaboration on the dimension with the lowest agreement "Platform Service Used" revealed that multiple respondents thought that it is unlikely that there will be services hosted on the UDP and hence the distinction in this dimension was not given anymore. Hosting was mentioned to be out of scope for UDPs by four respondents (E4, E1, E12, E5) – E5 "*this (hosting) will not be an activity of the platform. You will have a commercial hosting company* *doing this and organizations just using the data*". UDPs were described as data warehouses or data platforms and not as software platforms that offer hosting capabilities – E6 "*it (UDP) is just a data warehouse*". Only one panelist mentioned that hosting might be possible in the future regarding citizen science projects - E3 "*they (citizens) might do a project and not have a solid surface to put their programs on, so in that sense we might also offer hosting in the future*". This notion that there will only be data exchanged was shared by E5, E6 and E12, who all mention data to be the only product to be exchanged via the UDP - E12 "*We want to be open so that we can host all different types of data sets and have data as the product that is exchanged via the platform*". Thus, "Platform Service Used" was excluded from the business model framework by quantitative consensus further strengthened by the arguments brought forward by the respondents.

"Public Value" as a dimension also did not receive the required 9 "agree" votes and was also excluded from the framework. The justification for excluding this dimension was mentioned by five participants (. E8, E5, E3, E6, E11) to be the fact that public value is tough to measure, even though the dimension itself is interesting for cities – E 6 "*it (public value) might be more something cities are looking for. Also, it might be very hard to measure*". Such a function should be ensured by making sure that the companies adhere to laws, that must ensure public value creation – E8 "*the laws should ensure that there is public value generated, but it (public value) is really hard to actually measure*". E3 and E4 proposed to include a legal dimension instead to show public value creation by the companies adherence to laws. The legal dimension was considered as a new main dimension henceforth as can be seen in the findings of the new dimension section.

The last dimension that was removed with 8 agreements instead of 9 was the "Cost associated to data" dimension. The most frequently stated reason not to include this as done by E8, E11 and E12 followed the reasoning of E10 that there is "*Just free data and not costs associated to this*". Additionally, the revenue model was found to be more important in the defined UDP context meaning that costs should be excluded to avoid unnecessary complication of the framework - E4 *"I believe the revenue model is more important than the cost model*". Due to these expert opinions and the failed qualitative consensus, the cost dimension was removed from the iterated business model framework.

New Dimensions

Following the exclusion of these three dimensions, the experts were asked to indicate if they thought that any dimensions were missing. The most frequently mentioned ones are included in this section and are considered to be added as a new main dimension in the iterated business model framework at the end of the first Delphi round. There was one platform dimension added and two new operational dimensions, restoring the original balance of 5 platform and 5 operational dimensions.

The first new dimension to be included is the dimension of key partners. This dimension is mentioned by five experts (E2, E4, E5, E11, E14) which shows the need for this dimension to be added, given the fact that the question for missing dimensions was open-ended and the participants had no idea what others answered before them. The reason to include such a dimension was caused by the complexity of tasks in the environment of UDPs that required a value network and thus partners to help one company create a value proposition - E 4 "*there are different activities that a company can all by themselves or do as part of an ecosystem… depending on the business case you either do it alone or need a lot of partners to build a solution*". These partners are so important that they can become the deciding factor for companies to engage with a UDP or not - E14 "*how much they (organizations engaging with UDP) rely on them (the partners) and who those partners are and what they are doing*". The importance of this dimension for the business model is described by E5 who acknowledges that "*80% of the work is getting the right partners together"* showing that depending on the value offering this dimension is of crucial importance to enable the business model in the first place. Therefore, following this reasoning the dimension of "Key Partners" is added to the iterated business model framework to show how many partners the organizations need for the business model facing the UDP, what these partners are doing and how important they are to the value proposition that is generated.

A second dimension that was frequently mentioned concerned the type of engagement that the organizations have with the UDP. This included the classification if the engagement to the UDP to generate the value proposition was focused on using data from the UDP, producing data to be shared on the UDP or both in a combined business model. It was included, since all experts agreed that the engagement with a UDP of an Organization can either be producing data and sharing it via the UDP, using it from the UDP or both types of engagement in unique cases - E8 "In *this context they are either using or supplying the data to the UDP or maybe both*".

These types of engagements appear to have an influence on which business models are possible and are hence important to include in such a framework - E7 *"will be a different range if models depending of you are a data producer or user"*. Due to its descriptive nature regarding the overall engagement of the organization with the UDP this dimension might even be a higher order item that has an influence on other main dimensions - E3 "*the engagement is important for the overall nature of the business*" to be analyzed. Due to the frequent mentioning a valid point brought forward by the panelist, the dimension "Type of Engagement" is included in the iterated framework as a new main dimension.

The third dimension that emerged from the interviews as a new dimension is the offering that is generated by the business model of the organizations engaging with the UDP. On the open-ended question about any additional dimensions that are required, E14, E5 and E1 all mention the importance of the nature of the value proposition - E1 *"include what they (companies) are producing. This could be data or algorithm"*. Another common theme that appeared in the interviews was the separation on tangible versus intangible products - E5 *"tangible, when they (companies) build new physical things due to data from the UDP, while others like algorithms or knowledge is intangible"*. During the interviews, there were several examples mentioned regarding the different types of offering. Knowledge as a type of value proposition was mentioned in a use case where a company used weather data from a UDP to build a prediction model for farmers that they then sold - E14 "*they tried to understand, when to seed and when to cut the crops*". At the same time, there was one example that proved that not all products in these business models, such as a company that improves a physical product due to the data from the UDP, that improved tracking devices for senior people to better help with elder care. This company used data from the UDP about weather and other environmental factors that could then be used to predict when elders are feeling bad or good and improve the service they offered to private customers by improving the sensors in the tracking device - E14 "*it's both product and service business improved by UDP data which they use*". Building on all these points it was decided to include the main dimension "offering" with the subdimensions of data, reflecting the points made by E1, information or knowledge mentioned by E1, E5 and E14 and non-data product to cover the distinction made by E5 and the example brought forward by E14.

Another point that was mentioned by six panelists (E1, E3, E4, E8, E11, E14) in some point of the interview to be included in the framework was the dimension of law and regulation.

E1, E3, E8 and E11 mention the importance of laws and regulation in the context of public value creation. The argumentation to include laws as a dimension was related to the public value creation - E1 "*to ensure public value is created we have to control for this, if they adhere to law or not".* However, there was also a different line of reasoning to include laws as a subdimension brought forward by E3 and E4 who both mention that there might be differences in the regulations of companies depending on their location that cause unique advantages and disadvantages - E4 "*It can highly depend on the local law. Who would actually be the owner of the data and what can I as a company do with it*", referring to the fact that in different countries there are different legal environments that give companies different degrees of freedom and responsibility. Even though this point is highly relevant for the operation of the businesses, the environment of the businesses was assumed to be stable for this research to reduce complexity as described in section 2.2.1. Consequently, the legal dimension was not included in the iterated business model framework since it is assumed to be a constant for the purpose of this research.

After an analysis of the main dimensions, three dimensions were removed, and three new ones were added and discussed in detail in this paragraph to show the reasoning of the panelists for exclusion or inclusion, respectively. The next paragraph will discuss the validity of the remaining seven main dimensions, as brought forward by the experts.

4.2.2. Findings of the Confirmed Main Dimensions

In this section the validity of the seven main dimensions that were quantitively validated in the first round is discussed to support the quantitative findings with qualitative themes that the panelists mentioned during their interviews, focusing on the subdimensions that are deemed plausible for each of the main dimension. This result section includes a description of the subdimension with examples as given by the experts and describes the validity of existing subdimensions, the changes to existing subdimensions if needed and the addition of new ones if proposed by the panel of experts.

Type of Data Exchanged

11 out of the 12 panelists agreed to keep this dimension in the iterated framework, showing its importance to describe the business model of organizations engaging with UDPs. E2 explained his reasoning on why he decided to include this dimension, "*This (data type) is important for the business model because with different types of data you can do different things*". Following his reasoning, data that scores differently in this dimension and its corresponding

subdimensions enables the organization using it to have different key activities and hence a different value proposition. Focusing on the subdimensions of Data Type, the most frequently mentioned one is "velocity" with 13 codes in the interviews relating to this subdimensions and all confirming its importance during an analysis of the business model. E8, E 12, E6 and E11 all confirm that they are offering both types of data on their platform and have a similar argumentation to E11 who states, "*What we see in Nice is that they are using both kinds of data, real time data to take decisions and historical data for some kind of analysis and prediction models that they build".* This shows that depending on the velocity of the data that organizations receive from the UDP, they can either build prediction models from historical data or they can make real-time decisions based on real-time data. Especially real-time data appears to be appealing to businesses as mentioned by E12, "*there is a big hunger for it (real-time). Not only from businesses but rom citizens and students. This will be really useful, and people will use it many times"*. Besides this, the possibility was mentioned that there could be more than one type of data used per company - E11 - "*one company can use multiple types of data"* to indicate that there might be real-time and historical data used by the same company under the same business model. Due to this perceived importance and the fact that both types of data are available and allow for different actives, the velocity is kept as a highly relevant subdimension of the main dimension "Type of Data".

The next subdimension of "Type of Data" is variability. This dimension differentiates whether data is static, not changing frequently, or dynamic, changing frequently. This dimension was also kept in the framework, following the reasoning of E6, "*Static data is easier to use because I don't need to make updates all the time. Dynamic data might be more interesting sometimes, but it is also more tricky and you need to have more advanced capabilities".* Following his reasoning, depending on the variability of the data, the company might need more advanced capabilities and thus might require more skilled personnel. While this results in a larger effort, it can also open the door for more valuable activities.

The subdimension of the domain of the data was mentioned twice by the experts directly. E3 and E8 both found the domain to be interesting because they saw a different demand for data from different domains and hence concluded that companies produce different types of value. E8 stated, "*Domain is interesting. For example, we are seeing a very high peak at traffic data at the moment. There is a lot of companies trying to improve the traffic problems that we have in Hamburg and this is why this data is very interesting to them*". This shows that depending on the domain of the data and the environment where the data is collected, companies will prefer one type over the other and different types of organizations are attracted to develop value propositions based on this data. Due to the previously mentioned positive attitude towards including “domain” that was not contrasted by any negative statements, it was decided to keep “domain” as a subdimension of “Type of Data Exchanged”.

Type of Data Exchanged in terms of whether it is visual, textual or other data was covered by the subdimension “Type” and was contentiously discussed by the panel of experts. E11 and E14 voiced the same opinion as E6 concluding, “*I don’t really see the distinction there regarding the type”*. Five panelists (E4,5,6,11,14) mentioned the importance of raw versus aggregated data regarding the main dimension of “Type of Data Exchanged” and E4, E11 and E14 proposed to replace the original separation of the subdimension “Type” with visual and numerical and other types to be replaced by raw versus aggregated data. The reasoning why the distinction between raw versus aggregated data is important to be included as a subdimension of “Type of Data Exchanged” on a business model framework was expressed by E4, “*I understand the type of data as a subcategory more as if it is pristine so raw data or whether it be the urban data platform has already been able to provide a service to me by aggregating it to certain to sort of form to certain level. Because if I no longer need to do my analysis myself that’s a big plus*”. He also explained that in a case when an organization has a more precise understanding of what it wants, it would use aggregated data to avoid doing the analysis again, as opposed to the scenario when the goal is not as well defined ex ante and the organization needs to do some exploring, since then raw data offers more freedom – E4 “*I want to find the signal in the noise. If I already know what I am looking for and I can directly download the signal this is great. Otherwise, if I want to do more exploring I want raw data”*. Following the suggestions of all these experts, the subdimension “Type” of the main dimension “Type of Data Exchanged” was changed to represent the distinction whether the organization is receiving or sharing raw data versus aggregated data due to the different risks and benefits associated to these two types of data.

As a last subdimension to “Type of Data Exchanged”, the “nature” of the data is added due to a frequent mentioning by the panelists. The most frequent distinction regarding the nature of the data that is accessible from the platform relates to how open the data is. E14 states, “*sometimes you have data from the UDP that was not open to everyone and sometimes you have really open data*” explaining that within the same platform different natures of data are offered. The reason to include closed data was mentioned by E6, "*other parts are not available to everyone and you will need to have a privacy declaration or sign up*" so to represent data that had to be closed from the public due to privacy reasons but was still available free of charge. Further, the statement from E6 provides a good definition of closed data that it is not available to everyone and requires a sign-up or the signing of some documents to receive this data. Privacy might not be the only reason to close data sets but generating revenue from it might be another reason – E1 "*you could close the data to make money from the data by requiring the user to pay for it*". E14 mentions another distinction that has to be made regarding closed data as he elaborates on a use case from an organization using data from the UDP in a new business model to produce an app that predicts the amount of pollen in different parts of the city to help allergic persons. E14 asserts, "*sometimes the one sharing it (data) wanted something in exchange, as with the asthma prediction service when the city is sharing the data for free and wants the company to build a prediction model that improves the lives of the citizens".* This demonstrates that there was a barter happening where something else than money was exchanged for closed data. Such a model is found to be feasible by E1, E6, E7 and E14. The model might not only be restricted to exchanging data for a service, but it can be a data for data exchange via the UDP - E1 "*we will both be smarter by using each other's data from free*". Hence, "barter" was also included as a distinction of closed data, next to "free" and "paid". Panelists E8 and E3 included one more type of the nature of data differentiating between open, shared and closed - E8: "*In general, we can either publish it as open. The next level is that is only open for all of the different departments of the municipality or the last one is that is only shared for a certain team or group of people*". However, since this separation was only mentioned by two panelists and is another added layer of separation so that even the three-type differentiation can be represented with the two types "open" and "closed" only those two ones were incorporated in the subdimension "Nature". In total six panelists (E3,6,8,11,12,14) mentioned this distinction separately and it was decided to include it as a fifth subdimension of "Type of Data Exchanged" with the separation of open versus closed data and further dived closed data into close data that is available for free and closed data that is paid for. The new subdimensions of the iterated main dimension of "Type of Data Exchanged" after round 1 of the Delphi study are visualized in Figure 11.

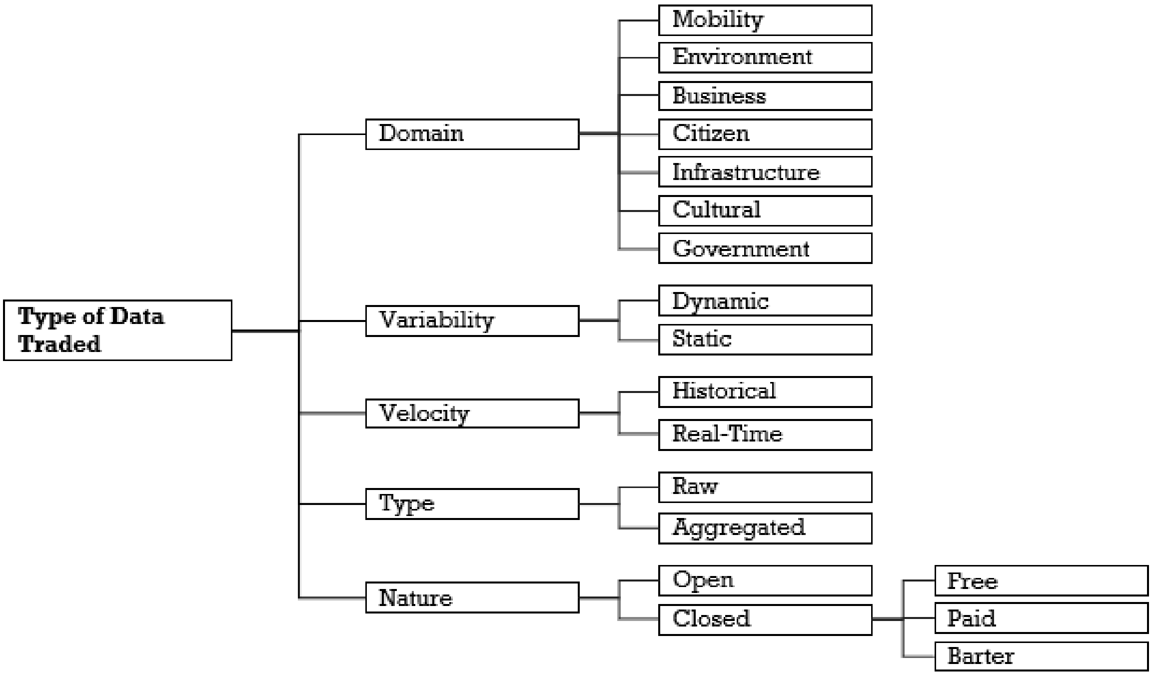


Figure 11. Overview of the iterated Subdimensions of "Type of Data Exchanged" after Round 1

Type of Access

The overall importance of this dimension with 9 out of 12 panelists agreeing to keep this in the framework for the next iteration can be summarized in the statement by E4: *"I need to find a way to transport the data to me and depending on what I want to do with it I need different types of access*". The type of access previously had the subdimension of REST API and Streaming API. The difference between these two types as valid subdimensions of "Type of Access" was confirmed among others by E3 and E4 who stated, "*REST API and streaming API are a valid distinction because REST API can even be done for historic data*". Even though this distinction is valid, there appeared to be a need to separate the dimensions on a higher level, since three experts (E3,4,6) mentioned the availability of downloads as an alternative to API, such as E6 who announced, "*sometimes you may just want to download because you want to do something just once*". Even though E11 disagreed with this and stated that in the UDP that he was affiliated with there were no downloads, "*not really any downloads… from the platform*", "downloads" were included as a higher level subdimension as opposed to API, since not every subdimension needs to be applicable to the organizations engaging with every platform, but for every platform environment there should be a separation regarding the main dimension possible.

Moreover, there were different opinions regarding which type of access would be more sought after by businesses and what the preference depends on. E3 – "*developers want API and citizens*

... just want a download" so the type of user might have different preferences for different types of access. Which is further supported by the statement made by E6 "*then (with downloads) you will always have an update issue*" mentioning that when dynamic data is used downloads might cause problems and APIs are preferred. This link to the main dimension of "Type of Data Exchanged" is further supported by E3 and E4 who voice similar believes. Overall four respondents (E3, E1, E6, E8) mentioned that based on their experience APIs are preferred by the users due to, while just E7 mentions that he sees downloads as the preferred option. E8 and E4 both describe that downloads are only preferred in cases when large amounts of data need to be downloaded - E8 "*only if we have very large files ... it doesn't make sense to transfer them via an API*". The importance of "Type of Access" might be higher, the larger the amounts of data required, as described by E4 with the example of training an AI – "*it (type of access) is especially important if you're training an AI...*". It appears that there is no clear trend which type of access is preferred over the other, while some scenarios are mentioned under which one might be preferred to the other by the organizations engaging with the UDP, which is the reason why "download" and "API" with the subdimensions of "streaming" and "REST" were included as the subdimensions of "Type of Access" in the iterated framework after round 1.

Degree of Interoperability

The degree of interoperability does not have any subdimensions but is supposed to describe to how many external platforms the organization is connected apart from the UDP it is engaging with. Therefore, the findings of this main dimension concern the arguments of the panelist that were made regarding if a high or a low degree are deemed to be feasible for a business model of an organization engaging with a UDP. There appears to be a trend towards a high degree of interoperability that is wanted by the businesses as stated by seven panelists (E2, E3, E4, E5, E6, E7, E8) – E5 "*most of the companies will have high interoperability and offer their service in multiple cities*". Among the reasons mentioned why the experts foresee this trend, the most frequently mentioned (E3, E4, E6) was the advantage of the scalability of being connected to multiple platforms. E3 reasoned in the following way – "*if you have high interoperability you can scale the solution that you have developed over multiple cities and spread the costs that you had during the development, while having access to more revenue sources*". Another reason for the trend towards higher interoperability was the risk associated to only having one source of data – E11 "*I believe that companies with a low degree of interoperability have much more risk if they just do it for one city*".

Even though the experts widely described this trend, they still describe cases when a low degree of interoperability is used and even preferred to a high degree of interoperability. E14 specifies "*in my cases, they were using data mostly from just one source… they needed interoperability but not with other platforms, but with their own data to perform the analysis*", showing that there are cases when companies have a very low degree of interoperability, as confirmed by E1 for the context of Rotterdam. E3 described the vertical strength of the company to be a key factor that has to exist if companies have a low degree of interoperability in their business model – "*If you have your own sense or your own database, your own dashboard, your own app, then it might be that you rely on your own vertical strength instead of connecting to multiple different platforms*". Additional examples for business models with a low degree of interoperability were given by E2, E2 and E6.

The experts also mentioned that the degree of interoperability that an organization has in its business model regarding a UDP connection does not always depend on the strategic choice of the company, but on the capabilities that the platform can offer and. E1, E2, E8 and E11 all mention aspects of standardization regarding "Type of Data Exchanged" or "Type of Access" to be important determinants of the degree of interoperability that an organization can achieve – E11 "*we are currently engaged in a project with Italy to allow shared access to the tourism data that we have and that the Italians have. When we offer the same standers for access and data type users can use really easy use different data sets in the same application across the two countries, which is really interesting for them*." Moreover, the focus of interoperability is not limited between different platforms to which the organization connects but can also indicate interoperability with the internal platforms of the organization – E14 "*They needed interoperability but not with other platforms, but with their own data to perform the analysis*". Based on this evidence, high and low degree of interoperability appear to be possible in a business model of organizations engaging with the UDP and this dimension remains unchanged in the iterated business model framework after round 1.

Native of UDP

Similar to the main dimension "Degree of Interoperability", "Native of UDP" does not have any subdimensions but contains a continuum between "Urban Data Pure Players" and "Better Business through Urban Data". To qualitatively confirm this dimension after the quantitative agreement has been reached (75% agree), the opinions of the experts on both extremes of the continuum are described to show its validity.

During the interviews both extremes of the continuum were found to be existent in the business models of organizations engaging with UDPs by E2, E5 and E14 stating this explicitly – E2 "*Both types could happen, and I think they are a good separation*". Five panelists (E1,3,5,8,14) mentioned examples that described business models of "Urban Data Pure Player" – E8 "*Mundraub.org is native to our UDP in a sense because they show you where there is fruit growing on public ground so that everyone can harvest it. This is to my knowledge only possible, because we provided them with the location and nature of all the trees and continuously update this*". The other extreme of the continuum of "Better Business through Urban Data" was acknowledged three times with examples by E3, E7 and E14 who mentioned an example where an organization used weather data from a UDP to improve their prediction model of when to harvest - "*They had this model already based on farm data, but by incorporating data from the UDP they were able to improve it*".

