The created value of an Urban Consolidation Centre differentiated in last-mile and network-associated value

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Abstract

The last few miles when transporting goods are often the most expensive. This is called the 'Last-mile' and is under increasing attention in literature and with decision makers. In addition to being expensive the last mile frequently runs through urban areas and contributes to local pollution and congestion. One possible method to increase efficiency in the last mile, whilst keeping pollution and emissions low, is the Urban Consolidation Centre. In spite of the high number of projects started, there is still relatively little known on what value this concept can generate. The objective of this study is to explore the potential sectors in which the UCC can add value and how much value is actually created.

We found that the construction sector can be a suitable sector for the UCC to pursue, although it necessary to do more research to determine how much value this sector can generate. The waste sector has some potential, but also has some drawbacks on suitability of waste flows for consolidation and legislation. The actual value of two cases, shipper and carrier, were studied and shows a last-mile savings between €7 and €8 per stop consolidated for most scenarios. The network effects increase this value to €12,65 for the shipper when 35 cities are included. For the carrier this value is only increased to €8,42 when 35 cities are included. These results provide the necessary basis for an accurate business model to be further developed and tested. The network effects were not previously reported and therefore add significantly to the value proposition of the UCC's business model.

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Although the end result is not exactly how I planned it to be, I hope all the people involved can use this thesis in some way to benefit as I definitely gained from their inputs. I hope that this thesis can also stimulate the interviewees to continue informing information-deprived students in the future.

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Kind regards, Stefan van den Berg

Summary

The last few miles when transporting goods are often the most expensive. This is called the 'Last-mile' and is under increasing attention in literature and with decision makers. In addition to being expensive the last mile frequently runs through urban areas and contributes to local pollution and congestion. One possible method to increase efficiency in the last mile, whilst keeping pollution and emissions low, is the Urban Consolidation Centre. In spite of the high number of projects started, there is still relatively little known on what value this concept can generate. This is due to the high number of trials with a scope of just a single city. Therefore it is currently now known whether a national scope would change the value proposition of the Urban Consolidation Centre through network effects. The objective of this study is to explore the potential sectors in which the UCC can add value and how much value is actually created.

The first question is about the different sectors that can profit from the Urban Consolidation concept. Retail is normally targeted as the first choice, although multiple other sectors are not commonly researched. Therefore we conducted interviews with companies in other sectors, mainly construction and waste.

To study the network effect we did simulations for two cases; a shipper and a carrier. These simulations were done through a Vehicle Routing Problem Analysis with the ArcGIS®Software package. The calculation was done in three steps: The baseline, the Same Sequence, an the Full Optimisation step. The baseline is normal routing, while the Same Sequence implements UCCs with the same routes as the baseline. The Full Optimisation has no routes pre-specified. This enables us to determine the value created by implementation of the UCCs, not just on the last-mile but also value created due to network effects on a national scale.

We found that the construction sector can be a suitable sector for the UCC to pursue. The waste sector has some potential, but also has some drawbacks on suitability of waste flows for consolidation and legislation. The actual value of two cases, shipper and carrier, were studied and shows a last-mile savings between €7 and €8 per stop consolidated for most scenarios. The network effects increase this value to €12,65 for the shipper when 35 cities are included. For the carrier this value is only increased to €8,42 when 35 cities are included. This difference is most likely due to the substantial higher amount of orders done by the carrier. The cost savings are therefore more reliant on the marginal costs between orders than on the distance to the depot.

This thesis starts with a concise background of the UCC concept and the last-mile environment in section 2. It is followed by an overview of the relevant theoretical components surrounding the subject in section 3. The state of the theory leads to the research approach and methodology in section 4. Then the results of the study are reported in section 5 and 6. The thesis is concluded in section 7.

This master thesis was done under supervision of the TU Delft and executed at TNO as an internship. The consolidation centre involved was Binnenstadservice located in multiple cities in the Netherlands. Additionally multiple companies and institutions provided interviews for this study.

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Glossary

There are many terms surrounding the last-mile which needs defining before going into detail where they belong. These terms are either subjective or have a large gray area subject to interpretation. This is for example obvious with the term 'city centre'. Depending on the context it is discussed, it can be interpreted as the historic centre, the largest shopping area, the highest population density, etc. These terms need to be defined to keep the research done consistent and no bias is incorporated. For example when orders are consolidated to an UCC there needs to be a definition of these service area to know which orders to include and which to leave out.

- *Suburban Area:*
  A morphologically continuous area with mainly a group of residential buildings with a clear recognisable street pattern of a minimal size (CBS (Centraal Bureau voor Statistiek), 2008). Additionally this area must be linked to the city centre.
- *Neighbouring Suburban Area:*
  Suburban area morphologically linked to the area in question. The neighbouring area should not be delineated visually from the area in question and should not cross municipal borders. This is necessary to prevent extremely large suburban areas stretching whole regions and keep the definition to the problematic city centre.
- *City Centre:*
  The centre of the city as put forward by the governing municipality. If none is specified, the shopping area of the historic centre is taken. If there is no distinct historic centre with shopping facilities, the largest general shopping area is used. This excludes additional centres put forward by municipalities, as long as there is a primary centre identified.
- *Urban Freight Transport:*
  The delivery of goods in city centres and neighbouring suburban areas by commercial transport, including the reverse flow of used goods and waste. (Adapted from OECD (2003); Dablanc (2009))
- *Urban Consolidation Centre (UCC)*:
  A transshipment facility located at the edge of a single urban area with the core business of urban consolidation of goods. The centre receives goods destined for the area, consolidating the goods to fewer or smaller vehicles, and arrange distribution for them within the urban service area. The centre can also provide other types of value propositions, as long as these are additional to the primary consolidation service.
- *UCC service areas:*
  The city centre and neighbouring suburban areas of the city the UCC is located in. This is different from the past where solely the city centre was targeted, however the city centre is not the only problematic case in a city (Olssen and Woxenius, 2014).
- *Viable business case:*
  Able to sustain operations on revenue gained by own business operations as a private organisation. This excludes revenue gained from sources not linked to the direct value creation of the company, such as subsidies, or public business not requiring a solid business case to survive. (Adapted from van Dam (2014, Appendix VII.3.1.))
- *Logistically challenged cities:*
  The relative difficulty of entering a city to the city centre through road transport. This is estimated from the zoom level at which a 10-minute driving area from the city centre can be completely visualised within ArcMAP.

1 Introduction

The last mile of transport is often the most expensive and time-consuming. The destination is often located in densely populated urban areas. Freight destined for inner-city industry and businesses, urban freight, is the lifeline of the inner-city economy. However, this same supply line is also a major source of pollution and congestion. Hence urban freight presents a paradox for the urban area as it is a necessity for the urban economy, but a threat to the urban quality of living.

Higher authorities, such as the European Commission in Europe, have implemented norms to reduce air pollution in urban areas (EC, a). Lower authorities, mainly municipalities, have to achieve these norms or risk building stops (MIE, 2014a; MHWS, 2013). Additionally the cities themselves experience problems with congestion, trucks in shopping streets, and the air quality. This makes many municipalities search for policies to reduce these factors (Anderson et al., 2005; Quak, 2008; Browne et al., 2007a; BCI (Buck Consultants International), 2011). These implementations are frequently restrictive in nature, for example municipalities can restrict city centre access to low-emission vehicles to reduce local pollution. Not all policies used by municipalities have the positive effect that was expected and some can even be counter-productive or cause side-effects to other actors or in other areas. Inner cities are therefore continually striving to evaluate and implement more effective measures to address emissions and congestion.

Carriers responsible for delivering goods to the city are subject to the same sort of problems as the authorities. Congestion takes time and hence money and therefore is also relevant to the carriers. Additionally being 'Lean and Green' is becoming more important to carriers to keep or increase their current business. Hence multiple kinds of organisational responses have emerged to address the same issues, albeit with a different goal in mind compared to the authorities (NCFRP, 2013; Quak, 2008; Verlinde et al., 2012). A combination of the two perspectives, if possible, could potentially lower costs for carriers and lower the negative externalities to the municipality and other stakeholders. If the current tendency of urban restrictions continues the problem for carriers are likely to only increase as costs and restrictions increase (Quak, 2012; Muñuzuri et al., 2013).

One concept put forward as a solution to the problem is the Urban Consolidation Centre. This concept consists of a logistics warehouse at the edge of a city or urban area, which is able to consolidate freight of incoming carriers to fewer or smaller vehicles. In this way it decreases the number of vehicles (and driven kilometres) or decreasing the emissions produced during distribution. This concept has shown to be very difficult to implement in practice and has multiple obstacles to overcome (Allen et al., 2012; Posthumus et al., 2014). The biggest problem is the inability to create a viable business case for this concept without relying on subsidies. To create a viable business case it is important to know exactly for whom such a centre can create value and how these can be monetised.

This study attempts to contribute to the concept by gathering information on the value that other stakeholders perceive. This is important as an UCC replaces the last-mile of its potential customers. Additionally this study calculates the actual value of the consolidation service provided by the UCC on a local and network level. This is mainly important as the bulk of the trials done with an UCC have been single-city trials, where no network effect can be seen. This is studied in this paper and can provide an additional value proposition to the UCC concept.

2 Background

This section describes the background of the subject based on the literature found by desk research. This literature contains articles, websites, governmental white papers, and other kinds of published sources. First the concept of Urban Freight and the components of the sectors are defined and explained, followed by the problems encountered therein. Then the solutions tried and suggested are laid out, mainly policies and innovations, and their effects on Urban Freight are described. Then the UCC is explained in more detail as it is the main subject of the study. This section will conclude in the core problem definition, which will lead to the objective of the study.

2.1 Urban Freight

Urban freight is a combination of inbound, outbound and intra-urban traffic. Goods are moved to and from the city, but additionally returns and waste are collected to return to their origin or third party. The definition used here is adapted from the OECD (2003) definition:

> *The delivery of consumer goods in city and suburban areas, including the reverse flow of used goods in terms of clean waste.*

Stakeholders

There are multiple stakeholders involved in the last-mile of transport, which are described by the papers of OECD (2003), Lemstra (2004), and STRAIGHTSOL Deliverable 3.2. The first stakeholder is the shipper, often the seller of the product and needs to send the goods to the client. The second stakeholder is apparent as that is the client which ordered the good(s). There are two types of clients: The retailers that acquire supply and end-consumers. The retailer is not necessary in the supply chain, which is mainly the case in e-commerce. In most cases there is at least one intermediary between the shipper and the client, which is a carrier. Although some shippers even provide all the distribution in-house. The carrier picks up the goods at the shipper and delivers the good to the receiver. For certain areas this carrier can hire a subcontractor to deliver the good. Municipalities (and other levels of governmental institutions) are influenced by the freight activities, as mentioned before, but are not an actor in the supply chain. They can affect the supply chain indirectly by issuing policies and providing infrastructure. Lastly other traffic, residents and visitors of the area are affected by freight activity. These non-supply chain stakeholders are mainly impacted by the negative and positive externalities of the freight activity: pollution, congestion, the local economy impacts, and even the number and/or severity of accidents (SWOV, 2011; MDS Transmodal Limited, 2012).

2.2 Last-mile environment & policies

As mentioned in the introduction, the European Commission has strict regulations for pollution within the European Union (EC, a). These are part of the Clean Air Policy Package enacted in 2013. This package strives to remove pollutants affecting health of citizens and the environment. Even though the situation has improved, many urban areas are still unable to conform to the limits (MIE, 2014a; MHWS, 2013). This can have adverse effects, such as fines or a 'building stop' in the area. These regulations provide the context of municipal measures to try to limit local pollution levels.

