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THE DYNAMIC INTERPLAY BETWEEN PLATFORM AND PILOT

How digital platforms contribute to the upscaling processes of smart city pilots

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IHS
Making cities work

Gemeente Rotterdam

The dynamic interplay between platform and pilot:

How digital platforms contribute to the upscaling processes of smart city pilots

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Summary

Cities are trying to counter complex urban planning challenges by transforming their city into a 'smart city'. One major policy instrument that aims contribute to this is the initiation of smart city pilots. Moreover, cities are also establishing digital platforms that facilitate interaction within and between communities. However, these two developments are accompanied by two issues, namely a practical issue as well as a knowledge issue. First, a main practical issue is that smart city pilots are popping up in every major city, while they often fade out after the pilot phase and fail to come up with scalable solutions. Second, there is a knowledge issue regarding the relationship between smart city pilots and digital platforms. Cities that aim to become *smart* are more and more adopting so-called 'open innovation platforms' to foster smart city pilots, but there is no academic consensus about the added-value that that these platforms have in the upscaling process of pilots. An interesting case of the development of a digital platform is *the Digital Twin* in Rotterdam. To address the abovementioned issues, the following research question is investigated: *What is the role of the Digital Twin in upscaling processes of smart city pilots in Rotterdam and how can this role enhance these upscaling processes?*

This research question is examined by conducting interviews with different actors that are involved in four pilots related to the Digital Twin, namely: SAFE3D, QR code visualisation through augmented reality, participation and 3D building permits. To measure the concept of *upscaling processes*, the theoretical framework is presenting an overarching categorization of technological, human and institutional conditions. The concept *the role of the platform* is divided into two main roles, namely integrating technology and fostering collaboration, with both their subdimensions. The results of this research are that the technical conditions are not present in the pilots, the human conditions are mostly present in the pilots and the institutional conditions are differing in presence between the pilots. The role that the platform plays in the upscaling process consists mainly out of four ways. First, the role of transversal and interoperable systems contributes to the technical conditions, namely data standards and an accessible IT infrastructure. Second, leverage dynamics contribute to a lower threshold to join a collaboration because of the creation of a shared reality and therefore increases the institutional conditions. Third, attractor effects stimulate the institutional conditions because it increases the engagement of third parties. Fourth, synergy is stimulating the governance of data-sharing by fostering the resource sharing amongst actors. Because of their complex and face-to-face nature, the human conditions are only limitedly facilitated by the platform and should be organized in a non-platform environment. Thus, for each pilot that is launched, the initiators should take in consideration how the platform can be used in their advance and which upscaling conditions need to be organized in a non-platform environment.

Preface

Conducting research on the cutting edge of innovation within the field of smart cities is inspiring, challenging and relevant for the future. Inspiring because of the fact that I had the opportunity to follow an internship at the digital city and data-driven organization programmes of the municipality of Rotterdam I literally had a look behind the scenes how innovation in the public sector could take place. Challenging because, with the emergence of big data and the platform economy, governments all over the world have to reinvent the way they are working, what their role is in this changing world and how they can ensure public value in the digital society. Relevant because this field of research is relatively new and I am investigating a conceptual relationship that had limited academic attention. The thesis process has been a challenging and long process in which I, due to the Corona crisis, spent most of my time together with my laptop. Therefore, the working activities that I had to do related to my internship at the municipality of Rotterdam were a welcome change. In particular I want to thank Roland van der Heijden for the opportunity to undertake an internship within the *Digital City* program and for this enthusiastic and inspiring vision on the future of city life. Moreover, I want to thank Ingrid Klunne and the rest of team *datadiensten* for the weekly structure and phone calls that helped maintaining the connection with the organization in a time of working from home. Furthermore, I want express my gratitude to Jan Fransen for the substantive supervision and helping me keeping track of the point on the horizon and Peter Scholten who became my second supervisor spontaneously halfway the thesis process.. Finally, I would like to thank all the people in my immediate surroundings, friends, family, fellow students and my girlfriend for tolerating my complaints and help to cocreate the development of ideas for my thesis. All of this resulted in this wonderful end product: a master thesis on the relationship between digital platforms and smart city pilots.

I wish you a lot of reading pleasure.

Hugo Hegeman
19th of July 2020

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1. Introduction

All over the world, people are more and more settling down in cities. According to the United Nations (2018), 55% of the world's population is living in urban areas, a proportion that is only about to increase, up to 68% in 2050. This rapid urbanization is exerting pressure on fresh water supplies, the living environment, and public health (United Nations, 2020). In other words, this population growth leads to the fact that local governments need to face new and more complex issues. To address these problems, the concept of 'smart cities' was coined. Cities are aiming to counter complex urban planning challenges by trying to transform their city into a 'smart city' (Kuyper, 2016). When the concept of smart cities came up in the societal and scientific discourse, this led to an immense increase in cities that wanted to become smart (Hollands, 2008; Kuyper, 2016). At the beginning of 2018, smart city pilots attracted technology investments of more than $81 billion globally. This number is only expected to grow, to a total amount of $158 billion in 2022, according to the new release of the International Data Corporation (IDC, 2019). Not only the amount of money but also the number of smart city projects is increasing exponentially. In 2014, there were approximately 143 smart city projects worldwide (Lee, Hancock & Hu, 2014), while in 2018 there were already 1.000 smart city projects (The Economic Times, 2018). These projects are focused on addressing sustainability issues, improving the effectiveness of urban services, and enhancing the quality of life of citizens (van Winden & van den Buuse, 2017). Another policy instrument that is being used to become a smart city is the establishment of digital platforms. These platforms are online networks that facilitate digital interactions between people (Deloitte, 2019). The creation of platforms in the public sector can foster collaboration between different governmental institutions and place citizens at the heart of public service delivery (Demos Helsinki, 2018). Moreover, these platforms are a new way in which governments can engage with local communities (Demos Helsinki, 2018).

1.1 Problem statement

The problem statement that is central in this research is two-fold, consisting out of a practical issue as well as a knowledge issue. First, the main practical issue is that smart city pilots are popping up in every major city, while they often fade out after the pilot phase and fail to come up with scalable solutions that increase the quality of urban life (van Winden & van den Buuse, 2017). Therefore, the impact of these pilot projects on urban development remains limited (Van Winden, 2016). The lack of scaling of smart city pilot projects is widely perceived as a major problem that needs to be addressed (van Winden & van den Buuse, 2017). The European Innovation Partnership on Smart Cities and Communities (EIP-SSC) even states that scaling is crucial in order to make these projects economically sustainable and effective in tackling societal issues (EIP-SCC, 2013). Second, there is a knowledge issue regarding the relationship between smart city pilots and urban digital platforms. As stated, cities that have formulated the ambition to become a smart city are more and more adopting so-called 'open innovation platforms' as important policy instruments (Cotton, 2018; City Framework Guide, 2014). The main function of these platforms is to organize innovation processes and co-creation practices in one environment in order to create value (Raunio, Nordling, Ketola, Saarinen & Heinikangas, 2016). Within the academic literature, there has been written a lot both on digital platforms as well as smart city pilots, but the existing body of knowledge fails to explain the relationship between these two phenomena. Investigating the link between these smart city pilots and digital platforms will require more research, to which this thesis aims to contribute. In conclusion, it is the question if addressing the abovementioned knowledge issue on the relationship between digital platforms and smart city pilots could potentially help to solve the practical issue that these pilots often fail to scale up. In other words: could a digital platform be an instrument to scale up smart city pilots?

1.2 The case of the Digital Twin

An interesting case of the development of a digital platform in the public sector is 'the Digital Twin' in Rotterdam. The municipality of Rotterdam is working together with a broad range of stakeholders to create a digital 3D copy of the city (Platform31, 2018). In the Digital Twin all the information and data that is available in Rotterdam is bundled in one digital environment (Ten Kate, 2019). This platform can be used in a broad range of possible ways, for example, the fire department can have access to see which routes can be used to get into buildings that are on fire (Ten Kate, 2019; Rotterdam, 2019; see figure 1). Despite the fact that the Digital Twin is still under development, there are already some smart city pilots initiated related to the platform.

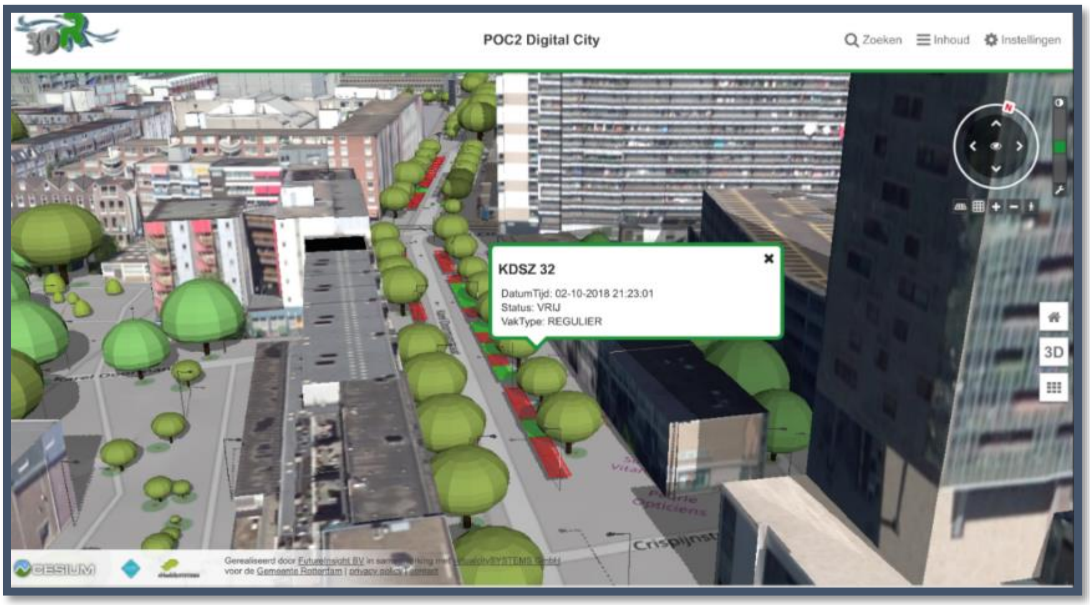

Figure 1: visualisation through the Digital Twin

1.3 Research aim and question

The aim of this research is to understand the role of the Digital Twin in facilitating the upscaling process of smart city projects. To do so, this research will explain the relationship between the platform and the related pilots Therefore, it is interesting to look at the role of the Digital Twin in the upscaling process: which success conditions for upscaling can be realized through the use of the Digital Twin? This leads to the following research question: *What is the role of the Digital Twin in upscaling processes of smart city pilots in Rotterdam and how can this role enhance these upscaling processes?*

To answer this main research question, multiple sub-questions are investigated. Some of these questions will be answered in the literature review and others will be answered in the empirical analysis of this research.

1.3.1 Theoretical questions

1. What are the different types of upscaling?
2. What are the success conditions for upscaling smart city pilots?
3. What are the functions of digital platforms?
4. How can digital platforms contribute to the upscaling processes of smart city pilots?

1.3.2 Empirical questions

5. To what extent are the smart city pilots related to the Digital Twin already in the process of upscaling?
6. Which upscaling conditions are present in smart city pilots that are related to the Digital Twin?
7. How can the Digital Twin enhance the upscaling conditions present in the smart city pilots related to the platform?

1.4 Relevance

1.4.1 Societal relevance

The societal relevance of this research becomes obvious when linked to the potential benefits of smart city pilots. After all, when the dynamics of a successful relationship between smart city pilots and the platform the Digital Twin become clear, this can be used to upscale these pilots and broaden their added value. Upscaled pilots can contribute to local economic growth, more efficient public service delivery, higher citizen engagement and more sustainable cities (Kortit & Nijkamp, 2012; Smart EU-China & Green City Cooperation, 2014). In addition to this, van Winden and van den Buuse (2017) argue that upscaling smart city pilots improves the chance that sustainable issues get addressed and that the quality of life of citizens increases. Therefore, the upscaling of smart city pilots could address the objective of the Sustainable Development Goal: "make cities inclusive, safe, resilient and sustainable" (United Nations, 2020). As mentioned earlier, one of the pilots focuses on increasing the effectiveness and efficiency of fireman activities. Thus, the pilot contributes to the overall safety within Rotterdam. If the Digital Twin can foster the upscaling processes of this specific pilot, the positive effects on safety will spread to the whole city.

1.4.2 Academic relevance

The emergence of smart city concepts and digital platforms is a relatively new development in scientific research, which leads to the fact that the existing literature lacks clear definitions (Dameria & Cocchia, 2013). The significant amount of knowledge that is available in this field focuses on defining and conceptualizing smart cities on a high level of abstraction. Ansell and Gash (2018) agree on this by stating that detailed case studies are lacking when it comes to identifying the dynamics of public platforms as governance strategies. The fact that this research will focus on a more in-depth understanding of smart city pilots in relation to digital platforms adds value to the existing body of literature. There are a few authors that zoom in on the concrete level of smart city pilots (Kuyper, 2016). Hielkema and Hongisto (2013) identify upscaling processes of smart city pilot projects and Knorringa, Meijerink & Schouten (2011) describe the different challenges that occur when governments aim to upscale smart city pilots. There are also some academic authors that focus on the role of digital platforms in urban environments (Kenney & Zysman, 2015). What is missing in the scientific literature, is the connection between these two streams of literature: what is the relationship between digital platforms and smart city pilots? This literature gap can be closed by zooming in on the role that digital platforms can play in upscaling processes. This way, this research will make a significant contribution to the scientific literature.

1.5 Research outline

After the introduction of the research topic, the most important theoretical concepts will be discussed in chapter two, namely upscaling conditions and digital platforms, which will lead to the conceptual model of this research. The third chapter explains the methodological approach that is taken in this research, in this case, a qualitative analysis of four pilot projects that are linked to the Digital Twin. The fourth chapter analyses the presence of upscaling conditions within the four pilot projects and zooms in on the added-value of the platform to these conditions. The fifth chapter discusses the most remarkable results in the light of the existing literature and will present a new, enriched conceptual model. The sixth and final chapter will summarize the results, form the conclusions, discuss the limitations of this research and present scientific and practical implications.

2. Theoretical framework

In the theoretical framework, the most relevant concepts in the field of smart cities and digital platforms are being discussed. The following concepts are addressed: smart cities and smart city pilots, upscaling conditions of smart city pilots and the role of digital platforms. Moreover, the pilots between the two main concepts of this research, namely upscaling conditions and digital platforms will be outlined. Finally, the conceptual model that forms the basis of this research will be presented. In figure 2, the overview of the theoretical framework is visually represented.