Another theme that was expressed by multiple panelists (E7, E5, E11) was regarding the higher risk and higher dependence on the UDP, that a company faces if they decide to pursue a "Pure Player" business model due to a high reliance on the UDP – E7 *" If you as a company have a business model for this engagement you will also have much less risk if you are not that reliant on the data from a UDP*". E11 expressed the same issue in terms of responsibility that the UDP has towards "Pure Players" to deliver the right quality of data – "*For the pure players they will be much more reliant on the quality of data that we can give them*".

Furthermore, E4 mentioned a relationship between the "Nature" of data and the possibility to operate a "Pure Player" business model – "*what I do see is that there aren't any businesses that actually can build a business model purely on open data*". To be able to be native of the UDP, it is required to combine the open urban data with other closed data to avoid easy imitation by competitors - E7 "*Everyone could replicate what you are doing. You need to combine the open data with some other closed data to have a valid business model*".

Moreover, being "Pure Player" does not mean that the organization only uses data from one UDP, but the received data has to be of high importance to generate the value proposition from the engagement with the UDP. An example of such a case was given by E14, "*if you look at the example of the asthma prediction, they used other data sources than urban data. They had the records when people felt bad, but they would not have been able to generate the new business model without the pollen measurement data, so in that sense you could argue that it was sort of a pure player*". To measure the position of the organization, a systematic scale is required - E5 "*include a scale with steps between the two extremes"*.

Both extremes of the continuum are found to be valid by the panelists and were therefore included as a seven-step continuum, with the number of steps chosen by the researcher (for better placement of the cases), from “Pure Player” to “Better Business” to describe the main dimension “Native of UDP” in the iterated business model framework after the first Delphi round.

Key Activities

Key activities had five subdimensions in the initial framework, who were discussed by the panelist. The most frequently mentioned subdimension was analysis. This was mentioned seven times with an example (E1, E3, E5, E6, E11, E12, E14). Whenever the panelist referred to “analysis” they mentioned “analytics” as a subdimension, not “analysis”. Therefore, it was decided to rename this category from “analysis” to “analytics”. E14 mentioned the dominant focus on analytics that he witnesses during his time running a new business model enablement program for companies engaging with UDPs – “*the focus in the program was exploiting data analytics*”. While analytics is the most frequently mentioned subdimension of “Key Activities”, E14 separated this subdimension further into predictive, descriptive and diagnostic analytics all of which he witnessed in real-life – *“From my point of view, it was data analytics, predictive, descriptive and diagnostic analytics*”. To enable analytics there appeared to be a need for historical data and hence a link to the “Type of Data Exchanged” to have a foundation of data that can be used to perform analytics – E4 “*in descriptive analytics, diagnostic analytics and even predictive analytics I would like to train those models using historic data”*.

The subdimension of aggregation was mentioned twice with examples by the panel of experts (E3, E6). E6 explained the rise in data to be the reason for the validity of this subdimension and that he saw the reason to exist for aggregators in the combination of data from different sources to enable the generation of new information – “*there is more and more data from different sources… aggregators can start combining these data and make new information by combining it*”.

Data collection and data generation were found to be very similar by E3 and E6 who stated, “*I am confused about the difference between data generation and data collection….”* and both opted to combine them into one category. No other panelist mentioned the need to have a distinction between the two dimensions and they were therefore combined under the title “data collection” in the iterated framework after round 1.

App development was mentioned by E1, E2, E5, E12, and E14 as a valid dimension with an example that they saw in their UDP environment – E14 "*they developed a model to predict the allergy and asthma risk in different parts of the city. Based on this model, they then developed an app for citizens*". While this dimension was mentioned frequently, the term "app development" appeared to be too focused on app development for mobile applications and not for the entire broad spectrum of applications as computer programs. Thus, it was changed to "Application Development" as a subdimension in the iterated framework to reflect the broader scope– E3 "*If you mean application development in a broader sense than just an APP but more in terms of a computer program that you develop, this is correct*".

"Enrich" as a subdimension was added to "Key Activities" since it describes another not yet mentioned key activity as suggested by E14, E8, and E4. Activities under the topic of enrichment are combining the data from the UDP with closed data sets to generate a new data set that has more value than the UDP just by themselves – E4 *"when you combine the data from the UDP with closed data so that you then have a new more valuable data set"*. Another task that is performed by this activity is reformatting of different data set so that they are more useable by other users – E8 "*or enrichers are doing is that they download the data and offer them in many different formats".*

Regarding the overall dimension of "Key Activities", four panelists (E3, E7, E11) voiced their opinion that these key activities are related to a value chain of data and as a consequence one organization can perform multiple key activities depending on what the end-product is – E11 "*First collect data, then analyze it and then maybe build an app, but you could also sell the algorithm that you generate for the analytics*". Another theme that emerged regarding "Key Activities" as a whole was that depending on the "Type of engagement" different key activities might be performed where the data producer engages in data collection and the data user engages in all other types of key activities – E7 "*the data collection gathering structuring the data as a data producer and the other one is using the data with all other activities*". These findings are relevant for a later discussion but had no influence on the validity of the subdimensions. After the first round if the Delphi study, the main dimension "Key Activities" therefore contained five subdimensions to be validated in the next round.

Revenue Model

All but one subdimension of the revenue model were supported by the opinions of the panelists. E1, E2, and E6 argued that all types that were included in the preliminary model were valid in the context of business models of organizations engaging with UDPs – E2 "*All the ones that you have included here are possible*". Only the dimension of leasing was deemed to be not possible in the context of UDPs by E3 and E11 – E3 "*Leasing Data, I've not seen that one and I can't imagine this will work in the context of UDPs*". No expert voiced any doubts regarding the validity of any other type. One type of revenue model that was incorporated as a new subdimension following the statements of E3 and E7 was the "Freemium" model – E3 "*you have the freemium premium model. So free is a thousand request per day and if you want more you have to take a subscription*". To reflect the opinion of the experts freemium was included as a subdimension of "Revenue Model" to describe the revenue models when the organization offers a free service and requires the customer to pay after a certain threshold has been reached. Another subdimension that appeared to be essential to be able to place all organizations engaging with UDPs in this framework is "internal efficiency" – E7 "*not all companies will generate a product that they can sell, by using the data. Some might just use it to generate internal efficiency*".

Thus, "Revenue Model" contained licensing, subscription, advertising, sale, pay per use and internal efficiency as subdimensions in the business model framework after round 1 of the Delphi study.

Target Customer

Target customers had four subdimensions in the preliminary framework that were discussed by the panelists during the interviews. Businesses, government and citizens were mentioned by four experts (E1, E7, E4, E14) to be valid subdimensions. Examples given by the UDP professionals further validated all of these dimensions. For "citizens" E1 mentioned the example of "*Tourists helping them by searching free parking spots*". For the government E14 explained a use case he had observed when a company developed a prediction model for social exclusion of children based on UDP data – "*The company developed a prediction model which was then sold to the city because they can act on the findings*". E 14 further mentioned another use case of a health forecasting model to predict the wellbeing of elderly people that was developed for private organizations that owned senior homes – "*And then their customers are private which have senior homes*".

The fourth dimension of devices as a target customer was only described once to be a suitable target customer by E10 saying that "all types are applicable", while four other panelists found devices to be either a subcategory of businesses or citizens – E8 "*devices are part of the business I think or of citizens, because they are owned by someone and are not stand-alone customers*". Following this reasoning, "devices" were removed as a stand-alone category and became part of either businesses or citizen who own the devices. Hence, they are the representative target customers as owners, should an organization produce a value proposition for devices.

The subdimension of "non-profits" is added to the iterated framework, considering it has been mentioned by three panelists individually (E3, E10, E11). This subdimension is a different type of target customer since non-profits have different requirements regarding the value proposition than the other types of customers and often strive to generate value for a larger part of the society – E11 "*I think there are some universities or other non-profits that are targeted by the offerings generated from UDPs, because they are often trying to generate public value they often benefit from for example enriched UDP data or a prediction model that they can use*". Following these changes and validations by example, the main dimension "Target Customer" had four subdimensions of "Business", "Government", "Citizens" and "Non-profits" in the iterated business model framework after round 1.

Figure 12 contains an overview of the UDP-engaging business model framework after the first round, containing the three new dimensions and the seven remaining dimensions with their subdimensions.

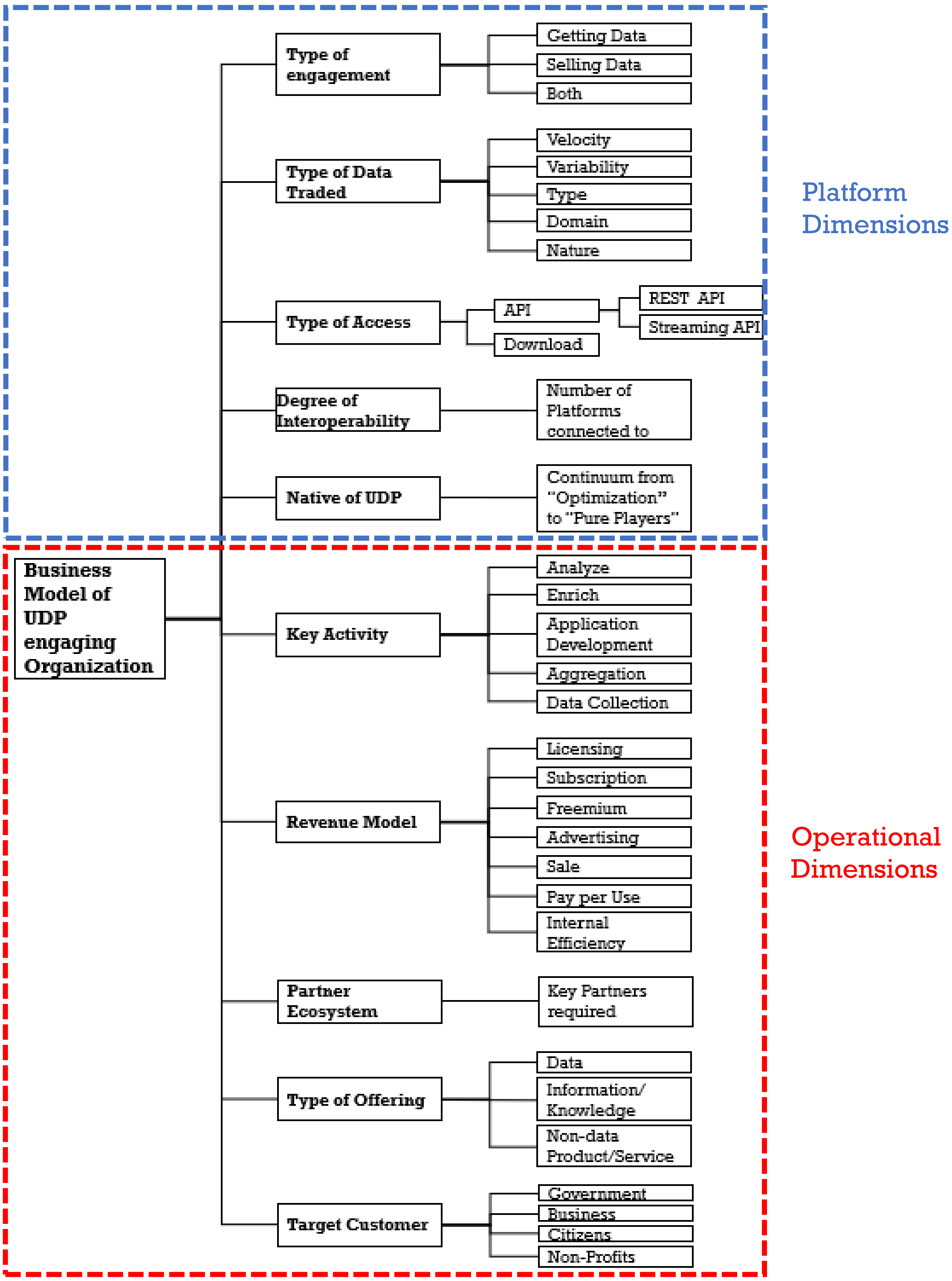


Figure 12. Iterated Business Model Framework after Round 1 of the Delphi Study

4.2.3. Other Findings

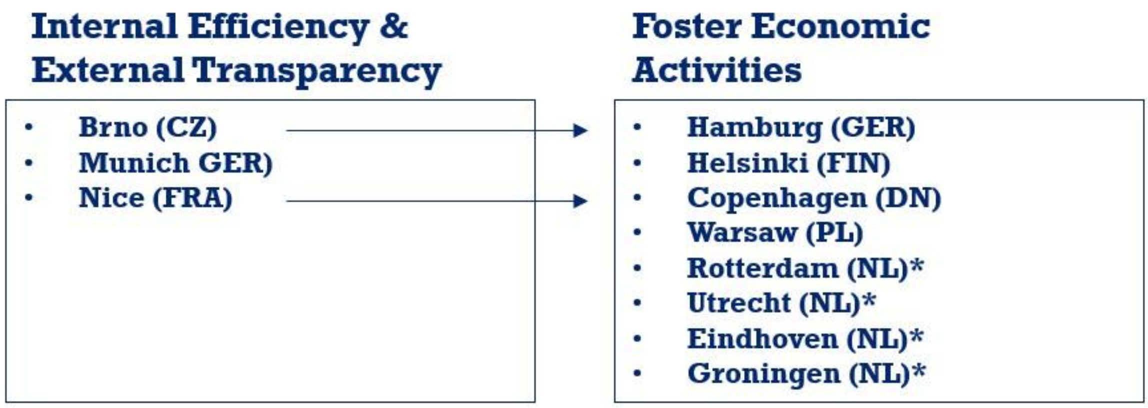
During the qualitative analysis of the interviews, some additional findings were identified from the statements of the interviewees, that were unexpected given the current body of literature. This section gives an overview of these findings that must be seen as stand-alone findings of 14 expert interviews since they were not further validated during the Delphi methodology.

However, as explained in section 4.2 these interviews give a solid foundation for qualitative findings following Grounded Theory (Strauss & Corbin, 1997).

Urban Data Platform Focus

There appear to be two stages of platform development with a different focus. The first one focuses on internal efficiency and external transparency. The city of Brno, Munich, and Nice appeared to have this as a key focus of the UDP that they were operating. E12 mentioned, "the m*ain goal was to to involve the public not even just coders or students but also really wide public. For example, we have the city report per year there are like really simple infographics some interesting facts about Brno. We created a really simple way so that normal people can understand stuff. We tried to keep it really simple. The goal was also to educate people… we have 80 application about everything that informs citizens about the economy, about the traffic environment and much more".* The other representatives argued along the same lines adding the fact of internal efficiency should be increased by the use of the UDPs – E9 "*like every other city in the world we ended up with data silos… by having a central platform, we hope to jump over this hurdle and make it easier for the departments to share data and increase city efficiency*". These two concepts were central to these four cities and their main customers of the UDP were citizens to generate awareness of activities in the city and internal efficiency gains from the platforms. Interestingly, except Munich the representatives of all the UDPs in this category voiced their opinion to focus more on businesses in the future, as a next step – E12 "*the focus of our platform is not really on engaging a lot of businesses but more generating transparency, so this might not be so useful for us today. In the future, we might very likely be moving towards a company focus and the this will be interesting*". Due to competition with the city-owned organization "Die Stadtwerke" Munich is currently not pursuing a strategy to open up their data as a resource to foster economic development on a broad scale.

Another type of UDP appeared to be platforms that have a goal of engaging businesses to foster economic development, additional to transparency and internal efficiency. The interviews with the representatives from Hamburg, Helsinki, Copenhagen, Warsaw, Rotterdam, Utrecht, Eindhoven and Groningen agreed that they try to foster economic growth by allowing businesses to have access to data via a UDP. It must be mentioned that Rotterdam, Utrecht, Eindhoven and Groningen are still in pilot phases, while the other platforms are already entirely operational. This platform focus appeared to be in no way an alternative to the first-mentioned type of focus on internal efficiency and external transparency. Rather, appeared to be an additional focus that is set by these platforms that also wanted to foster internal efficiency and external transparency, while at the same time also fostering economic development by enabling businesses to engage with their UDP. E8 explains the reasoning for Hamburg, "*before the businesses had to by a lot of the data which was really expensive for them because we sold it. Now they can easily access them. So, we as a city are losing the revenue that we used to make before on selling this data, but by fostering economic growth in Hamburg we hope to regain this loss and even more"*. Figure 13 shows the two different focus stages and places the cities from this research in the applicable platform focus, including the indication from Brno and Nice to move to the next stage.



** UDP still in pilot phase*

Figure 13. Different Types of UDP Focus

Further, multiple interviewees (E1, E3, E5) suggested that there is not one UDP per city. Rather, they proposed that there can be multiple urban data platforms per city that are either run by the municipality or by companies. In the broadest sense, even Google Maps can be considered an urban data platform since it allows interested parties to access urban data – E5 "*Every city will have thousands of different data platforms all interlinked with APIs. Although we speak conceptually of one urban data platform, I think it's one of the biggest mistakes. To think about this as one concrete platform… even Google Maps could be seen as an Urban Data Platform*". Another interesting finding was that a UDP as a data-marketplace, when the UDP serves as a market allowing companies to buy and sell data, is not found in any of the example cities. In the case of Copenhagen such a marketplace existed but had to be discontinued in 2018 due to lack of interest caused by high-quality urban data being available for free – E13 "*it's very difficult business area running a data market in Denmark since you have very high-quality public data for free*". It appears that there is demand, by the businesses, but due to the alternative of free urban data, this marketplace had to close. Other cities such as Nice, Rotterdam, Utrecht, and Groningen are considering such a marketplace to be facilitated in the future – E11 "*It is an* *objective of the city to create such a marketplace, but it is currently under construction*". In these cases, the city appears to be the entity that is buying and collecting the data from different entities for increase city efficiency – E11 "*we buy that (data) and we can use it for ourselves, but we can share it with a company to develop a system for ourselves*".

Different Types of Use Cases

The last unexpected finding was regarding the different types of use cases that were possible regarding data users. There were distinct groups of users that were mentioned during the interviews. A first separation could be made between public and private use cases. A second split can be made for private use cases into cases where the city "contracted" a private organization to perform a service for them based data received from the UDP and "free" use cases where the private company decides to use the UDP out of their own motivation – E8 "*The first one is that we do something with the data as the city. Then we will also have a business model with a public use case. Then businesses can use it completely freely where we just provide it and they know what they want to do with it and generate value. But there is also another use case when we as a city hire a private company to do something for us. So, we might need a new AI to help us with the planning of social housing, but we cannot do this ourselves. Then we go out and say; okay, who can build this for us. So, this is sort of a contractor engagement and they come in on a project basis and use the UDP to generate a product or service for the city*". This structure is depicted in Figure 14, including a reference to the cities where the interviewees described an example for such a use case.

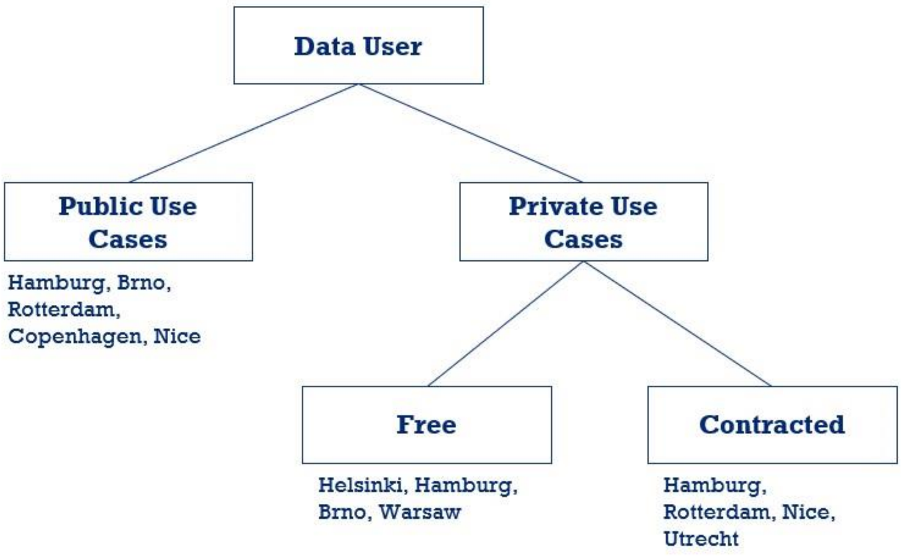


Figure 14. Different Types of Use Cases with Cities

E2 and E5 also expressed the need to separate private and public use cases, while E14 mentions that he also sees a separation between free and contracted private use cases. Figure 14 shows that the type of "Public Use Cases" is the most frequently mentioned business cases (five times) when the municipality or another public organization engages as the data user mainly to increase governmental efficiency – E13 "*I would say that the general business case for these urban data has been governmental efficiency that we achieved by building use cases as the city of Copenhagen"*. At the same time, "Private Free" business cases are the least frequently cited (three times) ones with examples during the interviews as depicted in Figure 14.

The previously mentioned finding regarding the focus of UDPs and the use cases that are possible are not further considered for validation during the second iteration of the Delphi study.

4.3.Findings of Round 2

The questionnaire in the second round was addressed to the 12 panelists who were qualified for the first round of Delphi. The questionnaire was based on the quantitative and qualitative findings of the first round and allowed the participants to show their opinion on the main dimensions and subdimensions of the iterated framework after being shown the iterated results. 10 panelists answered the questionnaire in the required timeframe and the results are discussed in this section. After the trichotomization of the Likert scale to only represent "agree" (items 1&2), "neutral" (item 3) and "disagree" (items 4&5), the results were analyzed for consensus. The agreement scores indicate the percentage of the respondents that agreed to keep the dimension or subdimension in the framework. For example, 80% of the panelists agreed that "Type of Data Exchanged" is an important dimension for a business model framework for organizations engaging with UDPs. Since the 80% agreement score is higher than the predefined 75% needed for consensus as described in section 3.2.4 the dimension remained in the framework. The scores of the subdimensions must be interpreted differently, since only the panelist who agreed with the main dimension were able to vote on the subdimension, to avoid biased results as mentioned in section 3.2.4. Hence, the interpretation for e.g., the subdimension "Variability" must be 88% (7 panelists) of the 80% (8 panelists) of the panelists who agreed to the main dimension of "Type of Data Exchanged" agreed to that "Variability" is a valid subdimension of the "Type of Data Exchanged".

Following the agreement analysis approach done in the first round, consensus on all 10 main dimensions was achieved, as can be seen in Table 7.