There are multiple sources of pollution, from households to industry and urban freight. Depending on the study, this sector causes 20 to 30 percent of all urban vehicle emissions with only 14% of vehicle kilometres driven Schoemaker et al. (2006, chapter 7.2.2). Dablanc (2007) states them higher at 20-30% of vehicle kilometres and 16-50% of emissions. Moreover up to 70% of this urban freight originates from outside the urban area (Schoemaker et al., 2006, Table 5-9). These numbers show the reason why urban freight is targeted by municipalities. A contributing factor of the last few decades is the occurrence of logistics sprawl in this sector, the relocation of logistics facilities outside urban areas. This concept leads to the increase in vehicle kilometres around cities and hence is part of the problems of current last-mile transport (Dablanc, 2009; Dablanc and Rakotonarivo, 2010).

The majority of municipalities with the need to address pollution and congestion have used policies to restrict traffic in their centres and improve the air quality. Frequently used policies to do so include time-windows, low-emission zones, dedicated (un)loading places, congestion charges, and often combinations of such policies. However the effect they have can range from positive to counterproductive effect on pollution (air quality and noise), congestion and cost of transport. The papers of Anderson et al. (2005), Quak (2008), Browne et al. (2007a), and BCI (2011) describe these measures and their (limited) effects in more detail. The effects of the policies can vary depending on the properties of the policies (e.g. which time window, cost of the congestion charge, low emission requirement) and the locational properties of the municipality (e.g. the amount of deliveries/destinations or the presence of alternative routes). On the other hand the papers mentioned also describe supportive measures possible for authorities, for example the dedicated (un)loading areas near frequent destinations.

Municipal policies frequently have side-effects which affect other actors. A policy can have a positive effect locally, while it has a negative effect on a regional or national level. Policies frequently restrict access to city centres, increase requirements of vehicles or simply establish a fee. These measures are effective from their social effects and the environment, but can significantly raise costs of transport to and from the area (Muñuzuri et al., 2013). Another example is the time-windows, which are frequently implemented to restrict deliveries during the busiest hours of the day. Even though it is effective in decreasing noise and traffic by goods vehicles during those hours, they can severely increase the costs for the carriers operating the goods vehicles as well as congestion outside of the time-window(Quak, 2012). This forces carriers to make due with sub-optimal planning, are forced to use peak hours with congestion or use expensive off-hour delivery (Quak and de Koster, 2007, page 182; Schoemaker et al., 2006, table 5-4; (BCI (2011))). It is important to note that for some policies the negative effects can be mitigated by aligning policies among multiple municipalities in a region. For example by aligning time-windows sequentially, carriers can make a more optimal planning as they do not have to service all municipalities in the same time-slot (Groothedde et al., 2003; Dablanc, 2009). This also functions as an example as to how policies can have (negative) regional effects, even though they are locally applied. These papers show that the effects of municipal policies varies widely, depending on their properties or the situations in which they are applied.

2.3 Market initiatives

The market uses multiple different initiatives to address the last-mile costs, especially due to restrictive policies, and emissions. There are many different kinds of solutions to the problem of high last-mile costs. The following is just a short description of some of the more popular measures taken or creative solutions which are in their experimental stage. Afterwards the focus will be on the UCC and how the concept differs in effects from the other solutions. The market solutions are taken from the NCFRP (2013) paper, the doctoral thesis of Quak (2008) and the article of Verlinde et al. (2012).

Night-time delivery is the delivery of goods outside the normal working hours. This makes the carrier less dependent on time-windows, however, it does require quiet vehicles as often these hours are during the night or early morning. This method has been implemented successfully in New York (Hodge and Holguín-Veras, 2013; Holguín-Veras et al., 2014), although access to the property and legislation can hinder implementation, especially for smaller retail stores (Quak and Tavasszy, 2012).

Another example of a technological method is the use of Intelligent Transport Systems (OECD, 2003; van Wesel, 2005). This is a whole field of IT related systems and can mainly make planning more efficient and can streamline the planning of multiple actors to increase efficiency.

Decoupling is a method often mentioned with Long Heavy Transport (LHV). LHVs have more capacity and hence less vehicles are needed for regional transport. Smaller (policy-abiding) vehicles can then be used within the urban area for final distribution (Quak, 2012). Simply decoupling has a very low extra handling costs. The extra trailer only has to be decoupled and there is no need for additional transshipment processes. Unfortunately, it does not decrease driven kilometres within a city and the larger size of these vehicles can present issues when transporting goods internationally (logistiek.nl, 2012, 2014).

Related to decoupling is the consolidation concept. The difference is that this method is focused on LTL loads and consolidates these into a single FTL load. There are two major types of consolidation: Regional consolidation by a collaboration of carriers and last-mile consolidation. There are multiple examples of successful consolidation schemes. For example long distance transport citep-Muylaert2014, cold transport (Verstrepen and Dooms, 2014), and health care and hospital delivery consolidation (CB-Logistics, 2014). Additionally there are multiple partnerships of regional carriers utilising consolidation, a carrier network. These carriers are all individually active in a single region, but together can service on a national scope. On the other hand there is the smaller-scale consolidation in urban areas. These are expended upon in the next section as this is the main subject of this thesis.

Another form of decoupling is Multi-modal transport. This concept uses waterway and rail transport to reduce costs and emissions in long distance trips or expensive routes. This is also decoupling of one mode and continue with a more suited one; However this is often, but not always, used over longer distances. Multi-modal transport thrive on long distances due to their cost advantages (Freight Best Practice, 2007), but they can also have an advantage when inner cities are very expensive for road transport. For example Utrecht has barges delivering beer and barges picking up waste, both in the inner city (Civitas, 2011; volkskrant.nl, 2012).

Simple technical innovation is also done frequently to experiment with other means of logistics. The most obvious example is the use of electric vehicles in inner cities to decrease the emissions. Electric vehicles are also sometimes exempted in relation to time windows or allowed to make use of bus lanes. However other innovations in this category are for example the use of parcel stations (Quak et al., 2014) instead of service points.

2.4 Urban Consolidation Centre

The UCC concept was first initiated more than 40 years ago (Allen et al., 2012; Taniguchi and Qureshii, 2014) and has been implemented in many different forms and scopes. Hence it has been given many names dependent on the exact application, definition given, or services provided: Urban Freight Centre, Freight Distribution Centre, Freight Consolidation Centre, Freight Delivery Area, etc. In this thesis the term Urban Consolidation Centre (UCC) is used. The largest overview of research into UCCs is by Allen et al. (2012) and lists 114 projects. Although this is an impressive number of projects, only 50 projects reached an operational state and 40 of which are estimated to be still operational in 2012. Additionally in the evaluations of these projects there is frequently a lack of suitable data for comparison or a lack of available data in the case studied (TURBLOG, 2011, Chapter 8).

UCC types

Several types of UCCs are known and are based on their target area: Construction area, Landlord area and the Urban Area. These types are described in the paper by Allen et al. (2012). The UCC at construction sites is temporary and of a limited area of operation. The Landlord UCC can have a larger area of operation and consist of can contain many different sectors and clients. The UCCs at construction areas and areas with a single landlord are easier to implement due to the small scope and the power of the decision maker in the area. A contractor is the owner of a construction site and a landlord can force tenants to make use of facilities. In contrast, the UCC in a larger urban area is the most difficult to implement on a large scale and with a long start-up time; This is due to the lack of a single powerful actor and hence the time it takes to attract partners and clients. The urban area type can be further decomposed based on the size of the area serviced. A single consolidation centre can service a municipality (Olssen and Woxenius, 2014), a city centre or neighbourhood (Taniguchi and Qureshii, 2014), or a street (Lorvik, 2012; ELTIS). This can be relevant as it is not currently known at what distance from an urban area (or city centre) an UCC is most effective.

The problematic situation in municipalities is rarely a landlord area or a complete construction area. To study the UCC in a municipality, this will have to be an urban area UCC without a single governmental actor. So even though the landlord and construction area UCCs appear to be more straightforward than urban area UCCs, they are also impossible in the environment that we study. A hybrid can result in reality, depending of the business model of the UCC in question. As landlord areas and construction areas are commonly present somewhere within a municipality, they can be serviced by an urban area UCC.

Business model properties

The concept introduces an extra step in the logistic process leading to extra transshipment costs and less carrier-client contact between the carrier and receiver. Secondly, the gains achieved with the UCC are very hard to monetise as there is disagreement on the distribution of benefits and compensation. Although the success-rate of UCCs is quite low, the cost savings effect is present in most studies and can be quite significant (Browne and Holguín-Veras, 2014). Most projects have been focused on local impacts of the UCC and hence do not present a clear picture of the regional or national effects of the concept.

The major issue with past experiences is the inability to generate sufficient revenues. First of all there are positive externalities (less pollution, noise and congestion) which cannot be monetised (Blom, 2009). Although frequently mentioned as a large advantage, it adds little for the viability of an UCC. On the other hand there is an issue with the cost savings, as these are gained in another company than the UCC itself (Posthumus et al., 2014). Thirdly, the concept will only have a positive effect when it has a sufficient market share, approximately 30% (van Duin et al., 2012), which is one of the main problems in launching it from scratch. This problem of market share is emphasized by Slabbekoorn (2014) and van Dam (2014); These theses both observe and describe the conflict of starting volume and stakeholder participation. To gain the necessary starting volume the UCC can best use an existing carrier to start-up. If the study by Marcucci and Danielis (2008) is close to reality, the market share could be an obstacle extremely unlikely to be overcome. They state that 25% is already a high performance situation, only reached with additional municipal policies. The UCC could also operate as a subcontractor for carriers, which could enable the UCC to gain market share fairly quickly as there are fewer parties to attract and convince.

An UCC is dependent on the binding of many or large actors in the area. An UCC can target local entrepreneurs or inhabitants as customers or target the distributors. This choice influences the basis of the business model of the UCC. Mainly it determines where the revenue should come from and which party will pay for the service. The management of stakeholders, and primarily the potential clients of the UCC, is a crucial factor in the success of the UCC (Hogewoning, 2005; Allen et al., 2012; Slabbekoorn, 2014). Considering the unsuccessful track record and the unknown actual created value this is a major issue when initiating an UCC project. An important component of stakeholder management is the balance between starting a neutral body, or starting from a current distributor in the area. A neutral body is needed to increase stakeholder participation, while it brings up very little starting volume. However according to Slabbekoorn (2014) this is necessary for future growth and stakeholder participation. The alternative would be that an existing party initiates the project, which can prevent competitors or other parties of joining the initiative.

The actual value create by an UCC is still not known exactly. On the one hand it is suggested that the concept is viable (Marcucci and Danielis, 2008), while on the other hand it is suggested that it never will be viable (Browne et al., 2007b). Moreover, there is little knowledge about which companies would benefit the most from an UCC. Most projects start without a clear value proposition and start with subsidy for the duration of the project. However for a future perspective the 'subsidised' label should be avoided (Quak, 2014), which may be a difficult task if the concept indeed is determined to be not viable. Additionally the viability may differ greatly, depending on the type of logistic companies involved and the environment it is located in (Quak, 2014). Therefore a reliable value proposition can support the business model generation of future UCC projects.

Preliminary research objective

Even though the UCC concept has had an unsuccessful track record, it is still under study due to the theoretical advantages when successfully implemented. There is still a lack of evidence on whether how much of an effect the UCC can have on urban freight. The large discrepancy between the potential effects frequently suggested and the results achieved by projects shows the importance of further study on this subject. The potential of the UCC is theoretically very high as it is a complete package of the three aspects of urban logistics: Planet (less emissions), People (less noise, emissions, congestion) and Profit (less costs) (Quak and de Ree, 2009). The UCC can in theory affect all of these factors: It decreases vehicle kilometres, emissions (due to driven kilometres and/or clean vehicles), congestion, and noise pollution. The scope of the effects is what makes the solution so attractive; It has the potential to mitigate multiple issues with one solution. The main problem with the concept is the difficulty in making it commercially viable and hence to make it independent from consistent governmental subsidies. Therefore the concept requires a study in the actual created value of the UCC, to determine whether an UCC just needs to pass a threshold, or whether it would have to be subsidised indefinitely to keep it functioning. Additionally it is not known whether a national presence of the concept changes the business model compared to a solely local implementation. Therefore the objective for this study is to investigate the financial value of the UCC and its viability on a national scale.