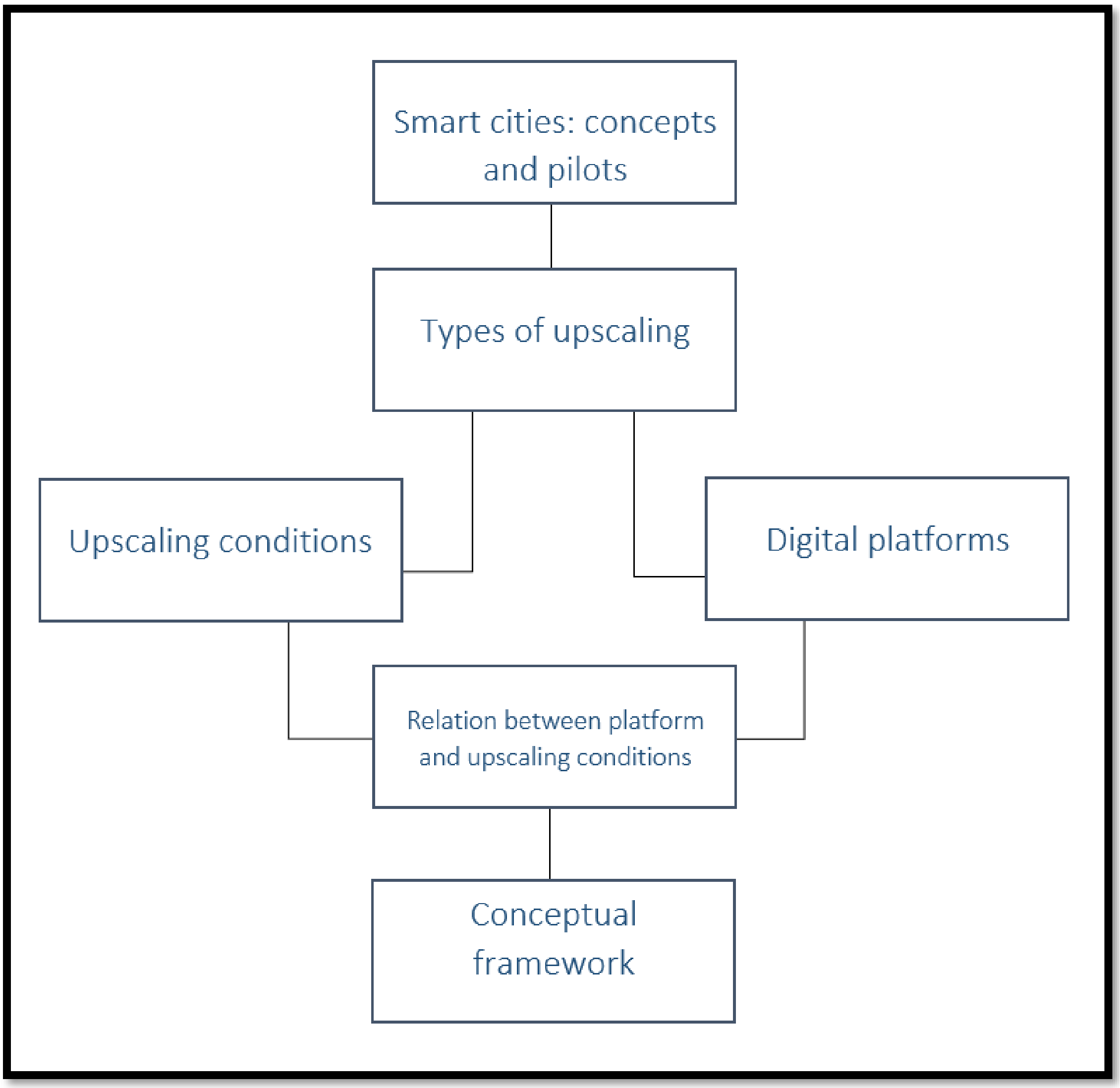

Figure 2 table of contents theoretical framework

2.1 Smart cities

There are some difficulties in defining the concept of smart cities. In the discourse, new hypes, such as smart cities, are constantly popping up (Hollands, 2008). In this era, it seems like every city wants to be smart, but what that contains remains vague (Lombardi, Giordan, Farouh and Yousef, 2012). To pin down what it takes to be a smart city, Nam and Pardo (2011) reviewed all the existing literature and re-categorized their insights in three main categories, namely: technology, human and institutions (See figure 3). First, issues of technological infrastructure and enabling technologies are at the heart of smart cities (Nam & Pardo, 2011). The key to a digital, smart city is the infrastructure and interoperability of the technologies within the city that facilitate interconnectedness between public services and actors (Yovanof & Hazapis, 2009). Second, the presence of human capital and education in urban environment defines the smartness of cities (Nam & Pado, 2011). Human factors, like lifelong learning and participation in public life, play a key role in becoming a smart city (Giffinger & Gudrun, 2010). Third, institutional factors are of key importance to define smart cities. Smart governments need to interconnect dynamically with citizens, communities and businesses to stimulate innovation (Nam & Pado, 2011; Caragliu, Del Bo & Nijkamp, 2009).

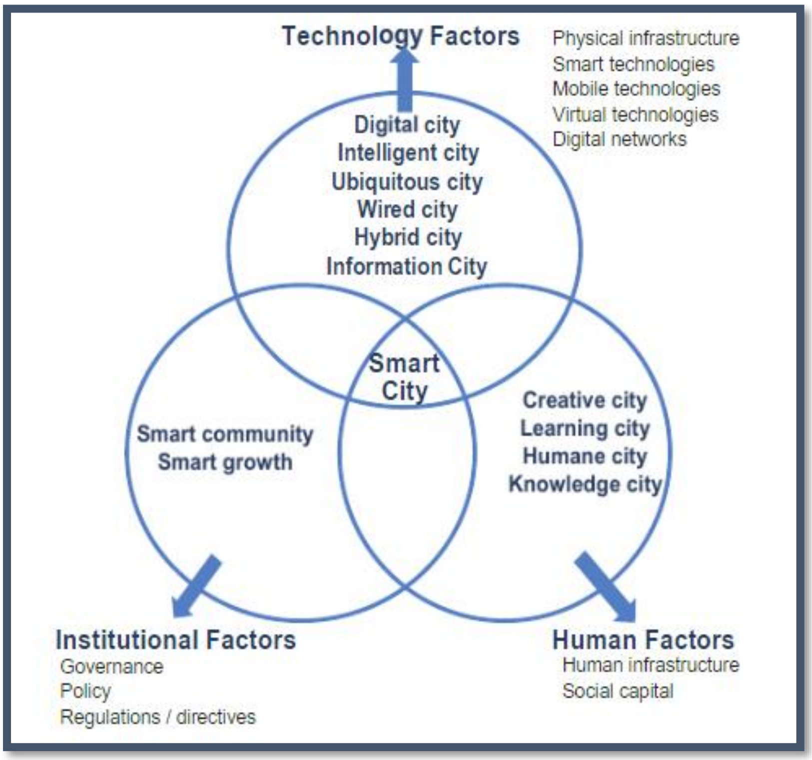

Figure 3 Fundamental components of Smart City adapted from Nam and Pado (2011)

2.1.2 Smart city pilots

The question remains how to take the first concrete steps in becoming a smart city. In the literature, the answer consists mainly out of initiating smart city projects that contribute to the overall goal of becoming a smart city (Hollands, 2008; Townsend, 2014). Smart city pilots come in many forms, sizes and types and are emerging in every city around the world (Van Winden & van den Buuse, 2017). The underlying idea of this growth is that these pilots contribute to more liveable, sustainable and inclusive cities. (Townsend, 2014). However, it is important to keep in mind that smart cities are not just the sum of its parts (Deloitte, 2015). There is a danger that cities will end up initiating all kinds of pilot projects that have a limited scope or impact and do not interact with each other (Deloitte, 2015). Therefore, upscaling these pilots is a crucial element in becoming a smart city (Van Winden, 2016). The next step is to discuss what it takes for smart city pilots to scale up.

2.2 Upscaling smart city pilots

To address complex urban issues, the literature commonly suggests that smart city pilots need to upscale (Van Winden, 2016). In this subchapter, the most important stream of literature related to upscaling is presented: Strategic niche management. Subsequently, this chapter will dive deeper into the multiple types of upscaling. Finally, the success conditions that need to be present to upscale smart city pilots will be discussed.

2.2.1 Strategic niche management

The literature on strategic niche management has a prominent role in innovation studies, especially when it comes to upscaling pilots (Dijk, De Kraker & Hommels, 2018). Geels (2004) makes this theory more concrete by constructing a 'multi-level perspective on socio-technical transitions'. This model visualizes the adoption of radical innovations, that are developed in protected areas, by the socio-technical regime, which is the collection of established practices and rules (Geels, 2011, see figure 4). Seen from the multi-level perspective, upscaling refers to mechanisms by which niche innovations get adopted by the socio-technical regime (van Winden, 2016; Geels and Schot, 2007). Thus, a pilot is upscaled when it is able to fit in the established formal and informal institutions. This is, however, a somewhat superficial way of describing the upscaling process. In practice, the mechanisms of upscaling are far more complex and multi-dimensional, which will be discussed in the following paragraph.

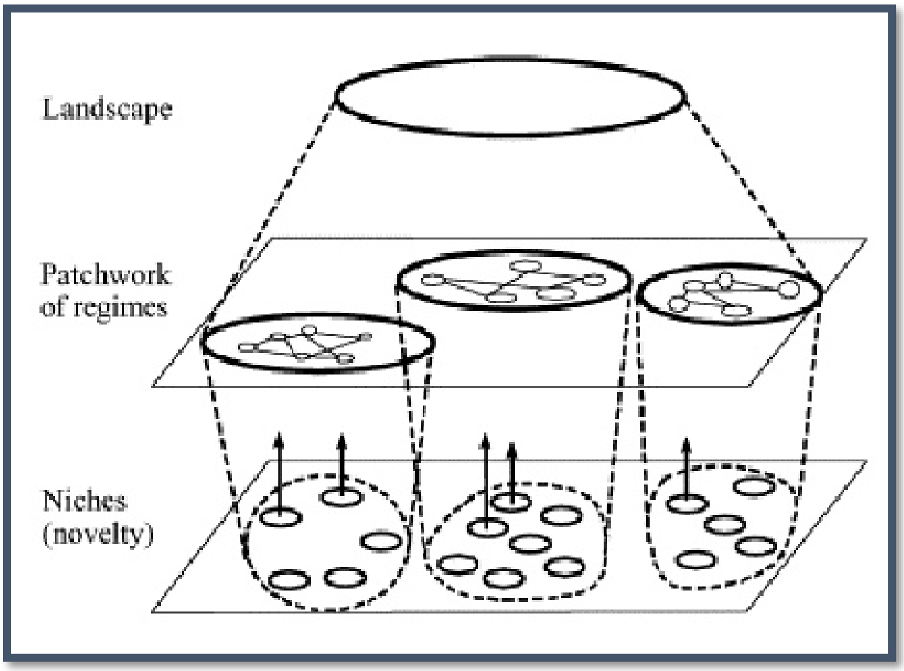

Figure 4 Multi-level perspective socio-technical transitions (Geels, 2004)

2.2.2 Definition and dimensions of upscaling

As mentioned, there are several definitions of upscaling. Hartman and Linn (2008), state for example that upscaling means "expanding, adapting, and sustaining successful policies, programs, or projects in different places to reach a greater number of people". However, the concept of upscaling contains more than just reaching more places or people (Ulvin, 1995). To illustrate this, Van Winden and van den Buuse (2017, see figure 5) identify three different scaling types: *roll-out*, *expansion* and *replication*. *Roll-out* focuses on the application of the initiative in the area that it is already in. It means that the specific smart city solution or pilot is brought to the consumer. *Expansion* contains the increase of partners, users or functionalities of a certain pilot or enlarging the geographical area. *Replication* aims to copy and use the solution that has been created in a certain pilot into another context.

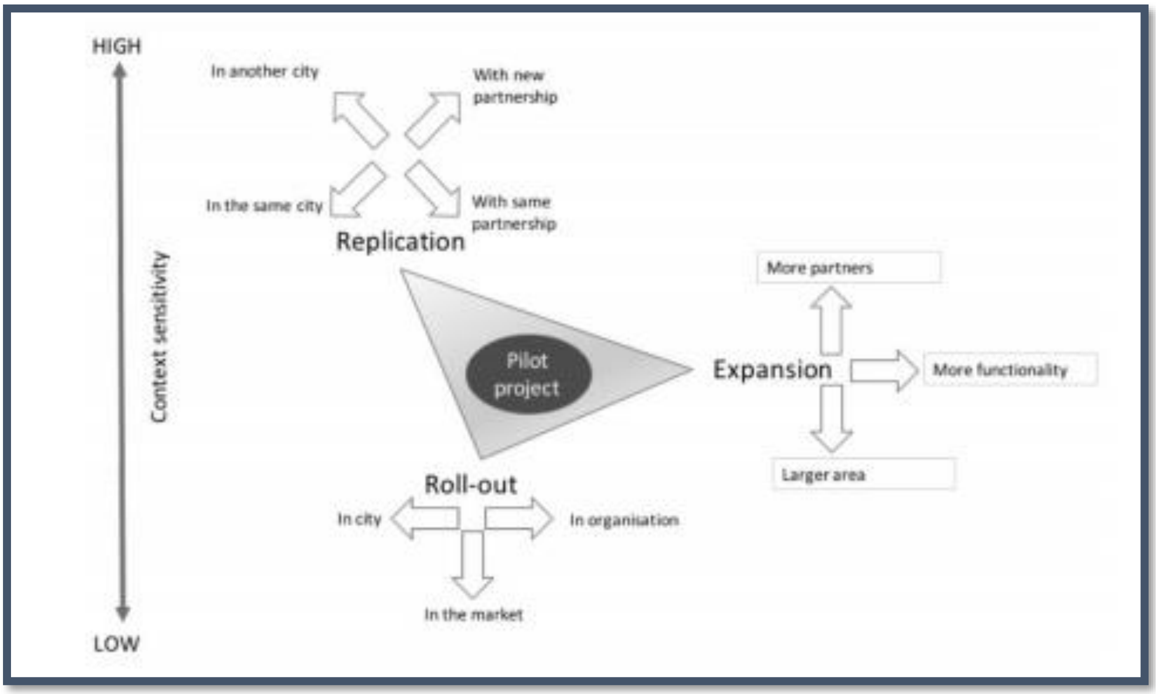

Figure 5 types of upscaling (van Winden, 2016)

2.2.3 Conditions for upscaling

In recent years, a broad range of conditions that could contribute to the successful upscaling of smart city pilots has emerged. However, an overarching, more comprehensive approach to these success conditions is lacking (Buntak et al., 2019). The only overarching model related to success conditions in smart cities comes from Nam and Pado (2011). Their distinction of technical, human and institutional factors is, however, mainly focused on the city-level instead of the pilot-level and therefore remains somewhat superficial. Therefore, a translation of their categorization to the pilot-level will be made by critically reflecting on the existing literature and bundling the insights of different academic authors together. By doing this, a new overarching framework of upscaling conditions is presented, using the fundament of the categorization, as described by Nam and Pado (2011), namely technical conditions, human conditions and institutional conditions.

Technical conditions

In academic research, technology is one of the main components of smart cities (Dirks & Keeling, 2009; Ebrahim & Irani, 2005). The emergence of new ICT solutions and technologies are the driver of smart city pilots (Hollands, 2008). Therefore, there are two relevant success dimensions for upscaling that need to be mentione: *ICT infrastructure* and *data standards* (Ebrahim and Irani, 2005; Alawadhi et al., 2012). Firstly, *ICT infrastructure* focuses on the availability of reliable IT networks and communication systems (Dillon and Pelgrim, 2002). This means that the systems need to be interconnected to ensure its accessibility (Heeks, 2001). Moreover, the different governmental systems need to be integrated and able to 'talk' to each other. (Moon, 2002). Secondly, smart city projects are often built upon data sets and the potential for data exchange between organizations (van Winden and van den Buuse, 2017). Therefore, the presence of *widely accepted technical (data) standards* is a major success condition is scaling up smart city projects. Van Winden and Van den Buuse (2017) argue that this is especially relevant for multi-stakeholders, platform-type projects in which data exchange and sharing is a key element.

Human conditions

Regarding human conditions, there are three important success conditions described in the existing literature: *reflecting and evaluating*, *transferring and sharing information* and *skills and competences*. Firstly, Bekkers et al., (2013) state that an open culture in which actors are able to *reflect* on the process and where progress is made through 'trial and error' is of major importance. This learning-by-doing is needed to improve the pilot. Oomen (2016) agrees on this by stating that learning capabilities and processes are crucial for the upscaling process. Moreover, van Winden and van den Buuse (2017) argue that *evaluation* practices should be structurally embedded within the pilot project. Secondly, van Winden and van den Buuse (2017) state that in order to upscale, *transferring knowledge and sharing information* between involved actors is crucial to address societal issues more effectively. After all, bringing knowledge and insights from different disciplines together fosters creative solutions for existing problems. Thirdly, an important success condition is the presence of the right *ICT skills and competences* to deal with technological systems and applications (Ebrahim and Irani, 2005). In the literature, the absence of the right skills to use technological systems is often described through the concept of 'digital divide'. This refers to the "the social implication of unequal access of some sectors of the community to ICT and the acquisition of necessary skills" (Partridge, 2004, p. 2). It is not only important that the people within the pilot organisation itself can use ICT in order to enhance smart city services, but also that the end-users are able to use the end-product without constraints (Hollands, 2008).

Institutional conditions

Another relevant body of literature focuses on the institutional environment around pilots. In this respect, three aspects are relevant, namely: *vision and goals*, *the inclusion of stakeholders* and *demonstrating value*. Firstly, Dijk et al., (2018) underline the importance of a *clear vision*, the presence of a long term perspective, a picture of the future and clearly defined common goals upon which all the partners have agreed. Hartman and Linn (2008) add to this by stating that it is especially important that there is a *vision of scale*. This means that when starting a pilot, it is necessary to already think about how the pilot can scale up, which needs to be taken into account in developing the underlying business model. After all, smart city pilots are too often designed as one-time events that do well on a limited scale but cannot reach a higher level. Secondly, Dijk, Kraker and Hommels (2018) state that the *involvement of relevant stakeholders* is a success factor in addressing constraints for upscaling. They argue that this can lead to an increase in legitimacy and a more effective implementation of the project. Van Winden (2016), argues that it is necessary to focus on the facilitation of an open discussion between the relevant stakeholder to understand each other's perspectives. Thirdly, an important factor for upscaling smart city pilots is *showing the impact of the actions* (Komninos, Bratsas, Kakderi and Tsarchopoulos, 2015). This way, investing public money and private injections can be justified through the demonstration of the added value of the project (Oomen, 2016).