	Agree (relative %)	***Agree (absolute)***
Type of Engagement	**100%**	**10**
Data User	**100%**	**10**
Data Producer	**90%**	**9**
Both	**90%**	**9**
Type of Data Exchanged	**80%**	**8**
Domain	**75%**	**6**
Variability	**88%**	**7**
Velocity	**100%**	**8**
Type	**100%**	**8**
Nature	**100%**	**8**
Type of Access	**80%**	**8**
API	**100%**	**8**
Download	**75%**	**6**
Degree of Interoperability	**80%**	**8**
Native of UDP	**80%**	**8**
Key Activity	**80%**	**8**
Analyze	**88%**	**7**
Enrich	**100%**	**8**
Application Development	**100%**	**8**
Aggregation	**88%**	**7**
Data Collection	**100%**	**8**
Revenue Model	**90%**	**9**
Licensing	**89%**	**8**
Subscription	**78%**	**7**
Freemium	**22%**	**2**
Advertisement	**33%**	**3**
Sale	**78%**	**7**
Pay per Use	**78%**	**7**
Internal Efficiency	**89%**	**8**
Partner Ecosystem	**90%**	**9**
Offering	**80%**	**8**
Data	**88%**	**7**
Information/Knowledge	**100%**	**8**
Non-Data Product/Service	**63%**	**5**
Target Customer	**90%**	**9**
Government	**78%**	**7**
Business	**100%**	**9**
Citizens	**100%**	**9**
Non-Profit	**78%**	**7**

Table 7. Results of Delphi Round 2

While all main dimensions reached consensus, three subdimensions did not reach consensus and were therefore excluded from the framework. The two subdimensions, "Freemium" (22% agreement) and "Advertisement" (33% agreement) had to be excluded from the main dimension "Revenue Model". Finally, the subdimension "Non-Data Product/Service" was excluded from "Offering" due to a too low agreement percentage. These changes resulted in the final business model framework, as shown in Figure 15, adding the subdimensions of "Type of Data Exchanged" from Figure 11.

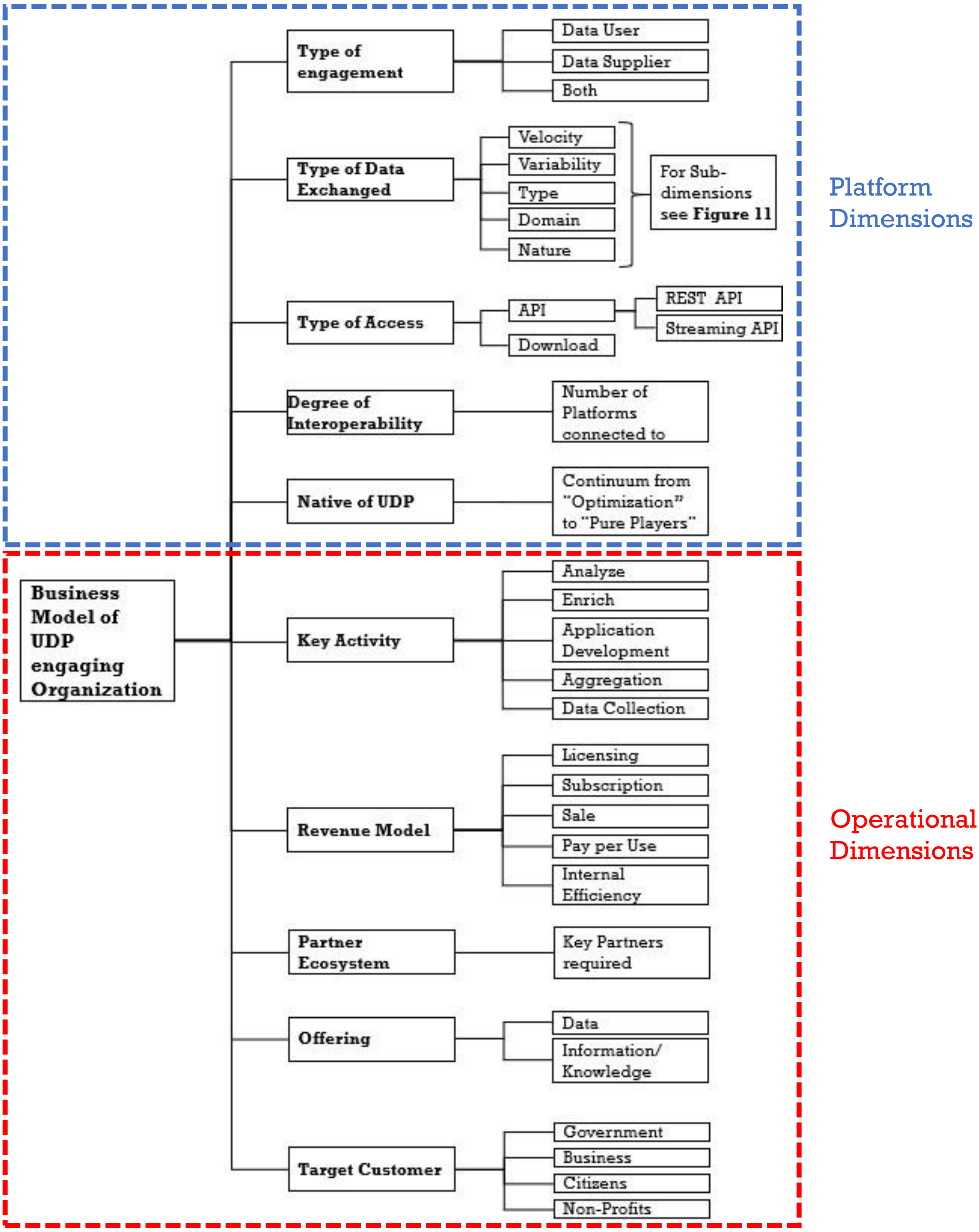


Figure 15. Validated Business Model Framework of Organizations engaging with UDPs

4.4.Discussion of the Delphi Study

The Delphi study was conducted to develop a business model framework for organizations engaging with UDPs either as Data Users or Data Producers. This will help to fill the research gap that there used to be no business model framework that was developed for this specific scenario and incorporated the influence that the UDP has on the business models of the organization by including dimensions to express this unique connection. The research question of which dimensions should be included and the sub-question of which subdimensions should these main dimensions have, were answered iteratively, by using a two-round Delphi method and developing a UDP-engaging BM framework with 10 main dimensions. In the following, it will be discussed whether the dimensions that were selected during the Delphi study exist in related frameworks or not, what the reasons might be to include them in this framework regarding the theoretical background of the dimension and what different scores in the dimension could mean during a business model analysis. This is done on a per-dimension basis. By doing so, the overall framework is discussed in a very detailed way, since it is made up of the discussed main dimensions with corresponding subdimensions. This is followed by a discussion of the other findings in section 4.2.3 and their influence on the overall validity of the developed BM framework. The last subsection will discuss the practical implications of the developed business model framework.

4.4.1. Discussion of the Main Dimensions

The most appropriate literature to compare the business model framework to are the Data Driven Business Model Framework by Hartmann et al. (2014) (Appendix 3) and Urban Data Business Model Framework by Mcloughlin et al. (2018) (Appendix 4), since they are both in closely related domains and have both developed their own set of dimensions to classify business models in a specific context. The business model (BM) framework that was developed in this research has some unique characteristics and dimensions that distinguish it from other BM frameworks focusing on data-driven business models or urban data business models. The UDP-engaging BM framework contains five dimensions (type of engagement, type of data exchanged, type of access, degree of interoperability and native of UDP) that are targeted to explain the role of the UDP for the business model developed by the analyzed organizations. Except “Type of Data Exchanged”, none of these dimensions have been included in previous business model frameworks, which should enable researchers using the UDP-engaging BM framework developed in this thesis to describe new business models. As such, the initial idea that platform dimensions have to be included in this research was supported by the outcome of the Delphi methodology. The operational dimensions also have a UDP focus since they are also influenced by the engagement to the UDP and, therefore, have a different set of possible subdimensions compared to other frameworks. This section will examine whether the dimensions that were selected during the Delphi study exist in related frameworks or not, what the reasons might be to include them in this framework regarding the theoretical background of the dimension and what different scores in the dimension could mean during a business model analysis.

Included Main Dimensions

The dimension "type of engagement" is not entirely new to a business model framework. It can be compared to the "Platform" dimension suggested by El Sawy & Pereira (2013) in their VISOR framework, but it focused on describing the connection between an organization and a platform instead of describing the platform that is used. This is due to the fact that the type of platform, that the organizations are engaging with, are predefined to be urban data platforms. UDPs are a distinct type of data platforms from the perspective of the organizations engaging with it. The subdimensions are in accordance with the ones proposed by Schroeder (2016) who defined that an organization can take the roles of a data user or data supplier to a platform. These types have already been described in the context of open government data by Ubaldi (2013). This framework is building on the description made by previous authors and incorporates this as a distinction regarding the business model. The subdimension "both", when an organization uses and supplies data to a UDP can be compared to the customer type of a prosumer, described by Parag & Sovacool (2016) for the first time to exist in a platform context. As such, the existence of organizations that have "both" as a type of engagement can be a practical example that prosumers exist in a platform context. The other two differentiate distinct types of engagements, that was suggested to have an influence on other dimensions, such as "Key Activity", since depending on the engagement an organization will either collect data or engage in other data using key activities.

The "Type of Data Exchanged" is very frequently used in business model frameworks in an Information System setting as done by Hartmann et al. (2014) and six other publications as described in section 2.2.2. However, due to the focus of exchanging data as part of the business model, this dimension describes other characteristics of the data by having different subdimensions, compared to the closely related Urban Data Business Model (UDBM) framework from Mcloughlin et al. (2018). Including "Variability" and "Velocity" is coherent to the findings of Pan et al. (2016) who propose to use the 5Vs of big data to describe urban data. Compared to the UDBM framework, some subdimensions such as "Dimension", "Velocity" and "Variability" remain the same, while "Type" has a different meaning in the UDP-engaging BM framework. In this context, it is focusing on the size and complexity of the data, because data will be sent and or received in this UDP-engaging BM, compared to the UDBM framework, where the data is produced by the company itself (Cheng et al., 2015). The same reason applies to the inclusion of the subdimension "Nature". It reflects the aspect of data being exchanged in this UDP-engaging BM since open or closed data require different efforts of companies to get the data. Closed data exchanged as a barter requires even more specific considerations of which data to offer in exchange, causing a variety of security and privacy concerns before the engagement that are not present if the organizations rely on their own data (Janssen & Zuiderwijk, 2014). In this context, the findings suggest that "closed" data is data that is not shared with everyone for free but requires sign up or other efforts to get access. As such, the definition is different than the one proposed by Clarke & Margetts (2014) who refer to "closed" data, as being collected covertly. Thus, while the "Type of Data Exchanged" dimension builds on the "Data" dimension defined by Mcloughlin et al. (2018), since in both cases urban data is described, it includes different dimensions to represent the fact that the data is exchanged in very distinct ways between organizations and the UDP. Due to the general availability, it will be interesting to see if there can be open urban data pure players, as suggested by Magalhaes et al. (2014) or if the theme found from the interviews, that no open data pure players are possible will hold true. This indicates that there might exist a relationship regarding the nature of the data and the dimension "Native of UDP". For example, whenever an organization engages in barter with the UDP it must be "both" regarding the "Type of Engagement" indicating a relationship between the two dimensions under certain circumstances (Parag & Sovacool, 2016).

The main dimension of "Type of Access" is frequently mentioned to influence the business models of the organizations engaging with UDPs as suggested by Barns (2018). While this dimension has been very frequently cited to be essential in describing the engagement of an organization with a platform, it is the first time that it is included in a business model framework. In the framework, it represents the influence of the access that a company receives or grants to data has on other value-generating activities. Including this dimension to describe the UDP-engaging BM framework is another indication of the focus on the data exchange via a UDP being part of the business models that will be analyzed with this BM framework. The subdimensions appear to be a reduced set compared to the variety of access types that are available in platform architecture literature (El Sawy & Pereira, 2013). This reduced set might be caused by the fact that UDPs are still a very dynamic and emerging topic and the ones included appear to be the most common ones, while more complex types of access might become relevant in a more mature stage of UDPs (Santana et al., 2016). Depending on the velocity and variety of data, there appear to be different requirements regarding the type of access, since real-time data seems to be not feasible to be downloaded but requires APIs as described in the field of object programming by Kim (2000). Thus, knowing the velocity of the data exchanged can enable to draw conclusions about the type of access required.

In existing literature, the "Degree of Interoperability", has often been described from the perspective of platforms, who are offering standards to ensure that interoperability exists among different platforms to enable the companies to connect to them (Lopez et al., 2012; Ubaldi, 2013). Yet, it has never been included in a BM framework before. Incorporating this aspect in the UDP-engaging BM framework changes the perspective of interoperability from the view of a platform, to the point of view of the organization engaging with it. As such, it allows to describe how high their requirement for interoperability is regarding the UDPs that they connect to, from a company's perspective. What is new to the body of literature are interoperability requirements regarding the internal platforms of the organizations. It appears to be important that the UDPs do not only offer interoperability among each other but that they are also interoperable with the internal platforms that the data users and suppliers have. All these requirements are reflected in this dimension and are included for the first time in a business model framework to incorporate the platform influence in the BM context of UDPs. A high degree is an indicator of a broader data focus, while a low degree might be a signal for a very focused business model when the organization is looking for a particular dataset. The more external platforms an organization connects to, the more challenging it might be to convert different datasets into the same format to perform analysis on them. Nevertheless, having multiple sources could limit the dependency on one specific data source (Holzinger, Treitler, & Slany, 2012). Further, key activities such as enrichment might not be possible when just connecting to one UDP. Thus, the degree of interoperability can be used to limit the number of possible key activities of the organization.

"Native of UDP" as a dimension is also a novelty in a business model framework. This dimension has already been described as an important separator of businesses using open government data, but it has not yet been included in a business model framework (Magalhaes et al., 2014). As a dimension, this will provide a good overview of how important the UDP engagement is for the company. A high score would indicate a business model that might not be possible without the UDP engagement and hence, a high reliance on the UDP to supply data for the organization. The high reliance that these companies are expected to have on the quality of data and data continuity is a logical conclusion from this explanation of a very native BM. Using this dimension should also enable platforms, when they perform an ecosystem analysis, to see for which data and activities the companies tend to be more native to the UDP and hence adjust their offering accordingly to provide high data continuity and quality on these data types and to these organizations (Magalhaes et al., 2014).

Including "Key Activities" in a business model framework is, opposed to the previous two dimensions, very common and done in many contexts of BM frameworks. This dimension was mentioned by Osterwalder et al. (2010) in their business model canvas and subsequently included in the Data-Driven Business Model Framework by Hartmann et al. (2014) and in the UDBM framework from Mcloughlin et al. (2018) in an urban data context. The subdimensions of "Key Activities" are similar to the ones proposed by Hartmann et al. (2014), but in a reduced form, since some activities proposed by Hartmann et al. (2014) such as data acquisition are performed by the UDP in the context of the BM framework developed in this thesis. The subtypes of the subdimension analytics (such as predictive, prescriptive and descriptive) are also implied in this work, but not explicitly mentioned to avoid overcomplexity by introducing a level of "sub-subdimensions". The subdimensions from the developed UDP-engaging BM framework were frequently mentioned to be part of a data value chain, enabling a company to perform multiple activities as shown by Klievink et al. (2017) in Table 2. "Data Collection" is part of the first stage of the value chain labeled "Collection" which also includes other activities that are not part of this framework due to non-applicability in the context of organizations engaging with UDPs. The next part in the value chain called "Combination" has two activities represented in the UDP-engaging BM framework; "Enrich" and "Aggregation". The next stage in the data value chain, "Analytics", is directly mentioned by the subdimension "Analyze", while "Application Development" is not directly part of the value chain, but can be seen as a follow-up step after "Analytics" (Klievink et al., 2017). Placing them in this value chain enables to draw conclusions about the position of the analyzed organization in a broader data value chain (Klievink et al., 2017). The subdimension "Analytics" was frequently mentioned with examples and it appears that many of the "data user" business models of organizations engaging with UDPs will at some point perform analytics of the data that was exchanged as proposed by Klievink et al. (2017) in a government data context and by Zikopoulos & Eaton (2011) in the context of streaming big data.

The “Revenue Model” is cited with the same frequency in business model literature as the “Key Activity” and is part of all comparable relevant frameworks. The subdimensions form Hartmann et al. (2014) and Mcloughlin et al. (2018) are identical in this regard since the latter framework builds on the one created by Hartmann et al. (2014). Most of the subdimensions mentioned by these two frameworks were also included in this business model framework by expert consensus. Including “internal efficiency” in the revenue model is uncommon in BM literature, since most of the subdimensions of revenue model are facing to the outside of the company. However, since the focus of this BM framework is on the value proposition that an organization is producing by engaging with a UDP, the company can have different value propositions and business models simultaneously as mentioned by Casadeus-Masanell & Tarzijan (2012). Since the other frameworks adopt a more global, all-encompassing perspective and try to describe the overall business model of an organization, a subdimension of “Internal Efficiency” is not possible, since the organization will need to generate revenue from external customers to remain profitable. Mcloughlin et al. (2018) still try to express this distinction, by including a separation between “Cost” and “Value” driven organizations. However, under the definition of the business model utilized by this research, “Internal Efficiency” is a valid and essential subdimension of the revenue model to describe activities of organizations who do not directly generate revenue from the data. This subdimension has theoretical support from the findings of Beniger (2009) who describes that data does not always need to generate revenue for the organization directly but can also be used to internally to inform strategic decisions and improve business processes. This is also supported by the proposal of Magalhaes et al. (2014), who propose to include “Integrators” as a type of business model, who are just integrating urban data into their existing business model and by doing so generating a business model on its own. Other dimensions such as advertising or leasing that were excluded during the Delphi study might be applicable, once the concept of UDP has further matured and organizations start to develop more complex revenue models form UDP engagements (Barns, 2018). Different types of revenue models are very important in the description of business models since they express different ways of profit is generated and as such can have an influence on almost all other main dimensions (Osterwalder & Pigneur, 2010).

Including “Partner Ecosystem” in a business model framework is frequently done in any framework that builds on the Business Model Canvas (Osterwalder & Pigneur, 2010). Nonetheless, the more closely related frameworks from Mcloughlin et al. (2018) and Hartmann et al. (2014) don’t include this dimension. From a theoretical standpoint, it is no surprise that this dimension is included in this BM framework since this framework was specifically developed to be applicable in a platform context that has a value network to generate value propositions as a key characteristic (Stabell & Fjeldstad, 1998). Given that the other previously mentioned BM frameworks are not created for a platform-specific context, the difference to exclude “Partners” can be explained by the non-existence or lesser importance of value networks in the focus of those frameworks. “Partner Ecosystem” as a main dimension is another reflection of the platform centrality of this framework due to the value network that often arises in the presence of platforms, which could have been a theoretical explanation why this dimension has been included. The more value co-creation an organization engages in, apart from using the platform, the more partners it can be expected to have in such a dimension (Fehrer et al., 2018). Relying on multiple key partners can be an indicator of very complex tasks performed, or it could also be the case for organizations that are very new to using urban data who have not enough skills to perform such tasks on their own (Chesbrough & Schwartz, 2007).

After the first round, the main dimension “Offering” was included in the UDP-engaging BM Framework which can be described as the expression of the experience that a customer will receive from the supplier (Barnes, Blake, & Pinder, 2009). This changed the perspective of the business model framework since initially, the value proposition was assumed to be a result of the activities that the businesses undertook and that were described in the business model framework as done by Mcloughlin et al. (2018). However, following the expert’s opinion, the offering was included, underlining its key importance in the business model analysis in the context of UDP engagement. By doing so, this framework follows the proposition from Fielt (2013), who argue that the value proposition must be included in any business model framework. The subdimension “Non-Data Product” was removed after the second round of the Delphi study, which is different from what Hartmann et al. (2014) proposed. This divergence shows that the panelist expected the UDP engagement to result in intangible products and that the users of the urban data will not produce tangible products based on these insights. This finding is not surprising given the focus on data as a key resource. The work of Mcloughlin et al, (2019) in an urban data context, the work of Schroeder (2016) on big data business models, the research from Rizk et al. (2018) on data-driven digital products and even the work of

Hartmann et al. (2014) on data-driven business models, who proposed the inclusion of "Non-Data Product" as a subdimension, did not find any business models that produced tangible offerings as can be seen in Table 1. The remaining two subdimensions can be related to the data value chain in Table 2, since they will be the type of offering for any value proposition that does not involve key activities after "combination", because in the step "analytics" information or knowledge is produced, by interpreting the data (Miller & Mork, 2013). Hence, there appears to be a relationship between "Key Activities" and the "Offering" main dimension. "Data" as a key product is expected to have different values for the platform and the operational dimensions, as opposed to "Information/Knowledge", due to the difference in security considerations, as well as the position in the data value chain (Klievink et al., 2017).

The last main dimension that was included in the framework is the one of "Target Customer". This dimension represents to whom the value proposition was targeted. It is also frequently cited in other works and is an important part of the business model description, since the customer is the group that the organization is considering when generating the value proposition and therefore highly influencing the entire process of value generation in a business model (Hartmann et al., 2014; Mcloughlin et al., 2018; Osterwalder & Pigneur, 2010; Schmidt et al., 2018). A difference to the current body of literature is the addition of non-profit organizations. Including non-profit organizations as a specific type of customer can be explained from a theoretical perspective by the special role that non-profits and research institutions that are combined under the subdimension "Non-Profit", have in the context of smart cities (Lindskog, 2004). As demonstrated by this example, different types of customers might have implications on the key activities that are required to be performed to generate value propositions for different customer groups (Osterwalder & Pigneur, 2010).

Excluded Main Dimensions

There were several reasons for the removed dimensions not to be included from a theoretical angle. "Platform Product/Service used" was removed by consensus stating the main issue was that there was no other platform service used in this context apart from data. Following platform literature, it was expected that UDPs also offer some hosting capabilities (Tiwana, 2014). This was however denied by the panelists who saw UDPs only as a data-platform or data-market. If UDPs come to reach a more mature stage, this might change in the future and this dimension could be relevant for future research. "Public Value" as a dimension was found to be very interesting but was excluded since multiple experts expressed issues of measuring this. The issue of the complexity of measuring public value is frequently mentioned in academic literature, but this dimension could be included in the future should the tools to measure public value become more advanced and widely adopted (Jarrar & Schiuma, 2007). The "Cost" dimension did not offer much added-value in the form that it was used in the preliminary framework. It became apparent that for the business models of the organizations it is more important if the data is open or closed and then distinguish between free and paid data, rather than describing multiple types of costs that they occur. This is in accordance with the findings of Hartmann et al. (2014) who found that after analyzing the business models of 94 data-driven companies they could not find any differences regarding the cost structure that they incurred due to the data used. This finding seems to hold true for organizations engaging with UDPs.