3 Research Framework

The literature review described the outline of the problems encountered in last-mile logistics, the solutions tried in practice or suggested, and the currently still mixed results of the UCC concept to address this problem. After identifying the main problem and objective in the review, it is important to chart the known relationships in the theory. This creates an inventory of concepts which provide a positive or negative contribution, but also which contributions we do not yet fully know. This framework additionally identifies the exact knowledge gaps and hence determines the value of this thesis to advancing the knowledge about the theory in question.

The most abstract relations are the theories, which in this case is one of the theories under the subject of Supply Chain Management. A theory has one or more principles which state the causal effects hypothesized in the theory. The theories can be further decomposed to concepts, which are less abstract and narrower in scope than the theory. A theory is essentially a statement describing causal effects, while a concept is an abstract object subject to or the cause of the effect. The relationships between concepts are propositions and describe the positive or negative effect a concept has on another concept. Concepts are still abstract and cannot be measured directly and hence should be further decomposed to variables or proxies. These can than form the exact hypotheses tested in the study.

The following paragraphs detail the properties of the concepts, their relations and the motivation for including them. It is important to keep in mind that the relationships between the concepts in this figure have not all been researched yet. This means that the relationships shown here can also be a source of knowledge gaps and suggestions from literature.

3.1 Theory

The main suggested advantage mentioned in the literature review is the consolidation of goods by multiple competitors to increase the loading rate, bundle deliveries in one stop, and decrease the amount of vehicles and driven kilometres. This is actually a proposition - *cooperation increases last-mile efficiency* - and it is part of the theory of *Coopetition* described by Hunt (1997). This theory is part of the larger Resource-Advantage theory and describes how cooperation is possible and even advantageous with competitors. Consolidation fits this theory as it enables competitors to mutually benefit due to the increased efficiency, or economies of scale, when cooperating. Coopetition is then divided in Vertical and Horizontal cooperation. Consolidation will always involve a competitor, as the suppliers of the goods otherwise would deliver the goods themselves. However this is just part of the trip and leaves a vertical relationship in the new situation.

Figure 1 shows the different kinds of concepts under the coopetition theory. The first image shows a normal situation in which all carriers function independently and have an efficient routing. The second image shows the Urban Consolidation concept used by UCCs, where only the last-mile of the routing is consolidated. Regional consolidation is shown next and is a similar concept, but it is regionally focused and not just on the last-mile. This concept is used by carrier networks like Transmission, whereby regional carriers joined together to create a national network. Cooperation can be based on capacity or order sharing, but also complete routing can be utilised in cooperation (Cruijssen et al., 2007; Verdonck et al., 2013). This is Joint Route planning and is shown in the last image. This concept consolidates full routes and hence increases efficiency further. An example of this is the collaboration between P&G and Tupperware in the conference presentation of Muylaert and Stofferis (2014).

However there is a crucial difference between Urban Consolidation and the other concepts. Urban Consolidation is a service towards any carrier willing to pay for it. Hence it has a vertical cooperation which is inclusive in nature. Regional consolidation on the other hand is mostly a collaboration of a limited number of (regional) carriers, which is strictly exclusive to these participants. This is the

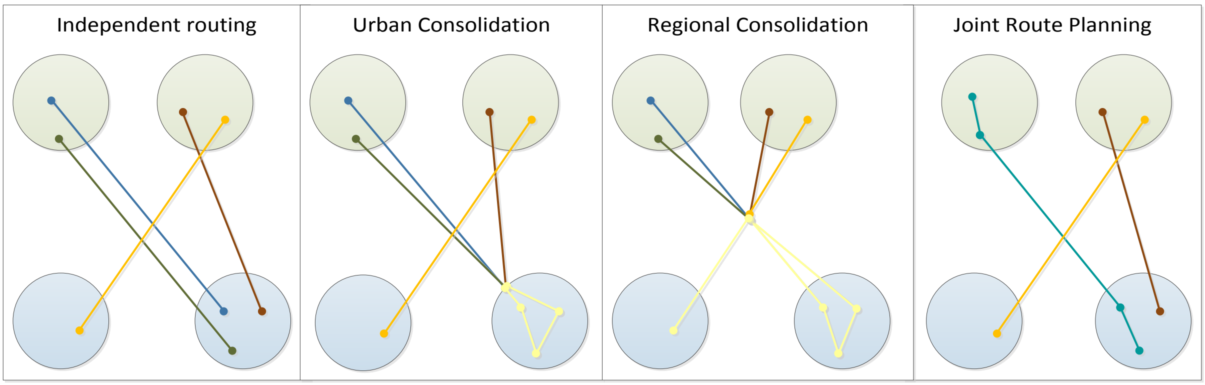

Figure 1: A comparison between the concepts of Urban Consolidation, Regional Consolidation, and Joint Route Planning. Urban Consolidation is a replacement of just the Last-Mile, Regional of inter-urban transport, while Joint Route Planning is full-route horizontal cooperation.

difference on the basis of the division between vertical and horizontal cooperation within the theory of coopetition. Urban Consolidation has a vertical cooperation due to its inclusive nature of multiple 'suppliers' up the chain, while regional consolidation is a (limited) cooperation on a horizontal level with other carriers. Although the UCC in principle includes multiple supply chain, the concept itself is regarded as vertical[1].

Cooperation is not limited to competitors, but can be done up- or downstream in the supply chain. This is vertical cooperation, where no other supply chain is directly involved. In this study the focus is on the vertical effect of consolidation and not the horizontal effect. This means that our focus is on the effects between a transporter and an UCC and not on horizontal cooperation between transporters or between UCCs. This is the first step in our framework and is visualised by figure 2.

3.2 Scope

There are multiple ways of viewing the problems with the last-mile, as they are described in the background. Municipal research focuses on emissions and congestion, while supply chains focus mainly on the financial costs of the last-mile. Although the municipal perspective is important in its own right, and often a reason to start an UCC project, in this thesis the supply-chain perspective is researched. This has consequences for the results that were gathered, as for a municipality the local results are important while for a carrier its whole network (often nationally) is important. This difference is clearly mentioned by (Quak, 2012), even though the last-mile is efficient from a supply chain perspective, it seems chaotic and inefficient from a city perspective. Hence we will not just study the effects on a single city with the local scope, but take a national view and incorporate multiple cities in the equation. Additionally the focus of this study is on the value creation by the UCC with respect to the supply chains. In this way we can check whether indeed the UCC is a desirable solution to increase efficiency at a local and a national scale. This value can be qualitative in nature (e.g. service quality) as well as quantitative. So for this study we study vertical coopetition in the form of UCCs, with the focus on nationally created value in the supply chain.

Research on the subject has primarily consisted of evaluations of trials. As mentioned in section 2, there are a large amount of case evaluations on specific UCC implementations. However, the individual causal effects of the concept still need to be determined. Examining the complete concept in practice is routinely done, as the reviews of OECD (2003); Browne et al. (2007b) and Allen et al. (2012) show. However these mainly study a single UCC in a single city or region. There are a few concepts which have been studied in more detail or a broader scope. Quak and de Ree (2009) charted the effects of

[1] From the upstream parties it does have an upstream component, as their last-mile is shared with the last-miles of other, horizontal, parties.

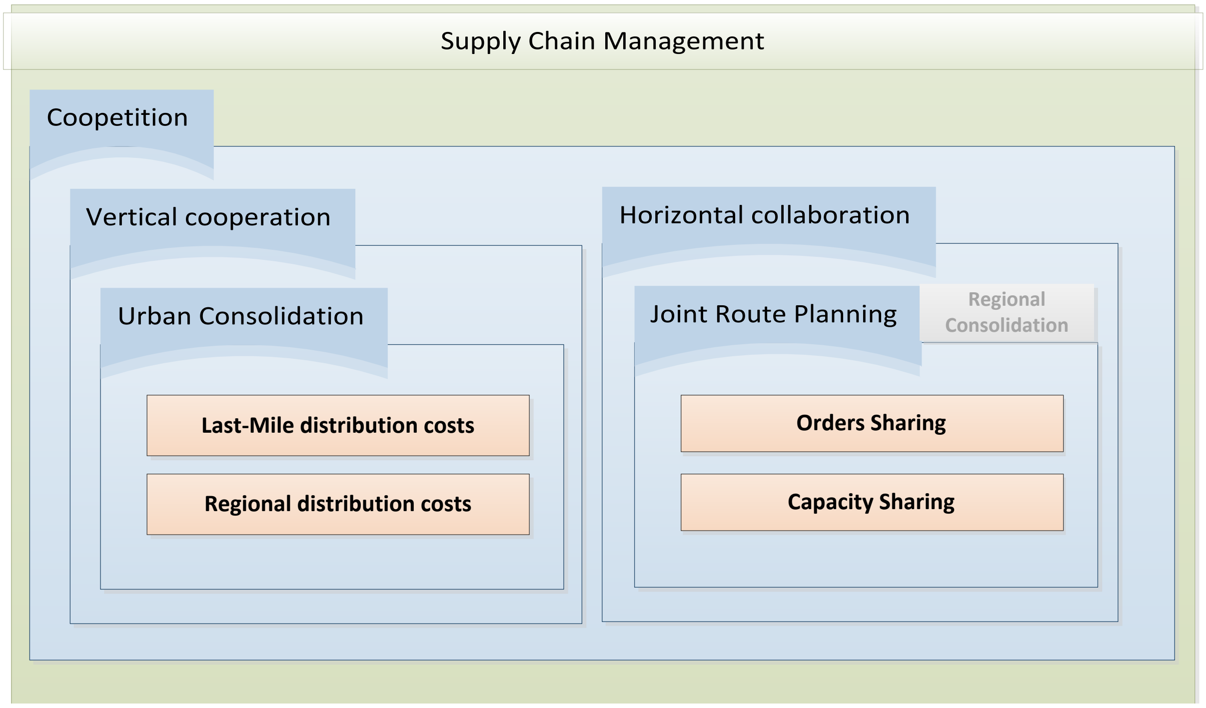

Figure 2: A visualisation of the placement of this research within the total Supply Chain Theory. The gray boxes show the alternatives which are left out of the scope of this study.

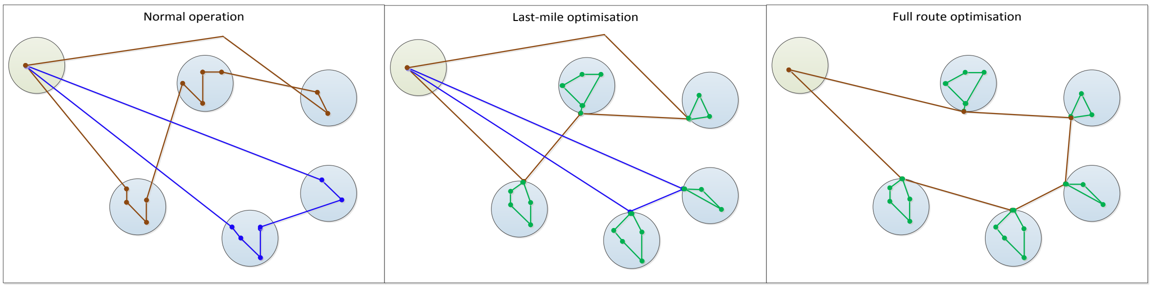

Figure 3: An abstraction of the last-mile effects and the total network effects of having an UCC doing the last-mile.

an UCC on carriers supplying retailers in a city centre, through simulations of multiple scenarios, and showed the potential cost savings for these carriers and the effects on externalities. This study also showed the exponential increase in cost savings for the carriers when the UCC was present in other cities across the country. This shows that a scope considering a single city is insufficient to chart all value created by the UCC concept. The principle of last-mile versus these additional network effects is visually shown in figure 3.