Wrap-up

In short, there is a broad range of literature that discusses relevant pieces of the puzzle when it comes to upscaling smart city pilots. However, there is not one single framework that covers the whole process of upscaling (Kuyper, 2016). Therefore, the different insights of the above-reviewed literature have been combined in three main categories, based upon Nam and Pado (2011): technical conditions, human conditions and institutional conditions. In table 1, the dimensions of these categories are summarized.

Dimension	Academic authors
Technical conditions	
IT infrastructure	Dillion a Pelgrim, 2002; Heeks, 2001; Moon, 2002
Data standards	Van Winden and van den Buuse (2017); Van Winden et al., (2016).
Human conditions	
Reflecting and evaluating	Bekkers et al., 2013; Oomen, 2016
Sharing knowledge	Van Winden and van den Buuse, 2017
Skills and competences	Hartman and Linn, 2008; Dijk et al., 2018; Ebrahim and Irani, 2005; Partridge, 2004
Institutional conditions	
Vision and goals	Dijk et al., 2018; Van Winden, 2016; Hartman and Linn, 2008
Inclusion of stakeholders	Van Winden, 2016; Dijk et al., 2018
Demonstrating value	Komninos et al, 2015; Oomen, 2016

Table 1 upscaling conditions of smart city projects

2.4 Urban digital platforms

The other main concept of this research is the functioning of *digital platforms*. The concept of platforms serves as an umbrella in the academic literature (Ansell & Gash, 2018; Barns, 2016; Klievink, Bharosa & Tan, 2016). The term first started as a way to describe organizations that were real-life places that facilitated the circumstances to innovate (Ciborra, 1996). In recent years, the definition of platforms shifted within the literature from a real-life place to a more digital environment (2018). The state of the art has mostly focused on two main functions of digital platforms: open data platforms (Barns, 2016) and collaborative platforms (Ansell & Gash, 2018). Beneath, these approaches will be discussed more in-depth.

2.4.1 Open data platforms

The increased data generation in the modern world leads to the fact that new ways to structure and facilitate data exchange need to be developed (Jetzek, Avital & Bjorn-andersen, 2014). Bertot, Gorham, Jeager, Sarin and Choi (2014) argue that governments all over the world use web-based platforms or specialized open data platforms to process, store, translate and provide data. Within the academic literature, there is a consensus on the definition of open data: data should be freely accessible, usable, adaptable and shareable by anyone, for any purpose (Open Definition, 2020). Digital platforms are in this case the portals that allow actors to access and use the data. Neuroni et al., (2019, p. 72) state that the accessibility of data through platforms "is essential to allow innovators to concentrate on the added value of their applications and not on the technicalities of data collection, which leads to faster innovation cycles". Brandão, Joia and do Canto Cavalheiro (2019) agree on this by stating that, in order to facilitate the development of smart city applications, the data platform should be openly accessible to everyone. Moreover, the availability of open data infrastructures and data commons within digital platforms are the starting point for an innovative environment (Klieving, Neuroni, Fraefel & Zuiderwijk, 2017). In other words, a platform with the function to store, share and connect data can stimulate innovation.

2.4.2 Collaborative platforms

To add value, Komninos (2009) argues that a platform needs to be more than technology: it facilitates the development of creative skills, innovation-oriented institutions, networks and virtual collaborative spaces. In other words, platforms can serve as collaboration places where people come together, exchange knowledge and ideas and make decisions for the future. Therefore, another perspective that can be distilled from the existing literature is that digital platforms are places of collaboration. The most notable body of literature focuses on the concept of 'the-city-as-a-platform' (Hwang, 2020). This concept has the underlying principle that a smart city works at its best if it is built upon citizens and their social relations (Anttiroiko, 2016). Therefore, platforms need to be places where people gather to communicate. share ideas and co-create solutions to both utilize opportunities and solve urban problems (Love, 2016). This way, the platform can contribute to more effective and efficient innovation processes (Anttiroiko, 2016; Hwang, 2020). Moreover, the emergence of digital platforms to collaborate upon also adds a new dimension to so-called network effects (Van Winden & Van den

Buuse, 2016). Networks effects aim to describe the dynamic that the value of a product or service increases with the number of people that use them (Shapiro, Varian & Becker, 1999). When it comes to digital platforms these network effects are two-sided (Parker, Alstyne & Choudary, 2016). On the one hand there is the supply side, which contains, in the case of the Digital Twin, the smart city pilots and on the other side the demand side, which contains the end-users of these smart city pilots (Van Winden & Van den Buuse, 2016). This means that the more people interact upon a platform, the easier scaling and innovation processes are occurring. In short, digital platforms that have the function to engage a significant number of suppliers and demanders and that foster collaboration amongst these actors can stimulate innovation.

2.4.3 Wrap up

The existing literature distinguishes two main functions of digital platforms: open data platforms and collaborative platforms. Both of these functions can stimulate innovation processes in different ways and can manifest in one single platform. The Digital Twin in Rotterdam is both an open data platform as well as a collaboration platform (Plaftorm31, 2018). The question remains, however, what the relationship is between these platform functions and the upscaling conditions of smart city pilots. The next subchapter will elaborate more on this relationship.

2.5 The relation between digital platforms and upscaling conditions

2.5.1 Boundary objects bridging the gap

After diving into the main concepts of this research, the question remains how these concepts relate. As stated in the introduction of this study, there is a gap in the literature when it comes to describing the link between upscaling conditions of smart city pilots and the role of digital platforms. The literature on so-called boundary objects can bridge this gap. Boundary objects are "artefacts, practices, representations and technologies which are shared across two or more communities" (Star and Griesemer; 1989, p. 393). These boundary objects are both plastic enough to adapt to local needs, yet robust enough to maintain a common identity across different sides of the boundary (Akkerman & Bakker, 2011). These boundary objects are able to increase integration and communication between different parties on both sides of the boundary (Star, 2010; Green, 2010). This way, these objects can fulfil a boundary spanning role that deals with the multi-dimensional and complex processes of upscaling smart city pilots. After all, the issues that smart city pilots aim to address are often wicked, do not have clear boundaries and have a transcendent nature (Williams, 2002). Therefore, these complex societal issues need to be addressed not in a linear, but in a non-linear way. In other words, the complexity needs to be embraced instead of developing straightforward solutions (Van Meerkerk & Edelenbos, 2016). Urban digital platforms can be perceived as a *digital* boundary objects that help to embrace complexity in urban issues because they increase interaction among a broad range of different actors. After all, the three main boundary spanning activities, connecting people; selecting relevant information and translating this information on both sides of the boundary are all functions that could be addressed by a digital platform (Van Meerkerk & Edelenbos, 2016). As mentioned earlier, both open data platforms, as well as collaborative platforms, can contribute to innovation (Antirroiko, 2016; Klievink et al., 2017). Therefore, digital platforms could contribute to upscaling conditions in two ways: in a technological and a collaborative way.

2.5.2 Platforms to integrate technologies

At the basis of smart cities lies the integration of heterogeneous technologies and infrastructure (Hollands, 2008). According to Freafel, Haller and Gschwend (2017) the added value these technologies can only be realized through an integrated platform for those capabilities. This way, the integration of technologies and systems can enhance the upscaling conditions of smart city pilots in three different ways: through *real-time data delivery*, *leverage* and *interoperable and transversal systems*. Firstly, Yang et al., (2015) state that such integration can offer governments *real-time combined data* from a broad range of sources throughout the whole city to monitor progress and as a basis for decision-making. The availability of real-time data creates the opportunity to monitor the progress and success of a pilot on a very detailed level and could thus contribute to the upscaling condition reflecting and evaluating (1). Second, Ansell and Gash (2018) describe so-called *leverage* effects, which means that a common architectural platform leads to multiplier effects. Thomas, Autio and Gann (2014) agree on this by stating that a platform can lead to scale benefits through the development of shared assets, designs and standards. This way, a digital platform can be an instrument from which pilots could benefit because of the widely accepted data standards (2). Thirdly, Walravens and Ballons (2013) state that platforms need to have *transversal and interoperable systems* so that they can facilitate data-sharing amongst actors from all kinds of backgrounds, with both private and public interest. This could potentially contribute to upscaling processes because it facilitates the upscaling conditions of integrated systems (3). Table 2 summarizes how the integration of technology could contribute to the upscaling conditions of smart city pilots.

Integrating technology	Upscale conditions
Real-time data	1. Reflecting and evaluating (Human)
Leverage	2. Data standards (Technology)
Transversal and interoperable systems	3. Integrated systems (Technology)

Table 2 Integrating technology contribution to conditions

2.5.3 Platforms to foster collaboration

As described earlier, a major function of digital platforms is to foster collaboration among all kinds of actors (Ansell & Gash, 2018). As Ranchordas (2017) state: urban digital platforms can contribute to the alignment of public and private interests through collaboration with inside and outside-government actors. This way, digital platforms are able to increase public value by stimulating the initiation of smart city projects through involving, empowering and connecting all different kinds of actors. Ansell & Gash (2018) describe three ways in which *collaborative platforms* can contribute to the success of projects: *Attractor effects*, *learning* and *synergy*. First*, Attractor effects* aim to describe the phenomenon of that success attracts success (Ansell & Gash, 2018). Digital platforms can be a podium to share and showcase best practices. Stakeholders may be more willing to join and invest time, energy and resources when they see the valuable impact of the pilot(Ansell & Gash, 2018). This way, digital platforms can contribute to the condition of demonstrating value (1) and to visualize and formulate a vision of scale (2). Second, *learning* focuses on the collaboration in itself: when collaborating with a broad range of actors through the platform, the actors can learn lessons that can be used in establishing new collaborations for new issues (Ansell & Gash, 2018). This way, the learning aspect of the platform can contribute to reflecting and evaluating aspects of upscaling conditions (3). Moreover, the platform can a place to share information, learn from each other and thus gain the right skills to use these kinds of technologies (4). Third, *synergy* describes the characteristics of platforms to bring stakeholders with synergistic knowledge, resources and perspectives together. The presence of a platform can thus contribute to upscaling conditions regarding the inclusion of relevant stakeholders (5) and sharing knowledge and information (6). Table 3 summarizes how fostering collaboration could contribute to the upscaling process of smart city pilots (See table 3)

Foster collaboration	Upscaling condition
Attractor effects	1. Demonstrating value (Institutional)
	2. A vision of scale (Institutional)
Learning	3. Reflecting and evaluating (Human)
	4. Skills and competences (Human)
Synergy	5. Inclusion of relevant stakeholders (Institutional)
	6. Sharing knowledge and information (Human)

Table 3 Collaboration contribution to upscaling conditions

2.5.4 Wrap-up

To summarize, there are two main ways in which digital platforms could contribute to upscaling conditions: integrating technology and fostering collaboration. As distilled in the previous paragraphs, integrating technology contributes mainly to technical conditions and a bit to Human conditions and fostering collaboration mostly contributes to human and Institutional conditions (See table 2 and 3). However, the reality of smart city pilots is often complex so the data for the research will be collected in an open way.

2.6 Conceptual framework

Based on the findings in the theoretical framework it can be stated that upscaling is a multidimensional process in which the success of this upscaling process is dependent on a broad range of factors which are re-categorized in three main overarching themes: *technical conditions*, *human conditions* and *institutional conditions*. Moreover, there has been written a lot about the emergence of digital platforms. However, what the specific functions of these platforms are, can differ a lot between academics. Therefore, I reviewed the literature and came up with two important roles of urban digital platforms: *integrating technologies* and *fostering collaboration*. As stated in chapter 2.5 there are several ways in which the literature suggest that digital platforms, as boundary objects, contribute to the upscaling processes of smart city pilots. Notably, the role of integrating technology is mainly able to foster technical and a for a marginal part human conditions and the role of fostering collaboration is contributing to human and institutional conditions (See table 2 and 3). These relationships are drawn in the conceptual model as visualized in figure 6. However, in reality these relations will be not that linear because of the complex nature and multidimensional characteristics of upscaling processes (See 5.5.1). More complex, self-organizing dynamics will not be investigated within this research. Therefore, this study aims to explore how the collaborative and integrating technology roles contribute to the upscaling processes of smart city pilots related to the Digital Twin. To do so, the extent to which these roles contribute to technical, human and institutional conditions will be analysed. In this case, integrating technologies and fostering collaboration are the independent variables and technical, human and Institutional conditions are the dependent variables (See figure 6).

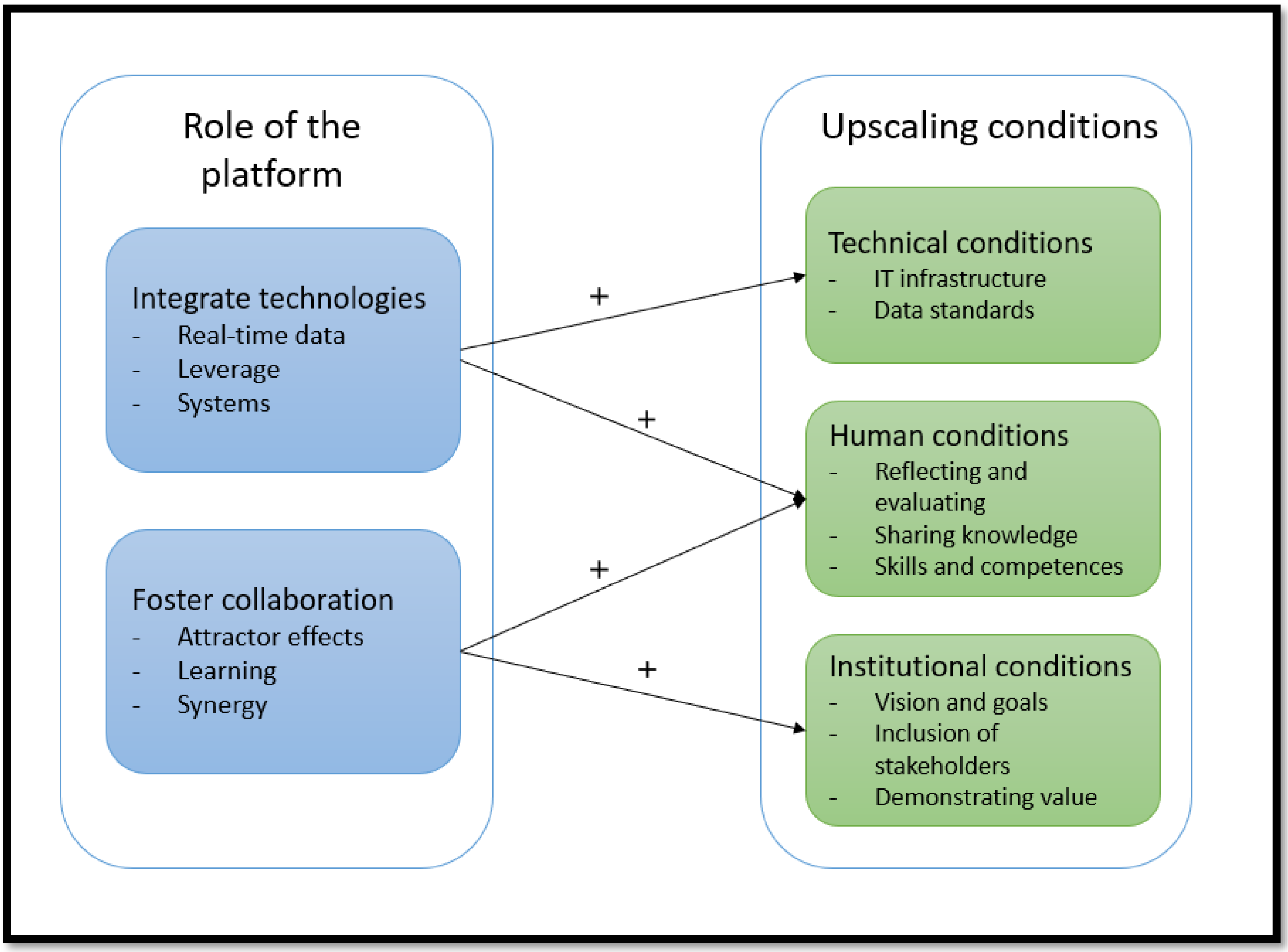

Figure 6 Conceptual model

3. Methodology

In this paragraph, the methods of this research will be outlined. The following elements will be discussed: the research design, research instruments, data analysis, operationalisation and limitations and ethics.