4.4.2. Other Findings

The finding that not all urban data platforms are focused on business engagement and generating economic influence is a crucial finding that has to be considered when analyzing the economic environment. UDPs that are focused on internal efficiency and external transparency only will not enable the creation of new business models, since they will not share relevant data with outside organizations. As such, UDPs, who have this focus, are one-sided platforms, since the customer side of "data users" is missing compared to two-sided platforms (Tiwana, 2014). However, as the research revealed out of the 11 platforms of whom representatives were interviewed, 8 were already focusing on driving economic activities via UDPs and two of the three who were not focused on economic development wanted to do so in the future. This shows that 10 out of 11 platforms will create or already have created a UDP ecosystem by functioning as two-sided platforms in which companies can develop novel business models due to the availability of urban data as a new key resource.

Another interesting finding relates to the data exchange on UDPs. While some platforms consider creating a data-market place, where organizations can exchange data, the panelists suggested that most of them did not engage in such a process. Most of the time a UDP was a datahub where multiple data sets were stored, sometimes of very specific data. However, the depiction in Figure 4 remains valid regarding the data supplier. The difference is that in most cases the data supplier will not have an engagement with a data user facilitated by the UDP, but it will be the platform owner buying the data from the companies to share them via the platform. Hence, even UDPs that do not function have cross-side network effects in the sense, that more data producers on one side of the platform will benefit the data user on the other side, even though there is no direct interaction (Gallaugher, 2018).

Additionally, the finding that UDPs will, in most cases, not offer hosting services and hence are datahubs or data platforms, allows for an interesting description of the perspective that data users have on UDPs (Tiwana, 2014). From their perspective, UDPs appear to be a specific type of *data-as-a-service* offerings. Data-as-a-service is described as a cloud computing service that provides data on demand, giving the user access to data assets that would be more costly to collect himself, or the user would be unable to collect on his own (Vu et al., 2012). Showing how the UDP appears from a data user perspective supports the initial idea to incorporate the data-driven business model (DDBM) framework as a source of inspiration for the UDP-engaging BM framework, since the DDBM framework explicitly tries to describe businesses models of organizations that use data-as-a-service offerings (Hartmann et al., 2014).

Another interesting finding was that there is sometimes not one central urban data platform in the city, but that there were multiple platforms within one city. This is a different perspective than the conceptual model obtained by Hashem et al. (2016) who envision this platform to be the central data hub in a city containing a large variety of data sets. While last part of the definition still holds true, the findings of this research are more in line with the argumentation of Barns (2018) who finds that there can be a range of different urban data platforms developed by the city. Including private companies as the owners of urban data platforms, such as Google or other companies that offer urban data has not been mentioned before in the literature, but they have also never been explicitly excluded. However, while it can be argued that these platforms are no urban data platforms since the municipality does not govern them and they often only offer data from one source, from a platform architecture point of view these constructs are very similar to urban data platforms from the perspective of an organization engaging with them. The only difference from a data user perspective is that central urban data platforms, governed by the municipality can offer data from different data suppliers. The data platform from TomTom for example also contains very different types of data from address data to traffic data to geofencing data sets and maps that are accessible via APIs or download (TomTom, 2019). This data all comes from one organization but is also originating from multiple domains. Comparing this to a case, when a city opens up data sets from different city departments, allows to see main similarities in terms of the platform offered in terms of data offered and origin of the data, since the data on a UDP might also come from a single entity.

The only key difference in this case, is that the focus of an urban data platform governed by the city is public value creation and transparency, while the private urban data platforms often pursue the goal to generate revenue. However, in case of the city pursuing a data marketplace strategy for their UDP, from a data user point the platform will be a marketplace, because it offers access to different data sets that have to be paid for in many cases. This is the same type of engagement data users would have during a connection to a private urban data platform. Hence, it can be concluded that city-owned urban data platforms and private urban data platforms appear to be similar from a data user perspective.

The last unexpected finding regarding the different user groups of UDPs is interesting to add to the body of literature since such a description does not yet exist considering that such a conceptualization of the UDP company engagement has not been done before. Following the structure of Figure 14 will give researchers and practitioners a good starting point to analyze the data user side of a UDP.

4.4.3. Practical Relevance

Systematically analyzing a business on these dimensions will allow for the classification of unique business models of the organizations that are engaging with UDPs. This is only possible because four dimensions are new in the context of BM frameworks and the dimensions that already existed are geared to reflect the dynamics of an UDP ecosystem. Such a BM analysis has several unique advantages in practice. The practical relevance is shown for the two main actors in a UDP ecosystem, the organization operating the UDP and the organization engaging with the UDP.

For the UDP operator the advantages of analyzing the business models of the companies surrounding it are their possibility to improve their offering depending on the business models found. Since UDPs are often operated by municipalities with the target to foster economic value creation in the city, the platform operator has multiple tools to support the businesses. However, to efficiently support the businesses, they first need to know how the engagement from the companies with the UDP looks like. Applying the business model framework from a platform owner perspective will provide a tool to get a coherent overview of the different business models that organizations in the platform ecosystem are using. The platform operators can then choose to support different groups with different initiatives depending on the needs identified. An excellent first indicator might compare actors that have a highly native business model to the UDP, who have a larger reliance of the platform, and compare how they generate a value proposition with their business model compared to organizations that are less native to the UDP. This could help the platform owners to identify different measures for different target groups to increase the overall value creation caused by the UDP and motivate low native companies to become more native. Since the platform owner has a direct impact on the business model of the organizations engaging with it, by means of providing different types of data, access, etc. they have multiple measures that they can take if they see that a particular characteristic of the engagement is supporting a business model that is especially beneficial for the entire city.

The other actor in the UDP environment who will have a practical advantage is the organization engaging with the UDP. Shafer, Smith, & Linder (2005) describe that knowing your business model has intra-company benefits, such as strategic clarity and overview, as well as inter-company benefits, such as better understanding of the strategic position compared to competitors and the influence of a key resource, such as the data received from a UDP. The dimensions and features can provide guidance for organizations, that are not yet engaged to a UDP, to form a business model for their specific venture by using the identified BMs as a blueprint. Form an organizations perspective this framework allows identification and assessment of potential ways to engage with a UDP in a new UDP-engaging business model and finds ways to produce a value proposition. Moreover, it gives a comprehensive set of potential key activities and revenue models to be used in this context. Additionally, practitioners can position their organization in the competitive landscape and by doing so, identify potential gaps in the market.

5. Case Studies

To further validate the framework as well as to describe and compare two actual cases, the Delphi study was proceeded by a multiple, embedded case study. The cases were selected based on the criteria described in section 3.3.1. Further, the findings from section 4.2.3, summarized in Figure 14, were used to select two different cases in the context of a UDP. The first case study was selected to be a public, free use case because in this type, the business model is expected to contain more novelty as opposed to a public, contractual setting. This novelty is due to the fact that in a free setting the company has their own use case for the UDP engagement and is not just an executive, private unit of the municipality as in the contracted setting. The selected case was GoBike, a company who developed a traffic light prediction and routing service from their engagement with the UDP in Rotterdam. For the second case study, a public use case was selected, since this type was cited most frequently in the interviews during the first round of the Delphi study. A case from the city of Amsterdam was chosen who developed a crowdedness prediction model of the city based on data from multiple UDPs. The key requirement for both cases was that they are connected to some type of urban data platform. An overview of the selected cases is given in Table 8.

	Private, Free Case Study	**Public Case Study**
Organization	GoBike Nederland B.V.	City of Amsterdam
Description	E-Bike sharing company with operations in multiple Dutch cities and 21 docking stations in Rotterdam alone (GoBike, 2019)	Frequently cited as a leader in smart city initiatives (Macpherson, 2017)
Case	Traffic light prediction and routing service	City crowdedness prediction application
Interview Partner	**Jeffrey Dost (CEO)**	**Ger Baron (CTO)**
Description	Co-Founder of GoBike in 2015. Proven track record as entrepreneur and expert on urban mobility and information services	CTO for more than 5 years. Under his leadership, Amsterdam became one of the leading data-driven cities in the world. Cited in MIT Sloan Management Review (Fitzgerald, 2016)

Table 8. Overview of the Cases

5.1.Findings

Two use cases were analyzed using interviews and publicly available data to build two case descriptions of the business models used by these organizations to generate a value proposition from their engagement with a UDP. In this section first, the two cases will be described, followed by a comparison of the two cases on the dimensions of the business model framework using a pattern-matching strategy (Yin, 2009). In this way, the different aspects of the business model framework developed during the Delphi study are matched against the empirical findings by the case studies, to show the validity of the business model framework by identifying different business models in a real-life application, as well as showing the difference between the business models along the dimensions of the UDP-engaging BM framework.

5.1.1. Case Description GoBike

Introduction

GoBike offers E-bike sharing services between 21 docking stations across Rotterdam. The E-Bikes are equipped with large screens, where the customers can enter their login data and target address. Depending on the target address, GoBike then selects the best route for the customers to get to their destination, depending on the shortest route in terms of time. The customer pays for the service per minute of usage. The company is involved with the municipality of Rotterdam in a pilot project that enables the company to get access to data from the urban data platform of Rotterdam. The pilot is focused on the traffic lights at the Williamsburg and the neighboring crossroads. GoBike receives urban data from the UDP about when the traffic lights will turn red. The company incorporates this data in their routing algorithm and signals to customers that are approaching the traffic lights if they can make it across the green light at their current speed or not. In addition, GoBike is using the data to improve its navigation service, considering when the lights are green or red.

Type of engagement

GoBike's engagement to the UDP of Rotterdam is the one of a "Data User". However, Jeffrey Dost foresees this to change in the next step of the pilot, "*in a later phase, we will also be supplying data to the platform such as routing, speed, etc., so we will transition to the "both" category. Then the city will be able to adjust when they turn the traffic lights*".

Type of data exchanged

The velocity of the data used for GoBike's business model with the UDP was real-time, which was a requirement to give the customer up to date information. The variability of the data is dynamic. However, in the beginning GoBike used static and historical data from the UDP to build the model that is predicting if the customers can make it over the light and to anticipate when there will be a lot of red lights to change the routing of the customer – Jeffrey Dost "W*e used static data as a starting point for the algorithms. To be able to train them, so this was also historic data. So that they understand the situation. But now that the system is in operation the dynamic data is the one that we are receiving and that is giving the input to our algorithms".* While the day to day business requires dynamic real-time data, GoBike uses static, historical data biannually to evaluate the performance of their predicate analytics model. They receive aggregated data as an input for their algorithms which has the advantage of smaller size over raw data making it easier and cheaper to download for the company – Jeffrey Dost *"Aggregated data is more useful for us because it is not as much to download as raw data"*. The nature of the data that the company receives is closed and required GoBike to sign an agreement with the municipality of Rotterdam due to privacy reasons. At the time of the interview the data could be considered to be free, but the company had to agree to share some of their data at a later stage when the nature of data will move from closed and free to closed and barter – Jeffrey Dost "W*e don't pay for it, so at the moment it is for free. This will change later because our partners receive some data in exchange…. But there is no invoice send out*".

Type of Access

The type of access that GoBike has to the UDP of Rotterdam is via streaming APIs. This is necessary for the company since they are using real-time data. This is especially important because the company is generating real-time insights for its customers – Jeffrey Dost *"For the data that we get it is via streaming APIs because it is real-time data and we need real-time data to give the indication of the red light to the customer in real-time, so this is really important for us"*.

Degree of interoperability

GoBike connects to three UDPs, stressing the importance of interoperability for their service. Even within one city, there were multiple UDPs, and GoBike has to connect to multiple to be able to offer the advanced routing service. They do not only connect to the UDP for traffic data but also require information on the routes of ambulant and sometimes mobile providers to be able to route the customer in the best way possible. This makes interoperability vital for them not only when they want to operate in multiple cities but even within one city – Jeffrey Dost "*Even if we did not want to operate in multiple cities, we would need access to multiple platforms because we need other inputs for example to emergency accident data additional to mobility data. So that there are ambulances on the way, and we can improve our routing service"*.

Native of UDP

The CEO placed GoBike on a 6 regarding on a seven-point Likert scale ranging from 1 "Pure Player" to 7 "Better Business". The routing service and the overall ride-sharing service are found to be to a large extent independent of the UDP. The company can still use the movement data from the bikes, customer information and information collected from the docking station next to freely available traffic data from other sources to offer routing services to their customers. Only the indication to the customer, if he can make it over the red light would not be possible without the UDP connection – Jeffrey Dost "*We receive a lot of data from our own network, this is really important for us, from the stations and the bikes, so we have a good overview. Of course, any other data that we add is valuable and important. So, if we would not* *have the data from the UDP, our service level would decrease for sure, but the service would still be useable with most functions*”.

Key activities

GoBike performs two key activities in their business model for their UDP engagement. First, the company is analyzing the data from the UDP to predict either if the customer could make it over the green light or to adjust their routing service accordingly. For the information shown to the customer, GoBike has to combine the UDP data with company-owned data about the speed of the bike and routing information to know if the customer was heading towards a traffic light. After analytics were performed on the data, GoBike had to undertake the one-time effort to build an application that showed the customer how to cope with the traffic light. Thus, for this service two activities are needed. Regarding the routing improvement, only analytics has to be performed, since the company already operates a navigation application that is only improved by the insights from analyzing the UDP data – Jeffrey Dost “*First analyze and then application development for the traffic light info. So, we are improving our overall service of the bike ride, by offering new smaller services and these can be enabled by the UDP data*”.

Revenue Model

The revenue model that the company has for their UDP engagement is an increase “internal efficiency” regarding the navigation system that is improved by UDP data and the traffic light application. By doing this, Jeffrey Dost feels like the company is able to offer to the customer. By improving the navigation app and showing the customer if he can make it over the green light, the company generates added value for the customer using the service and hence might lead to more customers using the bike sharing service – Jeffrey Dost “*But generally, we increase revenue due to increased internal efficiency. Maybe it is not really internal efficiency but we increase the service that we are able to offer to the customer and then we get more customers*”.

Partner Ecosystem

GoBike does not require any partners to generate the value propositions from the UDP engagement – Jeffrey Dost “*For us there are no one’s involved*”.

Offering

The type of value proposition in the case of GoBike is information or knowledge – Jeffrey Dost “*This is clearly information that we are offering*”. Either it might be information shown to the customer, if he can make it over the traffic light, or it might be information concerning the quickest route to the customers target destination. Once the company engages in the barter setting with the UDP, the type of offering will then also contain data that is offered to the UDP in exchange for other data – Jeffrey Dost "*In the future, Data would also be the type of offering that we are providing if we supply it to the platform*". Nevertheless, the overall type of offering will not change, since the data is just a mean to get the data from the UDP to generate the value proposition of increased navigation service and traffic light prediction for the customer. Generally, the value proposition that is created in the business model that GoBike has regarding their engagement with a UDP is two folded. By showing the customer if he will make it over the green light or not, the security of the customer is increased, reducing stress and increasing the overall ride experience. The ride experience is further increased by incorporating the traffic light data into the navigation service. Hence two different offerings create one value proposition of improved service to the customer by using real-time, closed UDP data to perform analytics on them.

Target Customer

The target customers of the value proposition that GoBike generates from their engagement with a UDP in Rotterdam are citizens, since they will enjoy a higher quality of service due to the improvements made by the corporation – Jeffrey Dost *"It is primarily the citizens as users, they have a better experience during their bike ride"*. At the same time, there is a different customer segment that is indirectly targeted with the value proposition generated from the UDP engagement. GoBike has contracts with multiple companies to offer their ride-sharing services to them. The companies then allow their employees to use the bike sharing to travel between different points within the city, for example, if they have a meeting at another office. To these corporations, GoBike offers an advanced navigation service since the employees often travel from and to similar points. Therefore, GoBike has a lot of precise data of the frequently taken routes of the employees of a specific company. By incorporating information about traffic lights in their navigation service, GoBike can offer a higher service level to these companies, as well since their employees will be able to take faster routes when they travel during work time and hence waste less time for the company – "*We have a lot of agreements with companies and they are benefitting indirectly because their employees get quicker from A to B, so they also have increased efficiency in that sense*".

Figure 16 shows the summary of the previously discussed dimensions of the GoBike's business model for its engagement with a UDP in Rotterdam.

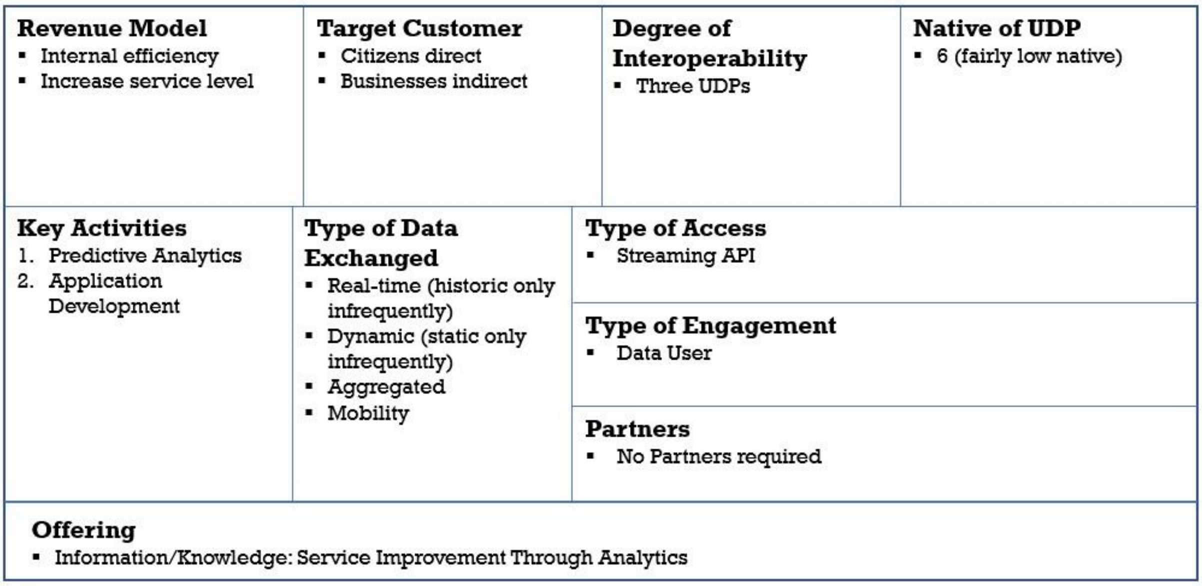


Figure 16. Business Model of GoBike's Engagement with UDP

5.1.2. Case Description Municipality of Amsterdam

Introduction

The municipality of Amsterdam has developed an application from multiple UDP engagements, to predict how many people will be in which part of the city during the cause of the day. While analyzing the interview and building this case study, it became apparent, that this case study constitutes a special type of data user. The crowdedness application that the municipality of Amsterdam build is connected to multiple private and public UDPs as discussed in section 4.4.2. The data from these platforms is combined and analyzed to create another, "urban-data-platform-like" business model on the data from the other platforms. This type of UDP is different from other types of UDPs, since it does not offer access to urban data that is gathered from multiple sources as it is the case normally. Instead, it connects to these platforms as a backend of creating a prediction model for how many people will be in different parts of the city. This model is then accessible to other parts of the city as well as to businesses and at a later stage citizen. As such this business case builds on the findings, that there are multiple UDPs within the city and that there are different types of UDPs, some of which are not owned by the city itself but can be operated private companies. The resulting engagement and focus of the case study are shown in Figure 17.

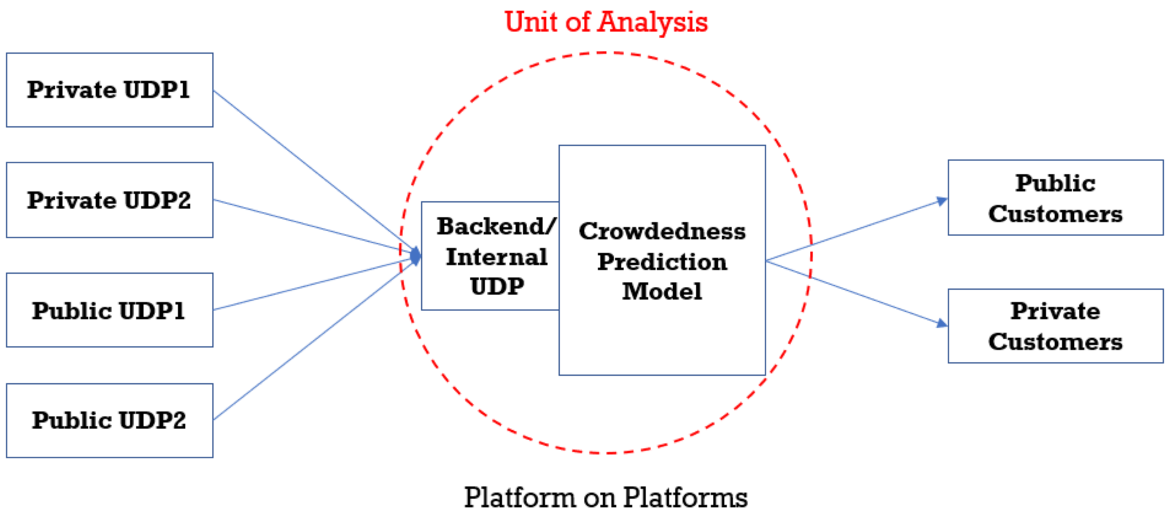


Figure 17. UDP engagement Amsterdam

Type of engagement

The type of engagement of the case study in Amsterdam is as a "data user" of other UDPs. For the business model the platform is connected to multiple other UDPs, such as private UDPs from TomTom or Ways, while also connecting to the UDPs of different city departments, such as the Transport Authority and also the open urban data platform of Amsterdam, data.amsterdam.nl. To build the prediction model data from all these different platforms is used – Ger Baron "*We use data from multiple platforms. We get data from TomTom, Ways, etc. and also from the Transport Authority for example*".