It is important to chart the scope of the nature of the transport. The last-mile is used as a term to denote the transport within an urban area. However with pick-ups this would technically be the first-mile. To keep it simple in this study the term last-mile is used for all transport within in urban area, as long as the origin or destination of the goods are outside of the city.

Aside from the geographical scope, we need to determine in what supply chains an UCC can be active. Normally retail in the city centre is targeted, and hence carriers and shippers delivering there. However other sectors may also benefit from an UCC, such as the waste sector that Gevaers and Van de Voorde (2013) suggests combined with parcels. Other sectors such as construction and health also have some consolidation practices and can be targeted (Adriana, 2013; CB-Logistics, 2014). Therefore this study does not scope solely to retail but also researches the possibilities in other sectors.

3.3 Research Approach

The objective of this study follows from the problem, theory, and scope mentioned. The problem identified describes the inability to generate a commercially viable business case for an UCC, while there is a lack of knowledge in how and where an UCC creates value. Or equally important, how much value is created and how an UCC can use it to create a business model. Hence the objective of the study is to find a solution to the problem on a national scale. The objective for this study is therefore defined as follows:

> Research Objective: *To determine the perceived value of the UCC concept in other sectors than retail.* Research Objective: *To determine, and differentiate between, the last-mile and network value of an UCC when implemented on a national scale.*

This is the all-encompassing goal of the study. However we need to specify the research question to determine what we actually need to know to determine the value created. They were based on the following propositions related to the concept.

> 1st Proposition: *Implementation of the UCC creates cost savings in the urban last-mile of transport.*

> 2nd Proposition: *Implementation of the UCC creates cost savings in the network of the shipper or carrier using it.*

> 3rd Proposition: *Enough revenue is gained from the last-mile and network cost savings to provide a viable business case when considering the costs of the UCC.*

Research Questions

1. What value does an Urban Consolidation Centre create and how can these values be exploited to generate a business case?

To answer this question we need to answer the following central questions:

1. What services does an UCC provide?
2. What actors benefit from these services?
3. What kind of effects are considered important by the actors?
4. What are the expected effects of the services?
5. Which services have the highest expectations?

The framework of our study is shown in figure 4. This framework shows the theory and our scope which are followed by the knowledge that we strive to collect; The perceived value and the actual value of the UCC in multiple settings. This provides the general framework after which the methodology is based.

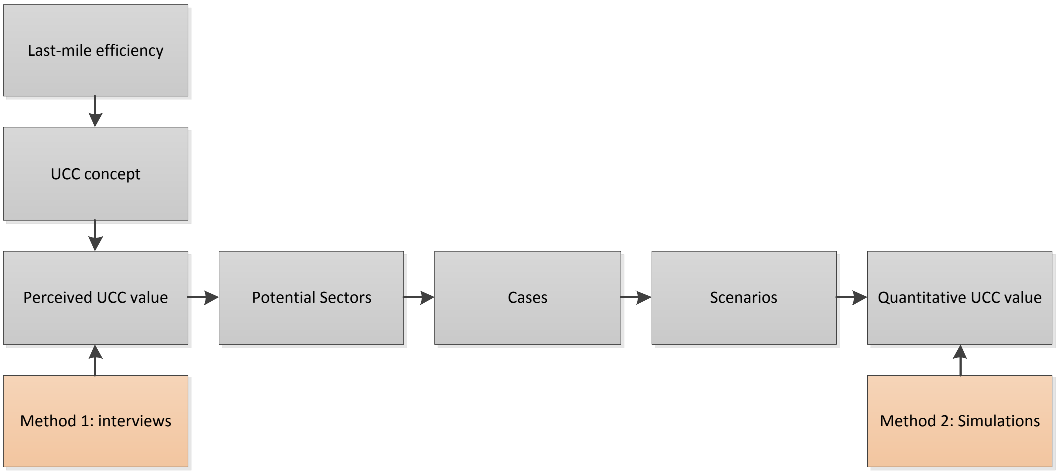

Figure 4: Research Approach of this study

4 Methodology

This section provides the used methods for our study. First the methods for the perceived UCC value are described, afterwards the methods for the actual UCC value are stated. Appendix A contains more detailed descriptions of parts of the methodology, which were too detailed to fully describe here.

4.1 Method 1: Perceived UCC value

The first three research questions apply to the perceived value of different sectors about using an UCC.

1. What sectors are involved in urban freight?
2. What kinds of value is important for these sectors?
3. Which sectors how the highest perceived value when using an UCC?

The knowledge required for the first question is a list of sectors that are active in urban freight. To this end literature and expert interviews can be used to chart these sectors. For the second question there is knowledge needed about the values hold in the sectors themselves. Therefore companies within the sectors themselves must be contacted through interviews to chart what is considered important in the sectors when considering value. Additionally these companies can shed light on their expectations of the value gained when using an UCC in their supply chain.

Since we study the potential sectors with a broad scope, we do a semi-structured interview with the companies. This makes sure that the required knowledge of expectations of these companies are charted. Additionally this method enables the interviewees to put forward expectations, obstacles and other relevant information that would not be present in a fixed interview or survey. Hence this provides the opportunity for more broad and in-depth information on the foundations of their expectations. The notes taken during the interviews were verified by email afterwards.

However with just the interviews it is difficult to chart how much value is perceived when considering the UCC, especially when the value is qualitative. For this reason it is important to quantify the expected values. This can be done through a Multi-Actor Multi-Criteria Analysis, based on a survey. The interviewees were asked to fill out a survey consisting of the expected value, but also ranking them on importance. This leads to a combined quantitative value of the expectations. This method enables a quantitative ranking of perceived values in the sectors based on these combined values.

The survey is based on expert interviews and literature. Experts were asked about the important criteria used in the sectors for decision making. These criteria could be quantitative (monetary value) or qualitative (strategic value), there was no restriction. The survey was then formed with the criteria put forward int he interviews and literature. The survey is shown in appendix A.

4.2 Method 2: Actual value

The other research questions have to do with the quantitative value of an UCC when implement in the retail sector.

4. How is the UCCs value created?
5. How much of this value can be captured in a revenue stream to the UCC?
6. How does the value change in different situations?
7. What business case results from the UCCs value?

The costs of distribution are largely dependent on the size and number of routes, vehicle capacities, kilometres driven empty, (un)loading time and the amount of (successful) deliveries and/or waste handled (FreightBestPractice, 2006). These factors may increase or decrease on threshold levels (e.g. number of routes) and must be simulated to gain insight in the effects of the service. The last-mile is skipped by using an UCC, which is the first change in the logistic organisation. However, the optimal route along the total orders can also change, which is the second change. When the last-mile deliveries are dropped at the UCC this saves time and distance travelled (the first change), however when multiple routes are driven, over the extra time available in the other routes due to the time saved (Tavasszy et al., 2014). To calculate the savings generated in these two ways, the routes of the carrier must be simulated, after which the costs can be compared between a simulation of the last-mile value and the regional value.

4.2.1 Cases

To study the cost savings caused by an UCC we first need cases. Two datasets were made available to us for the purpose of this research. The first case is a shipper and the second case is a carrier. The cases are simply called by these terms in the thesis. Table 1 shows the core data for these two cases.

Case	Locations	depots	orders	Routes	Vehicles	Veh. Capacity	#stops/route	Period
Shipper	174	1	1390	128	8	26,8m3	10,9	Month
Carrier	6737	12	31080	1156	-	26,8m3	27,0	Month

Table 1: The two cases included in this thesis. The locations is the total number of unique locations visited in the period observed. The orders and routes values are monthly values, which are for the carrier extrapolated from the first week.

The shipper is a retail chain supplying their own stores. The dataset for their orders in the Netherlands was made available and all calculations of the shipper are based on this dataset. The dataset ranges from 3 September 2013 to 27 September 2013 and consists of four weeks of four days. In total there are 174 unique delivery locations in this dataset, spread out over the period. The shipper makes use of a single depot for deliveries, located in Hilversum. Figure 5 shows an overview of the depot and orders of the shipper in one month.

The carrier's dataset also consists of one month of orders, however due to time constraints only the first week has been used in the calculations. This dataset describes the period of 2 September 2014 to 26 September 2014, again with four days a week. The total dataset consists of 6737 unique delivery locations and these are supplied from 12 depots throughout the country. This set is different from the shipper on the amount of orders, however more interestingly is the multiple depots the carrier uses. This changes the average number of stops in a route and the distance between the stops and the depots. Figure 5 also shows an overview of the depots and orders of the carrier.

The UCC in this thesis is based on the properties of the UCC concept as executed by Binnenstadservice. This company is currently active in several cities in the Netherlands. As the depots are actually franchises, they can differ in their properties. We use the concept as it is currently done in Nijmegen, where the actual deliveries are outsourced and the depot receives, consolidates, and hands over the goods to a local carrier. The service area of this depot is not limited to the city centre. This complies with our defined service area for the UCC as the urban area and not the city centre alone.

For the cost input of the cases we use the costs as given in BCI (2013), appendix table 5, these are costs per vehicle. The vehicles in the datasets were 12 tonnes (26,775 m^3) for the shipper and the carrier and hence give costs of €0,27 per kilometre and €0,573 per minute (€34,37 per hour) according to the table. Although the carrier also uses larger vehicles, their fleet is not known and hence there is no way to accurately simulate the difference in trucks. Therefore all vehicles used in the simulation were assumed to be the 12 tonnes vehicles.

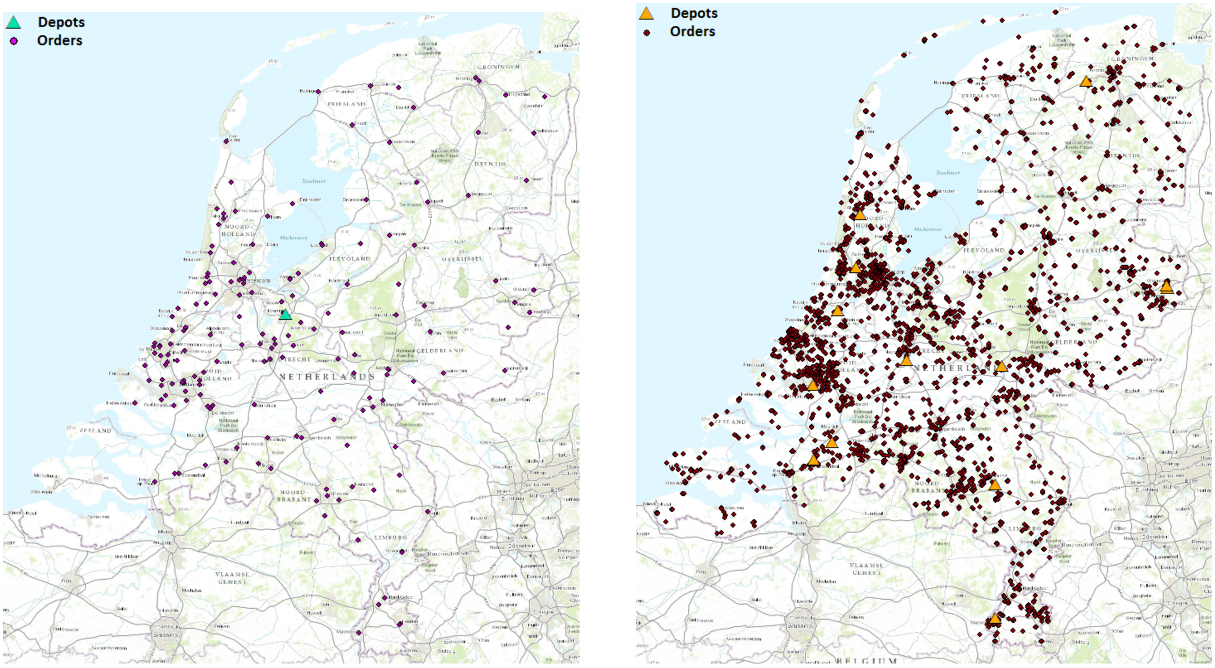

Figure 5: Overview of the shipper's dataset (left) and the carrier's dataset (right).