3.1 Research design

The design of this research is a multiple case study. This design enables the extensive comparison between different cases (Bryman, 2016). This means that at least two different cases will be analysed in an identical way (Bryman, 2016, p.72). In this research, the pilots SAFE3D, QR codes, Participation, and 3D building permits, all related to the Digital Twin, are extensively studied. These cases will be discussed briefly in the case-selection (3.2.1). To analyse these cases, a qualitative research method is used. This way, it is easier to dive deeper into the different cases (Bryman, 2016). After all, this research method focuses on understanding underlying reasons, relations and motivations instead of quantifying the problem (Bryman, 2016). This helps to understand the underlying dynamics of smart city pilot projects and how they relate to the Digital Twin. Moreover, it helps to dug deeper and understand the real perspectives of people towards the Digital Twin. Beneath, I will elaborate more on the use of the research instruments.

3.2 Research instruments

To execute the earlier described research design, the appropriate methods for analysing and collecting the data on four selected cases will be used. This section discusses the case selection and data collection.

3.2.1 Case-selection

The main case in this research is the Digital Twin in Rotterdam. As stated in the introduction, this is a 3D platform that is the visual representation of the city of Rotterdam in which all the real-time data of the city is stored and upon which collaboration can occur. Related to the Digital Twin, there are several smart city pilots initiated. When selecting which subcases are suitable for analysis, the researcher can either decide to select heterogeneous cases or concentrate on a homogenous set (Van Thiel, 2014). In this research, the focus will be on studying heterogeneous cases, because that opens up the possibility to investigate what the effect is of the variation between variables (Van Thiel, 2014). King, Keohane & Verba (1994) state that contrasting cases should be determined on the basis of the independent variable. In this research, the role of the platform is the independent variable, divided into a collaborative as well as a technical role. Therefore, smart city pilots that either uses the more collaborative function of the platform or the more technical function of the platform will be selected

(Ten Kate, 2019). However, despite the fact that the selection of cases should preferably be based on the literature, in reality, a more pragmatic approach is needed (Van Thiel, 2014). After all, it is impossible to know in advance if a certain pilot project uses more the collaborative function or the technical function. Moreover, there is no strict distinction between these two roles: the Digital Twin facilitates both functions. This led to the selection as illustrated in table 4.

Function	Technical function	Collaborative function
Pilot project	QR Code Visualisation	Citizen participation
	3D building permits	SAFE3D

Table 4 Case selection

Thus, the following four smart city projects will be analysed: SAFE3D, QR Code Visualisation, Citizen participation, and 3D building permits. These cases will briefly be described beneath.

QR Code visualisation is a project in which citizens who encounter a new building project in their neighbourhood scan a QR code and see a 3D version of what is being constructed. This way, citizens have a better understanding of what is going on in their neighbourhood, why this is from added value and how this will impact their day-to-day life.

Citizen Participation visualizes building projects in the environment and opens up the discussion with a citizen about these building projects. This way, the citizen-government dialogue is based upon a well-informed knowledge base.

SAFE3D is a project that focuses on combing the internal visualisation of buildings with the external visualisation of the city. This way, the end-product of the project enables the personnel of fire agencies to access information about the inside and surroundings of buildings more efficient so they can formulate a better-informed strategy on how to deal with a certain emergency.

The 3D building permits is a project that tries to make the decision-making process of construction permissions smoother and more efficient. Building proposals can be tested directly through the platform and it is been automatically tested if it fits the criteria for building licences.

3.2.2 Data collection

Interviews

Qualitative data will be collected through active interviews as described by Holstein and Gubrium (2016), who hold the view that an interview is essentially a directed conversation. This technique accepts that the interviewer is part of the conversation and also influences the direction of the interview. This methodology allows the interview to guide the conversation, without letting it get constrained by the research operationalization (Van Thiel, 2014). In other words, the active interview is open to new insights that can add value to the results. Such a method aims to collect insights and perspectives that were not expected on forehand. Bryman (2016), describes this research methodology as the conduction of 'semi-structured interviews'. Through these semi-structured interviews, the perspectives of the relevant actors involved in the four selected cases, on upscaling conditions and the role of the Digital Twin will be collected. Because this method measures perspectives, it is important to have a broad, representative group of respondents per case.

Respondents

For each of the selected cases, respondents representing different stakeholders will be interviewed with the purpose to map out the presence of upscaling conditions and what the specific role of the Digital Twin is in this process. Within every case, four respondents that all represent a different view on the project will be interviewed: a project leader, technical expert, external partner and a policy-maker. All of these respondents reflect an different perspective on the pilot. The project leader can give a general overview of the pilot and reflect on institutional and human conditions; the technical expert can mainly reflect on the technical conditions for upscaling; the external partner is able to reflect on the human conditions and will have a more neutral view on the technical conditions; the policy-maker can mainly reflect on the institutional conditions. This way, it can be ensured that every perspective on the pilot is represented, which will lead to a rich and complete dataset. In table 5, the respondents with who the semi-structured interviews are conducted are summarized.

Number	Subcase	Function
1	General	Program leader digital city
2	General	Policymaker I-vision municipality
3	General	Architecture expert municipality
4	SAFE3D	Project leader SAFE
5	SAFE3D	Policymaker SAFE
6	SAFE3D	Knowledge institution
7	QR Code visualization	Project leader
8	QR Code visualization	External company
9	QR Code visualization	Policymaker municipality
10	Citizen participation	Project leader
11	Citizen participation	Project leader
12	Citizen participation	Project leader
13	Citizen participation	Urban planner
14	Citizen participation	Policymaker
15	3D building permits	Project leader
16	3D building permits	Technical worker municipality
17	3D building permits	Knowledge institution
18	3D building permits	Policymaker
19	Expert	Comparison of governance of platforms

Table 5 Overview respondents

Documents

In addition to the qualitative interviews, policy documents on the digital city program and the pilots will be analysed. These documents give a general overview of the goals, aims and ambitions of the pilots. Moreover, the documents give insight into the used policy instruments to reach these goals. Beneath, you can find an overview of the documents that are analysed (Table 6).

Case	Documents
General program	*D1: Presentatie – 4 Smart City - Rotterdam* *D2: Presentatie digitaliseringsagenda* *D3: Presentatie– Gemeente Rotterdam* *D4: SC_Argumented reality in Rotterdam* *D5: VoorstelCMRSamenDigitaleStadRotterdam*
SAFE	*D6: Projectplan 0.9 SAFE3D* *D7: SAFE3D krachtenveld* *D8: Tussentijdse Lessons Learned Rotterdam 3D*
QR codes	*D9: Augmented Reality van bouwprojecten obv 3D* *D10: Projectidee van QR naar AR*
Citizen participation	*D11: Samenvatting Usercases Pilot Participatie* *D12: Presentatie Pilot Participatie*
Automatizing licences	*D13: Projectplan DS 3e pilot OW* *D14: BIM verzamelen, verbinden, visualiseren*

Table 6 Overview analysed documents

3.3 Data-analysis

To analyse the collected qualitative data the transcripts of interviews were stored and ordered in the coding program Atlas.Ti (Van Thiel, 2014). These results were triangulated with secondary sources such as policy documents, project plans, internal evaluations and personal communications between pilot partners and project leaders. This method of analysis is partly based on the empirical multiple-case study on smart city pilots in Amsterdam conducted by Van Winden and Van den Buuse (2016). Another similar approach to the analysis of smart city pilots is proposed by Mora, Deakin, Reid and Angelidou (2018), who have reviewed all the used methodologies in smart city research. Mora et al., (2018) state that the coding process of qualitative interviews is of major importance to structure the results and identify relevant insights. Therefore the next step is to give codes to different parts of the dataset (Van Thiel, 2014). The establishment of the codes will mostly be based upon the literature in the theoretical framework, but if relevant new insights are popping up during the data collection, these will be added to the coding scheme (Bryman, 2016, p.112). First, the coding process will contain open, coding in which the researcher is open for all the different data that has come out of the data collection, then the process will continue with axial coding, namely trying to divide different codes into overarching themes and categories and finalize with selective coding in which relationships between different concepts will be sought (Boeije, 2014, p.134). The scheme of codes can be found in appendix C.

3.4 Operationalization

The operationalization of the main concepts is based upon the theoretical framework, as visualized in the conceptual model. In order to be able to measure the chosen conditions empirically, they need to be converted into measurable indicators. Beneath, the main concepts will be operationalized: upscaling conditions namely, technical, human and institutional and two main roles of platforms, namely technical and collaborative integration.

3.4.1 Upscaling conditions

Technical conditions

Dimension	Definition	Indicator
IT infrastructure	"the availability of reliable IT networks and communication system" (Dillon and Pelgri, 2002)	The IT system used in the pilot is **accessible for all the involved actors**
Data standards	"The extent to which data complies to the same standards so they can interact with each other" (Khatri & Brown, 2010)	The involved actors are able to share data easily because of the fact that they use **commonly agreed technical data standards**

Table 7 Operationalization technical upscaling conditions

Human conditions

Dimension	Definition	Indicator
Reflecting and evaluating	Open culture in which actors are able to learn and reflect on the process and where progress is made through 'trial and error' (Bekkers et al., 2013)	There are structurally embedded **evaluation processes** present in the pilot.
		Within the pilot, there is a culture of learning by doing: experimenting through **trial and error**
Sharing knowledge	"Transferring knowledge and sharing information to combine resources and address societal issues" (Van Winden and van den Buuse, 2017)	The involved actors in the pilot are (willing to) **share their knowledge** and resources for the sake of the pilot.
Skills and knowledge		Initiators need to have the right **IT skills**

	“The presence of the right IT skills and knowledge to deal with technological systems and applications" (Ebrahim and Irani, 2005)	The pilot product should be **easy in use so** that the end-users are able to

Table 8 Operationalization human upscaling conditions

Institutional conditions

Dimension	Definition	Indicator
Vision and goals	“A clear vision, the presence of a long-term perspective and picture of the future and clearly defined common goals of the projects upon which all the partners have agrees” (Dijk et al., 2018)	The involved actors have thought out a **vision of scale** on how the project should continue after the pilot phase
		The involved actors have commonly agreed upon the formulated **vision and goals**
Inclusion of stakeholders	“The facilitation of an open discussion between the relevant stakeholder to understand each other’s perspectives” (Van Winden, 2016).	The collaboration process within the pilot consists out of **open discussion and dialogue**
		All the **relevant partners are included** in the pilot and have a say at the table
Demonstrating value	“showing the impact and added-value of the activities” (Oomen, 2016).	The initiators of the pilot can **showcase the impact** and added value of the pilot

Table 9 Operationalization institutional upscaling conditions

3.4.2 Role of digital platforms

Integrating technologies

Variables	Definition	Indicators
Real-time data	“Data from a broad range of different sources throughout the whole city is constantly updated” (Yang et al., 2015)”	The platform facilitates the **availability of real-time data**
		The available data is used for **monitoring progress** (of pilots)
Leverage		The shared architecture of a platform leads to **scale benefits**

	"Leverage effects refer to the fact that a common architecture for a platform leads to multiplier effects" (Ansell & Gash, 2018)	The shared architecture facilitates better **coordination** among actors
Transversal and interoperable systems	"The extent to which systems are able to communicate with each other and datasets can be transferred" (Walravens & Ballons, 2013)	The platform facilitates the extent to which **open data standards** can be arranged and organised.

Table 10 integrating technologies

Fostering collaboration

Variables	Definition	Indicators
Attractor effects	"Attractor effects describe the phenomenon to which success attracts success" (Ansell & Gash, 2018)	The online urban platform is used to **share best practices** and show success
Learning	"The emergence of new collaborations can enhance the lessons learned of all actors" (Ansell & Gash, 2018)	The users of the platform will improve their **(IT) skills** through the digital platform
		Learning lessons from collaborating
Synergy	"The extent to which stakeholders with synergistic knowledge are brought together" (Ansell & Gash, 2018)	The platform is used to **share knowledge**, skills, resources and perspectives

Table 11 Fostering collaboration

3.5 limitations and ethics.

3.5.1 Reliability

Reliability means the extent to which the same results can be obtained if the research is repeated. In other words, the results have to be independent of the researcher (Bryman, 2016). Regarding the reliability of this research, there are two main issues that need to be addressed. First, the fact that this research uses a qualitative research approach that measures perceptions from stakeholders on the Digital Twin and the related pilots leads to difficulties in making objective conclusions. To overcome this issue and make more general conclusions, the interviews were structured based upon the literature and the results of this thesis will be compared with the existing literature. Second, a qualitative research method contains the risk that the perspective of the researcher steers the results of the research. After all, the conducted interviews are a steered conversation between interviewee and respondent. This issue is mitigated through structuring the interviews on the basis of literature and recording and transcribing the conducted interviews. This way, other academics are able to repeat the research.

3.5.2 Internal and external validity

Internal validity refers to the degree to which the research measures the reality that is been studied (Bryman, 2016). This can be challenging because data will be collected from a limited number of respondents per case. To deal with this, respondents with different backgrounds and perspectives on the situation are interviewed (See table 5). In addition to this, the research method triangulation is applied, which means that using multiple instruments - qualitative interviews, document analysis and observations from team meetings – will ensure internal validity. Moreover, the researcher needs to constantly check if they understood the respondent correctly. This method is called respondent validation (Bryman, 2016). External validity refers to the extent to which the results of the research can be transferred and applied to other contexts (Bryman, 2016). Because this research focuses on cases, it is difficult to generalize the results beyond this research. However, in the theoretical reflection of this research, the results from case-study will be linked to the existing body of literature to make more general conclusions (chapter 5).

3.5.3 The influence of the Coronacrisis

Since the beginning of 2020, the virus Covid-19 is affecting day-to-day life all around the world. I will briefly discuss the implications that this has regarding this research. First, the interviews will all take place through online meetings via MS Teams. This will affect the research results because it is more difficult to detect certain non-verbal, emotional reactions of the respondents. Second, the Corona crisis can affect the results of the research in two ways: on the one hand, it could lead to a push of digital ways to communicate and collaborate, but on the other hand, a lot of projects are also at risk for delays because a lot of organizations have other business to do. These issues will be dealt with by including questions in the interviews that focus on the circumstances around the Coronacrisis and will adapt the research methods if the circumstances ask for it.

4. Results

The results of this research will be presented according to the following structure. First, I will explain to what extent each investigated pilot is meeting the described technical, human and institutional conditions. The presence or absence of these conditions will be summarized in a table, using the colour marks green (condition is present), orange (condition is somewhat present) and red (condition is not present). Second, for each pilot the added-value of the platform, the Digital Twin to these aforementioned conditions will be described. To do so, the two main roles that are presented in the theoretical framework of this research will be used, namely *integrating technology* and *fostering collaboration*. The specific roles that contribute to certain upscaling conditions will also be written down in a table. Thirdly, the remarkable differences and parallels between the investigated pilots will be discussed. This comparison will also be visualized by a table, using the earlier mentioned traffic light colours. Finally, the respondents often referred to the fact that the platform is still under development and that the platform in itself is still a pilot that needs to be upscaled. These findings will be discussed in the last subchapter of the results.

4.2 Pilot SAFE3D

SAFE3D is a pilot that aims to develop an innovative solution to ensure the security and safety within the city of Rotterdam. At the moment, when there is an emergency, the security agencies are still dependent on 2D pdf information, which is time-consuming and difficult to read. The main **goal** of the pilot is to develop an overview of the building and its surroundings that helps to understand what the risks are in tackling the issue (R2-R3 & D6).

> D6: "The common vision of SAFE3D is to enhance the safety policy in the Rotterdam region. (…) The pilot creates data-driven ways to stimulate the dialogue between stakeholders in Rotterdam."

To reach this goal, there are several **stakeholders involved**. The main involved parties are the Veiligheidsregio, the municipality of Rotterdam, GCI, and BOLD. The Veiligheidsregio is the customer of the end-product, the municipality of Rotterdam is fulfilling the coordinating role within the project, GCI is developing the concrete software and BOLD is a knowledge institution that is conducting research that supports the project developments (D8, R1-R3). Moreover, the RET and the Havenbedrijf are indirectly involved as possible customers in the future. The **progress of the pilot is demonstrated** regularly during meetings with all the involved stakeholders (R2). A major benefit is that the 3D end-product is visually attractive, which makes the progression more clear (R2-R3). The collaboration process between all these stakeholders started with very much energy because the innovative idea was appealing. However, when there had to be made concrete arrangements, it became somewhat more difficult.