Type of Data Exchanged

Regarding the domain, Ger Baron points out the distinction that the city has to make between citizens and businesses as subjects, whose data have to be treated differently with more security since they own their data, as opposed to all other domains. To predict the fullness of the city, the data from the multiple UDPs is from all domains. Regarding the variability of data in their business model, Amsterdam is using dynamic and static data with a higher focus on dynamic data with a real-time velocity. Historical data was only used in the beginning to have a basis on which to start the prediction model. The current urban data received from the UDPs has changed to real-time. Regarding the type of data Ger Baron mentions that most of the data that they receive is aggregated data, while in some instances, for example from the CCTV cameras on the streets, they get raw data. The city then needs to process this data with object recognition software to detect how many people are in the image, causing additional effort compared to aggregated and processed data containing just the signal in the noise – Ger Baron "We *would like to have aggregated data as much as possible*". The nature of the data that is received from the UDPs differs depending on the engagement and is partly open and partly closed data that is used. However, even the closed data is not paid for, but for free – Ger Baron "*If we get data that is closed, then it is for free. We don't pay for the data*". In getting this data Ger Baron sees an advantage of being a large city, since they can push data providers to offer the data for free – "*We try to push companies that are collecting data in public spaces to open up the data … and this works quite well*".

Type of Access

The type of access that is used by Amsterdam for this business model is using REST and streaming APIs to get the data from the UDPs due to higher convenience – "*This is just APIs. It's both streaming and REST API, its' easier this way".*

Degree of Interoperability

To enable the city crowdedness prediction model, the municipality is getting urban data from 13 platforms out of which 10 are private UDPs and 3 are public, municipality owned UDPs – Ger Baron "*So we are currently connected to 13 urban data platforms. Three from the municipality, like transport authorities etc. And 10 private ones like Google, TomTom they all have UDPs, and we connect to them with APIs*". This results in a high degree of interoperability that is required to operate the business model.

Native to UDP

Amsterdam has a very UDP native business model. Without the urban data that they get from the UDPs, such a prediction model would not be possible, scoring a 1 on the 7-point Liker scale, qualifying the business model as an urban data pure player – Ger Baron "W*e are very highly dependent on the data from the different UDPs, as I said. With our data alone, we cannot generate such a model, so we need to combine it with other data*". Despite this high score, Amsterdam is not highly reliant on a certain UDP, but overall the business model of the prediction model is highly reliant on UDPs, but in this case13 UDPs in total. Due to the fact that the connection is to such a multitude of platforms, this score does not describe how native the business model is to one certain UDP. However, the reliance on the individual platforms also appears to be high, since Amsterdam wants to introduce audits of the data generation and processing of the UDPs from which they gather the data to ensure accuracy of the data to avoid biases in the prediction model that Amsterdam generates – Ger Baron "W*e are planning to do audits with the partners from which we receive the data, so that we know how they got to their data and how they process it*".

Key Activities

In their business model there are multiple key activities that the city of Amsterdam performs. The most visible to the end user is application development, building the application that is useable and callable via API by the customers in the end. This is also the last step in the data value chain after the urban data is received from the platforms. First, the data is enriched by combining all the different obtained data streams to perform cross analysis at a later time and also add some internal data of the IT-Department. Then predictive analytics are performed on the data to generate a prediction of how many people are going to be in which part of the city, before an application as an end product is generated – Ger Baron "*So first it is data enrichment, when we combine their external data with our data and then we perform analytics based on them and based on this we have created an application, and this is the end product after all"*.

Revenue Model

The focus, once the prediction model is created, is on subscription or licensing access to the application to private companies. Simultaneously, there is another revenue model for the usage of the application of other city departments, internal efficiency. The other departments get access to the information for free to improve e.g. waste disposal and as such increase the internal efficiency of the municipality – Ger Baron "*It can be subscription or licensing … And within the city it will be internal efficiency. So, the different departments of the city don't need to pay for the information"*. Hence, a conceptual separation between internal and external revenue model has to be made.

Partner Ecosystem

While Amsterdam does require some free-lancers to generate the value proposition, there is no larger key partner required – Ger Baron "*We don't need any partner to build our software*". Ger Baron sees lower development cost and higher speed as the main advantages of producing the application completely in-house, compared to scenarios, when partners are involved.

Offering

The offering is a prediction model that forecasts how many people will be in different parts of the city. As such, the value proposition is of type information or knowledge that is provided to the customer in real-time to inform him of any changes in the prediction, as well as giving him information about the actual fullness of the city – "*So, this is information or knowledge that we offer. So how many people will be where? This information in real-time*". For the municipality the added value of the offering will be increased efficiency, the businesses can also increase their efficiency and the citizens will have more transparency regarding the activities in their city – Ger Baron "*for the municipality it will be an efficiency model that they increase their efficiency for the businesses it will be an added value to use for their product or service and for the citizens it will be … transparency*".

Target Customer

For the crowdedness prediction model Ger Baron sees different target customers. The largest customer is the government who is using the fullness prediction to increase their efficiency. An example of this is the routing of garbage trucks. By knowing, at the start of the day, how many people might be where the city can adjust their routes accordingly to empty the bins in more crowded areas more often and not having to reroute their normal tour due to overflowing waste bins in some parts of the city – Ger Baron "T*he first target customer of the service that we offer is the government and they will remain the largest group*". The second group of target customers is businesses, such as Schiphol Airport who can schedule more or less personnel according to predicted peaks in customer traffic. Another business user group are event organizers who can use the model to plan the flow of visitors better through the city. The visitors benefit because they can come more quickly to the event location, and also supplies can be delivered by moving through parts of the city that are predicted to be emptier to ensure punctual delivery – Ger Baron "W*e also want to give this to businesses we want to work with them on customer journeys so for examples with Schiphol Airport so that they know how many people to expect of for events*". The third customer group that is not yet able to use the service, but will be in the future, are the citizens themselves. Before opening the model up to the interested public, some legal issues have to be clarified. Ger Baron expects this tool to be used by the citizens like the weather forecast, so that the citizens know which parts of the city will be overcrowded with tourists and which one are still enjoyable – Ger Baron "T*o the citizens a bit like the weather forecast, so that they know where it's crowded, and they might not want to go there*".

This business model can be described as a modified version of a public UDP since like other UDPs, it offers information on multiple different domains of a smart city, but in a combined format. However, unlike traditional UDPs, this one does not offer the data to be accessed or a dashboard with some information about the city but provides real-time information from an advanced predictive model. The data that is gathered from multiple private and public urban data platforms is not accessible to the public but is only used by the application that is built on top of it and functions as the backend of this application.

The summarized business model is presented in Figure 18.

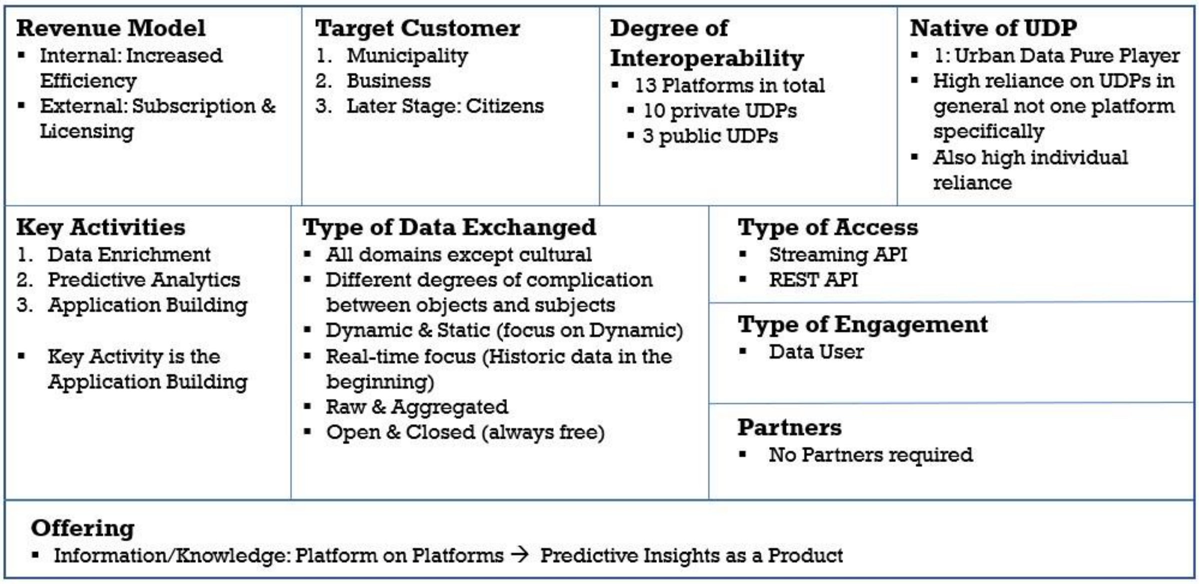


Figure 18. Business Model Amsterdam

5.1.3. Cross-Case Analysis

The previous two sections described two different business models that were developed once by a public bike sharing company and in the second case by the municipality of Amsterdam. To show the differences and similarities of these business models regarding their activities, as well as the use and connection to one or multiple UDPs, they will be compared along the dimensions of the UDP-engaging BM framework to systematically assess similarities and differences as displayed in Table 9.

	GoBike	**Municipality Amsterdam**
Type of Engagement	▪ Data User	▪ Data User
Type of Data Exchanged	▪ Real-time (infrequent historic) ▪ Dynamic (infrequent static) ▪ Aggregated ▪ Mobility	▪ Real-time (historic in the beginning) ▪ Dynamic & Static (focus on Dynamic) ▪ Raw & Aggregated ▪ All domains except cultural
Type of Access	▪ Streaming API	▪ Streaming API ▪ REST API
Degree of Interoperability	▪ 3 UDPs	▪ 13 UDPs ▪ 10 private UDPs ▪ 3 public UDPs
Native of UDP	▪ 6 (just improving business)	▪ 1 Urban Data Pure Player

Key Activity	1.Predictive Analytics 2.Application Development	1. Data Enrichment 2. Predictive Analytics 3. Application Building
Revenue Model	▪ Internal Efficiency ▪ Increased Service Level	▪ Increased Efficiency (Internal) ▪ Subscription & Licensing (External)
Partner Ecosystem	▪ None	▪ None
Offering	▪ Information/Knowledge ▪ Service improvement through analytics	▪ Information/Knowledge: Predictive Analytics Model base on multiple UDPs
Target Customer	▪ Citizen (Direct) ▪ Business (Indirect)	1. Municipality 2. Business 3. Citizens (Conceptual)

Table 9. Cross-Case Analysis of the Business Models

Platform Dimensions

Looking at the platform dimensions first, even though, both business models are engaged as a Data User with UDPs, they are very different from each other. Regarding the platform dimensions the first observable difference lies in the sheer discrepancy of the number of platforms connected to between GoBike and Amsterdam. While GoBike is connecting to just three UDPs to generate its value proposition, Amsterdam is connected to 13 UDPs, private and public. In this lies the next distinction that GoBike is connecting to municipality owned UDPs while Amsterdam is also connecting to multiple private owned urban data platforms. The reason for this difference is that the focus of the business model of GoBike is to improve their service with a very specific use case and is therefore only connecting to the UDPs in cities where it operates. Amsterdam also has this city focus but needs a much more diverse set of data in order to generate a stand-alone service and not just an improvement to an overall value proposition as in the case from GoBike. This is also an explanation of why Amsterdam has a much more native business model to UDPs. Nevertheless, when comparing the two business models, one has to keep in mind that this score is for 13 UDPs combined in the case of Amsterdam, while the focus in the interview with GoBike was just on one UDP of the municipality in Rotterdam. Even though this difference in interpretation exists, due to the improvement nature of the business model of GoBike facing UDPs, it can be assumed that even combined for all three platforms to which GoBike connects the BM will be less native to them than the stand-alone application developed by Amsterdam.

The type of access is similar for both businesses since they are both relying on real-time data. A relationship between the subdimension velocity and type of access was confirmed in both cases. The difference in variability can potentially explain why Amsterdam is using also REST APIs additional to the Streaming APIs that both organizations are using. Interestingly, both companies are using closed, free data, while Amsterdam is also using some open data. The reasons why the data is free differs, however, between the two cases. GoBike has to promise to also share some of their data in order to obtain the data for free, while in the case of Amsterdam it appears to be the size and importance of the city that motivates especially private UDPs to share their data with them. This is because they often operate in the ecosystem of Amsterdam in which the municipality has great power over the actors. The difference between the type of data that both receive, with Amsterdam getting both raw and aggregated data, while GoBike just receives aggregated data, appears to be caused by the availability of data, since Amsterdam would also rather receive aggregated data but sometimes has no options to select from.

Operational Dimensions

The operational dimensions of the two business models from the organizations have differences and similarities. Both organizations perform predictive analytics on the data that they receive, based on which they then build an application that can be used by the end-customer. The difference is that Amsterdam has to perform some data enrichment one step earlier in the data value chain before they start with the analytics. This is caused by the variety of data that Amsterdam receives, compared to the relative simplicity of the data that GoBike uses. Receiving data from 13 different sources, Amsterdam has to combine them, recalculate some of the data and reformate it, to be able to perform analytics on it. The rest of the value chain activities are the same for both organizations. The revenue model is internal efficiency for both organizations. GoBike wants to offer a more efficient and attractive service to its customers, whilst Amsterdam can increase the efficiency of different units of the city by giving them access to the predictions of the analytics.

Additionally, the crowdedness application has external end-users that are purchasing the information from the prediction, as opposed to GoBike, whose customers still purchase the same overall value proposition of an e-bike ride. The external revenue model from the city crowdedness application will be a subscription or licensing from private customers, while GoBike does not generate a stand-alone revenue model form the engagement with the UDP. The different revenue models, in the case of Amsterdam, lead to a broader target customer group as opposed to GoBike. The government is the customer of the application developed in Amsterdam to drive the previously mentioned internal efficiency and receive the service for free. The business customers of the municipality are targeted with the aforementioned two revenue models and are much more in focus as opposed to the case for GoBike, where the businesses benefit indirectly from their employees receiving better service from GoBike. The citizen type of customer is the key customer group of the service offered by GoBike, while it is only a future target group for the crowdedness application developed in Amsterdam. Both business models do not need any partners to generate the value proposition having the impression that the value generating activities can be performed more efficiently and with more control by doing them in-house. The offering itself is in both cases of type information/knowledge, and while the scale of the operations in Amsterdam is much larger, in the end both use predictive analytics, based on urban data received from a UDP or UDPs to offer value to their target customers.

5.2. Case Study Discussion

Being able to describe two different business models and being able to show differences and similarities is an example of the real-life applicability of the UDP-engaging BM framework, as well as some other relevant insights. Following the in-depth case analysis and the cross-case analysis the first research question of which dimensions should be included in a framework is revisited to show the applicability of the framework in a real-life scenario and increase the validity of the dimensions found in the previous Delphi research. Additionally, the research questions regarding which business models exist of organizations engaging with UDPs and how they differ are discussed based on two cases that are analyzed along the previously established dimensions, before the practical implications of the findings of the case studies are discussed.

5.2.1. Comparison of Findings to Existing Literature

Applying the UDP-engaging BM framework to two real-life cases on which an in-depth analysis was performed has shown that the framework provides added value to researchers, as well as demonstrated that the included dimensions appear to fulfill their function of describing the business model of an organization in terms of analyzing the value creation logic of an organization incorporating the role of UDPs. The framework was not only able to describe the business models in two different scenarios, but following a cross-case analysis, it was also established that by following this framework business models can be compared, and the resulting descriptions are representing distinct business models. Especially the role of UDPs was clearly outlined in the two described examples. In a broader sense, the framework validation can be described using analytic induction, using all dimensions of the business models as dimensions of a framework to be validated (Robinson, 1951). Such a framework can be validated using analytic induction with case studies if all cases fit in the framework (Robinson, 1951). In both cases the business models of the organizations could be placed in the framework and analyzed following the dimensions and subdimensions of it. Another way to display the validity of this framework is to compare the analysis done following the dimensions of the UDP-engaging BM framework with related frameworks, such as DDBM BM framework of Hartmann et al. (2014) or the UDBM framework Mcloughlin et al. (2018). Comparing the business model analysis done with the framework developed in this thesis, to analyses using already existing frameworks, shows how this framework is an addition to the current body of literature, by adding more depth and providing meaningful separation in the systematic analysis of business models of organizations in the specific context of UDP-engagements.

Comparison to Urban Data Business Model Framework

The first aspect of the business model that would have been missed using the UDBM framework would have been the "Type of Engagement". In the business models this was a vital aspect to represent the position of the organization in the UDP ecosystem. Using the UDBM framework (Appendix 4), the description of data for both business models would have been similar regarding the subdimensions velocity and variability as subdimensions of "Type of Data Exchanged". However, important information of a business model with an engagement to a UDP such as whether the data is open or closed and the distinction between raw and aggregated data would have been lost. By using the UDP-engaging BM framework, practitioners can see the first indication that organizations performing analytics might be more interested in receiving aggregated data, as suggested by both business models analyzed. This information can help platform operators to adjust their offering. This reasoning would not have been possible using the UDBM framework. Regarding the key activities, the subdimension of the UDBM framework would only have outlined predictive analytics to be a key activity in both business models. The distinction that Amsterdam is also performing enrichment as a difference compared to GoBike and that both perform application development as a final step would not have been possible in the UDBM framework which is lacking other tasks in the data value chain compared to the UDP-engaging BM framework (Klievink et al., 2017). The dimension "target customer" is the same and hence would not have produced any differences. The revenue model as discussed in the UDBM framework would have caused an issue for the business model used in both business models, since the UDBM does not incorporate internal efficiency as a source of revenue and therefore would not have been able to place GoBike and Amsterdam correctly.

Information about how many platforms the organization connects to, for the business model and how native the BM is on these UDPs, are both dimensions that would have been missed by the UDBM, since there are no dimensions to describe this. As a result, the difference between the high interoperability of 13 platforms used by the prediction model developed in Amsterdam and the smaller degree with just three platforms by GoBike would have been missed. Also, the difference in reliance on these platforms to generate the service would have remained hidden using the UDBM framework, another critical difference between the business models deployed by GoBike and the municipality of Amsterdam. Thus, comparing the results of the in-depth analysis done with the UDP-engaging BM framework to how the result would have been using the UDBM framework, one can conclude that each business model would not have been described as accurately, missing key dimensions of how the value proposition is created and the role of the UDP. Furthermore, a cross-case comparison using the UDBM framework would have yielded in very similar business models of the two organizations, when, as shown by the UDP-engaging BM framework, they are different along multiple key dimensions.

Comparison to Data-Driven Business Model Framework

Comparing the case study to the DDBM framework by Hartmann et al. (2014) (Appendix 3) also shows several aspects of the business models that would have been missed by applying the DDBM framework. The DDBM framework allows for the separation between internal and external data but lacks aspects such as the "nature" of data to describe if the data was open or closed or obtained with a barter. Hence, all the considerations regarding security, privacy and costs that a business has to take when they utilize data of different nature would not have been represented using the DDBM framework (Janssen & Zuiderwijk, 2014). The key activity dimension of Hartmann et al. (2014) also includes multiple activities an organization can undertake along the data value chain (Klievink et al., 2017). Nevertheless, application development based on the data that is obtained, which is done by both, GoBike and the municipality of Amsterdam, is missing according to this framework. Target customer as a main dimension is solely the separation between B2B and B2C in the DDBM framework (Hartmann et al., 2014). An analysis with this framework would have missed the fact that Amsterdam is highly focused on providing their value proposition to the government and businesses, compared to GoBike who is focused on citizens. This additional distinction is especially important given the fact that the business models of the organizations analyzed using the UDP-engaging BM framework are located in a smart city context in which the city takes a key role in the ecosystem (Batty et al., 2012). Concerning the revenue model dimension, the DDBM framework, like the UDBM framework, does not contain an internal efficiency dimension which could be caused by the fact that both of these business models try to analyze the overall business model of the organization and neglect the fact that a business can have multiple business models (Casadeus-Masanell & Tarzijan, 2012). However, by not incorporating this dimension, the case of GoBike would have been unable to be placed in any subdimension of the DDBM framework and for Amsterdam the most important source of increased revenue generation would have missed. Additionally, the DDBM contains a dimension to show a specific cost advantage that an organization has. This dimension is not relevant regarding the UDP-engaging business models, since it would only be of importance in the case that an organization receives paid data, which was not the case in both of the use cases described, and hence both would not have fitted into this main dimension. Like the UDBM framework, the DDMB framework lacks relevant platform dimensions such as "native to UDP", "interoperability" and "type of engagement". This would have caused the same, similar description of both business models of the case studies that was already explained in the paragraph regarding the UDBM framework. This underlines the relevance of including these additional platform dimensions in the applicable context of the framework developed in this thesis.

5.2.2. Business Model Analysis and Comparison

The paragraph discusses the differences and similarities from the business models described in section 5.1.1 and 5.1.2 compared to the business models described by the closest related research, as shown in Table 1.

Service Improvement from Analytics (GoBike)

In section 5.1.1 the business model of GoBike and the company's engagement to a UDP is described. This business model can be described as "service improvement from analytics". From related business models, this business model is similar to the "free data knowledge discovery" business model described by Hartmann et al. (2014). This model is described by performing analytics on free available data (Hartmann et al., 2014). This is similar since the key activity of GoBike in the "service improvement from analytics" business model is also analytics. However, the "service improvement form analytics" model receives the data only temporary for free, since the company has to share some of their data in a barter at a later point of the UDP engagement which is different than the "free data knowledge discovery". Another key difference is that the "service improvement from analytics" does not have a stand-alone revenue model but increases the revenue generated from a larger overall business model of GoBike, whereas “free data knowledge discovery” assumes that the insights from the analytics are sold to other companies. Furthermore, the “free data knowledge discovery” business models do not further specify the sources from which the organization receives the data, other than that the data is received for free. Relevant descriptions, such as the low degree of nativity to UDP of the “service improvement from analytics” business model for the type of data are missed in the “free data knowledge discovery model” due to the missing dimensions in the DDBM framework, as previously discussed.

“Service improvement from analytics” as used by GoBike can also be compared to the “Informing Business Decision” model described in the context of big data (Schroeder, 2016). This business model emphasizes that data does not need to be monetized directly to have an economic impact but can be used to improve business processes and inform strategic decisions instead. While this part is crucial to the business model described by GoBike, the “informing business decisions” business model is missing a description of platform dimensions entirely. Moreover, the business model described by Schroeder (2016) is focusing on utilizing internal data for the improvement activities which is a key difference to “Service improvement from analytics” since this type of business model is relying on a very specific type of external data, urban data from a UDP. Nevertheless, from a theoretical angle, “Service improvement from analytics” can be seen as a particular subtype in the context of UDPs and using external data of “Informing Business Decision”. While, Rizk et al. (2018) don’t describe any comparable business model in their digital-driven services framework, the business model of “service improvement from analytics” would have been classified as an “Integrator” business model as described by Magalhaes et al. (2014). The authors find this type to be companies that integrate urban data into their existing business model to improve their existing offering. As such, “service improvement from analytics” can also be seen as a subtype of an overall body of integrator business models in a UDP context. Such a business model can be interesting to a broad range of companies, since it can be implemented in a short amount of time and does not require extensive analytics skills or effort to implement.