4.2.2 Scenarios

To study the actual value of an UCC in multiple situations, we created three scenarios. The difference between the scenarios is the number of cities that contain an UCC. The exact scenario set-up is as follows:

- Scenario G4: The four largest cities of the Netherlands are assigned an UCC.
- Scenario G14: The G4 and 10 cities of the G32 organisation that are determined to be the least accessible (see appendix A). Combined with the G4 this makes the G14 scenario.
- Scenario G4G32: This scenario assigns UCCs to all 38 municipalities that are part of the G32 organisation, this includes the cities of the other scenarios[2].

These scenarios enable us to gather the value created by the UCC concept in multiple situations. These scenarios are researched for both studied cases. Appendix A shows all the cities that are included in the study, along with some of their properties.

Since the UCC in our case has a presence in only a subset of cities mentioned in the G4 and G32 organisations, all cities were assigned a location. The location of the depot can be an important factor

[2]The discrepancy between the number of cities and the organisation numbers is due to the G32; This organisation currently consists of 41 municipalities. Three of them are not included as they joined after the study started; These are Roosendaal, Hengelo, and Alphen a/d Rijn.

in the efficiency of an UCC (van der Poel, 2000) and hence can be important in its value proposition. The exact method for choosing a location is explained below. This provides a consistent method for choosing the location and prevent bias that would be incorporated when choosing with a more arbitrary method. The process is shown graphically in figure 6. The assigned locations are shown in appendix A as well as the list of cities included in this thesis. The actual locations of the UCC are not taken into account, as this would present a bias between the southern and eastern cities, where they are currently predominantly located, and the western and northern cities.

1. The city centres are determined based on searches of the relevant municipal websites with the key words; *Binnenstad* (Inner City), *Centrum* (English: Centre), *Stadscentrum* (English: City Centre), *Winkelstraat* (English: Shopping street), or any combination thereof.
2. The middle-point of the centre is picked as accurately as possible, mainly dependent on the information found. This middle-point is extracted as a balance between the exact middle-point of the centre (insofar as the centre is clearly delineated) and the accessibility to the nearest larger road network. This to account for cities where the middle-point is fully accessible and the actual problematic streets are not exactly centred.
3. The distance from the middlepoint in minutes is then charted. This is the distance at which is takes 5 minutes to reach the middlepoint. See section B for an in-depth explanation of the tool and which settings were used.
4. The actual location is chosen based on the driving time of the 5 minute border; To have a reproducible result the locations are determined by:
   - Determining the fastest route from Utrecht to the middle-point of the centre. Utrecht is not the exact middle-point of the Netherlands, however it is assumed to be the central point of the national road network. This fastest route is called the *Utrecht Vector* in this thesis and along this route the location is picked. This was done through a simple Google Maps®solve of the quickest route from 'knooppunt Lunetten' (3439 LG 7) to the city centres[3].
   - The intersection between the 5 minute border and the Utrecht Vector yields the preliminary location.
   - The 5 minute area most often is in the city itself and the intersections can be accurately chosen. However for a larger distance, such as the 10 minute distance, the location is often along a highway. This means that the location can be less than 10 minutes away from the centre at an appropriate exit in such a scenario. But this is a variance that cannot be avoided; If the location is taken at the intersection it will result in a location that is not reachable.
   - The location is not necessarily an industrial area or actually suitable for an UCC. Although this makes the results less realistic, it does make our method reproducible and prevents bias between cities due to local variations and land availability.

Simulation method

To perform simulations for logistic issues we decided to use Vehicle Routing Problem software. This type of problem solving can generate optimal routes for multiple vehicles and a large amount of orders. Additionally it reports the driven kilometres, time spend, and costs of the optimal routes. This can be used to calculate the costs of the solution and compare these costs to solutions with a different

[3]This is a location with a highway in all major directions of the Netherlands and suits perfectly to find a route from Utrecht to all other centres in the Netherlands. For Utrecht itself the quickest route to The Hague will be used as a vector. This is done because the Randstad is the major economic region of the Netherlands and hence a priority over the other regions for the UCC depot of Utrecht.

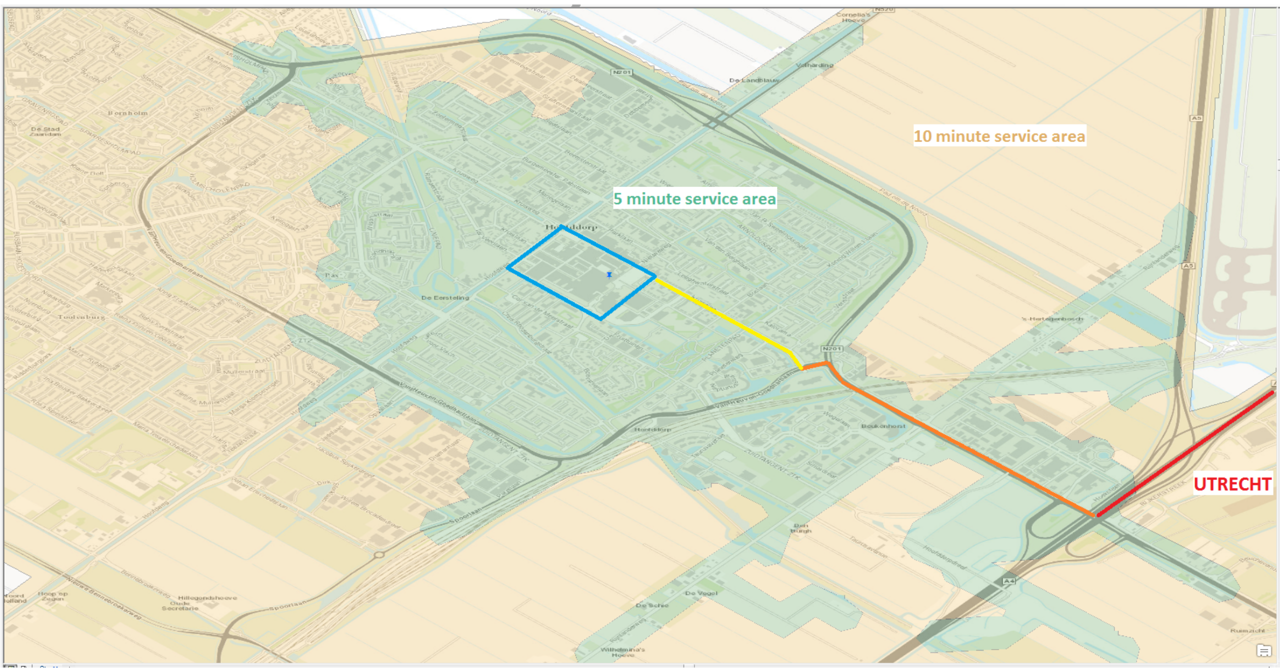

Figure 6: The city of Hoofddorp with the city centre (blue), the Utrecht Vector (yellow,orange,red) and the 5 and 10 minute distance. The location was in this example chosen near the highway exit, as the vector and the border of the 5-minute area intersect here.

input. So through this method type we can gather knowledge about the actual cost change after using UCCs, and thus the value that an UCCs generate for logistic operators.

The software available to us is the ArcGIS®software package and TransCad®software. Both software packages provide the ability to solve vehicle routing problems. However the TransCad software does not include network maps of the Netherlands. Public network maps (such as OpenStreetMap) can be used, but its accuracy is not shown. The ArcGIS software package does have a network map included. This map is based on the NAVTEQ®satellite data and contains all information necessary to solve the problems accurately (speed limits, turn restrictions, etc.). Additionally the software contains other tools that could be used to transform data or perform alternate analyses. Hence for this research we used the ArcGIS®software, as it includes the necessary tools to perform the study.

The software generates an output for the routes allocated, the stops assigned, and the stops left out of the solution. The most important of these is the total costs, which is used to compare solutions. However the other results can also be used to determine additional findings or explain what variables caused the total costs generated.

4.2.3 Calculation

This main calculation method is adapted from the paper by Quak and de Ree (2009), which also used VRP calculations to determine cost savings for carriers when an UCC is included. As was mentioned before, we use the software to generate the total costs, which can be compared between different solutions. The input for the calculation are orders for a single day. As we have datasets of more than one day, the results can be added to get the results over a week and a month when needed.

To get a meaningful comparison, we do the calculation in three parts. First a baseline is created to gather the normal situation results. If this baseline was not done, any result would systemically come out with positive cost savings (Janssen, 2011), as the normal routing of the cases may not necessarily be optimal. The other two steps are included to differentiate between the last-mile effects and the network effects. To get the last-mile effects the routing of the baseline must be the same as the routing for these effects. When these baseline routes are let go in the third calculation, the solver can redetermine the routes to gather a whole new optimum, including the network changes. This sequence enables us to determine the last-mile effects of the inclusion of UCCs, as well as the network effects.

Calculation a: Baseline: The determined optimal routing with no alterations or UCC implemented.

Calculation b: Same Sequence (SS): This step introduces the UCCs in the problem. It uses the same routes as the baseline to exclude the network effects and result solely the last-mile effects.

Calculation c: Full optimisation (FO): This step is the same as the former step, except that it recalculates the routes instead of using the baseline routing. This results therefore in the total effects of the UCC, including network effects, when present.

For the results the output is further transformed in an excel sheet to come to more useful numbers. The direct output are absolute numbers per route, so first the total amounts are summed from the individual routes. Additionally the results are per day, which are combined to form the absolute results per week. In the results the driven kilometres, time spend, number of routes, and the amount of orders are mostly given as a relative number to indicate the change. This is done simply by dividing the absolute numbers over their corresponding numbers in the baseline. The costs are handled further in the same way. However, they are also divided over the difference in orders, to determine how much savings there are per order. This is important as the UCC itself has to pay a price per order to a subcontractor. This enables us to compare the numbers and determine whether there is room for a profit margin when the cost per order is subtracted.

Due to an update in the software, the routing for the carrier's case was not possible to run for the Same Sequence calculation. Therefore we used an alternative method to determine the last-mile effects of this case. First the costs to enter a city was determined and averaged per scenario. This was done with a separate VRP solve with a single order per city, as follows:

- One vehicle per city and a single order in the city centre.
- One vehicle per city and a single order at the UCC location.

The output contains the independent routes and as every route has a single order (the city centre of the UCC), the difference between the two solves result in the last-mile effects per city. Afterwards the marginal costs of orders within a city were determined. The results of this calculation yield a formula for each scenario to calculate the last-mile effects. In these formulas M represents the marginal costs, while E represents the costs to enter a city. E is differentiated between the city categories, as the largest cities of the G4 do not have the same costs to enter the city as the smaller cities. These costs are multiplied by 2 to include the costs of moving out of the city. The marginal costs are taken from a single city that includes orders in the city centre, as well as in other parts in the urban area.

- Scenario G4:
  $Last - milecosts = 2(E_{G4}) + M_{time} + M_{distance}$
- Scenario G14:
  $Last - milecosts = 2(E_{G4} + E_{G14}) + M_{time} + M_{distance}$
- Scenario G4G32:
  $Last - milecosts = 2(E_{G4} + E_{G14} + E_{G32}) + M_{time} + M_{distance}$

4.3 Results framework

The results are first given for the perceived value, followed by the actual value of the shipper and carrier dataset in separate chapters. Additionally the sensitivity analyses are stated in the last section.