> R3: “Working together with external parties is challenging, especially when you need to become concrete and design a way to coordinate activities”

The balance between setting up a flexible and innovative pilot and establishing concrete responsibilities in the pilot SAFE3D is a recurring theme (R1 & R3) Especially the question what is going to happen with the end-product after the pilot phase, is not thought out. There is no agreement about which actor is bringing the pilot to the next level (R2-R3). One topic that is agreed upon is the **structure of learning** withing the collaboration process. This structure is mainly based upon a so-called community of knowledge and a community of practice. In the ideal world, these two would strengthen each other because you can test new insights from the community of knowledge in the community of practice and you can develop new research questions in the community of practice. However, the interaction between these two communities stagnates occasionally (R2 & R3). The learnings are written down in a lessons learned report, written by CGI (R2 & R3). Another relevant topic is the **sharing of resources**. Firstly, this relates to financial resources. In the first instance, all the involved actors would each pay their fair share. In the end, however, the municipality funded it from out of the Digital City program (R2 & R3). Secondly, this also relates to sharing data because there are no clear agreements on which data is shared when (R1 & R3). Data-sharing does not only relate to the collaboration arrangements, but also the presence of commonly agreed **data standards**. Despite the fact that all the involved actors underline the importance of open data standards, there are in practice still issues regarding data formats because every actor has their own formatting policies (R1-R3). Moreover, there are no clear agreements on which data can be shared and how the alignment of dataflows should occur (R1 & R3). Not only the data standards but also the use of **accessible IT systems** is an issue. This is because the involved actors, both inside as well as outside of the municipality are making use of different IT systems. In other words, the systems are built to serve one single purpose instead of multiple (policy) goals (R2 & R3). Therefore, it is necessary that the files of a certain system are translated so that it can be used in another system.

> R2: "To visualize the data, the point cloud model file needed to be translated into a file that could comprehend and talk with the systems and files of the Veiligheidsregio Rijnmond".

Upscaling conditions	Subdimension	Score
Technical conditions	IT infrastructure	
	Data standards	
Human conditions	Reflecting and evaluating	
	Sharing resources	
	Skills and knowledge	
Institutional conditions	Demonstrating value	
	Inclusion of stakeholders	
	Vision and goals	

Table 12 Presence of upscale conditions SAFE3D

4.2.1 The role of the platform

As can be seen in the table above, a few conditions are not fully present in the pilot SAFE3D. How, according to the respondents, the platform the Digital Twin contributes to these upscaling conditions will be discussed briefly below.

Integrating technology

Firstly, the platform contributes to the pilot SAFE3D by facilitating the lack of **open data standards** (R1-R3). This is done through the *role of the interoperable and transversal system* of the platform. After all, every pilot that in the future wants to use the data on the platform knows in which language it will be delivered (D5, R3). More specific, one of the main goals of the pilot is to investigate to what extent the existing data on the interior of buildings of the Veiligheidsregio, which is available of almost every building in the Netherlands, can be translated to the Digital Twin (D6, R2-R3). If this conversion is done, upscaling is much more achievable.

> R2: "The platform could be the technological foundation of applying this pilot in the rest of the Netherlands. In that case, it is just a matter of turning on the converter once again."

Second, this facilitation of a basic infrastructure through a *transversal and interoperable IT system* contributes to the institutional condition **vision of scale** because the promise to convert 2D pdf information to 3D visualizations is a giant step in the direction of upscaling. Thus, there is already a concrete vision on how the pilot can be upscaled in the future.

Third, the Institutional conditions **inclusion of stakeholders** and **vision and goals** are crucial in this pilot because of the complex collaboration process. Through *leverage* dynamics, the platform creates a shared reality amongst all the involved actors. This means that, because of the fact that the actors are looking to the same 3D visualisation based on the same data, people are more able to understand each other's perspectives (R2 &R3). This common reality leads to major efficiency gains (R2 & R3). In

Fostering collaboration

Fourth, as mentioned earlier, the conditions **inclusion of stakeholders** and **vision and goals**, are struggling because of the complex collaboration process. These conditions are stimulated through so-called *attractor effects* of the platform: success will attract success. Within the pilot SAFE3D, this means that the initiators are constantly showing the product of the pilot so that other parties are convinced to bring it further (R2-R3).

Fifth, there is still a reluctance to **share resources** amongst actors. To deal with this, the platform stimulates *synergy* between the involved stakeholders (R1). Within SAFE3D, there are a lot of external stakeholders involved. The engagement of these **stakeholders** is already a step in the right direction, but the platform is seen as a tool and not as a place to collaborate and interact upon (R2-R3). In practice, this means that working together on such a project can stimulate collaboration, but that the platform is not yet fulfilling a role as facilitator in this process. In the future, this might change:

> R3: "We could create a social digital urban community. We do not know yet, that is still just a thought. (…). The platform can play a role in facilitating interaction"

Finally, there is also the challenge that the interaction between the community of practice and the community of knowledge is stagnating (R3). However, the respondents did not mention a way in which the platform contributes to **reflecting and evaluating.**

Wrap-up

The platform contributes in several ways to the upscale conditions of the pilot SAFE 3D. This is summarized in table 13.

Upscaling conditions	Subdimension	Contributing role of platform
Technical conditions	IT infrastructure	Transversal and interoperable systems
	Data standards	Transversal and interoperable systems
Human conditions	Reflecting and evaluating	
	Sharing resources	Synergy
	Skills and knowledge	
Institutional conditions	Demonstrating value	
	Inclusion of stakeholders	Attractor effects Leverage
	Vision and goals	Transversal and interoperable systems Attractor effects

Table 13: Contribution platform to upscaling conditions SAFE3D

4.3 Pilot QR code visualization through Augmented Reality

The Pilot QR code visualization focuses on visualizing the end-result of building projects through Augmented Reality. This way, citizens that walk by a certain construction site can visualize the end-result of the activities and understand how it will look like in the future (R4-R6 & D10). **The main goal** of the pilot is:

> D10: "Realizing a more modern and interactive way of communication with the citizen through QR codes that visualizes building projects in augmented reality."

This goal is mainly defined by the actors of the digital city program from the municipality of Rotterdam, instead of engaging a broader coalition within the organization to formulate the purpose of the pilot (R5 & R6). On the one hand, leads to more flexibility in executing daily activities and realizing a prototype (R6). On the other hand, this leads to issues in a later stadium regarding upscaling processes, because is less support within the organization to adopt the end-product (R5 & R6). This can also be found back in the aspect of the **inclusion of stakeholders**. The realization of the end-product is mainly headed by one project leader from the digital city program who interacts with an external app-developer, building companies and several departments within the organization itself (R4-R6).

R6: "The task division is very simple. I have the job to find out how I can realize this IT tool by finding whom I need and what I need from them.”

This is challenging because, especially in the organization of the municipality, it was difficult to determine who could help with which pieces of the project (R6). The progress of organizing this experiment within the municipality, relatively isolated from other departments, was a challenge on its own (R3 & R6). This led to the fact that the other – indirectly involved – stakeholders are not committed to the goals of the pilot (R4-6). These parties focused more on their own activities, rather than helping to embed the end-product (R4 & R5). However, one major benefit of the pilot to keep the parties engaged was the use of the technique of augmented reality, which gave an innovative sphere around the pilot that increased the commitment. This way, the end-product **demonstrated the added-value** of the pilot. The **lessons learned** that are written down during the pilot phase are mostly focused on technical issues (R4 & R6). Moreover, these lessons are written down in an ad-hoc manner: there is not a structural way to evaluate the dynamics of the pilot. The only important structure is the establishment of a project plan, but that is also quite superficial.

R6: “The learning goals in the project plan are not very specific. There are no concrete objectives like ‘we want to discover this or that’.

Moreover, the IT **infrastructure** of the municipality could not deal with the complex Building Information Models (BIM’s) of building companies (R4 & R6). In first instance, the BIM's that had to be visualized where too detailed and complex, leading to the fact that they could not be opened and processed on regular computers. On the one hand, the systems could not deal with the complexity of the existing BIM models. On the other hand, this is not only a problem that relates to the quality of the IT infrastructure, but this also depends on the high level of detail that was present in the BIM models. The reason that this issue occurred is mainly a lack of commonly used **data standards** in this field (R4 & R5). The issue is not that there are no data standards, but that every discipline is using their own standards (R6).

Upscaling conditions	Subdimension	Score
Technical conditions	IT infrastructure	
	Data standards	
Human conditions	Reflecting and evaluating	
	Sharing resources	
	Skills and knowledge	
Institutional conditions	Demonstrating value	
	Inclusion of stakeholder s	
	Vision and goals	

Table 14 Presence of upscaling conditions QR code

4.3.1 The role of the platform

As can be seen in the table above, a few conditions are not fully present in the pilot QR code visualization through augmented reality. The ways in which, according to the respondents, the platform the Digital Twin contributes to these upscaling conditions will be discussed briefly below.

Integrating technology

Firstly, the pilot QR code visualization through Augmented Reality has issues regarding the technical **open data standards.** The platform plays a role in facilitating the right open data standards through the role of *transversal and interoperable systems* (R4 & R6). To be concrete, the application of the pilot is, in that case, more easily realized because the application builder can decide which data is needed and download it immediately. However, in reality, the realization of such a platform is difficult:

> R6: "Developing an application on its own it is way easier than we did right now. (…) If you are developing it via a platform you are introducing open standards and such new things."

Because all the involved stakeholders have their systems to work in and work with, the platform does not facilitate a *leverage* role (R4 & R6).

Fostering collaboration

Secondly, the institutional conditions **vision and goals** and the **inclusion of stakeholders** are not present, mainly because it was difficult to collaborate with the internal organization (R5 & R6). The Digital Twin facilitates these conditions by the so-called *attractor effects* (R6). After all, the pilot is realizing an end-product that adds augmented reality as an extra dimension to existing projects (D9, R6). Moreover, this visual aspect of the platform is of added value for the pilot because it makes the communication amongst stakeholders more intuitive. Therefore, the platform contributes to the

demonstration of value. The challenge is, however, to come from a 'funny application' towards a product of added value for the society.

> R5: "For now, it is just a gimmick to attract people. I only believe in the added value if you can integrate this pilot with other use cases"

Third, the pilot mostly focuses on writing down technical lessons learned instead of more soft learnings during the **reflection and evaluation** process. In the data collection, there was not a role for the platform that stimulates this.

Wrap-up

The platform contributes in several ways to the upscale conditions of the pilot QR code visualization. This is summarized in table 13

Upscaling conditions	Subdimension	Contributing role of platform
Technical conditions	IT infrastructure	
	Data standards	Transversal and interoperable systems
Human conditions	Reflecting and evaluating	
	Sharing resources	
	Skills and knowledge	
Institutional conditions	Demonstrating value	Attractor effects
	Inclusion of stakeholders	Attractor effects
	Vision and goals	Attractor effects

Table 15: Contribution platform to upscaling conditions QR code

4.4 Pilot Participation

Because of the realization of the Omgevingswet, participation and involvement of citizens are becoming even more important for the activities of the municipality. Therefore, the main **goal** of the pilot is as following:

> "D11: "Investigate how use-cases in the digital city can be of added-value in time and place independent participation."

One way in which this is executed is to let citizens design their plans for a certain area. This is realized by the external company *GeoDome* (R10 & R11). Another product that is created is an interaction layer on the platform so that citizens can discuss whether or not they support a plan for the neighbourhood.(D12, R7, & R10). This end-product is being realized in collaboration with *ModelMe3D*

(D11 & R7 & R 10). Besides these software deliverers, another **stakeholder that is included** is the Omgevingswet program from the municipality. Within this pilot, the collaboration is mostly focused on the internal organization, namely the collaboration between the programs The Digital City and the Omgevingswet. The collaboration process is quite smooth because of the limited involved parties (R8-11). However, the actors are struggling with determining a **vision** on what needs to happen with the prototype after the pilot phase. After all, when there is a pilot within the municipality everyone wants to join because it sounds non-committal, but when the plans are getting concrete, it becomes more difficult (R7-9). Moreover, one of the main issues is that pilot projects are not matching the rule-nature of the municipality.

> R8: "Our organization is very much focused on justifying our actions and that is contrary to what you need to do in a pilot, namely collaborating with the city"

Within the pilot organization itself, however, the culture is more innovative (R7-11). There is a culture of **reflecting and evaluating** which means that every step that is taken is reflected upon (R11). Because of this innovative culture, it is difficult to structurally write down the lessons learned. Within meetings, there is always the discussion about what can be improved, but there is not one single structure to embed this (R7, R8 & R11). As mentioned before, the culture within the regular organization is less innovative. This can also be noticed when it comes to the aspect of **sharing resources** (R7-10). There are issues regarding the governance of the data-sharing process (R9 & R10). Especially when the situation is getting complex, the actors are getting reluctant to share their data because it is not clear who is responsible for which dataset. To foster data-sharing practices within the municipality, the organization is trying to arrange certain **data standards** (R8 & R11). It remains challenging, however, to translate all the information of both governmental departments as well as from external actors into 3D information that can talk to other datasets. Because the platform is going to be under development in the near future, the pilot participation has exported some data from the Digital Twin to an external server to develop the prototype (R7, R10, R11). Thus, for the sake of the pilot, the used **IT infrastructure** has a temporary nature.

> R11: "We copied a small part of the 3D city and with that foundation, we continued working on the simulation tool"

The uncertainty of the new procurement process for the new platform leads to the fact that the exportation of 3D data was necessary. Through this decoupling, it was still possible to continue the pilot without taking the risk that it would stagnate due to the IT infrastructure. However, this exportation also led to the fact that the back-end was less comprehensible (R10).

Upscaling conditions	Subdimension	Score
Technical conditions	IT infrastructure	(red)
	Data standards	(orange)
Human conditions	Reflecting and evaluating	(orange)
	Sharing resources	(orange)
	Skills and knowledge	(green)
Institutional conditions	Demonstrating value	(green)
	Inclusion of stakeholders	(orange)
	Vision and goals	(orange)

Table 16 Presence of upscaling conditions participation

4.4.1 The role of the platform

As can be seen in the table above, a few conditions are not fully present in the pilot participation. The ways in which, according to the respondents, the platform the Digital Twin contributes to these upscaling conditions will be discussed briefly below.

Integrating technologies

Firstly, the **inclusion of stakeholders** is an upscaling condition that is somewhat missing in the pilot. According to the respondents, the Digital Twin enhances the dialogue with the city by facilitating the availability or *real-timed data* (R8 & R9). This is from extreme added-value for the participation pilot because citizens, who are the end-users of the pilot, are participating and discussing based on information the is factual and up to date (R7, R9-11).

Secondly, the **inclusion of stakeholders** also benefits from the real-time representation when it comes to *leverage*. Because of the fact that multiple stakeholders have a shared image of what the city looks like and what the relevant issues are, it is easier to understand each other's perspectives (R10-R11).

> R11: "The 3D aspect allows you to visualize the situation and use the power of pictures. A visualization makes things easier and smoothens the communication”

Thirdly, the **IT infrastructure** and the **data standards** are not present in the pilot. However, the respondents did not see a concrete way in which the platform adds value to these technical upscaling conditions.

Fostering collaboration

Fourthly, the upscale condition **sharing resources** is not fully present in the pilot. The Digital Twin brings stakeholders from different backgrounds together to collaborate on different use cases and share their knowledge and expertise (R7 & R11). In other words, the *synergetic* role of the platform stimulates sharing of resources.

Fifth, not only synergy but also *attractor effects* occur. When all the actors will be built upon each other's perspectives and ideas, new use cases will be realized. In other words, these attractor effects lower the threshold for **stakeholders** to join the conversation.

Finally, there are two aspects of the upscaling conditions that are not present in the pilot and where the platform is also not able to contribute to, namely a **lack of vision** on the futre and the absence of structural embeddedness of **learning and evaluating.**

Wrap-up

The platform contributes in several ways to the upscale conditions of the pilot participation. This is summarized in table 13.

Upscaling conditions	Subdimension	Contributing role of platform
Technical conditions	IT infrastructure	
	Data standards	
Human conditions	Reflecting and evaluating	
	Sharing resources	Synergy
	Skills and knowledge	
Institutional conditions	Demonstrating value	
	Inclusion of stakeholders	Attractor effects Leverage Real-time data
	Vision and goals	

Table 17 Contribution platform to upscaling conditions participation

4.5 Pilot 3D building permits

The pilot 3D building permits is aiming to make the process of handing-out building licences more efficient by partly automatizing certain checks and controls in a 3D environment. The main goal of the pilot can be formulated as:

> D13: "The realization of automated building permit processes. To do so, an integral system, based on 3D, for digital testing of building permits is realized."