Predictive Insights as a Product (Municipality of Amsterdam)

The business model of the municipality of Amsterdam can be described as “predictive insights as a product” business model. By combining the data from multiple UDPs and performing predictive analytics on them, Amsterdam was able to generate an application that provides the insights about how full certain areas of the city will be during each hour of the day. This business model is conceptually related to the “prescriptive insights as a product” model described by Mcloughlin et al. (2018). Even though the two business models sound very closely related by name comparison looking at the underlying dimensions that describe the business model in more detail reveals major differences. While the business model from Mcloughlin et al. (2018) focuses on the government as a key customer, just like the business model found for Amsterdam in this research. Nonetheless, they only describe private companies to perform these business models and neglect the possibility that the government also has a business model and can engage in advanced analytics to generate revenue, as shown in this research in the context of UDP-engaging organizations. Also, the diversity of the customers as described in the “predictive insights as a product” business model is higher, by also focusing on businesses and in a later stage on citizens, as opposed to the business model described in the UDBM framework, that only focuses in the government as a customer. Another key difference between the two described models is that Mcloughlin et al. (2018) describe the generation of sensor data as a key activity and do not include data enrichment. This difference shows how the business model described in this thesis is a specific business model used in a UDP context, since it does not generate the data itself, but utilizes the data from different UDPs. This data has to be enriched and combined before performing predictive analytics on them. Overall, while the end-product of both business models is, to a certain degree similar, comparing both models in more detail reveals that the two have very different ways to generate the final value proposition originating from the use of an urban data platform in case of the “predictive insights as a product” business model described in section 5.1.2. This business model requires more effort compared to “service improvement from analytics”, since the analytical capabilities are more sophisticated, connections to more platforms have to be created and maintained and more steps in the data value chain have to be performed. Such a model can be interesting to organizations who are willing to invest a considerable amount of resources to generate a novel, stand-alone value proposition from a UDP-engagement.

Insights from the Cross-Case Comparison

To answer RQ3 regarding the differences and similarities between the two business models, the findings from section 5.1.3 are discussed in terms of key differences and their meaning for the body of literature. The most striking difference is that in the case of Amsterdam, the organization is producing a stand-alone revenue model, compared to the internal efficiency model utilized by GoBike. This is empirical support to the findings of Beniger (2009) who argues that the data can also be used for internal efficiency to generate revenue instead of monetizing the data or a product generated from it to external parties. This assumption appears to hold true in the context of UDP-engaging business models. This allows for the hypothesis that many business models found in this context will have internal efficiency at least as one of the main focuses.

An interesting similarity of both models is that while both organizations do not pay for their data, the data that they receive from a UDP is on both cases closed and free. This can be seen as an indication coupled with a statement made during the interviews, that it is very hard, if not impossible to have a business model based on open data, due to the threat of replication as mentioned in section 4.4.2.

Furthermore, in both cases, the subdimensions “velocity” and “variability”, seemed to influence the “type of access”, as indicated during the interviews of the first round of the Delphi study. If the data is real-time and dynamic, having a download option does not appear to be feasible by the organization, since it would require continuous redownloading. Yet, this cannot be proven to be correct, but in the cases, there was no evidence found that would contradict the statements made during the expert interviews about the relationship between “type of data exchanged” and “type of access”. Leaving this as another hypothesis that is interesting to validate in follow-up research.

Another interesting finding from the cross-case comparison was that both organizations used aggregated data, while raw data was only used by Amsterdam. Interestingly, the CTO of Amsterdam Ger Baron mentioned that this was not due to their choice but was caused by this being the only format on which data was available, indicating a preference for aggregated data due to easier operations on them. This is again in accordance with a theme from the panel interviews that also indicated that aggregated data would be preferred by the organizations engaging with UDPs due to better practicality. These findings allow to formulate another hypothesis, that aggregated data will be preferred in the business models of organizations engaging with UDPs.

The difference regarding the degree of interoperability between both business models shows that both cases are possible in the context of UDP-engaging organizations. This dimension seemed to have an influence on the how native the business models where. The higher the number of platforms used the more native and overall reliant the business models of organizations appeared to be. This relationship is an additional hypothesis that would be interesting to test it the future.

Hence, it can be concluded that by applying the UDP-engaging BM framework, it was established that there are key similarities, as well as differences, between the two cases identified. Those were regarding the way how the two companies create a value proposition and the role that a UDP plays as part of the business model (Fielt, 2013). Likewise, the cross-case analysis using this framework enabled the researcher to formulate several hypotheses of how the different dimensions and subdimensions of the UDP-engaging BM framework might be related. Finally, this permits to draw conclusions of the focus of the business models, as well as function as a starting point for a more in-depth analysis of the role of the urban data platform in the business model of organizations.

5.2.3. Practical Relevance Revisited

As discussed in the practical implications in paragraph 4.4.3, using the UDP-engaging BM framework to analyze business models of the organizations engaging with UDPs has several key advantages, as opposed to the BM frameworks that have previously existed. After applying the framework to two real-life cases to analyze their business models, these indications can be supported with actual examples of how the findings of the analysis can be used by different parties in the ecosystem of UDPs to their benefit. This is achieved by focusing on the added value of dimensions that are present in the UDP-engaging BM framework and hence the advantages of analyzing a business model with this framework, compared to other frameworks.

Both of the business models that were examined can serve as blueprints for other organizations that are considering an engagement with a UDP. The business model "service improvement from analytics" as used by GoBike can be interesting for many private companies that are seeking to generate additional revenue, by improving their current offering using analytics of urban data. Depending on the availability of appropriate data resources on a UDP, other companies can use the example of how GoBike connected to the UDP to build a business model on urban data themselves. The "predictive insights as a product" business model utilized in the case of Amsterdam can be followed by either public or private organizations that possess the sophisticated analytics skills required to run such a model. This business model shows, how an organization can generate value from connecting to multiple urban data platforms, while also reflecting important considerations in doing so. For example, as indicated by the high degree of interoperability required, organizations considering following such a business model themselves should first check if the different platforms that would be required provide interoperability and also consider the risk of being very native to these UDPs. For private organizations this can be a very high risk if they create such a high dependency especially with private UDPs of commercially oriented other companies since it might generate a lock-in effect

(Satzger, Hummer, Inzinger, Leitner, & Dustdar, 2013). Moreover, also organizations that already have business models engaging with UDPs can apply this framework to compare their platform dimensions and operational dimensions of their business model to the ones of the two cases described above, to see potential ways to increase the efficiency of their business model.

Changing the perspective to one of a platform operator in a UDP ecosystem, the two case studies also show several practical advantages. If the operator analyzes the business models of engaged organizations and realizes, that there are different data assets used by high native business models (Amsterdam Case), as opposed to low native business models (GoBike Case), he might decide to put higher emphasize on keeping the data used by the high native business models properly maintained compared to the one used by low native business models, since the higher native model require this type of effort from the UDP. Applied to the case studies this would mean that given both cases were connected to the same UDP, the operator should be more concerned to provide high quality, continuous data to the municipality of Amsterdam, as opposed to the data used by GoBike. Also comparing the types of access used by the business models of the engaging organizations can be beneficial. Should all organizations engage to the platform, only by API, as done by both case studies, the operator might consider not to offer downloads to save costs, while still enabling all present business models in the platform ecosystem. Overall, the five platform dimensions give a good overview of the functionalities of the UDP that are used.

As it was demonstrated with the cross-case analysis, utilizing this framework allows researchers and practitioners to systematically compare the differences and similarities of the business models. This allows to draw conclusions about what skills and types of connections are required in the particular UDP context, as well as to compare different UDP-ecosystems to understand what influence different UDP characteristics have.

Interestingly, with the case of the prediction model developed by the municipality of Amsterdam the framework was applied to a particular type of UDP, that was at the same time the data user of multiple other UDPs. It can be described as a UDP since it offers information on multiple different domains of a smart city (Barns, 2018). At the same time, it does not offer the data directly, but only offers information derived from the different UDPs to the end-customer as shown in Figure 17. If a UDP only functions as a data marketplace or as a data platform, as indicated by the expert interviews during the Delphi study, this framework will not be applicable to analyze their business model. This is explained by the fact that there is no related key activity that these platforms perform in that case. Therefore, the first reason, why the case of Amsterdam could be analyzed was because it did not function as a data platform but performed multiple, complex value-adding tasks to the data, before offering the aggregated product to the customer. The second reason was that the data that was used by the municipality came from other UDPs, in the broader definition of urban data platforms. If the data would have been gathered from city-owned, internal sources only, as it is the case in many UDPs, an analysis with the framework would not have been meaningful, since there would have been no real UDP from which the organization was a data user for the business model. Nevertheless, this example shows that given, that a UDP is combining data from other UDPs and only offers a product based on key activities performed on the data, the business model of this organization can be analyzed with the UDP-engaging BM framework as well.

6. Limitations & Implications for Future Research

A first limitation is that due to the mostly qualitative nature of this research, the results have smaller generalizability, as opposed to quantitative findings, even though all quality standards were met. While the influence of the researcher was documented in high detail, this influence still existed even though all measures were taken to minimalize the influence. As such, the background of the researcher could have a minor influence during the interpretation of the interviews, although the methodology was followed rigorously and all measures were taken to ensure the highest internal and external validity of the research (Schwandt et al., 2007). To improve the general issue of limited generalizability, a follow-up study with a larger expert panel using questionnaires would be interesting, as well as to analyze multiple UDP ecosystems to provide further validation to the findings of this study and establish the generalizability of the results from this thesis. A second limitation of the Delphi study is that the municipality of Rotterdam was slightly overrepresented in the sample size with three experts. However, given the overall panel size of 14 experts, the panel was still fairly diverse to achieve sufficient generalization of the results. But as proposed in the first limitation, a larger scale qualitative study would be useful to free the findings from any doubts. A third limitation of this research is that while the panelists who were all engaged in the supervision of a UDP, in some cases, the UDPs themselves were only operational with pilots. Even though there was no pattern observable among the responses of the panelists from fully operational platforms and platforms that were in the pilot phase, one could argue that pilot platforms might experience different types of engagement than established platforms. This issue was unavoidable given the novelty of this field of research and by incorporating a majority of panelist from fully operational UDPs, the influence was limited.

The most significant potential for further research lies in coupling a larger scale business model analysis utilizing the framework from this thesis with an analysis of the added value that the organizations are seeking from the UDP. Such research would give an indication of what the key aspects of a UDP are important for the organizations engaging with it and allow to asses if there are differences depending on the business models developed by the organizations. Also, novel business models could be established with more certainty by increasing the scope of the analysis and including more organizations. This could also help the UDP in the ecosystem to improve its' service to the organizations, by specifically tailoring its products and services to the needs of different groups of organizations following similar business models. Additionally, this research could help to validate the business model of "predictive insights as a product" and "service improvement from analytics" as they were found in this thesis since two cases provide little basis for generalization. A second area for future research is to test the hypotheses that were formulated based on the expert interviews and the cross-case comparison. This would shade more light into the question if different subdimensions are more likely to occur in the context of UDP-engaging business models and which relationships exist among different main and sub-dimension. Such an analysis could be done using the data of a large-scale business model analysis, as proposed in the first area of future research. From a theoretical standpoint, it would be very interesting to perform a business model analysis of a data supplier to see how this group of organizations engaged with UDPs generates value. Especially a comparison with the business models of data users in terms of similarities and differences could be very insightful.

Even though the key focus of this thesis was on business models engaging with UDPs, an adapted version of the framework might be applicable in a more general setting of organizations engaging with data-platforms. Nevertheless, several key differences have to be considered before doing so. Due to the unique context of urban data in terms of socio-political, ethical, technical and economic challenges additional to challenges of engaging with a platform and relying on external data, organizations that operate in this environment have to overcome additional challenges and might have conceptually different way of creating value propositions for a data platform engagement (Lakomaa & Kallberg, 2013). Hence, while an application to other actors in the UDP ecosystem might be possible and interesting for practitioners and researchers, such an effort has to be preceded by an extension of the Delphi process, since all main dimensions and subdimensions were developed specifically for organizations that take the role of a data supplier or data user in a UDP ecosystem.

7. Conclusion

The goal of this research was to fill the research gap that there was no business model framework to allow for the structured analysis of business models of organizations engaging with UDPs. This was achieved answering the research questions of which dimensions and subdimensions to include in such a framework and by exploring what business models organizations are using and how they differ. To elucidate these three exploratory research questions, an inductive research method consisting of two stages was chosen. The first question was answered in the first research stage, by conducting a two-round Delphi study with 14 experts from 11 different UDPs and 7 countries. This diverse panel reached consensus on 10 dimensions that should be included in a UDP-engaging BM framework (Figure 11 and Figure 15). Of these dimensions, five reflect the organizations' engagement with the UDP, while the other five focus on more operational features of the business model. A detailed examination in the discussion showed that the resulting framework is different from any existing business model framework because of two reasons. First, it incorporates the platform dimensions explaining how the organization is connected to a UDP, out of which four are new to being included in a business model framework. Second, the framework includes operational dimensions and subdimensions that are specifically applicable to analyze the creation of a value proposition of an organization engaging with a UDP. This allows researchers and practitioners alike to analyze the business models on all relevant dimensions and to find the small differences between models in this context. This was demonstrated by conducting a comparative case study in the second stage of this research to answer the second and third research questions about which business models are used by organizations engaging with UDPs and what are their differences.

The case study on GoBike, a Rotterdam-based e-bike sharing company, showed a business model with an internal focus, utilizing a UDP engagement to increase internal efficiency by performing analytics on the received data from a small number of UDP, in a UDP "un-native" business model. By comparison, the business model of the municipality of Amsterdam was generating revenue by creating internal efficiencies, but also producing a stand-alone product sold to external organizations, by combining the data from multiple UDPs in a highly UDP native business model. The following second discussion showed that by analyzing these cases with other frameworks, key differences, such as "native to UDP" would have been missed, while "generating internal efficiencies", as done by both cases was not included as a revenue model in any previous framework. The resulting business models from the analysis with preexisting frameworks were very similar, when they are in fact different along several key dimensions, as shown by the UDP-engaging BM framework. The benefits of conducting these case studies were threefold. First, two novel business models, that are variations of previously documented business models could be described, showing that organizations in the ecosystem of UDP are in fact deploying novel business models. At the same time, by doing so, demonstrating the high relevance of having a UDP-engaging BM framework to enable such research in the first place. Besides this, the application also demonstrated that the developed framework enables for in-depth case analysis, as well as a meaningful comparison of different business models. Based on the findings of the cross-case comparison, some interesting hypotheses about the importance of several dimensions and relationships between them could be found that are very interesting to be researched during a follow-up study. A logical first application of this framework can be a large-scale analysis of the ecosystem of a UDP to find how different business models have different engagements with the UDP and different ways to generate value from these engagements.

The framework has another use for researchers and practitioners since it was developed to represent all the facets that an engagement with a UDP can take from the perspective of a data user or supplier. Ergo, it serves as an overview of the capabilities that UDPs are currently offering to organizations and a summary of the activities and measures that are possible to be taken by the organizations engaging with the UDP.

Additionally, since UDPs are such a novel field of research, some additional findings from the interviews in the first round of the Delphi study are important to add to the current body of literature. First, there appear to be two different types of UDPs regarding the focus of these platforms. One type with an internal efficiency and transparency focus, the other building on the first one and having an additional focus on fostering economic activity by sharing data with other organizations. The latter type of UDP allows for several different types of use cases from public and private organizations. Second, it was suggested that UDPs can also be operated by private organizations, often with a commercial motivation and that there can be multiple UDPs in the ecosystem of one city, all specializing on certain domains or types of data.

References

Abbate, T., Cesaroni, F., Cinici, M. C., & Villari, M. (2018). Exploiting Internet-of-Things: Platforms and Business Models. In *Governing Business Systems* (pp. 101–118). Messina: Springer International Publishing. https://doi.org/10.1007/978-3-319-66036-3

Abella, A., Ortiz-de-Urbina-Criado, M., & De-Pablos-Heredero, C. (2017). A model for the analysis of data-driven innovation and value generation in smart cities' ecosystems. *Cities*, *64*, 47–53. https://doi.org/10.1016/j.cities.2017.01.011

Accenture. (2016). *Government as a Platform: Coming Soon to a Government Near You*. Retrieved from https://www.accenture.com/t20160831T013223__w__/us-en/_acnmedia/PDF-29/Accenture-Government-Platform-POV.pdf

Adler, M., & Ziglio, E. (1996). *Gazing into the oracle: The Delphi method and its application to social policy and public health*. Jessica Kingsley Publishers.

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

Amit, R., & Zott, C. (2001). Value creation in E-business. *Strategic Management Journal*, *22*(6–7), 493–520. https://doi.org/10.1002/smj.187

AmsterdamSmartCity. (2018). LoRa Smart Lighting + Lightwell - Amsterdam Smart City. Retrieved May 3, 2019, from https://amsterdamsmartcity.com/projects/lo-ra-smart-lighting--lightwell-dutch-design-friso

Arup. (2016). *Smart city opportunities for London*. London. Retrieved from https://www.arup.com/perspectives/publications/research/section/smart-city-opportunities-for-london?query=smart city

Baghbadorani, M., & Harandi, A. (2012). A Conceptual Model for Business Ecosystem and Implications for Future Research. *International Proceedings of Economics Development and Research*, *67*(12), 14–18. https://doi.org/10.7763/IPEDR

Bailey, J. J. (2008). First steps in qualitative data analysis: transcribing. *Family Practice Advance*. https://doi.org/10.1093/fampra/cmn003

Barnes, C., Blake, H., & Pinder, D. (2009). *Creating and delivering your value proposition: Managing customer experience for profit*. Kogan Page Publishers.

Barns, S. (2018). Smart cities and urban data platforms: Designing interfaces for smart governance. *City, Culture and Society, 12*(September 2017), 5–12. https://doi.org/10.1016/j.ccs.2017.09.006

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

Batty, Michael. (2013). *Urban Informatics and Big Data: A Report to the ESRC Cities Expert Group*. London. Retrieved from http://www.spatialcomplexity.info/files/2015/07/Urban-Informatics-and-Big-Data.pdf

Beniger, J. (2009). *The control revolution: Technological and economic origins of the information society*. Harvard university press.

Bertini, M., & Tavassoli, N. (2015). Case Study : Can One Business Unit Have 2 Revenue Models ? *Harvard Business Review*, (March), 1–14.

Brady, S. R. (2015). Utilizing and Adapting the Delphi Method for Use in Qualitative Research, 1–6. https://doi.org/10.1177/1609406915621381

Brownlow, J., Zaki, M., Neely, A., & Urmetzer, F. (2015). Data-Driven Business Models: A Blueprint for Innovation. *Cambridge Service Alliance*, (5), 1–17. https://doi.org/10.13140/RG.2.1.2233.2320

Caragliu, A., del Bo, C., & Nijkamp, P. (2011). Smart cities in Europe. *Journal of Urban Technology*, *18*(2), 65–82. https://doi.org/10.1080/10630732.2011.601117

Casadeus-Masanell, R., & Tarzijan, J. (2012). When One Business Model Isn’t Enough. *Harvard Business Review*, (January-February), 1–10.

Cheng, B., Longo, S., Cirillo, F., Bauer, M., & Kovacs, E. (2015). Building a Big Data Platform for Smart Cities: Experience and Lessons from Santander. In *Proceedings - 2015 IEEE International Congress on Big Data, BigData Congress 2015* (pp. 592–599). IEEE. https://doi.org/10.1109/BigDataCongress.2015.91

Chesbrough, H., & Schwartz, K. (2007). Innovating business models with co-development partnerships. *Research-Technology Management*, *50*(1), 55–59.

Clarke, A., & Margetts, H. (2014). Governments and citizens getting to know each other? Open, closed, and big data in public management reform. *Policy & Internet*, *6*(4), 393–417.

Costa, C., & Santos, M. Y. (2016). BASIS: A big data architecture for smart cities. *Proceedings of 2016 SAI Computing Conference, SAI 2016*, 1247–1256. https://doi.org/10.1109/SAI.2016.7556139

Creswell, J. W. (2007). *QUALITATIVE INQUIRY & RESEARCH DESIGN Choosing Among Five Approaches* (2nd ed.). Thousand Oaks: Sage Publications. Retrieved from https://s3.amazonaws.com/academia.edu.documents/53798327/creswell_2007_qualitative_inquiry_and_research_design__choosing_among_five_approaches__2nd_edition.pdf?response-content-disposition=inline%3B filename%3DSecond_Edition_QUALITATIVE_INQUIRY_and_R.pd

Dalkey, N., & Helmer, O. (1963). An Experimental Application of the DELPHI Method to the Use of Experts. *Management Science*, *9*(3), 458–467. https://doi.org/10.1287/mnsc.9.3.458

Dictionary.com. (2019). Software platform | Define Software platform at Dictionary.com. Retrieved March 23, 2019, from https://www.dictionary.com/browse/software-platform

Dijkman, R. M., Sprenkels, B., Peeters, T., & Janssen, A. (2015). Business models for the Internet of Things. *International Journal of Information Management*, *35*(6), 672–678. https://doi.org/10.1016/J.IJINFOMGT.2015.07.008

Dirks, S., Keeling, M., & Dencik, J. (2009). *A vision of smarter cities How cities can lead the way into a prosperous and sustainable future IBM Global Business Services*. Retrieved from http://www-03.ibm.com/press/attachments/IBV_Smarter_Cities_-_Final.pdf

Dutch Government. (2019). *Cities in the Netherlands*. The Hague. Retrieved from https://www.pbl.nl/sites/default/files/cms/publicaties/PBL-2016-Cities-in-the-Netherlands-2470.pdf

El Sawy, O. A., & Pereira, F. (2013). *VISOR: A Unified Framework for Business Modeling in the Evolving Digital Space*. Berlin, Heidelberg: SpringerBriefs in Digital Space. https://doi.org/10.1007/978-3-642-31765-1_3

Engelbrecht, A., Gerlach, J., & Widjaja, T. (2016). Understanding the Anatomy of Data-Driven Business Models - Towards an Empirical Taxanomy. *Research Papers*, *128*. Retrieved from http://aisel.aisnet.org/ecis2016_rp%0Ahttp://aisel.aisnet.org/ecis2016_rp/128

Evans, D. S., Hagiu, A., & Schmalensee, R. (2008). *Invisible engines : How software platforms drive innovation and transform industries* (1. MIT Pre). Cambridge, Mass: MIT Press.