5 Perceived value

This section contains the results gathered in the study. They are described per method in the same structure as section 4. First the results of the qualitative exploratory study are mentioned, followed by the quantitative results from two datasets and one regional example case from local data.

The first method consisted of going through the literature and conducting interviews. The main goal of this method was to;

- Determine the potential good flows.
- Determine criteria on which firms value a service.
- Indicate which sectors have the most potential.

In total 13 interviews were conducted to gather the information on expectations and obstacles in possible sectors. These were conducted in expert interviews, followed by interviews with firms themselves to get a more hands-on view of the possibilities and practical obstacles to be expected. The criteria were all predetermined by the literature and expert interviews, while the firm interviews are done for the expectations and practical opportunities and issues.

5.1 Criteria Determination

The expert interviews provided the relevant criteria on which the UCC concept can be assessed. The provided criteria were:

- Monetary Value: The expected monetary gains, such as additional revenue or a decrease in costs.
- Service quality: The expected change in provided service quality, such as a more accurate delivery or delivering in wider time-windows.
- Extra Services: The expected change in providing extra services for the receiver, such as installation of delivered good or repack and label goods.
- Reliability: The expected change in reliability of the distribution process, such as the state of the good (undamaged) and delivering on time.
- Strategic value: The expected gains on a long term or non-financial gains. For example when further municipal restrictions are introduced in the future, disposing of secondary activities, or penetrating a new market.
- Environment: The expected value on an environmental perspective for the firm's image.
- Visibility: The change in value by having less visibility locally. This entails the brand visibility within the urban area for PR, but also when visible during accidents.
- Enforcement: Whether there are expected obstacles on an organisational level, such as when additional actors are required to cooperate.

The criteria were taken first from Macharis et al. (2012) and the theses of van Dam (2014) and Slabbekoorn (2014). Afterwards the preliminary list of criteria was shown to the interviewees for additions and comments. The interviews used to generate the list are: Ploos van Amstel (2014); Coremans (2014); Nelck (2014); Rijssen (2014); Slotema (2014); Walinga (2014).

5.2 Additional Sectors

Construction

The construction sector is responsible for a large share of the local transport (CBS (Centraal Bureau voor Statistiek), 2012) and hence is a suitable sector to look into. Additionally some pilot projects have shown potential for consolidation schemes (Adriana, 2013; Wainwright and Browne, 2013).

Four interviews were conducted to gather the expectations of this sector. Two exploratory interviews (Merriënburg, 2014; Walinga, 2014) to gather general information about the sector and current initiatives and developments. Additionally three firms were contacted: one wholesaler (van Iperen, 2014), one tool and material supplier (Frazer, 2014), and one construction company (Schakenbos, 2014). This provided a clear view of the subject from three different perspectives of the construction sector. Most suggestions of where an UCC could provide the most value was shared by all parties.

Awareness
The transport costs in this sector are rarely calculated separately and companies are used to doing the logistics themselves. The wholesaler and the tool supplier both stressed that they can add much value for a construction company simply by moving the required goods and tools to the construction site, so all the individual construction companies do not have to do this themselves. The construction company confirms this value proposition as it uses a wholesaler in exactly this manner and reduces its own transport costs and increase time spend on construction. The main obstacle mentioned by all parties is the behavioural change needed, as it is grounded in the normal routine.

Phases of construction
Consolidation will probably be dependent on the phase a construction project is in. Broadly viewed a project consists of the Structure stage, which consists mainly of bulk goods. The second phase is Finishing and consists of smaller work, such as electrical installation, and contains goods with a wide diversity of sizes. The second phase is suggested to be much better suited for consolidation. However as figure 7 summaries, a clear phase border is not always the case in projects, especially with repeating units.

Planning This sector does have the advantage of having a single or only a few contractors, which in theory can force consolidation. Additionally the major advantage in this regard is related to the actual construction planning put forward by Walinga (2014). An UCC could be of value when logistics are integrated in the construction plan. As the UCC can deliver just-in-time and pre-package goods for specific locations of the site[4]. This would reduce storage on-site and enables workers to focus on construction without hinder of goods. This aspect can also increase the value proposition, as the UCC can contribute to a reduction in fail costs[5]. The requirements for such an UCC would be relatively low with mainly some IT integration and of course the manpower to consolidate the goods.

Extra services
An obstacle which can reduce the usefulness of an UCC in this sector is the ability to perform extra services on-site. This can range from an on-vehicle crane to lift goods to the preparation of the construction site. These kind of obstacles may be solved or circumvented, but it can reduce the potential good flows and thus the potential value proposition.

Waste logistics

The waste sector was studied based on the suggestions done by Gevaers and Van de Voorde (2013) and de Langhe et al. (2013). These papers mainly suggest parcel delivery as an opportunity for waste logistics, however through the interviews we also investigated whether other types of deliveries could

[4]Normally goods are delivered and stored on-site per supplier. However an UCC can bundle goods of all suppliers that are required on a specific floor.

[5]Costs associated with mainly delays, accidents, etc.

	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10
Foundation	House 1	House 2	House 3	House 4	House 5	House 6				
Structure		House 1	House 2	House 3	House 4	House 5	House 6			
Installation			House 1	House 2	House 3	House 4	House 5	House 6		
Finishing				House 1	House 2	House 3	House 4	House 5	House 6	
Interior					House 1	House 2	House 3	House 4	House 5	House 6
	Bulk goods period			Bulk and normal goods				Normal goods period		

Figure 7: Schematic overview of a repeated construction project. The phases (shown on the left) are not all handled sequentially, which complicates the distinction between the 'bulk goods' period and the 'small goods' period of the project.

be combined. The waste sector in the Netherlands consists of the concession-based household waste and the open-market commercial waste. Household waste is therefore done by single company per municipality.

For this sector a household waste collector (Inberg, 2014) was interviewed as well as a commercial waste collector[6] (Breeuwsma, 2014). One waste institute (Rijssen, 2014) was interviewed for more contextual information and the legislative environment regardless of their municipal or commercial scope.

Household waste
The waste flows handled are mainly: Paper, biodegradables, glass, plastics, small chemical, WEEE[7], and residual waste. Residual, biodegradables, glass, and paper flows are unsuitable due to their nature and volume. Only paper could generate some revenue as it has some inherent value, but still the volumes are generally too large. On the other hand the small chemical and WEEE flows are small in volume and hence are suitable for consolidation. Households only generate small amounts of these types and hence these could be collected by UCC vehicles during their routes. Especially WEEE has a large expected value, although the actual value is unknown. Collecting these types could mainly increase source-separation and hence reduce chemical waste and WEEE presence in residual waste.

Commercial waste
As any firm can choose their own waste collector, often multiple waste collectors are operating in the same area. Especially in the city centres this can generate many extra driven kilometres. The waste flows of municipal collectors are also present in the commercial part, however there are additional types that are commercial-specific. Examples are: Large chemical, Swill, and construction waste. Although not all types have been discussed in detail, there are some flows with potential: Construction and chemicals.

Construction waste is very diverse and is collected in open containers. The potential with this flow is mainly the empty kilometres when driving to the construction site, where the container is hoisted upon the vehicle. The vehicle could for example pick-up and deliver mobile parcel stations with the empty vehicle when the route allows for it.

Chemicals are stored in containers of various sizes and can be consolidated with other goods. It is also a low volume waste for most industries and hence has more potential for consolidation. The empty containers must be brought on the trip towards the customer, hence there is no fully empty trip by default. Other flows could perhaps be consolidated, but therefore the list of flows must be individually judged, which was too much for one interview. Additionally, changing vehicle design could increase the odds of working with certain flows. The current fleets are fully designed to transport waste. A vehicle designed to transport both could make more flows suitable for consolidation.

From the uses mentioned in the interview the main potential is by picking up goods at the UCC for

[6] Although also active in municipal waste, this interview was based on the commercial side of the company.
[7] Abbreviation for 'Waste Electrical and Electronic Equipment')

extra revenue, while delivering waste at the UCC is not a suitable option. The Waste collectors can therefore mainly operate as a subcontractor for the UCC, instead of the other way around. However this can also be due to the perspective of the waste collector, as collection is its business and delivering waste to someone else is (perhaps prematurely) discarded as an option. For the current type of UCC, outsourcing deliveries to local distributors, this does make sense as long as the routing allows it.

Additional obstacles
For both parts of the sector regulation and legislation raises an extra barrier for an UCC. Firstly, there is the regulation present in the waste sector, which makes permits necessary when transporting waste. Hence the UCC cannot do the last-mile of waste without acquiring such permits. Additionally there are also permits necessary for the (temporary) storage of waste at the UCC. These regulations for waste transport and storage make reception of waste by the UCC for consolidation unattractive.

The second regulatory obstacle mentioned is the 'Mededingingsauthoriteit', or the Dutch competition regulator. Although not specific for the waste sector, Rijssen (2014) mentioned that serious cooperation of waste collectors would be stopped by this authority to prevent monopolist constructions. As the commercial collector was less worried about this authority when using an UCC instead of direct cooperation, it is unclear in how far this would be a problem.

Food

No interviews were done before the end of the study. Hence there is only information from other literature sources. Primarily this means that future studies need to chart this sector on the possibility of consolidation by UCC.

BCI (Buck Consultants International) (2011) describes the opportunities of an UCC in the food sector. However they do mention that firms operating in this sector rather keep fulfilment within their own organisation and only outsource when uncommon fulfilment is done. Consolidation is mainly seen in the primary supply of the supply chain, while the last-mile is done mostly with own transport. This paper was based on the Food Center Amsterdam, which is a transshipment site for the food sector. Most of the transport after the transshipment towards the city of Amsterdam itself is done by own transport of local firms. The main question remaining is why the companies prefer own transport and whether this can be replaced by a UCCs distribution means.

Another paper on the food sector is Bleeke (2013) and studies two hotels in Amsterdam. This paper studies the frequent deliveries to these hotels and the possibilities for consolidation. It concludes that consolidation for fresh food deliveries is very difficult due the short lead times of often a few hours. Additionally it also mentions the supply being done with mostly own transport by the suppliers as well as the objection to cooperate with other suppliers. Interestingly this paper also mentions the opportunity for bundling the waste generated by the food sector, as the many food establishments use different waste collectors.

The food sector only has low potential for urban consolidation due to the short lead times and the use of primarily own transport. Future study is needed to determine in how far the potential is actually lower than the other sectors mentioned in this thesis. The short lead times argument suggests that service quality is very important, especially for fresh food. However it is unknown whether there are other criteria important for considering consolidation in this sector.

Health

The receivers in this sector are mainly Health Care Institutions, drug stores, and hospitals. These receivers have a high amount of suppliers with a regular delivery. CB Logistics consolidates the deliveries to these receivers, significantly reducing the amount of necessary supplying trucks. This company provided information on this sector by email (Pieterson, 2014).

The receivers have large volumes of supply and are frequently not located in the inner cities. A depot at the edge of a city therefore probably does not have very large potential savings for the carriers supplying hospitals, as the access is not a large problem. The receivers would benefit from the consolidation aspect, as CB Logistics shows, as the amount of suppliers is very large. The question remaining for these receivers is in how far the regional consolidation of CB Logistics would be more efficient than the use of an UCC, especially for the institutes and hospitals located in an urban area.