The main **stakeholders** that are related to the pilot are the municipality of Rotterdam, consisting out of the Digital City program and the building department and the knowledge institution TU Delft (D13, D14 & R14). The digital city program is responsible for coordinating the pilot and keeping an eye on the relation of the pilot with the Digital Twin (R14 & D14). The building department is responsible for the handing-out of building permits and therefore knows a lot about the process that needs to be translated to the 3D environment. The TU Delft is developing the software that is needed to automatize the process (R13, R14). The main communication instrument in which these parties were kept up-to-date about the progress and the **added-value of the pilot** consisted of organized workshops (R12-R14). These meetings went sometimes rather difficult because of the language barrier. This was especially difficult because it concerned complicated legal texts about building laws (R12-R14). Moreover, the collaboration also faced difficulties because not all the experts acknowledged the benefit of the pilot. (R12 & R14).

> R14: "That did not go smooth at all. The experts thought that the process was way too complex to automatize it"

In other words, some building experts believed in their expertise, leading to a distrust in automatization attempts (R14, R15). In addition to this, there was one specific actor from the building department putting a lot of effort into this project. Due to personal circumstances, he fell away and the project stagnated. This shows that the implementation of innovative pilots hangs often on individuals. When it comes to **reflecting and evaluating**, project-related issues, such as how to convince a department of the municipality to use an innovative tool, are not written down in the lessons learned report (R13-R15). This report, written by the TU Delft, focuses only on resolving technical issues (R13). The underlying reasons for this are the so-called 'free-style' culture within the pilot, which means that the involved actors prefer to work together without red-tape procedures and moreover, within the municipality, progression is mostly perceived as realizing a concrete result (R12, R14, R15).

> R15: “The municipality is a very much result-oriented organization. While sometimes a pilot can also be a success if it leads to a learning-result instead of a physical result”

Within the realization of the pilot, the aspect of **skills and knowledge** is one of the main focus points: the tool that is going to be realized needs to be user-friendly (R12-R15). Despite this user-friendliness, there is still training needed. Not because of the fact that the building department employees are not able to use the tool technically, but because there is scepticism towards the tool in itself (R15). A reason for this lies in the fact that they have an oversight on all the different 3D BIM **data-standards** that are present in their working field, which is difficult to bring together in just one tool (R12, R13). After all, a lot of parties are building their programs with their own standards, without any coherence (R12-R14). At the moment, the pilot is does not have an accessible **IT infrastructure** for all the involved actors. The integration of Building Information Models and Geodata is done in a computer program of the TU Delft without any integration with the processes or systems of the municipality

R14: "The data is collected in a computer program of the TU Delft that uses Python to write software for the 3D building licenses. So it is just located on the computer of one of the scientists"

Upscaling conditions	Subdimension	Score
Technical conditions	IT infrastructure	
	Data standards	
Human conditions	Reflecting and evaluating	
	Sharing resources	
	Skills and knowledge	
Institutional conditions	Demonstrating value	
	Inclusion of stakeholders	
	Vision and goals	

Table 18 Presence of upscaling conditions 3D permits

4.5.1 The role of the platform

As can be seen in the table above, a few conditions are not fully present in the pilot 3D building permits. The ways in which, according to the respondents, the platform the Digital Twin contributes to these upscaling conditions will be discussed briefly below.

Integrating technology

First, the technical conditions **IT infrastructure** and **data standards** are not present within the pilot 3D building permits. According to the respondents, the platform the Digital Twin contributes to these conditions by facilitating an *interoperable IT system* so that the manual conversion between data is not necessary anymore (R13-R14)

Secondly, the pilot stagnated because not all actors saw **the added-value** of the pilot. The platform fulfils the role of *leverage* for the Pilot 3D building permits because the common, overarching architecture of the platform leads to a conversation between actors where everyone is talking about the same factual information (R12 & R14). According to the respondents, not only does this lead to a more efficient way of working within the municipality, but the involved actors could also see the benefit of the pilot (R14 & R15). In other words, when every property developer is working with the same software as the municipality, the coordination between actors is more efficient. The leverage dynamics are thus not only stimulating the **demonstration of value**, but also the **inclusion of stakeholders**.

> R12: "You can overcome differences in perspectives because you are talking about the same situation."

Fostering collaboration

Third, and even though **sharing resources** as a condition was present in the pilot, the platform fosters collaboration through the role of *synergy*. Via the platform, different parties with synergetic knowledge can be brought together to develop new solutions for problems in the city (R12 & R14).

Fourth, the **inclusion of stakeholders** was organized professionally through the workshops, but in the end, it turned out that the pilot was depended on one enthusiastic employee and there was not a broad coalition within the organization (R14 & R15). The respondents did not mention that there was a way in which the platform contributed to this.

Fifth, the human conditions **skills and knowledge** and **reflecting and evaluating** are also lacking, but the respondents did not state that the platform fulfils a role in this.

Wrap-up

The platform contributes in several ways to the upscale conditions of the pilot SAFE 3D. This is summarized in table 13.

Upscaling conditions	Subdimension	Contributing role of platform
Technical conditions	IT infrastructure	Transversal and interoperable systems
	Data standards	Transversal and interoperable systems
Human conditions	Reflecting and evaluating	
	Sharing resources	Synergy
	Skills and knowledge	
Institutional conditions	Demonstrating value	Leverage
	Inclusion of stakeholders	Leverage
	Vision and goals	

Table 19 Contribution platform to upscaling conditions 3D permits

4.6 The relationship between platform and pilots

To formulate an answer to the research question of this thesis, it is important to compare the different cases with each other. Beneath, in table 20 an overview is presented on the absence or presence of upscale conditions in the examined pilots. When a certain upscale condition is present, the cell is marked green, when the condition is somewhat present, the cell is marked orange and when a condition is not present, the cell is marked red. Moreover, within specific cells, the roles in which the Digital Twin contributes to the upscaling process is written down. The remarkable results will be discussed and structured as follows: (4.6.1) technical conditions, (4.6.2) human conditions and (4.6.3) institutional conditions.

Upscaling conditions	Subdimensions	SAFE3D	QR visualization through AR	Participation	3D permits
Technical conditions	IT infrastructure	Transversal systems			Transversal systems
	Data standards	Transversal systems	Transversal systems		Transversal systems
Human conditions	Reflecting and evaluating				
	Sharing resources	Synergy		Synergy	Synergy
	Skills and knowledge				
Institutional conditions	Demonstrating value	Attractor Leverage	Attractor		Leverage
	Inclusion of stakeholders	Attractor	Attractor	Real-time data Leverage Attractor	Leverage
	Vision and goals	Transversal systems	Attractor		

Table 20 Overview upscaling conditions and role of the platform

4.6.1 Technical conditions

Within every pilot, the *technical conditions* are lacking. The explanation of the absence of technical conditions may differ from the fact that certain software is developed isolated from the working processes of the municipality of Rotterdam, as can be seen in the pilot 3D permits, to the fragmented landscape of 3D data standards, as can be seen in the pilot QR code visualization (R4-R6 & R12-14). Another, the more underlying reason is that the platform is still under development and therefore within every pilot, certain workarounds are developed to imitate the future platform-situation at best (R6, R10, R14, R3, R2). One example of this is that within the pilot participation the involved actors are exporting data from the platform to an external server to develop a prototype (R10 & R11). However, within the pilots SAFE3D, participation and 3D permits, the respondents state that the transversal and interoperable systems role of the platform contributes to the technical upscaling conditions. The reason for this lies mainly in the fact that the platform should be a place in which all the data of the city is collected and where common data standards are arranged (R3, R6, R11). Another notable result is that the availability of real-time data does not contribute to the technical upscaling conditions in one of the cases.

4.6.2 Human conditions

The *Human conditions* are in general more present in the investigated pilots. Especially when it comes to **skills and knowledge**, the pilots are performing above average. The reason for this is that all the examined pilots are working towards a prototype in which usability is an important criteria (R2, R6, R7-10 & R14). Therefore, the end-users do not need to master a high level of IT skills (R12, R15). However, the human condition **reflecting and evaluating** is lacking in every pilot (R3, R6, R10 & R14). It is the case that there are some attempts to write down certain lessons learned, but there can still me made major improvement. First, the reflection practices that are most common in the pilots are focused more on technical lessons learned (R3, R4, R10, R12). This leads to the fact that process-related lessons learned are somewhat overlooked (R10, R14). Second, writing down lessons learned happens at the moment mostly on an ad-hoc basis instead of structurally embedding these processes in regular working activities. As can be seen in table 20, there is not a role that the platform fulfils in strengthening the human condition reflecting and evaluating nor to the condition of skills and knowledge. The reason for this is that human conditions are more embedded in the culture of an organization and therefore are not easily solved through the deployment of an IT tool. Moreover, the platform is in the first instance focused on technical aspects, like facilitating a marketplace and infrastructure for the exchange of data (D1, D2 & R3). Human aspects, like collaboration and interaction, are functions that are getting more relevant in a later stage of the development of the platform (D1, D2 & R3). The last human condition, **sharing recourses**, is stimulated through the platform. Particularly in the case of SAFE3D, where this condition is somewhat lacking. The reason that sharing recourses is a more difficult condition to fulfil in the pilot SAFE3D lies in the fact that there are far more external stakeholders involved that have an active role in the collaboration process, which makes the aspect of sharing recourse more complex (R1 & R3). The platform of the Digital Twin contributes to the upscale condition of sharing recourses because it can bring together stakeholders both from within the municipality as well as external partners in one environment to exchange data in a synergetic way (R3, R6, R11, R16, R17).

4.6.3 Institutional conditions

The examined pilots are differing the most regarding the *institutional conditions*. When it comes to the condition of **demonstrating value**, three out of four pilots show the added-value of the pilot sufficiently. The reason for this is that the 3D aspect, on which all the developed prototypes are built, makes the product more understandable, more intuitive and more attractive (R2. R3, R4, R10). Only within the pilot 3D permits, the condition is not present. This is because the involved department of the municipality does not underline the added-value of the pilot. (R12 & R14). In the cases of SAFE3D and QR code visualization, the role of the platform *attractor effects* stimulates this upscaling condition because the appealing prototypes have a broader audience and other actors can build further upon the already existing pilot (R2. R3. R5 & R6). The condition **inclusion of stakeholders** was in all the cases not fully present. However, the underlying reason for the absence of this condition differed per case. Within the pilot SAFE3D, there were a lot of external organizations involved in the collaboration process which on the one hand led to a broader coalition that supported the sake of the pilot, but on the other hand, made it more complex (R1 & R3). Another example is that, within the pilot of QR code visualization, there was not a broad coalition of partners, which caused difficulties for the project leader in realizing the pilot and finding actors that could bring the pilot further (R4 & R6). Regarding the aspect of the inclusion of stakeholders, all the respondents stated that the platform stimulates this. The two main ways in which this occurs is through leverage and attractor effects. The 3D aspect of the platform makes that leverage creates a shared reality between all the involved stakeholders, meaning that they are talking on the same basis, causing more effective and efficient coordination. Moreover, the attractor effects, which stimulates the inclusion of stakeholders because the threshold to get involved and collaborate is lower and people see the success of a certain pilot and want to join (R3, R6, R11). The last condition, **vision and goals**, is present in two pilots and somewhat present in the pilots QR code visualization and participation. The reasons for this lie in the fact that there is not a clear vision about what is going to happen with the end-product after the pilot phase. In both pilots, there are already in conversation within the municipality if a certain department will take over the pilot and develop it further, but there is no clear agreement yet. The role that the platform plays in facilitating these conditions is somewhat limited. One way in which this could still occur it through attractor effects. After all, when you have to build further upon another pilot or product you have to force yourself to be concrete and formulate a dot on the horizon.

4.7 The platform in development

As mentioned before, the platform the Digital Twin is not fully operational and still in development. This leads to the fact that there is often a gap between the score of a certain upscaling condition and the role that the platforms play in stimulating this specific condition: the respondents often see a more prominent role for the platform than it is, in reality, is fulfilling (R3, R4, R5, R11). Moreover, the fact that the platform is still in development leads to two other interesting topics that need to be discussed: the two-folded relationship between platform and pilots and the implementation of the Digital Twin.

4.7.1 Two-folded relationship between platform and pilots

One of the main results of this research is that the relationship between the digital platform 'the Digital Twin' and the related pilots is non-linear and working in multiple directions. After all, the platform is still under development and can be seen as a pilot in itself. Therefore, the relationship between the digital platform and the related pilots is complex and works in two ways. On the one hand, as mentioned in the chapters before, there are several ways in which the platform can contribute to the upscaling process of pilots. On the other hand, the pilots serve a higher cause in demonstrating the value and the possibilities of the platform. This way, the pilots contribute to the development and upscaling process of the platform.

> R9: "The platform and the Digital Twin can strengthen each other. (…) A platform can cause the pilot to have broader reach and the results of certain pilots show the added-value of the platform".

Moreover, the definition discussion about when something is a called a platform and when something is called a pilot is marked by ambiguity. There is some agreement within the digital city program that line should be drawn as followed: "The platform is a place in which data can be collected, stored and visualized and a pilot is that what you do or create by using these aforementioned functions"

4.7.2 Implementing the Digital Twin

As described before, there are several ways in which the platform could contribute to the upscaling processes of smart city pilots in Rotterdam. However, because the platform is still under development, a recurring theme during the data-collection was how the Digital Twin could be effectively realized. To implement the Digital Twin, the technique was not an obstacle. The challenge was by far and foremost how to organize it within the whole organization.

> R3: "That is the ongoing discussion about it is 25% technique and 75% culture and organization

The reason that the platform has difficulties regarding the implementation is that the organizational processes are sometimes slow and inefficient (R4, R6). One of the main points that have been made in the interviews is that it is of major importance to have structural contact and coordination between the program and the departments of the regular organization. Moreover, these developments are often dependent on an enthusiastic individual. Therefore, it is of major importance to find these individuals within the organization and building a sustainable relationship with them (R14, R12, R17). Besides, it is helpful to build a broader coalition within a certain department so that when one of these individuals fells away, another actor can take it over (R14, R16, R17). Another problem is how these pilots or temporary programs need to be structurally embedded within the organization.

> R16: "In the end, the parts of the program need to find a place within the organization. It is always a balance between fast development within a program or structural development in the regular organization"

The main issue regarding this aspect is that when a pilot starts, all different kinds of stakeholders are willing to join an enthusiastic about the sake of the pilot because it is still a non-binding process. The enthusiasm reduces, however, when the end-result of the pilot has to be structurally embedded within the regular processes of the municipality (R8, R15, R16). This is something that also lies in the organizational structure. The fact that we are managed hierarchically, also causes people to be reluctant to take ownership responsibility because they could get judged upon that (R8, R9, R17). In other words, the structure of the organization does not fit with the ambition to be flexible and collaborate with the city. Therefore, some respondents argue that a bigger reorganization is necessary (R8, R16, R17, R18).

5. Theoretical reflection

To determine the value of the results that have been described in the previous chapter, it is important to reflect on the relevance of this research in a broader context. To do so, the results of this research will be discussed in light of the theoretical framework and where of added-value new academic literature is discussed. In other words, this chapter will zoom in on where this thesis confirms the existing body of literature and where it may add new insights to the scientific literature. First, the relevance of the categorization of upscaling conditions is discussed. Second, the relevance of the roles of the platform is addressed. Third, there will be zoomed in on the relationship between certain roles and specific upscaling conditions. Fourth, the fact that the platform is still under development is reflected upon. Finally, the new conceptual framework, enhanced with the insights of this thesis and insights from the existing literature, will be presented in figure 7.

5.1 Categorization of upscaling conditions

Within the theoretical framework, the smart city indicators, as described by Nam and Pad (2011), were translated into conditions for upscaling that suit the context of pilots, using insights from a broad range of academics, such as Van Winden and Buuse (2017), Bekker et al. (2013), Dijk et al. (2018) and Oomen (2016). This categorization turned out to be relevant during the data-collection. Therefore, this thesis adds a new, overarching framework to the literature that can be used to measure the upscale potential of pilots. Moreover, some of these conditions can be organized, using the functions that exist within digital platforms. This will be discussed later on in further detail, but it is clear that most human conditions, such as reflecting and evaluating, are organized more effectively in a non-platform context. However, it is not clear whether or not these human conditions can be stimulated through a digital platform in other cases. To investigate this, future research is needed, which will be discussed in 6.3.1.