Fehrer, J. A., Woratschek, H., & Brodie, R. J. (2018). A systemic logic for platform business models. *Journal of Service Management*, *29*(4), 546–568. https://doi.org/https://doi.org/10.1108/JOSM-02-2017-0036

Fielt, E. (2013). Conceptualising Business Models: Definitions, Frameworks and Classifications. *Journal of Business Models*, *1*(1), 85–105. https://doi.org/10.1177/0149206311406265

Fink, A. (2015). *How to conduct surveys: A step-by-step guide*. Sage Publications.

Fitzgerald, M. (2016). Data-driven city management: A close look at Amsterdam's smart city initiative. *MIT Sloan Management Review*, *57*(4).

FIWARE. (2019). FIWARE Open Source Platform. Retrieved May 14, 2019, from https://www.fiware.org/about-us/

Fletcher, A. J., & Marchildon, G. P. (2014). Using the Delphi Method for Qualitative, Participatory Action Research in Health Leadership. *International Journal of Qualitative Methods*, *13*(1), 1–18. https://doi.org/10.1177/160940691401300101

Foth, M., Choi, J. H., & Satchell, C. (2011). Urban informatics. In *Proceedings of the ACM 2011 conference on Computer supported cooperative work - CSCW '11* (p. 1). New York, New York, USA: ACM Press. https://doi.org/10.1145/1958824.1958826

Gallaugher, J. (2018). Chapter 8: Platforms, Network Effects, and Competing in a Winner-Take-All World. In *Information Systems: A Manager's Guide to Harnessing Technology* (7th ed., pp. 211–234). Boston: Boston Academic Publishing. https://doi.org/10.24926/8668.1101

Gawer, A. (2014). Bridging differing perspectives on technological platforms: Toward an integrative framework. *Research Policy*, *43*(7), 1239–1249. https://doi.org/10.1016/J.RESPOL.2014.03.006

Gawer, A., & Cusumano, M. A. (2014). Industry Platforms and Ecosystem Innovation. *Journal of Product Innovation Management*, *31*(3), 417–433. https://doi.org/10.1111/jpim.12105

GoBike. (2019). Gobike Rotterdam - an innovative system of electric sharebikes. Retrieved June 11, 2019, from https://rotterdam.gobike.nl/en/home-uk/

Goldsmith, S. (2014). *The Responsive City - ENGAGING COMMUNITIES THROUGH DATA-SMART #theresponsivecity THE RESPONSIVE CITY Bay Area Digital Government Summit*. Bay Area. Retrieved from https://datasmart.ash.harvard.edu/sites/default/files/2018-01/ResponsiveCityBayArea.pdf

Gonfalonieri, A. (2018). Big Data and Smart Cities: How can we prepare for them? Retrieved May 3, 2019, from https://medium.com/dataseries/big-data-and-smart-cities-why-we-need-them-now-a194b2498fb1

Hartmann, P. M., Zaki, M., Feldman, N., & Neely, A. (2014). *Big Data for Big Business? A Taxonomy of Data-driven Business Models used by Start-up Firms*. Cambridge.

Harvard Faculty of Sociology. (2013). Strategies for Qualitative Interviews. Boston: Harvard University Press. Retrieved from https://sociology.fas.harvard.edu/files/sociology/files/interview_strategies.pdf

Hashem, I. A. T., Chang, V., Anuar, N. B., Adewole, K., Yaqoob, I., Gani, A., … Chiroma, H. (2016). The role of big data in smart city. *International Journal of Information Management*, *36*(5), 748–758. https://doi.org/10.1016/j.ijinfomgt.2016.05.002

Hatzelhoffer, L., Humboldt, K., Lobeck, M., & Wiegandt, C.-C. (2012). *Smart City in Practice: Converting innovative Ideas into Reality*. Berlin: Jovis.

Holzinger, A., Treitler, P., & Slany, W. (2012). Making apps useable on multiple different mobile platforms: On interoperability for business application development on smartphones. In *International Conference on Availability, Reliability, and Security* (pp. 176–189). Springer.

Hossain, M. (2017). Business model innovation: past research, current debates, and future directions. *Journal of Strategy and Management*, *10*(3), 342–359.

Humphrey, C., & Hugh-Jones, S. (1992). *Barter, exchange and value: an anthropological approach* (1st ed.). Cambridge: Cambridge University Press.

IBM Analytics Hub. (2019). Infographic: The Four V's of Big Data | IBM Big Data & Analytics Hub. Retrieved May 4, 2019, from https://www.ibmbigdatahub.com/infographic/four-vs-big-data

Ifenthaler, D., & Widanapathirana, C. (2014). Development and validation of a learning analytics framework: Two case studies using support vector machines. *Technology, Knowledge and Learning*, *19*(1–2), 221–240. https://doi.org/10.1007/s10758-014-9226-4

Iyer, B., Lee, C.-H., & Venkatraman, N. (2006). Managing in a "Small World Ecosystem": Lessons from the Software Sector. *California Management Review*, *48*(3), 28–47. https://doi.org/10.2307/41166348

Janssen, M., Charalabidis, Y., & Zuiderwijk, A. (2012). Benefits, Adoption Barriers and Myths of Open Data and Open Government. *Information Systems Management*, *29*(4), 258–268. https://doi.org/10.1080/10580530.2012.716740

Janssen, M., & Zuiderwijk, A. (2014). Infomediary business models for connecting open data providers and users. *Social Science Computer Review*, *32*(5), 694–711.

Jarrar, Y., & Schiuma, G. (2007). Measuring performance in the public sector: challenges and trends. *Measuring Business Excellence*, *11*(4), 4–8.

Jorna, F. (2017, July 14). Het City Innovation Platform: Utrechts open urban platform. Retrieved February 6, 2019, from https://www.slideshare.net/FransJorna3/het-city-innovation-platform-utrechts-open-urban-platform

Kiel, D., Arnold, C., & Voigt, K.-I. (2017). The influence of the Industrial Internet of Things on business models of established manufacturing companies–A business level perspective. *Technovation*, *68*, 4–19.

Kim, K. H. (2000). APIs for real-time distributed object programming. *Computer*, *33*(6), 72–80.

Kitchin, R. (2014). The real-time city? Big data and smart urbanism. *GeoJournal*, *79*(1), 1–14. https://doi.org/10.1007/s10708-013-9516-8

Klievink, B., Romijn, B. J., Cunningham, S., & de Bruijn, H. (2017). Big data in the public sector: Uncertainties and readiness. *Information Systems Frontiers*, *19*(2), 267–283. https://doi.org/10.1007/s10796-016-9686-2

Kloeckl, K., Senn, O., & Ratti, C. (2012). Enabling the Real-Time City: LIVE Singapore! *Journal of Urban Technology*, *19*(2), 89–112. https://doi.org/10.1080/10630732.2012.698068

Krishnan, V., & Gupta, s. (2001). Appropriateness and impace of platform-based product development. *Management Science*, *47*(1), 52–68. Retrieved from https://search-proquest-com.eur.idm.oclc.org/docview/213230850/fulltextPDF/A1CF599BB8184EA6PQ/1?accountid=13598

Kuk, G., & Janssen, M. (2011). The business models and information architectures of smart cities. *Journal of Urban Technology*, *18*(2), 39–52. https://doi.org/10.1080/10630732.2011.601109

Lindskog, H. (2004). Smart communities initiatives. In *Proceedings of the 3rd ISOneWorld Conference* (Vol. 16, pp. 14–16).

Linstone, H. A. (1985). The Delphi Technique. In *Environmental Impact Assessment, Technology Assessment, and Risk Analysis* (pp. 621–649). Berlin, Heidelberg: Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-642-70634-9_22

Lokitz, J. (2018). Exploring Big Data Business Models - Business Models Inc. Retrieved May 14, 2019, from https://www.businessmodelsinc.com/big-data-business-models/

Lombardi, P., Giordano, S., Farouh, H., & Yousef, W. (2012). Innovation: The European Journal of Social Science Research Modelling the smart city performance. https://doi.org/10.1080/13511610.2012.660325

Lopez, V., Kotoulas, S., Sbodio, M. L., Stephenson, M., Gkoulalas-Divanis, A., & Aonghusa, P. Mac. (2012). QuerioCity: A linked data platform for urban information management. *Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, *7650 LNCS*(PART 2), 148–163. https://doi.org/10.1007/978-3-642-35173-0-10

Lueth, K. L. (2018, August 8). State of the IoT 2018: Number of IoT devices now at 7B – Market accelerating. Retrieved May 3, 2019, from https://iot-analytics.com/state-of-the-iot-update-q1-q2-2018-number-of-iot-devices-now-7b/

Lunsford, D. A., & Fussell, B. C. (1993). Marketing business services in central europe the challenge: A report of expert opinion. *Journal of Services Marketing*, *7*(1), 13–21. https://doi.org/10.1108/08876049310026060

Macpherson, L. (2017). 8 Years On, Amsterdam is Still Leading the Way as a Smart City. Retrieved June 11, 2019, from https://towardsdatascience.com/8-years-on-amsterdam-is-still-leading-the-way-as-a-smart-city-79bd91c7ac13

Magalhaes, G., Roseira, C., & Manley, L. (2014). Business models for open government data. In *Proceedings of the 8th International Conference on Theory and Practice of Electronic Governance - ICEGOV '14* (pp. 365–370). New York, USA: ACM Press. https://doi.org/10.1145/2691195.2691273

Mcilfatrick, S. J., & Keeney, S. (2003). Identifying cancer nursing research priorities using the Delphi technique. *Journal of Advanced Nursing*, *42*(6), 629–636.

Mcloughlin, S., Maccani, G., & Donnellan, B. (2018). A Framework for understanding & classifying Urban Data Business Models, (December).

Mcloughlin, S., Maccani, G., & Donnellan, B. (2019). *An Urban Data Business Model framework for identifying value capture in the Smart City : The case of Organicity*. Maynooth.

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

Miller, H. G., & Mork, P. (2013). From Data to Decisions: A Value Chain for Big Data. *IT Professional*, *15*(1), 57–59. https://doi.org/10.1109/MITP.2013.11

Moore, P. G., Lingstone, H. A., & Turoff, M. (1977). The Delphi Method: Techniques and Applications. *Journal of the Royal Statistical Society. Series A (General) TA - TT -*, *140*(2), 257. https://doi.org/10.2307/2344913 LK - https://eur.on.worldcat.org/oclc/7547290964

Mozuni, M., & Jonas, W. (2018). An Introduction to the Morphological Delphi Method for Design : A Tool for Future-Oriented Design. *She Ji: The Journal of Design, Economics, and Innovation*, *3*(4), 303–318. https://doi.org/10.1016/j.sheji.2018.02.004

Municipality Brno. (2019). DATA.BRNO. Retrieved May 4, 2019, from https://data.brno.cz/en/

Murry, J. W., & Hammons, J. O. (1995). Delphi: A Versatile Methodology for Conducting Qualitative Research. *The Review of Higher Education*, *18*(4), 423–436. https://doi.org/10.1353/rhe.1995.0008

Nam, T., & Pardo, T. A. (2011). Conceptualizing Smart City with Dimensions of Technology, People, and Institutions. In *12th Conference on Digital Government Research*. College Park. Retrieved from www.unfpa.org

Nambisan, S., Agarwal, R., & Tanniru, M. (1999). Organizational Mechanisms for Enhancing User Innovation in Information Technology. *MIS Quarterly*, *23*(3), 365. https://doi.org/10.2307/249468

Neirotti, P., De Marco, A., Cagliano, A. C., Mangano, G., & Scorrano, F. (2014). Current trends in Smart City initiatives: Some stylised facts. *Cities*, *38*, 25–36. https://doi.org/10.1016/J.CITIES.2013.12.010

Okoli, C., & Pawlowski, S. D. (2004). The Delphi method as a research tool: an example, design considerations and applications. *Information & Management*, *42*(1), 15–29. https://doi.org/10.1016/J.IM.2003.11.002

Osterwalder, A., & Pigneur, Y. (2002). An eBusiness Model Ontology for Modeling eBusiness. In *BLED 2002 Proceedings*. Bled. Retrieved from http://aisel.aisnet.org/bled2002/2

Osterwalder, A., & Pigneur, Y. (2010). *Business model generation: a handbook for visionaries, game changers, and challengers* (1st ed.). Lausanne: John Wiley & Sons, Ltd.

Ouariachi, T., Olvera-Lobo, M. D., & Gutiérrez-Pérez, J. (2018). *The Use of the Delphi Method to Define Criteria for Evaluating Online Climate Change Games*. *SAGE Research Methods Cases Part 2*. Thousand Oaks: SAGE Publications Ltd. https://doi.org/10.4135/9781526438317

Pan, Y., Tian, Y., Liu, X., Gu, D., & Hua, G. (2016). Urban Big Data and the Development of City Intelligence. *Engineering*, *2*(2), 171–178. https://doi.org/10.1016/J.ENG.2016.02.003

Papi, L., Bigoni, M., Bracci, E., & Deidda Gagliardo, E. (2018). Measuring public value: a conceptual and applied contribution to the debate. *Public Money and Management*, *38*(7), 503–510. https://doi.org/10.1080/09540962.2018.1439154

Parag, Y., & Sovacool, B. K. (2016). Electricity market design for the prosumer era. *Nature Energy*, *1*(4), 16032.

Pettit, C., Lieske, S. N., & Jamal, M. (2017). CityDash: Visualising a Changing City Using Open Data (pp. 337–353). Springer, Cham. https://doi.org/10.1007/978-3-319-57819-4_19

Phondej, W., Kittisarn, A., & Neck, P. A. (2011). The Seven Steps of Case Study Development: A Strategic Qualitative Research Methodology in Female Leadership Field. *Review of International Comparative Management*, *12*(124), 123–134.

Rådestad, M., Jirwe, M., Castrén, M., Svensson, L., Gryth, D., & Rüter, A. (2013). Essential key indicators for disaster medical response suggested to be included in a national uniform protocol for documentation of major incidents: A Delphi study. *Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine*, *21*(1), 1–11. https://doi.org/10.1186/1757-7241-21-68

Rayens, M. K., & Hahn, E. J. (2000). Building Consensus Using the Policy Delphi Method. *Policy, Politics, & Nursing Practice*, *1*(4), 308–315. https://doi.org/10.1177/152715440000100409

Rizk, A., Bergvall-Kåreborn, B., & Elragal, A. (2018). Towards a Taxonomy of Data-driven Digital Services. In *Proceedings of the 51st Hawaii International Conference on System Sciences*. Manoa. Retrieved from http://hdl.handle.net/10125/50022

Robinson, W. S. (1951). The logical structure of analytic induction. *American Sociological Review*, *16*(6), 812–818.

Rochet, J.-C., & Tirole, J. (2003). Platform Competition in Two-Sided Markets. *Journal of the European Economic Association*, *1*(4), 990–1029. https://doi.org/10.1162/154247603322493212

RUGGEDISED. (2019). *Urban data platforms – Governance and Buiness Models - A position paper*.

Saldaña, J. (2013). *The Coding Manual for Qualitative Researchers*. *International Journal* (2nd ed.). Thousand Oaks: SAGE Publications Ltd. https://doi.org/10.1017/CBO9781107415324.004

Santana, E. F. Z., Chaves, A. P., Gerosa, M. A., Kon, F., & Milojicic, D. (2016). Software Platforms for Smart Cities: Concepts, Requirements, Challenges, and a Unified Reference Architecture. *ACM Computing Surveys*, *50*(6). https://doi.org/10.1145/3124391

Satzger, B., Hummer, W., Inzinger, C., Leitner, P., & Dustdar, S. (2013). Winds of change: From vendor lock-in to the meta cloud. *IEEE Internet Computing*, *17*(1), 69–73.

Schmidt, J., Drews, P., & Schirmer, I. (2018). Charting the Emerging Financial Services Ecosystem of Fintechs and Banks: Six Types of Data-Driven Business Models in the Fintech Sector. In *Proceedings of th 51st Hawaii International Conference on System Sciences* (pp. 5004–5013). Waikoloa, Hawaii. Retrieved from http://hdl.handle.net/10125/50514

Schroeder, R. (2016). Big data business models: Challenges and opportunities. *Cogent Social Sciences*, *2*(1), 1–15. https://doi.org/10.1080/23311886.2016.1166924

Schwandt, T. A., Lincoln, Y. S., & Guba, E. G. (2007). Judging interpretations: But is it rigorous? trustworthiness and authenticity in naturalistic evaluation. *New Directions for Evaluation*, *2007*(114), 11–25. https://doi.org/10.1002/ev.223

Seagle, E., & Iverson, M. (2002). Characteristics of the turfgrass industry in 2020: a Delphi study with implications for agricultural education programs. *Journal of Southern Agricultural Research*, *52*(1), 1–13.

Shafer, S. M., Smith, H. J., & Linder, J. C. (2005). The power of business models. *Business Horizons*, *48*(3), 199–207. https://doi.org/10.1016/J.BUSHOR.2004.10.014

Skulmoski, G. J., & Hartman, F. T. (2007). The Delphi Method for Graduate Research. *Journal of Information Technology Education*, *6*.

Stabell, C. B., & Fjeldstad, Ø. D. (1998). Configuring value for competitive advantage: on chains, shops, and networks. *Strategic Management Journal*, *19*(5), 413–437.

Statista. (2019). • Netherlands - urbanization 2017 | Statistic. Retrieved June 17, 2019, from https://www.statista.com/statistics/276724/urbanization-in-the-netherlands/

Stebbins, R. (2011). Exploratory Research in the Social Sciences. *Sage Research Methods*, 2–17. https://doi.org/10.4135/9781412984249

Strategic Highway Research Program. (2013). Verification Case Studies. In *Incorporating Reliability Performance Measures into the Transportation Planning and Programming Processes* (pp. 35–40). Washington, D.C.: Transportation Research Board. https://doi.org/10.17226/22596

Strauss, A., & Corbin, J. M. (1997). *Grounded theory in practice*. Thousand Oaks: SAGE Publications Ltd.

Thomas, L. D. W., Autio, E., & Gann, D. M. (2014). Architectural Leverage: Putting Platforms in Context. *Academy of Management Perspectives, 28*(2), 198–219. https://doi.org/10.5465/amp.2011.0105

Tigelaar, D., Dolmans, D. D. H., Wolfhagen, H. a., & van der Vleuten, C. P. (2004). The development and validation of a framework for teaching. *Higher Education*, *48*(2), 253–268. https://doi.org/10.1023/B:HIGH.0000034318.74275.e4

Tiwana, A. (2014). *Platform ecosystems: aligning architecture, governance, and strategy*. Retrieved from https://www-safaribooksonline-com.eur.idm.oclc.org/library/view/platform-ecosystems/9780124080669/?ar&orpq

TomTom. (2019). TomTom Data Platform. Retrieved June 14, 2019, from https://developer.tomtom.com/

Turber, S., vom Brocke, J., Gassmann, O., & Fleisch, E. (2014). Designing Business Models in the Era of Internet of Things. In *Advancing the Impact of Design Science: Moving from Theory to Practice* (8463rd ed., pp. 17–31). Cham: Springer. https://doi.org/10.1007/978-3-319-06701-8_2

Ubaldi, B. (2013). *Open Government Data: Towards Empirical Analysis of Open Government Data Initiatives* (OECD Working Papers on Public Governance). https://doi.org/https://dx.doi.org/10.1787/5k46bj4f03s7-en

United Nations. (2019). About the Sustainable Development Goals. Retrieved February 3, 2019, from https://www.un.org/sustainabledevelopment/sustainable-development-goals/

van Osterhout, M., & Cllclough, G. (2019). Path to more targeted investment in smart cities and communities - Insights from the EIP-SCC network. In *Connected Smart City Conference 2019*. Brussels.

Van Urk, F., & Grant, S. (2016). Involving stakeholders in programme theory specification: discussion of a systematic, consensus-based approach. *Evidence & Policy* , *12*(4), 541–557. https://doi.org/10.1332/174426415X14474260456850

Vargo, S. L., & Lusch, R. F. (2016). Institutions and axioms: an extension and update of service-dominant logic. *Journal of the Academy of Marketing Science*, *44*(1), 5–23.

Veal, A. J. (2005). *Business research methods: A managerial approach*. Pearson Education Australia/Addison Wesley.

Visnjic, I., Neely, A., Cennamo, C., & Visnjic, N. (2016). Governing the City: Unleashing Value from the Business Ecosystem. *Califronia Management Review*, *59*(1), 109–141. https://doi.org/10.1177/0008125616683955

von der Gracht, H. A. (2012). Consensus measurement in Delphi studies: Review and implications for future quality assurance. *Technological Forecasting and Social Change*, *79*(8), 1525–1536. https://doi.org/10.1016/J.TECHFORE.2012.04.013

Vu, Q. H., Pham, T.-V., Truong, H.-L., Dustdar, S., & Asal, R. (2012). Demods: A description model for data-as-a-service. In *2012 IEEE 26th International Conference on Advanced Information Networking and Applications* (pp. 605–612). IEEE.

Wieland, H., Hartmann, N. N., & Vargo, S. L. (2017). Business models as service strategy. *Journal of the Academy of Marketing Science*, *45*(6), 925–943. https://doi.org/10.1007/s11747-017-0531-z

Woerner, S. L., & Wixom, B. H. (2015). Big data: extending the business strategy toolbox. *Journal of Information Technology*, *30*(1), 60–62.

Wolff, A., Kortuem, G., & Cavero, J. (2015). *Urban Data in the primary classroom: bringing data literacy to the UK curriculum*. Oxford. Retrieved from http://www.dataliteracy.eita.org.br/wp-content/uploads/2015/02/Urban-Data-in-the-primary-classroom-bringing-data-literacy-to

Worldometers. (2019, January 10). World Population by Year. Retrieved February 5, 2019, from http://www.worldometers.info/world-population/world-population-by-year/

Yin, R. K. (2009). *Case Study Research: Design and Methods* (4th ed.). Thousand Oaks: SAGE Publications.

Zikopoulos, P., & Eaton, C. (2011). *Understanding big data: Analytics for enterprise class hadoop and streaming data*. McGraw-Hill Osborne Media.

Zygiaris, S. (2013). Smart City Reference Model: Assisting Planners to Conceptualize the Building of Smart City Innovation Ecosystems. *Journal of the Knowledge Economy*, *4*(2), 217–231. https://doi.org/10.1007/s13132-012-0089-4

Appendix

Appendix 1: Interview Outline First Round Delphi Study

1. Introduction
- Introduction of the interviewer (Student, 24 years old, Master in Business Information Management at Erasmus, write my thesis on platforms and Smart City)
- Get consent for recording
- Purpose of the interview (done for University & Thesis)
- Mention why the participant has been selected (Role with an overview of the ecosystem of a UDP)
- Assure anonymity
- Assure that the made statements will not be personally identifiable
- Outline of the interview
- Questions of the interviewee?