Additionally there is the supply of the smaller institutes and drug stores in the city, which can be integrated in an UCCs routes. It is not known from the answers whether or not CB Logistics consolidates for these receivers in the inner cities. Deliveries to these receivers could therefore be consolidated by an UCC, just like other retail goods. One practical implication is the transport of cooled goods to these receivers. It is not known what share of these goods should be cooled, so this could be an obstacle if the UCC does not consolidate cooled products. To determine whether this part of the health sector can profit from an UCC, further research is necessary. Furthermore there is little information on the deliveries of the institutions and drug stores else in the city, as this company does not perform these deliveries. Therefore further research should determine whether this part does consist of many small deliveries, suitable for an UCC.

Survey

To quantify the perceived value we created a survey based on the criteria found in the interviews. This survey contained the expectations on these criteria, as well as a valuation of the importance of each criteria. Combining these numbers would yield a mean value across all criteria. When sufficient response is gathered, the results indicate which criteria were most important and how they are valued. The combined value would indicate the overall expectation of the UCC concept.

Unfortunately only two responses were received for our survey. The response is too few to provide meaningful results and hence are excluded. The survey is shown in appendix A. The survey can still be valuable in further research as a template for the perceived value determination of UCCs. This could then provide insight in the relationship between qualitative value and the quantitative value of the concept, as well as to indicate which sectors value an UCC the highest.

6 Actual value

The following results were gathered through the VRP simulations on the data of the shipper and carrier case. Afterwards the sensitivity analyses are mentioned.

6.1 Shipper

The results for the shipper dataset are shown in table 2. The table only shows the absolute cost savings per store consolidated through the UCC and the relative cost savings for the distance traveled, time spend, and the number of routes. The main question answered by this method was the actual value created by the UCC. Relevant for both parties is the value created per stop that is consolidated. This is the first value mentioned in table 2 as well as the other relevant results from the calculations.

The created value in the last-mile was determined by the Same Sequence (SS) calculation, while the value created of the whole network was determined by the Full Optimisation (FO) calculation. For this dataset it is important to keep in mind that the shipper has very few stops compared to the carrier. In the smaller cities there is just one stop, while in the larger cities there are mostly two or three. Table 1 in section 4 shows the properties of the cases. Table 3 shows the number of stops within the urban area per case. This is an average over the cities which had an UCC assigned. This table shows the difference ion order count of the cities in the scenarios of the cities involved.

The last-mile value ranges from €8,94 per order in the G4 scenario to €7,79 in the G14 scenario and €7,08 in the G4G32 scenario. This shows that the last-mile cost savings are larger in the G4 cities, while it is lower in the G14 and G4G32 cities. Additionally the savings on time costs appear to be larger than the savings on distance costs in all scenarios. This suggests that saving time in routing has more effect than the reduced kilometres themselves.

Interestingly, the direct last-mile value is lowest in the scenario with the most cities, while the value is highest in just the G4 cities. One would expect that the larger cities with more stops would actually be relatively less beneficial to use an UCC, as you have more stops in the city to divide your costs over and hence would be more efficient from a shippers perspective to distribute himself. However the costs of the last-mile apparently rise very quickly, as the extra stops do not make the UCC less attractive compared to own transport. The additional cities in the G14 and G4G32 scenario can also simply be more accessible than the G4, resulting in less cost savings by using an UCC.

For the shipper the network effects show a rising effect from the G4 scenario to the G4G32 scenario. Oddly enough, the G4 cost savings with the FO calculation are actually smaller than the SS calculation (€8,15 per order vs. €8,94 in the SS calculation). The only difference between the two calculations is the lack of the restricted routes (as SS is restricted to the baseline routing to get the last-mile savings), hence one would expect the results of the SS calculation as a minimum with FO optimising further. As the same routes can be used when removing the restrictions, these results have also been applied to the FO calculation. In the G14 scenario the savings rise to €9,37 per order and in the G4G32 the network effects increase to €12,65 per stop. This clearly shows the additional benefits gained outside of the last-mile.

The steep increase in savings from the G4 and G14 scenario (-3,3% and -6,4% respectively) to the G4G32 scenario (-16,7% costs) shows that the relation between the number of cities and the network effects is not linear. It would be interesting to see whether an even larger amount of cities with UCCs continue to raise these effects even more than the increase from 14 to 35.

Scenario	Calculation	Savings per stop	Costs	Stops	Distance	Time	No. of routes
G4	SS	€ 8,94	-3,6%	-10,3%	-1,1%	-4,6%	0%
G14	SS	€ 7,79	-5,3%	-13,9%	-1,9%	-6,7%	0%
G4G32	SS	€ 7,08	-9,3%	-21,2%	-3,9%	-11,7%	0%
G4	FO	€ 8,94	-3,6%	-10,3%	-1,1%	-4,6%	0%
G14	FO	€ 9,37	-6,4%	-13,9%	-2,0%	-7,7%	-7,8%
G4G32	FO	€ 12,65	-16,7%	-21,2%	-11,6%	-17,9%	-21,9%

Table 2: Results of the shipper dataset

Case	Scenario	#Stops	Cities	Stops/City	Period
Shipper	G4	185	4	46,25	Month
Shipper	G14	315	14	22,5	Month
Shipper	G4G32	607	38	16,0	Month
Carrier	G4	3.240	4	810	Month
Carrier	G14	6.012	14	429,4	Month
Carrier	G4G32	11.104	38	292,2	Month

Table 3: The number of stops within an urban area. Combined with the number of cities in the scenarios, this shows the different nature of cities in the scenarios involved.

6.2 Carrier

The results for the carrier dataset are shown in table 4. The average order count per city for the carrier is also shown in table 3 along with the shipper's. The set-up for the carrier is the same as the shipper's results. However, note that there are two differences compared to the shipper case. First the baseline of the carrier was done in a split VRP. This is shown visually in figure 8 in appendix A and therefore the additional FO (E+W) calculation is included. This simply is the FO calculation where the East and West results are added to get the national result. Secondly the last-mile values are calculated differently due to the update of the software, as mentioned in the methodology.

The last-mile scenarios (SS) show a very consistent savings pattern with just a range from €8,28 in the G4, €8,49 in the G14, and €8,69 in the G4G32 cities. However this is to be expected with the changed method for the last mile and should not be taken at face value. Our new method uses a fixed 'Enter city' value which differs just slightly between the categories of cities, from €5,87 (one-way) in the G4G32 cities to €6,06 in the G4 cities (see section C for all results and the numbers used in this calculation). The marginal costs are calculated based on the number of stops, their service time, and the travel time and distance within a city. These generate a marginal cost of €8,04 per stop, even higher than the costs of entering the city itself.

The full network effects are interestingly enough equally similar across the scenarios. In the G4 the savings are €8,73 per stop, with €8,78 in the G14 and €8,42 in the G4G32. Compared to the last-mile costs the improvement is lacking completely, indicating that no substantial added value is created in the network when more cities have an UCC.

Scenario	Calculation	Savings per stop	Costs	Stops	Distance	Time	No. of routes
G4	SS	€7,56	-7,3%	-10.4%	-	-%	0%
G14	SS	€7,86	-13,9%	-19,3%	-	-	0%
G4G32	SS	€8,06	-26,3%	-35,6%	-	-	0%
G4	FO(E+W)	€8,39	-7,4%	-10,4%	-2,2%	-8,1%	-8,0%
G14	FO(E+W)	€8,40	-13,7%	-19,3%	-5,0%	-15,0%	-12,8%
G4G32	FO(E+W)	€8,06	-24,4%	-35,6%	-8,7%	-26,6%	-19,7%
G4	FO(total)	€8,73	-7,7%	-10,4%	-3,3%	-8,3%	-6,9%
G14	FO(total)	€8,78	-14,4%	-19,3%	-7,6%	-15,3%	-12,5%
G4G32	FO(total)	€8,42	25,5%	-35,6%	-11,5%	-27,4%	-20,8%

Table 4: Results of the carrier dataset

An interesting result is the decrease in routes for the shipper and the carrier both to around 20%, while the cost savings per stop decreases for the shipper, but not for the carrier. The explanation for this could lie in the number of orders that the carrier has to service, but it can also be affected by the organisation of the depots. To determine what explains the results, the cost savings are split between marginal stop costs (the costs incurred between two stops) and the first/last order costs (the costs incurred from the depot to the first order and the last order tot he depot). The first/last order costs can be relatively low due to the multiple depots, decreasing the distance and hence lower the effect of the decrease in routes. On the other hand this can be explained by the lower share of the first/last order costs compared to the marginal stop costs.

To check what causes the lower cost savings per stop at the carrier, we have done a small analysis on the travel time and travel distance to the first and from the last order of a route. The first week from the carrier's and the shipper's results in the G4G32 scenario was picked for the analysis. Due to the large difference in cost savings in this scenario, this makes identifying the cause easier. The average distance and time for all routes to their first and from their last stop were charted, followed by the number of routes to determine the total cost to the first and last order for each dataset. If the number of orders and spread out depots indeed affect the network savings we would see a difference between the shipper's and the carrier's savings compared to their routes.

Table 5 shows the results for this analysis. The shipper's dataset shows a decrease of 15,6% in routes and 21,6% in costs, while the carrier's dataset states a 20,8% decrease in routes and 22,4% decrease in costs[8]. Thus in both datasets the route decrease is associated with a similar cost decrease. This means that regardless of the organisation, the cost savings are accounted for by the decrease in first and last order costs. Hence the marginal costs play just a minor role in the network cost savings, regardless of the depot and order properties. This also explains the lower cost savings per stop for the carrier as it has more marginal stops per route. The first and last order costs then occupy a smaller share of the total costs saved (Only 1,0% for the carrier, while they are 11,8% of the shipper's savings). Hence the decrease in first and last order costs have a smaller impact on the carrier's total costs, than they have on the shipper's cost.

[8]Note that the decrease is somewhat overstated due to the extra optimisation over the base, as the base was split in two sets. This was due to the software not being able to handle the 2000+ orders of the baseline scenarios

Dataset	Scenario	Calculation	No. of routes	Routes	First/last costs	First/last costs	Total cost savings	First/last share
Shipper	G4G32	Base	32	-	€1421,23	-	-	-
Shipper	G4G32	FO	27	-15,6%	€1251,71	-11,9%	€1430,59	11,8%
Carrier	G4G32	Base	289	-	€5284,39	-	-	-
Carrier	G4G32	FO (E+W)	232	-19,7%	€4693,50	-11,2%	€92194,76	0,6%
Carrier	G4G32	FO	229	-20,8%	€4353,86	-17,6%	€93511,65	1,0%

Table 5: Results of the first and last order savings for the carrier. It shows the relationship between the decrease in routes and the decrease in cost to and from the first and last order in the routes. It also relates these savings to the total savings, mentioned in the last column.

6.3 Sensitivity analyses

For this study a number of decisions were made in the methodology which could have impacted the results of the study. In this section we will provide results with altered inputs to check for these decisions and in how far they may have influenced the results. The location of the UCC depots were checked twice: Once for their distance to the city centre and once by originating the vector differentially. Additionally the datasets were altered twice to check for an altered frequency of delivery and an increased volume for all orders. These are to check whether the specific properties of the datasets can have a decisive impact on the results. This is mainly to determine in how far these results are impacted by the properties of the deliveries instead of the network properties. The tables are consolidated on page 6.

UCC locations at 10 minutes drive-time distance

This alteration was done based on the Shipper dataset with the G4G32 cities scenario. The difference with the normal scenario is that instead of having the UCC locations at a 5 minute drive to the centre, the UCCs were located at a 10 minute drive distance. Both locations are shown in section C per city. The further distance is mostly on top of a highway. To have a realistic solve the locations were not put next to the 10-minute mark but to the closest exit. For all cities where this was the case, the exit was first located towards the city to stay within the 10 minute zone. This did result in some locations which did not differ much from the 5 minute drive location. An example was the case of Lelystad, which is only a stone's throw away from the 5 minute location.