5.2 Relevant roles of the platform

The question remains, however, what the concrete role of the platform is in the upscaling process of smart city pilots. Within the theoretical framework, the theory of boundary objects is used to bridge the gap between the concepts of digital platforms and upscaling pilots (Cibora, 1996). Digital platforms can fulfil a boundary spanning role because of their boundary bridging nature (Star, 2010; Williams, 2002). In the case of the Digital Twin, this means that digital platforms connect people and integrate technologies that otherwise would not have interacted (Green, 2010). Therefore, digital platforms contribute to upscaling conditions in two specific ways, as described in the theoretical framework. (Ansell & Gash, 2018; Ranchordas, 2017; Yang et al., 2015): first, the integration of technology, with the subdimensions transversal and interoperable systems, real-time data and leverage; and second, the fostering of collaboration with the subdimensions attractor effects, learning and synergy. In the analysis of this research, it became clear that some roles contribute to specific upscaling conditions, namely attractor effects, synergy, leverage and transversal and interoperable systems. However, the other roles of the platform, learning and real-time data, were not mentioned in the data collection. Learning considers the fact that, via the interaction on the platform, actors learn lessons that can be used in establishing new collaborations (Ansell & Gash, 2018). One reason that this role was not mentioned could be that more soft dynamics such as learning should occur mostly in face-to-face contact than on a digital platform. As Ansell & Gash (2008) state in earlier academic work on collaborative governance, face-to-face dialogue is a major success condition in collaboration processes. Regarding the availability of real-time data, the data-collection ought to make clear that the availability of real-time information was not necessary for smart city pilots. The presence of high-quality data in itself, apart from being real-time, is enough to stimulate upscaling conditions. The reason for this could lie in the fact that data platforms are often more successful when the available data can be linked directly to a certain societal issue that needs to be addressed (Hogan, Ojo, Harney, Ruijer, Meijer, Andriessen & Groff, 2017) . In other words, the relevance of data is a more important success condition than its real-time nature (Hogan, et al., 2017). The irrelevance of these roles leads to two concrete adjustments in the conceptual framework. First, the learning role of the platform is left out because it turned out that this did not a relevant role. Second, the availability of real-time data is converted into the availability of relevant data, because that benefits the sake of the pilot.

5.3 Unfolding the relationship between platform and pilot

As stated in the section above, there are four main roles of the platform that play a role in the upscaling process of smart city pilots, namely: leverage, transversal and interoperable systems, attractor effects and synergy. However, within the existing literature, there is no clear agreement on which of these roles can contribute to which of the upscaling conditions of smart city pilots (Ranchordas, 2017 Freafel et al., 2017). This led to the theoretical assumption that "integrating technology contributes mainly to technical conditions and a bit to human conditions; and fostering collaboration mostly contributes to human and institutional conditions" (2.5.3 p. 22). In reality, it became clear that that the integration of technology through the facilitation of *transversal and interoperable systems* contributes to the technical conditions, but another aspect of the integration of technology, namely *leverage,* contributes more to the institutional conditions. Furthermore, regarding the aspect of fostering collaboration, *attractor effects* and *synergy* contribute to the institutional conditions. As mentioned earlier, the added-value of the platform to the human conditions is quite limited: only the aspect of sharing knowledge is stimulated through the synergetic role of the platform. This is visualized in the new conceptual model in figure 7, by drawing multiple relationship arrow. This way, this thesis adds to the existing literature by outlining a more comprehensive description of the relationship between digital platforms and pilots. Furthermore, it gave insight into the fact that human conditions are only limitedly facilitated through the platform and that the integration of technology also benefits the institutional conditions. Moreover, on forehand of this research, the assumption was made that pilots that involved a lot of collaboration benefitted more from the fostering collaboration role of the platform (see 3.2.1). Therefore, two collaborative cases and two technical cases were selected. However, it turned out that when a pilot is related to a digital platform, all the pilots benefited equally from both the integration of technology as well as the fostering of collaboration. The reason for this could lie in the fact that all the pilots are already related to the digital platform and therefore require a certain technical basis (Van Winden & Van den Buuse, 2016). Finally, it is important to note that, on the one hand this thesis gives insight in the complex dynamics of upscaling processes, while on the other hand, it is difficult to present a complete and all-including overview of the whole upscaling process. After all, a main characteristic of complexity and boundary objects is that it is difficult to pin down their specific dynamics (See section 2.5.1). One example that illustrates this is that it is unclear to conclude, on the basis of this study, if the dependent variables are mutually influencing each other. In the academic literature, this phenomenon is called interaction effects (Annuar, Salihu & Sheikh Obid, 2014).

5.4 The platform in development

Within the academic literature, digital platforms are often described as already existing digital entities that have certain characteristics and dynamics that foster collaboration and integrate technology to stimulate the emergence of ideas and projects (Ranchordas, 2017; Ansell & Gash, 2018). However, in in this case, the Digital Twin is still under development and the related pilots have the purpose to demonstrate the added value of the platform in itself. In other words, the Digital Twin is still a pilot that needs to be upscaled. This could explain the gap between the absence of certain upscale conditions even though the platform is facilitating these specific conditions (see 4.7). Moreover, the fact that the platform is not fully operational can also clarify why the roles *learning* and *real-time data* were not of added-value to the upscaling process of smart city pilots. Ansell & Miura (2020, p.271) state in a recent publication that digital public platforms promise to "connect government to distributed communities of citizens and stakeholders, to scale up activities, expand the scope of problem-solving efforts, and to provide greater leverage". Their research (2020) also uncovers that there are popping up digital platforms all around the world, but most efforts are still in an early phase of development. There are, however, also quite some success stories, such as the open innovation platform challenge.gov, that confirm that digital platforms bring about a wider and deeper transformation of government because of their organizational logic that enables the scale up of pilots (Ansell & Miura, 2020). Therefore, the platform itself needs to be investigated to determine the extent to which it was developed enough to fulfil the roles that is should fulfil (Ansell & Miura, 2020). One way this can be done in the future is to build research around the theory of *network effects*, which comes basically down to the following: the more users a platform has, the more successful it will be (Tiwana, 2013). Within this research, the network effects were left out of the conceptual model, but the amount of suppliers and demanders that are present on the platform determines for a major part the effectiveness of platform roles, specifically attractor effects and synergy (Van Winden & Van den Buuse, 2016; Parker et al., 2016). The extent to which success attracts success and how much synergetic relations can emerge are namely depended on the amount of users of the platform (Tiwana, 2013). In conclusion, it can be stated that the relationship between pilots and the Digital Twin is far more complex and in a two-way direction. After all, the success of a pilot influences the added-value of the Digital Twin, amongst others through network effects. As stated, this especially relates to the roles of attractor effects and synergy. Therefore, there is also drawn a relationship arrow from upscaling conditions back to the roles attractor effects and synergy in the new conceptual model (figure 7).

5.5 Enriched conceptual model

The insights of the theoretical reflection are all incorporated in the enriched conceptual model as visualized in figure 7. As stated earlier, the human conditions reflecting and evaluating and skills and knowledge are organized more effectively in a non-platform environment. Therefore, there is only drawn an arrow from the synergetic role of the platform to the human upscale condition sharing knowledge. There are, however, multiple ways in which the digital platform contributes to upscaling conditions more effectively, as visualized by the arrows drawn from the role of the platform to the upscaling conditions. The role of transversal and interoperable systems contributes to the technical conditions; leverage contributes to the institutional conditions and the fostering collaboration dynamics, namely attractor effects and synergy, contribute to the institutional conditions. Moreover, as described in 2.5.1 and 5.3, the process of upscaling is complex and multidimensional. The fundament that closes the gap between platform and pilots is the theory of boundary objects. However, this theory also underlines the presence of complexity, non-linearity and interaction effects. To some extent, the results of this research help to understand the dynamic, complex nature of upscaling processes by visualizing relations between the concepts roles pointing out that the relationship between platform and pilot is two-folded. As described in section 2.4 and visualized in figure 7, the upscaling conditions influence mainly the attractor effects and synergy. However, on the basis of this research, it is impossible to visualize all the relations that are relevant in the model. After all, interaction effects, the two-sided influence between independent variables (Kenny & Judd, 1984), were not measured in this research. Therefore, complexity is visualized as a external factor that potentially influences the upscaling process more intensively than on the basis of this study can be confirmed. The influence of complexity as an external factor is drawn in figure 7, visualized by a dotted line.

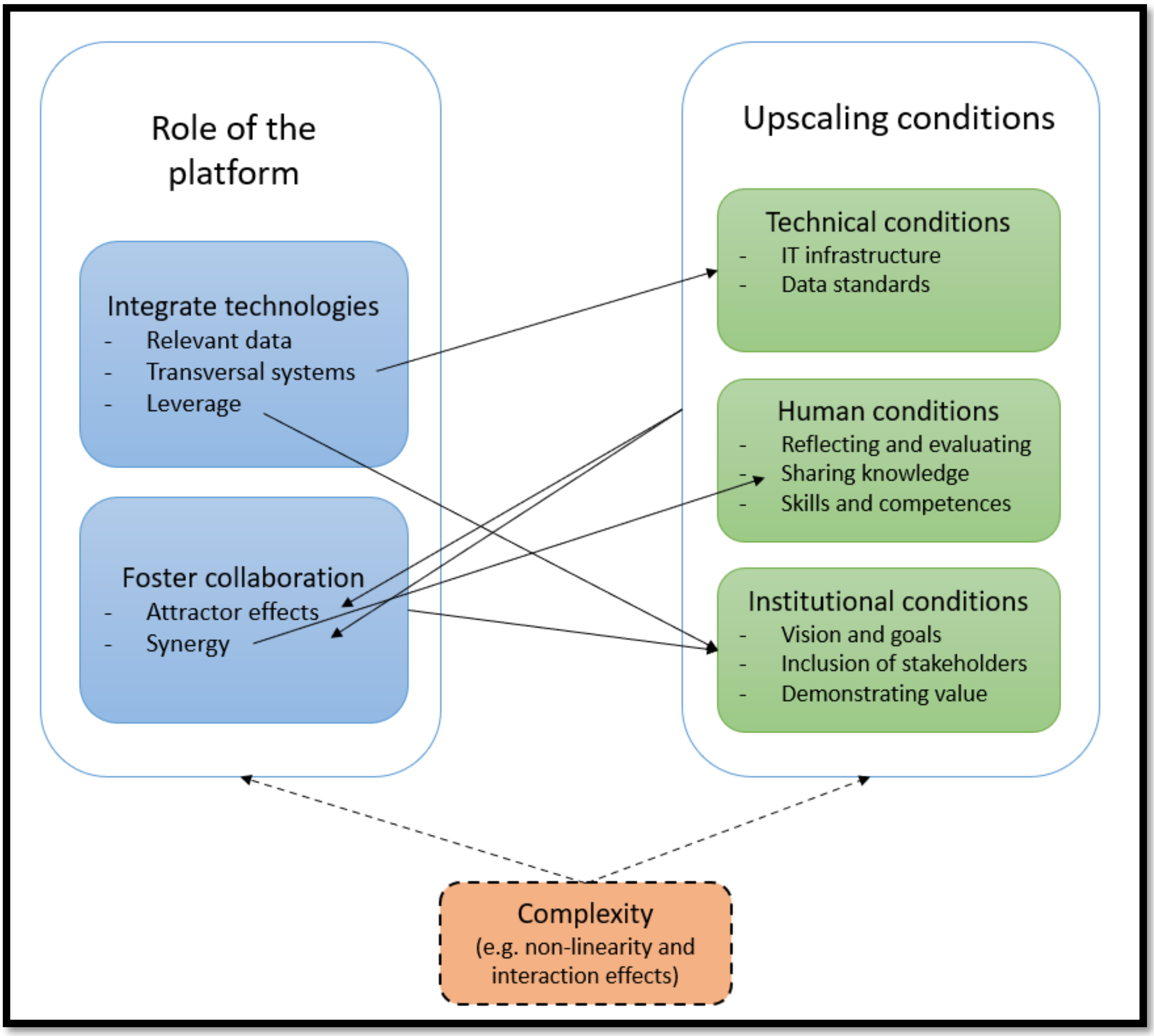

Figure 7 New and enriched conceptual model

6. Conclusion and discussion

The final chapter of this thesis contains the conclusion and discussion. In the conclusion, the most relevant results will be presented, structured by the empirical questions that are the foundation of this research. Moreover, the answer to the main research question is formulated. In the discussion, the limitations of this research will be discussed, after which scientific implications and practical recommendations will be presented.

5.6 Conclusion

This thesis aimed to contribute to the understanding of the relationship between smart city pilots and digital platforms. Therefore the overarching goal of this research is to understand the role of the Digital Twin in facilitating the upscaling process of smart city pilots in Rotterdam. Corresponding to this goal, the following research question was formulated: "*What is the role of the Digital Twin in upscaling processes of smart city pilots in Rotterdam and how can this role enhance these upscaling processes?* ". To come to a substantial answer on this research question, qualitative research was conducted on four subcases, namely SAFE3D, QR code visualization through augmented reality, participation and 3D building permits. To collect a rich dataset, stakeholders with different perspectives on these pilots were interviewed, leading to a total of 18 interviews. To structure the empirical research, the following empirical sub-questions were developed:

1. To what extent are the smart city pilots related to the Digital Twin already in the process of upscaling?
2. Which upscaling conditions are present in smart city pilots that are related to the Digital Twin?
3. How can the Digital Twin enhance the upscaling conditions present in smart city pilots?

Before answering the main research question, the answers on the empirical sub-questions will briefly be discussed.

First, *to what extent are the smart pilots related to the Digital Twin already in the process of upscaling*? All the investigated pilots are still in the development phase. The initiators are developing a concrete prototype and discovering what the added value of the platform is in tackling societal issues. Moreover, the platform is also under development. Therefore, pinning down the role of the platform in upscaling smart city pilots is mostly based on perceptions, which will be discussed in the research limitations. In addition, this also explains why some roles of the platform turned out to be irrelevant to the upscaling process of smart city pilots. After all, if the platform is fully operational it will probably fulfil a different, more prominent role. As stated in the theoretical reflection (5.4), there are already multiple success stories of digital platforms that foster upscaling dynamics, a development that draws a bright future for the Digital Twin.

Second, w*hich upscaling conditions are present in smart city pilots that are related to the Digital Twin*? Within the different pilots that have been investigated within this thesis, there are several upscaling conditions present or absent, as visualized earlier in table 20. The **technical conditions** are in all the pilots not sufficiently organized. One main explanation for this is that the platform is still under development, leading to the fact that within the pilots certain workarounds are used instead of using the common architecture of the platform. The **human conditions** are more present in the pilots, especially when it comes to the skill and knowledge of the involved stakeholders. The main issue regarding the human conditions is the lack of structural embeddedness of reflecting and evaluating and the focus on technical lessons learned instead of more collaborative, process-oriented learnings. The presence of the **institutional conditions** is varying the most between the investigated pilots. The success condition of demonstrating value is present in most pilots because there are structural meetings being organized and the 3D aspect is adding an extra intuitive layer to the showcase of the added-value. When it comes to the inclusion of stakeholders, there were more difficulties within the pilots, varying between a complex collaboration with external stakeholders in the pilot SAFE3D to a lack of stakeholder engagement within the pilot QR code visualization. The last issue considers the conditions vision and goals: it is hard to define on forehand how the project is developed further after the pilot phase. Thus, the of upscaling conditions, especially the technical and institutional conditions, need to be enhanced in order to broaden the impact of the pilots. The question remains, however, to what extent the Digital Twin can fulfil a role in this process.

Third, *How can the Digital Twin enhance the upscaling conditions present in smart city pilots?* During the data collection and analysis, there came up several ways in which the Digital Twin contributes to the upscaling conditions of pilots. The roles that were described mostly were: transversal and interoperable systems, attractor effects, leverage and synergy (See table 21). **Transversal and interoperable system**s relate to the fact that the platform is a place in which all the data of the city can be stored in a certain open data format. In other words, the Digital Twin could fulfil the role of a so-called common marketplace for data exchange. **Attractor effects** aim to describe how a successful project attracts other successful projects. Specifically for the role of the Digital Twin, this means that the platform shows certain successful projects that can stimulate others to build further on the results of that project. **Leverage** relates to the fact that the platform creates one shared reality that lays the basis of the dialogue between stakeholders from different backgrounds. This way, coordination and communication is more efficient. **Synergy** means that the platform plays a role in facilitating the exchange of data, information and perspectives between stakeholders. In the first place, this can be constituted through the earlier mentioned marketplace for data. In sum, there are several roles of the platform that the Digital Twin can fulfil in order to stimulate the upscaling conditions of pilots. In the answer on the research question, which is formulated in the next section, this specific process is unfolded and subsequently it is discussed how this process can be enhanced.