2. General personal questions
- How are you/your organization engaged to an Urban Data Platform?
- How do you know the ecosystem of an Urban Dara Platform?
    - Activities performed for creation, maintenance or governance of the platform
- Is the UDP you are affiliated with operational? (since when?)
- Who is using the data from the UDP? (Business, Citizens, Machines, etc.)

- Who is supplying the data to the UDP? (City, Businesses, Citizens?)
- Do you see new business models enabled by the UDP?
    - Examples?
- How many public companies are engaged either supplying data to the platform or using data from it?

3. Business Model Canvas of Companies engaging with UDPs
- ➢ Explain Goal:
    - Framework for the analysis of business models of companies engaging with UDPs
    - Separate companies from a UDP perspective
    - Enable researchers to characterize companies engaging with a UDP
- ➢ What are your thoughts on the overall structural separation of the dimensions into dimensions with direct contact and indirect contact?
- The Dimensions (get expert opinion of each of them and discuss subdimensions):
    - Primary Platform Impact Dimensions (also look for relationships among them)
        - Type of platform services used
        - Type of Data Exchanged
        - Type of Access
        - Degree of Interoperability (No of UDPs that they are connected to and number of cities in which the company is targeting customers)
        - Native of UDP
    - Any additional dimensions that you belief are important to holistically describe the business models of companies engaging with UDPs?

- Operational Dimensions
    - Key Activities
    - Revenue Model
    - Costs
    - Public Value Generated
    - Target Customers
- Any additional dimensions that you belief are important to holistically describe the business models of companies engaging with UDPs?

4. Use Case Companies

- Do you know of any use cases of companies engaging with a UDP that employ novel business models, that I could approach for an interview/case study?

5. Follow Up

- Would you be willing to answer a short follow up questionnaire concerning the iterated dimensions of the framework in approximately two weeks' time?

Appendix 2: Example Interview Transcript

All other interview transcript can be obtained for the next five years from the following e-mail: rasmusramm@aol.com and were excluded from the appendix to avoid a too long appendix

Interviewer: I can imagine that Amsterdam has multiple operations, where they act as the users of Urban Data Platforms?

Ger Baron: Yes, we have multiple use cases where we are users of the urban data platform, as well as the operators of an urban data platform? I would like to show you one case that is in the mobility domain, because then we are not working with the data of individuals. That's always more complicated.

Ger Baron: So, we basically created an application starting from the idea that we wanted to know how many people are in Amsterdam right now to make sure that we can do cleaning, law enforcement, etc. more data driven. It's about being at the right place at the right moment. So, this interface shows you how many people we expect to be in Amsterdam right now. As you can see, we're are currently just as full as we expected. But in some areas, we are fuller than expected then you can see red indicators to show this. Yellow means we are right on target and green means there are less people than we predicted. We use public transport data, parking data, Google popular times data, TomTom data, ways, Airbnb and booking data Schiphol Airport Data and some other sources. These are all the data sets, which are not ours, but we have access to them and based on this we build our prediction model. So basically, each of these different data sources is an urban data platform. They are all open either for everyone of after signing an agreement and we connected to multiple of these UDPs to generate a product that in itself can be seen as a platform again, but not a UDP but more like a platform business model. The prediction model we are using ourselves and also offer it to interested parties. But this model itself is again another UDP in that sense.

Ger Baron: But this has some dilemmas in it as well. When we started, we needed a starting point for our prediction model. That's when we realized that you have the popular times option to show on Google Maps. Based on Google Maps they register where the user has been and collect when people go where to every point of interest in Amsterdam. We wanted to get the data from Google, but they didn't give us access, so we build a tool to scrape it from their website to put the data on the UDP. Then we added counting cameras, WIFI and much more. Now we don't use the Google Data anymore. So, then we realized that the model that we were able to build on the data that we gathered from all those UDPs. Basically, our data source is not owned by use and it is just a list of APIs we get the data from. We use it in traffic control centers. Once you have the model you can generate a million of visualizations from this. So, this was the starting point for us. We wanted to know how many people are in the city and then we connected to multiple urban data platforms and created a service that answers this question. To get the data we had to sign agreements with all those parties and we also add some data from Data.Amsterdam.nl which we can also combine with the data from the other UDPs. Both sources alone are not good enough, but when you combine them, and you build some models on top of them you can do very interesting things with it. So, we get the data from the vendors, but we cannot resell the data alone. So, obviously when we get some data from Google for example, we cannot resell the exact data that we got from them for free, but we can use it to create a product.

Ger Baron: I myself don't believe that government data alone represents value. I don't know any city that was actually able to generate considerable revenue from selling their data. So, Copenhagen waster 50 million in their project. American cities try making money with it and it didn't work. So, 9 out of 10 times the data that we have is not the correct data. But if we build a service out of it, then it becomes interesting for users and creates value.

Interviewer: [Introduction to the framework]

Ger Baron: So, you need APIs to some UDPs and then you have to combine it with your own data and then you generate value from this. But before you can combine it with your own data you need to have access to the data from the different UDPs. This is the most important part.

Interviewer: So, what is important to connect to the different UDPs?

Ger Baron: Metadata is really important. You need to know what data you are getting.

Interviewer: Looking at the first dimension where would you position the business model of the initiative that you just described?

Ger Baron: We are data users. We don't produce any data that we then supply to UDPs. We use data from multiple platforms. We get data from TomTom, Ways, etc. and also from the Transport Authority for example. So, it's a chain. We get the data than we build the application, and this is where we create the value. So, the value is not in the data that we get from the UDPs but in what we build out of it. But we also don't store any data, so we just have a bunch of APIs of all the other platforms to which we connect in the backend.

Interviewer: Very interesting. Let's move on to the type of data that you receive from the different UDPs. Starting with the domain of data.

Ger Baron: So, the big difference here is citizens and business. The other ones are all objects. Businesses and citizens are subjects. This can be a person or a legal entity. That's different because the owner of the subject data is the subject itself. If you create the data, it is your data. That's different than a lamp post in the infrastructure category for example. So, there are different ways to get access and different ways to share it. So subject related data has to be treated differently and we need to publish this to be transparent, but we don't publish this kind of data at all. So, we have access to Business data from the chamber of commerce and also, we are collaborating with MasterCard to get some of the payment data on an aggregated street level. To see which type of product is being bought. But I am not sure if we actually want this. We need to know where we end up. So, we get data from all domains except cultural which is something that we don't have at the moment. So, for example a customer of us is Google Maps. They use the fullness prediction to lead customers to the right parking spot. Based on our prediction model we know when the different parking lost might be full and then we direct customers to different parking lots when they want to go to the stadium. Then you can also make reservations for the different parking lots. We want to increase this offering even further, by providing more detailed predictions to Google, so that you can then navigate to your seat and it tells you where to park, where to go and how long it will take all depending on how crowded we predict the parking spots and the areas around it to be.

Interviewer: How about the variability of the data?

Ger Baron: Yeah, so this is both static and dynamic data. We are now looking more into real-time data, streaming data. For example, from the street management we are looking to get information about waste on the street. They get the camera footage in real-time of the street. But we don't want all the footage, we just want the aggregated data if there is waste on the street in real-time. We are working on that at the moment.

Interviewer: Ok so regarding the velocity, you have real-time data. Do you also use historic data?

Ger Baron: Yes, in the beginning when we started this two years ago, we used historic data as a basis to build the prediction models, for example the Google data about popular times, this was all historic data. But now we are running on real-time data, so the predictions that we make were shaped in the beginning by historical data, so they were the basis and now we add real-time data on top to say how many people will be where tomorrow.

Interviewer: How about the type of data?

Ger Baron: It is more aggregated data, but sometimes as for example with the camera footage we also get raw data that we have to convert and work on. But we would like to have aggregated data as much as possible.

Interviewer: How about the nature of the data that you are receiving?

Ger Baron: Because we are connected to multiple UDPs it is partly open and partly closed. If we get data that is closed than it is for free. We don't pay for the data. We try to push companies that are collecting data in public spaces to open up the data so that there is free access, so if you collect data in the public you should also share it with the public. And this works quite well so far. What we do also show is where the data came from and based on which data, we make our prediction, so that the organizations using our service know what is in the prediction that we generate. Also, we are planning to do audits with the partners from which we receive the data, so that we know how they got to their data and how they process it. Or let other firms do audits on their algorithms.

Interviewer: Moving on to the Type of Access.

Ger Baron: This is just APIs. It's both streaming and REST API its' easier this way.

Interviewer: How about the degree of interoperability?

Ger Baron: So, we are currently connected to 13 urban data platforms. Three from the municipality, like transport authorities, etc. And 10 private ones like Google, TomTom they all have UDPs and we connect to them with APIs.

Interviewer: How important was interoperability for the overall business model pf the company?

Ger Baron: The platforms that we connected to are not that advanced in their operations. Sometimes we created de facto standards for getting the data. But what is also interesting is the interoperability of the service that we are producing. So, when Google uses our prediction model for example they also want interoperability because they again combine the information that we give to them with other data. So, they don't want to get information from different cities in different formats. But because we are such a large city, the customers of our product and the suppliers, so the UDPs listen to us and we have quite an advantage compared to smaller cities or companies who want to build such a model.

Interviewer: Alright moving on to the next dimension. Native of the UDP.

Ger Baron: So, regarding the model that we have built we are very highly dependent on the data from the different UDPs, as I said. With our data alone, we cannot generate such a model, so we need to combine it with other data. I would argue that this is something like a 1so we are pure players in that sense.

Interviewer: So which key activities are you currently performing regarding your business model?

Ger Baron: Application development is the most important. So first it is data enrichment, when we combine their external data with our data and then we perform analytics based on them and based on this we have created an application, and this is the end-product after all. And actually, by offering our service we might also be collecting user data in the end. But this is sort of another step that might happen.

Interviewer: What about the revenue model?

Ger Baron: It can be subscription or licensing. We won't sell the model and the application as such. Pay per use maybe but not sure. And within the city it will be internal efficiency. So, the different departments of the city don't need to pay for the information, but we will share it with them, so that they can be more efficient in their job. For example, if there are a lot of people expected to be in a certain area of the city we send more garbage trucks there, so they can do a better and more efficient job because we can anticipate up front how many people are going to be where.

Interviewer: How about the partner ecosystem? Do you have any key partners?

Ger Baron: We don't need any partner to build our software or something like this. We do that ourselves. I am not a big fan of the outsourcing for such things. If you get an out of the box product it is never what you want. It is also more expensive if we outsource it sometimes. We are also way faster to develop something when we build it ourselves. So, we do hire people to build this, so you could say that we use freelancers to help us, but not too much.

Interviewer: Alright. Moving on to the second to last dimension. The offering.

Ger Baron: So, this is information or knowledge that we offer. So how many people will be where. This information in real-time. So, data is not our business with the data that we collect from our users we don't want to generate any revenue so just information or knowledge.

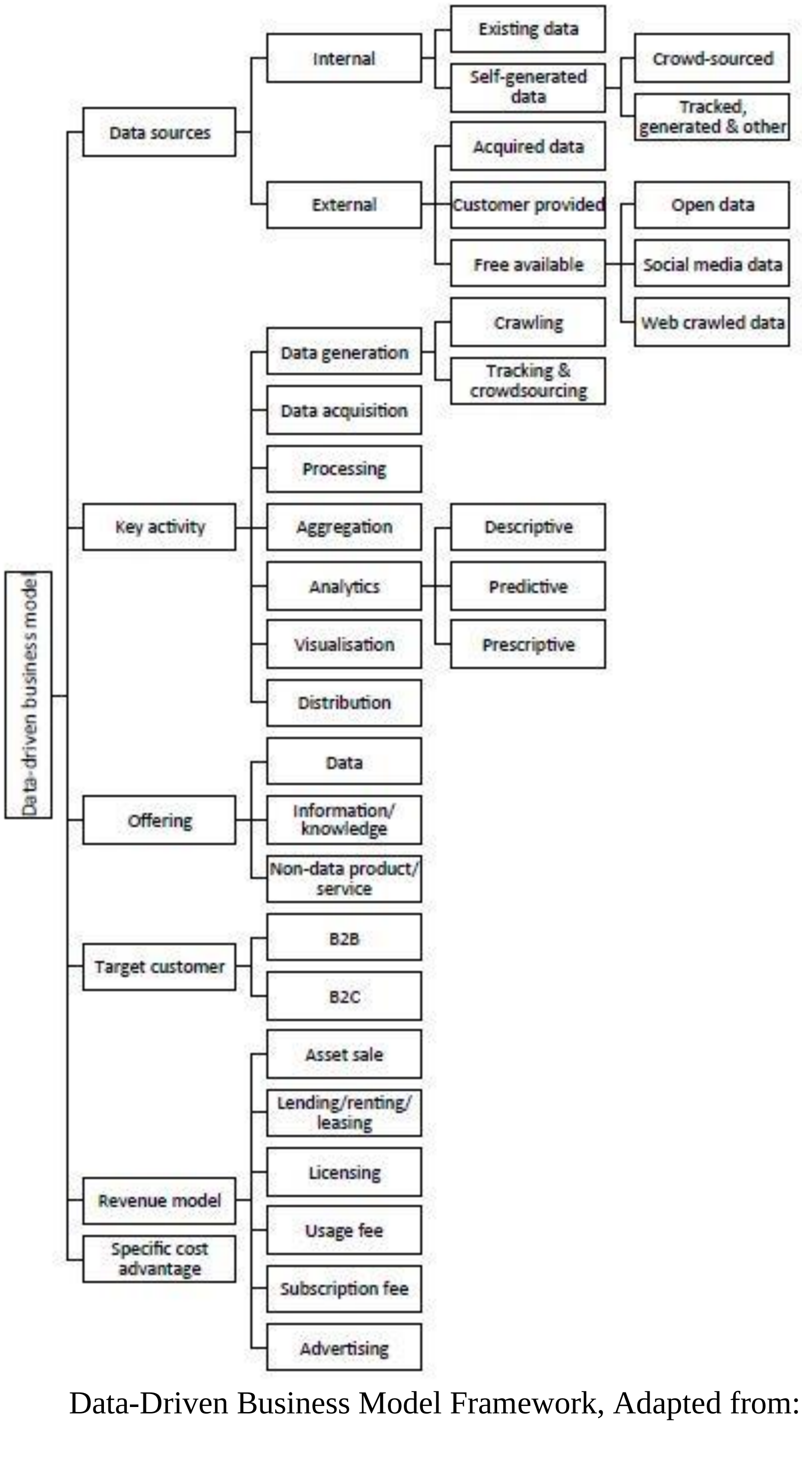
Interviewer: Moving on to the last dimension the target customer.

Ger Baron: So, the first target customer of the service that we offer is the government and they will remain the largest group. Other entities of the city will use this information to for example change the routes of the city cleaning trucks. So, every morning they use our service to see where is it going to be crowded and then they can change the routing of their trucks. Secondly, we also want to give this to businesses we want to work with them on customer journeys so for examples with Schiphol Airport so that they know how many people to expect of for events that the organizing companies know how many people are coming and where they are moving. And thirdly it is going to be citizens. Amsterdam is getting crowded with tourists this is one of the main issues that the citizens have at the moment. When we provide data on how many people are here how many people are coming this could be a service to the citizens a bit like the weather forecast, so that they know where it's crowded, and they might not want to go there and where it is less crowded, so they rather go there. But this is going to happen in the next stage, so the access is not yet open for citizens. We are sorting out legal issues, but we might go live in the next weeks. So, for the municipality it will be an efficiency model that they increase their efficiency, for the businesses it will be an added value to use for their product or service and for the citizens it will be additional information that they can use and also a bit of transparency.

Interviewer: Thank you very much for taking the time and this interesting interview.

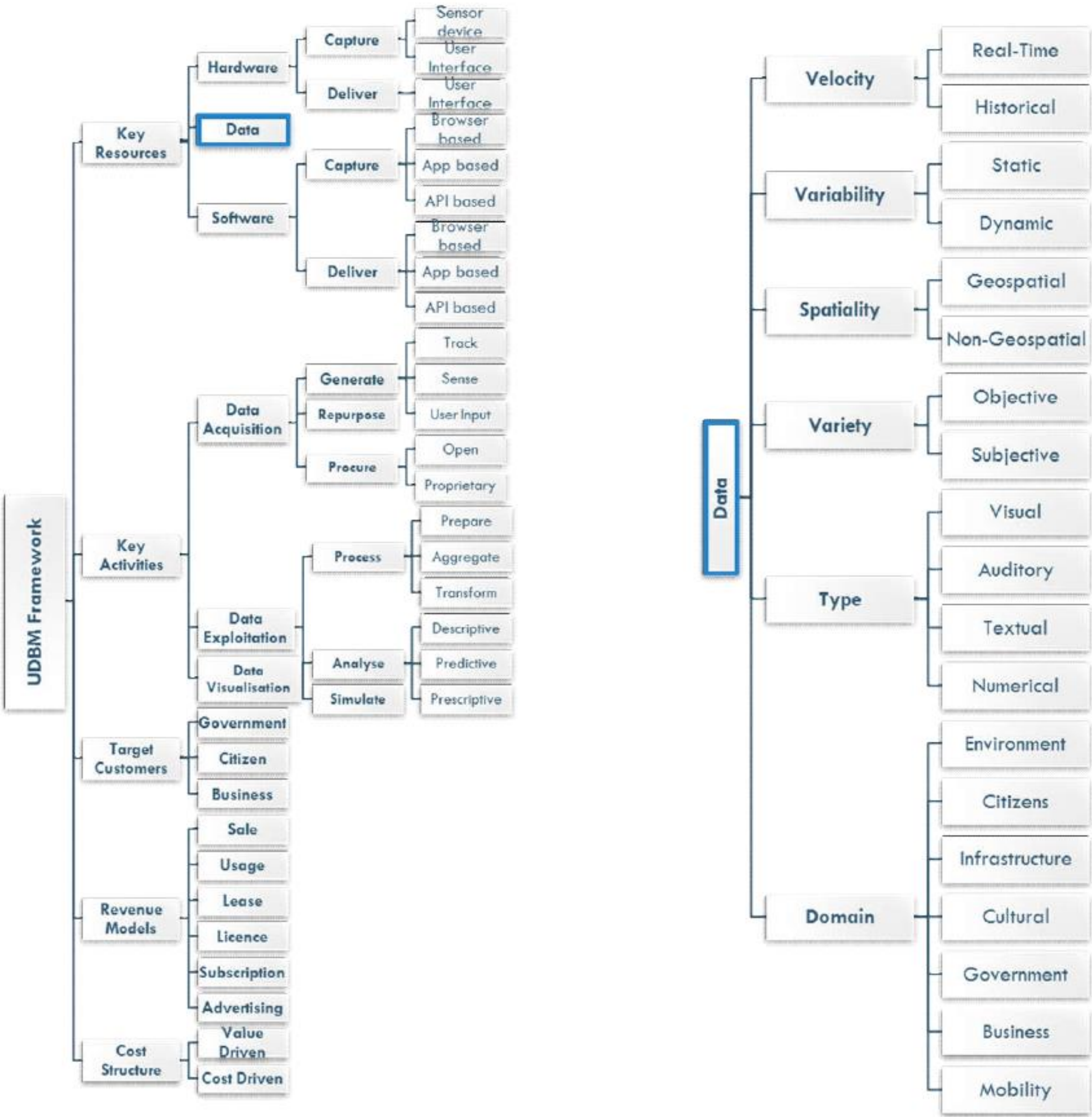
Ger Baron: No problem. Good luck with your work!

Appendix 3: Data-Driven Business Model Framework



Data-Driven Business Model Framework, Adapted from: Hartmann et al. (2014), p.11

Appendix 4: Urban Data Business Model Framework



Urban Data Business Model Framework, Adapted from: McLoughlin et al. (2018), p.11

Appendix 5: Example Question from Qualtrics Questionnaire used in Round 2 of the Delphi Study

Q7 **2 Main Dimension: Type of Data Exchanged**

Agreement - Dimension should remain in final framework
Disagreement - Dimension should be removed from final framework

Explanations in these brackets [] if required

	Strongly Agree (1)	Agree (2)	Neutral (3)	Disagree (4)	Strongly Disagree (5)
Type of Data Exchanged (1)	○	○	○	○	○

Display This Question:

If 2 Main Dimension: Type of Data Exchanged Agreement - Dimension should remain in final framework Disa... = Strongly Agree

Or 2 Main Dimension: Type of Data Exchanged Agreement - Dimension should remain in final framework Disa... = Agree

Q8 **2.1 Sub-dimension for Type of Data Exchanged**
Do you believe the following sub-dimensions to be **possible for the** Type of Data Exchanged**?**

Agreement = an organization engaging with a UDP **might have such a** Type of Data Exchanged
Disagreement = **no organization** engaging with a UDP **might be using such a** Type of Data Exchanged

Explanations in these brackets [] if required

	Strongly Agree (1)	Agree (2)	Neutral (3)	Disagree (4)	Strongly Disagree (5)
Domain [Mobility, Environment, Infrastructure, etc.] (1)	○	○	○	○	○
Variability [Dynamic vs. Static] (2)	○	○	○	○	○
Velocity [Historic vs. Real-Time] (3)	○	○	○	○	○
Type [Raw vs Aggregated] (4)	○	○	○	○	○
Nature [Open vs Closed] (5)	○	○	○	○	○

Appendix 6: Case Study Protocol for Interviews

1. **Introduction**

- Introduction of the interviewer: Student, 24 years old, Master in Business Information Management at Erasmus, write my thesis on the interaction between businesses and urban data platforms
- Purpose of the questionnaire: done for University & Thesis – no commercial purpose!
- Consent for mentioning his name and company during research
- Consent for recording
- Questions before we start?

2. **General Company Information:**

- Core Business
- Company Value Proposition
- Public vs Private

3. **Introduction of UDP by me**

4. **Introduction to use case with UDP:**

- How are you engaged to an urban data platform?
- General setting: Private (Free engagement vs. Contracted) vs. Public

5. **Business Model Canvas of Companies engaging with UDPs**
    - Discuss Dimension by dimension
    - Platform Dimensions:
        - Type of engagement
        - Type of data exchanged:
            - Velocity
            - Variability
            - Type
            - Domain
            - Nature
        - Type of access
        - Degree of interoperability
        - Native of UDP
    - Operational Dimensions:
        - Key activities
        - Revenue model
        - Partner ecosystem
        - Offering
        - Target customer
6. **Interrelations between dimensions**
    - Did one dimension influence the other