The answers on the empirical sub questions help to formulate a final answer on the main research question of this research, namely: *What is the role of the Digital Twin in upscaling processes of smart city pilots in Rotterdam and how can this role enhance these upscaling processes?* As stated in the answer to the third empirical question, there are several upscaling conditions to which the platform contributes. The most important relations are drawn in the enriched conceptual model (see figure 7). However, there are also a couple of conditions that are not improved through the dynamics of the Digital Twin. Reflection and evaluating is particularly something that should be organized in a non-platform environment. If the platform aims to stimulate the human upscaling processes of smart city pilots, it needs to be perceived, not just as a technical tool to exchange data, but more as an open innovation platform that facilitates the interaction between all the actors in the city. Moreover, not all the upscaling conditions may be suitable to be stimulated by a digital platform. In other words, complex social dynamics cannot simply be replaced by an IT tool and should instead be organized in face-to-face meetings. Thus, for each pilot that is launched, the initiators should take in consideration how they are able to use the platform in their advance and what, more human, upscaling conditions need to be realized in another way.

5.7 Limitations

When reflecting on the quality of the research, three main issues are relevant to mention. First, and one of the more fundamental limitations is that the results of a case study are difficult to generalize (Gomm, Hammersley & Foster, 2000). After all, looking into a specific case leads to the fact that other relevant cases will be left out. To overcome this, this research generalizes the empirical results that are found in the examined pilots through a theoretical reflection in chapter 5. Second, the Digital Twin is not fully operational yet. Moreover, the related pilots are also in an early phase of development. Therefore the data that has been collected within this thesis is not about concrete observations on the dynamics of the platform, but more about the perception from the respondent towards the Digital Twin. Third, the search for respondents started within the digital city program of the municipality of Rotterdam. Therefore, there is a risk that the respondents that were interviewed in the context of this research were sometimes positively biased towards the added-value of the Digital Twin. During the selection of respondents, this bias was limited by actively selecting less positively biased respondents.

6.3 Recommendations

In this subchapter, the scientific implications and practical recommendations of this research will be discussed.

6.3.1 Scientific implications

This research aimed to contribute to a better understanding of the role of digital platforms in the upscaling process of smart city pilots. In other words, the gap between two important streams of literature, namely digital platforms and upscaling smart city pilots has been reduced (See 1.4.2). The results of this research have led to answers regarding the added-value of the Digital Twin on the upscaling conditions of smart city pilots. These insights have been included in the new, enriched conceptual model that has been presented in chapter 5 (See figure 7). However, there are three main topics that need to be looked into more in-depth to get a better grip on how this added-value could be accomplished. First, the Digital Twin is still under development and and the smart city pilots that are examined are only in the starting phase. Therefore, it is of major relevance to do follow-up research on the relationship between digital platforms and the upscaling processes of pilots when the platform is fully operational. One way this can be done specifically is through panel data methods or cross-sectional time-series (Certo & Semadeni, 2006). This methods allow the researcher to map out the development of certain smart city pilots over the years. Second, by the start of this research, it was assumed that the platform-pilot relation was quite linear and working in one direction. However, during the research, it was discovered that not only the platform is of added-value to the pilots, but the pilots also had an important role in demonstrating the value of the Digital Twin. Therefore, it is interesting to dive more into the complex, two-folded relationship between platform and pilot, for example by focusing on the interaction effects (see 5.3). Third, this research showed that human conditions are only limitedly facilitated through the Digital Twin. The question remains, however, if a more social dimension is added to the platform, that it could stimulate these human conditions more adequately. To investigate this, more research is needed on a broad range of different 'open innovation platforms' and their added-value to human conditions in the upscaling process of pilots.

6.3.2 Practical recommendations implications

As stated in the introduction, if the impact of smart city pilots could be broadened by upscaling the pilot through the digital platform, this will have a major societal impact (See 1.4.1). This research has given insight into what should be considered in this upscaling process. After all, multiple insights were generated about where a digital platform could be of added-value in the upscaling process and where it was better to organize the condition apart from the platform. Moreover, the analysis brought up several ways of how the specific upscale condition should be organized. In order to translate these insights to a more practical level and make societal impact, a handling perspective for each upscaling conditions is described in table 21. This way, the results of this thesis may give practitioners in the field more knowledge on how to organize smart city pilots in such a way that the impact broadens and societal issues can be addressed. A more general recommendation contains the fact that the platform is still under development and to fulfil a prominent role in the upscaling process the platform needs to be fully operational. In addition, it is interesting to investigate the possibility to add a more social dimension to the platform, so that in the future human conditions could potentially benefit more from the platform. Moreover, one of the main outcomes of this research is that the relationship between platforms and pilots are far more complex and dynamic than on forehand expected. Therefore, it is important to note that this is complexity cannot be unfolded through straightforward, linear measures.

Upscaling conditions	Subdimensions	Handling perspective
Technical conditions	IT infrastructure	**Platform** - Use the role of 'interoperable and transversal systems' to ensure one single and accessible infrastructure that is used by multiple stakeholders. Specifically, this contains the fact that the platform is one system in which all the data of the city is stored and accessible.
	Data standards	**Platform -** Use the role of 'interoperable and transversal systems' to arrange the facilitation of (open) data standards within the platform. Specifically the aforementioned data-store should contain commonly agreed data standards to facilitate this.
Human conditions	Reflecting and evaluating	**Governance** - Organize this condition apart from the digital platform. The focus hereby should not only be on technical lessons learned, but also on process-oriented learnings. Moreover, this reflection should be structurally embedded. This can not only lead to a successful realization of the pilot but also contribute to the development of the platform.
	Sharing resources	**Platform** - Use the role of synergy to design the platform as a marketplace in which not only data, but also knowledge and perspectives could be exchanged.
	Skills and knowledge	**Governance** - This condition should be organized apart from the digital platform. To do so, certain workshops that focus on how to use the platform could be organized.
Institutional conditions	Demonstrating value	**Platform** - One of the major benefits of the Digital Twin is the 3D aspect that makes the demonstration of progress more intuitive and comprehensible. This can be used to ensure this upscale condition, especially when the attractor effects of the platform are at work.

	Inclusion of stakeholders	**Platform** - Several platform roles contribute to this condition: attractor effects, leverage and synergy. In other words, when you want to include a broad range of stakeholders that work together efficiently and share resources, the development of the Digital Twin is of major importance.
	Vision and goals	**Governance** - Regarding this aspect, it is most important to, apart from the platform, determine how the pilot is going to be developed further after the pilot phase. If this is not agreed on the forehand, this impact the upscale process negatively.

Table 21 Upscale model and handling perspective

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Appendix A: Data collection

Overview respondents

Number	Subcase	Function
1	General	Program leader digital city
2	General	Policy maker I-vision municipality
3	General	Architecture expert municipality
4	SAFE3D	Project leader SAFE
5	SAFE	Policy maker SAFE
6	SAFE	Knowledge institution
7	QR Code visualization	Project leader
8	QR Code visualization	External company
9	QR Code visualization	Policy maker municipality
10	Citizen participation	Project leader
11	Citizen participation	Project leader
12	Citizen participation	Project leader
13	Citizen participation	Urban planner
14	Citizen participation	Policy maker
15	3D building permits	Project leader
16	3D building permits	Technical worker municipality
17	3D building permits	Knowledge institution
18	3D building permits	Policy maker
19	Expert	Comparison of governance of platforms

Overview documents

Case	Documents
General program	*D1: Presentatie – 4 Smart City - Rotterdam* *D2: Presentatie digitaliseringsagenda* *D3: Presentatie– Gemeente Rotterdam* *D4: SC_Argumented reality in Rotterdam* *D5: VoorstelCMRSamenDigitaleStadRotterdam*
SAFE	*D6: Projectplan 0.9 SAFE3D* *D7: SAFE3D krachtenveld* *D8: Tussentijdse Lessons Learned Rotterdam 3D*
QR codes	*D9: Augmented Reality van bouwprojecten obv 3D* *D10: Projectidee van QR naar AR*
Citizen participation	*D11: Samenvatting Usercases Pilot Participatie* *D12: Presentatie Pilot Participatie*
Automatizing licences	*D13: Projectplan DS 3e pilot OW* *D14: BIM verzamelen, verbinden, visualiseren*

Appendix B: Topic list

<u>Introductie</u>

- Small talk
- Introductie van mezelf en het onderzoeksonderwerp
  - Hugo Hegeman, voormijn afstudeerproces van mijn studie Urban Governance loop ik stage bij de programma's datagedreven werken en de digitale stad. In dat kader doe ik onderzoek naar de rol dat het platform de digitale stad kan spelen in het opschalen van smart city pilots. Ik begin dit interview met eerst wat algemene vragen, daarna een aantal vragen gericht op de pilot waarbij jij betrokken bent ik sluit of met de relatie die de pilot heeft met het platform de digitale stad.
- Toestemming vragen om het gesprek op te nemen

<u>Algemeen</u>

- Kan je jezelf misschien kort voorstellen? Wat is uw **functie** binnen de pilot? Wat doe je als projectleider?
- Kun u wat meer vertellen over de pilot? Hoe is deze tot stand gekomen?
- Welke **functionaliteiten** heeft de pilot? (Type opschaling)
- Hoe ver zijn jullie in het proces? Op welke manier wordt de pilot op het moment **toegepast**? Is dit de eerste keer? (type opschaling)
- Wie zijn de **eindgebruikers**? En wordt het al gebruikt? (Type opschaling)

<u>Opschaal condities</u>

<u>Governance condities</u>

- Wat zijn de **doelstellingen** van de pilot? Hoe zijn deze doelstellingen tot stand gekomen?
- Welke **partijen** zijn betrokken bij de pilot? En welke **rol** heeft welke partij?
- Wat zijn de verschillende **taken en verantwoordelijkheden** van de verschillende partijen?
- Hoe vindt de **discussie/overleg** plaats tussen de verschillende betrokken partijen? (Open?)
- Op welke manier wordt de **progressie** van de pilot zichtbaar gemaakt?
- Is er nagedacht over **grootschalige toepassing** van de pilot? Hoe gaat het verder naar de pilotfase? Hoe ziet dat er uit?

<u>Human condities</u>

- Op welke manier wordt **er geleerd binnen de pilot?** Hoe zorg je er kennis wordt vergaard en dat opgedane kennis word bestendigd?
- Op welke manier vindt de **evaluatie** van de vorderingen van de pilot plaats?

- In welke mate en hoe vindt **kennis delen** plaats met de betrokken partijen?
- Beschikken de betrokken partijen over de **juiste (ICT) vaardigheden** om de pilot tot stand te brengen
- Is het **eindproduct** van de pilot **gemakkelijk** te gebruiken? Zo ja, waarom? Zo nee, waarom niet?

Technologische condities

- Van welke **technologische infrastructuur** maakt de pilot gebruik? (*Het deel van de ICT-infrastructuur dat is gericht op de exploitatie van de systemen (hardware, systeemsoftware, bijbehorende documentatie, etc.). Samen met de applicatiesoftware en de bijbehorende documentatie en procedures vormt dit de ICT-infrastructuur.)*
- Is deze **infrastructuur toegankelijk**? Makkelijk te gebruiken?
- Wordt er gebruik gemaakt van bepaalde technologische standaarden? **Zoals datastandaarden voor kwaliteit van data**?

Rol van het platform

- Wat is **de toegevoegde waarde** van het platform de digital twin voor jullie pilot? (Wat héb je aan het platform, anders dan geïsoleerd een pilot uitvoeren). Hoe kan het platform jullie pilot versterken?

Deze vraag open stellen. Inhaken op aspecten die de respondent noemt. In de eerste interviews in ieder geval de verschillende onderdelen van ‘integratie van technologie’ en ‘stimuleren van samenwerken’ bevragen, maar ook de blik open houden voor dingen die de respondenten hieraan toevoegen.

Integratie van technologie

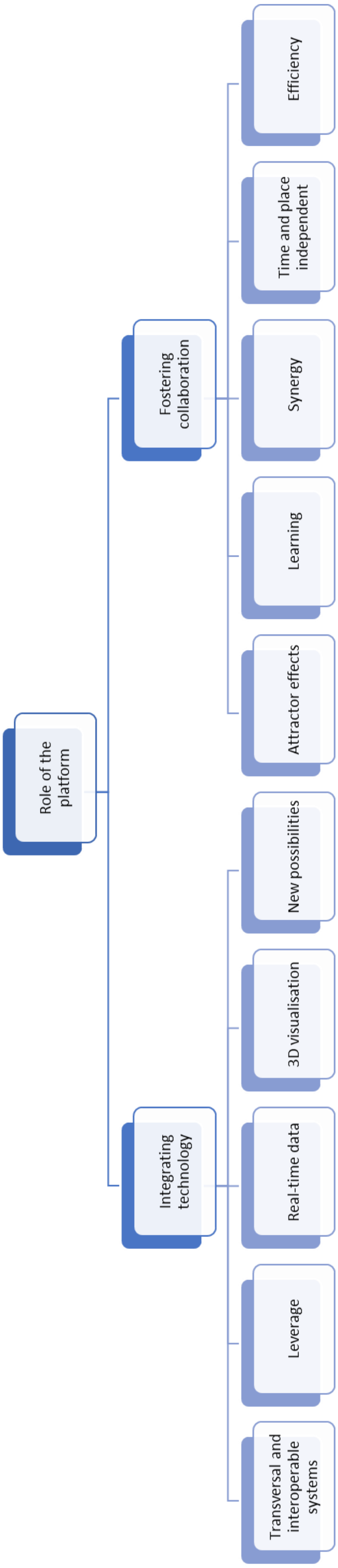
- Op welke manier kunnen jullie gebruik maken van **real-time data** van de digital twin? (Fysieke, real-time weergave van de stad).
    - “Gebruik maken van data die weerspiegeld is in de stad en dus de realiteit NU weergeeft”
- Op welke manier kunnen jullie gebruik maken van de **gemeenschappelijke technologische architectuur**?
    - Aanhaken op één generiek open urban platform
    - “Aanhaken op het platform – de beschikbare architectuur nodigt uit”
- Op welke manier kunnen jullie gebruik maken van de **open data standaarden** van de digital twin?
    - (Gedeelde data modellen en data bronnen zijn gelijk)

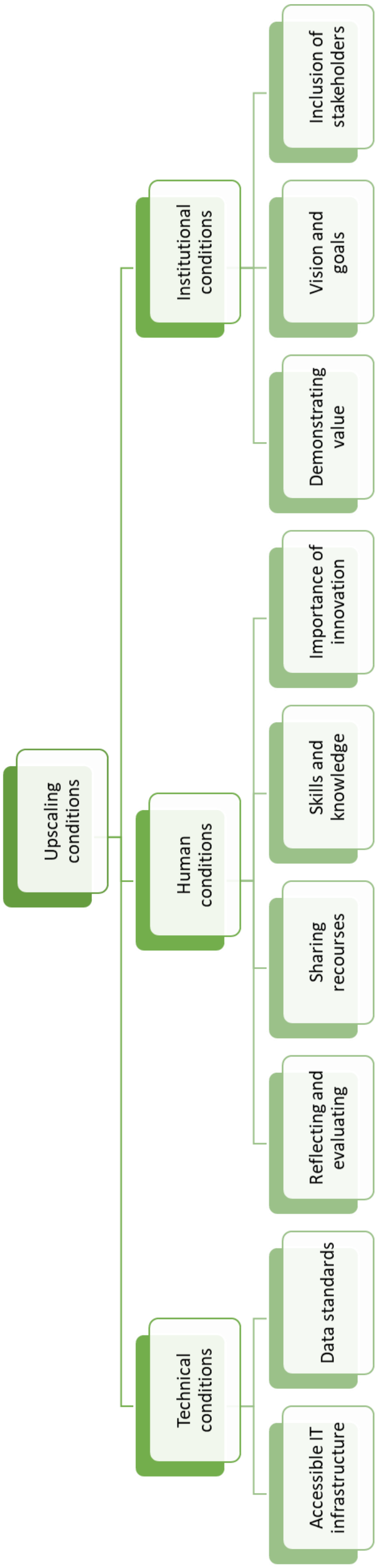
- “Standaarden voor data vergemakkelijkt delen van data”

Samenwerken

- Kan het platform een bijdrage leveren aan het **laten zien van het succes** van jullie pilot? Zo ja, hoe dan?
    - Visualiseren van pilotprogressie
- Kan het platform een bijdrage leveren aan het **ontwikkelen van kennis**? Zo ja, hoe dan?
    - Evalueren, leren via het platform, experimenteren
- Kan het platform een bijdrage leveren aan **het delen van kennis,** inzichten, perspectieven? Zo ja, hoe dan?
    - Samenwerken op een platform, kennis uitwisselen

Appendix C: scheme of codes





Upscaling conditions
Institutional conditions
Human conditions
Technical conditions
Inclusion of stakeholders
Vision and goals
Demonstrating value
Importance of innovation
Skills and knowledge
Sharing recourses
Reflecting and evaluating
Data standards
Accessible IT infrastructure