The results of this scenario are shown in table 6. This table shows the relative results in percentages as well as the cost savings per stop. It shows the difference between a 5 minute drive distance and a 10 minute drive distance, which is in favour of the former (€ 12,65 compared to € 11,22). Since the orders are completely the same, this difference falls completely on the different location of the depot. When only the last mile calculation is taken the difference is in favour of the 10 minute version, with (€ 7,08 to € 7,49). Which is as expected as it removes even more of the distance towards a city centre. The usage of a different location is not a big factor apparently on the VRP calculated savings, which can be due to many local factors and how the location is placed next to a highway. The preference for closer locations can be due to the misplacement of the locations, as exits are somewhat less flexible than normal roads with one-way properties and such. However, for now it suffices to say that the location is not a very large factor in the calculations on a national scale, although this can be more important when local decisions are made by the UCC. So when locations are chosen by an UCC, this must first be researched in a local scale to truly assess the best locations and the differences it makes on the entrance to that particular city.

UCC locations based on decentral carrier depots

As was mentioned in section 6, the carrier does not deliver from a central location but from multiple depots around the country. Since the shipper ships from the city of Hilversum, the Vector for Utrecht is appropriate as it is also located in the center of the Netherlands. However when using distributed depots the vector can be on the opposite side of a city compared to the used depot. To see whether this could influence the results we also ran a scenario where the vector was not pointed to Utrecht, but was pointed to the nearest depot. The depot was located by the 'Location Allocation' results we have seen earlier to split the VRP. This was also used for this calculation as the assumption underlying it are the same; The depot with the shortest drive time to an order would be most likely used to deliver that order.

For some cities this meant a location on the opposite side of the city, while for other cities this resulted in the exact same location. The exact addresses are shown in appendix A along with the addresses for the 5 minute and 10 minute drive distances. Table 7 shows the relevant results compared to the equivalent normal scenario. The carrier-oriented locations result in almost exactly the same savings and decreases across the board. This means that for the carrier it does not matter much at which side the UCC actually is located. Although somewhat counter-intuitive, it makes sense from a VRP perspective. As the carriers have orders in multiple towns and villages around the cities, the side at which the city is entered does not need to matter. For example imagine a city was normally supplied first from the depot and the carrier carried on to supply two more villages further away. When the UCC is located on the opposite side of the city this does not need to result in worse performance, as the city can simply be supplied on the way back with no extra miles driven. This is probably very location-dependent, so it does not need to be the case for all cities or regions.

Delivery frequency lowered from twice to once delivered per week in UCC cities

For the methods the assumption was that network effects would come from rearranging routes on a daily basis. However for recurring orders this does not need to be the case. Every location is visited twice per week of the calculation and hence the question is whether re-arranging the orders could further decrease costs. To check whether this is an important factor in network effects, the same methodology was used to generate another scenario.

All orders for the shipper were consolidated when they occurred twice a week[9]. Every Tuesday has the same orders as Thursday, while the Wednesdays share the same orders as the Fridays. Therefore this scenario moved all orders within the UCC service areas. All orders on Thursday were added to the orders on Tuesday and the same was done for the orders on Friday upon the orders of Wednesday. In theory this would lead to an increase in costs on Tuesday and Wednesday, due to the larger order size, and a (larger) decrease on Thursday and Friday as the UCC cities can be skipped completely. It is important to note that the results gathered were achieved by enabling the renewal of routes. This was necessary as the number of vehicles was insufficient to get the total capacity to the larger orders of the UCCs. As the fleet of the shipper is known, we enabled route renewal to keep the actual fleet size and only change how the fleet is used.

Table 8 shows the results for this scenario. As the results indicate, this scenario actually performs worse than the normal scenario. With a cost saving of only €10,49 per stop, it is smaller than the €12,65 cost saving per stop that is saved with the normal scenario. This means that the consolidated days (Tuesday and Wednesday) actually have a higher cost increase due to the raise in orders, than the non-consolidated days (Thursday and Friday) save by having fewer orders. Hence the results suggest that within the study parameters, there is no immediate network effect by consolidating orders in a repeating schedule.

The lack of effects is mainly due to the lack of cost decreases in the Thursdays and Fridays. This can be explained by the routes that the VRP generates. The routing is actually similar to the consolidated days, suggesting that the remaining orders (the non-UCC served orders in other cities or towns) are too spread out that the removal of cities from the equation leads to the same routes, as the neighbouring orders still has to be serviced. To make this frequency change work, the UCC should probably function outward as a regional operator to service the neighbouring villages. In this way the larger areas can be skipped and may result in the changes that were expected. A change in fleet can also affect the results, however to keep the results realistic, the current fleet of the shipper was kept in place.

Volume change for UCC orders

Both datasets are of low volume per order: The shipper distributes on average 1,1 m3 per stop and the carrier distributes 0,56 m3 per stop. To check whether the volume delivered has an effect on the results, we ran a scenario with double volume orders. As this impacts the baseline orders as well, the

[9] Only one location was not supplied twice a week, but only once.

baseline is also rerun with the doubled volumes. The shipper's dataset was used for this scenario and the G4G32 scenario was used as well in this analysis.

As the existing fleet is incapable of delivering these volumes, the fleet is expanded with 2 vehicles. Additionally route renewal was enabled, which enables vehicles to pick up a new load and hence enables multiple routes per vehicle. The reason this is added is that the deliveries to the UCCs in larger cities have a volume almost equal the vehicles max capacity. This lead to unrealistic results, as vehicles would have routes of sometimes less than an hour. In practice the vehicles would be re-used over the day, to keep fleet size down. Larger vehicles could also be used, but that would change too much of the original factors influencing the results.

Table 9 shows the results for this scenario. Both the SS and FO calculations were done and were mentioned for the normal volumes of the main results and the doubled volumes for this scenario. The double volumes scenario produced less cost savings for the last-mile and the network effects compared to the normal volumes. When just the last-mile is taken into account the savings per stop are only €4,95, which is much lower than the €7,08 saved in in normal volumes. When the whole network is taken into account the cost savings are increased, just like the normal volumes. However the savings only reach €9,07 instead of the €12,65 saved for the normal volumes. These results indicate that the volume of the deliveries have a large effect on the results. The results are not providing a realistic value for higher volume shippers, as the current fleet properties may be sub-optimal for these volumes. However it does indicate that the value of the UCC as calculated in this thesis, can not simply be extrapolated to other distributors.

Sensitivity impact

The sensitivity of the method used appears to be relatively minor based on the results gathered. The most pressing concern was the distance from the centre as well as the depot locations. When altered, both showed very little result in the results gained. This means that these factors did not generate a bias when generating the results.

Changing the frequency of deliveries was not as fruitful as expected. This was mainly to see whether the planning of the routes over the week can have an impact on the results gained. However this should be researched more intensely to figure out exactly what kind of scheduling can have effects on the consolidation value. Lastly the volumes were changed to check whether the results are specific for low volume distributors, which seems to be the case. Although this sensitivity is a research subject in itself, there are too many variables to consider, it does show that the results can not simply be externally applied on other shippers and carriers. It confirms the concept shown in the survey, to categorise distributors on their volume, as this indeed is a major influence on the results.

UCC locations	Scenario	Calculation	Savings per stop	Costs	Distance	Time	No. of routes
5-minutes	G4G32	SS	€ 7,08	-9,3%	-3,9%	-11,7%	0%
5-minutes	G4G32	FO	€ 12,65	-16,7%	-11,6%	-17,9%	-21,9%
10-minutes	G4G32	SS	€ 7,49	-9,9%	-3,7%	-12,5%	0%
10-minutes	G4G32	FO	€ 11,22	-14,8%	-8,2%	-16,8%	-21,9%

Table 6: Results for the UCCs at 10 minutes drive distance compared to the UCCs at a 5 minute distance.

Vector direction	Scenario	Calculation	Savings per stop	Costs	Distance	Time	No. of routes
Utrecht	G4G32	FO	€ 8,42	-25,5%	-11,5%	-27,4%	-27,4%
Carrier depots	G4G32	FO	€ 8,36	-25,3%	-11,2%	-27,2%	-27,2%

Table 7: Results for the UCCs located towards the carrier depots, instead of the direction of Utrecht

Frequency	Scenario	Calculation	Savings per stop	Costs	Distance	Time	No. of routes
twice a week	G4G32	FO	€ 12,65	-16,7%	-11,6%	-17,9%	-21,9%
Once a week	G4G32	FO	€ 10,42	-13,7%	-5,8%	-17,0%	-3,1%

Table 8: Results after the orders of all four weeks were consolidated from two deliveries per week to one delivery per week

Frequency	Scenario	Calculation	Savings per stop	Costs	Distance	Time	No. of routes
Normal volume	G4G32	SS	€ 7,08	-9,3%	-3,9%	-11,7%	-0,0%
Normal volume	G4G32	FO	€ 12,65	-16,7%	-11,6%	-17,9%	-21,9%
Doubled volume	G4G32	SS	€ 4,95	-6,2%	-1,0%	-8,5%	-2,9%
Doubled volume	G4G32	FO	€ 9,07	-11,3%	-5,9%	-12,9%	-12,3%

Table 9: Results for a scenario where all volumes are doubled. The doubled volume scenarios were run against a baseline that was rerun with the doubled volume.

7 Conclusion

This thesis strived to determine the quantitative value of an Urban Consolidation Centre, as well as determine whether additional services and logistic sectors can be incorporated in the business model of an UCC. For this purpose we did interviews to determine the potential and obstacles of these sectors and services. We also solved Vehicle Routing Problems on a shipper's dataset and a carrier's in multiple scenarios.

7.1 Perceived UCC value

Unfortunately the survey did not yield suitable results to lead to conclusions. The response was too low to get meaningful results. The template created in this thesis can be used in further study within this field.

In the construction sector there is more potential for consolidating goods. Partly the UCC can create value by providing an efficient last-mile. However the interviews showed that there is more potential for value creation in the sector. The UCC can be used to reduce on-site storage and obstacles with just-in-time delivery and pre-package goods of supplier. The UCC can in this manner prevent fail costs, especially when incorporated in a logistic construction planning. The main obstacle for this sector would be the lack of extra services that an UCC can perform.

The health sector needs to be researched further, as there was only an email response. Although the results show that the regional flows may largely be destined for locations outside the service area of the UCC. Also the size of the institutions supplied probably plays a role. The UCC could play a role in local distributions, for example from drug stores, but this should be researched further.

The food sector is difficult due to the cold transport requirements for most of the flows. Additionally fresh food often has multiple deliveries per day, which makes it even less suitable. Consolidation is possible in this sector, as the Food Center Amsterdam shows, but it is unlikely to have much potential for bundling with ordinary goods.

7.2 Actual UCC value

The quantitative value determined in this research is divided in the value created for a shipper and the value created for a carrier. The value was differentiated in a direct last-mile value and additional network optimisation value. The direct value for both datasets ranged from € 7,08 to a maximum of € 8,99, while the majority is around € 7,50.

For the shipper the last-mile has the highest value in the G4 scenario, while it decreased when more cities were added. Apparently the additional cities in the G14 and G4G32 scenario are more accessible and hence save less costs when consolidating these stops. The network effects of the shipper were higher as expected, as it raised value to € 12,65 in the G4G32 scenario. It seems that additional cities with UCCs can indeed improve the actual value of the network by making the total network routing more efficient.

The carrier's last-mile is similar to the shipper's last mile savings, ranging from € 7,56 to € 8,06 per bundled stop. This was calculated differently from the shipper's dataset and hence we do not draw conclusions from the similarity. The network effects seem much less impressive, with an increase from € 7,63 to € 8,82 as a highest value.

The distance between the depots and the orders have little effect as far as these results go. After the analysis this seems to be due to the small share of these costs on the total savings. In the carrier dataset this share was only 0,6%, while this was 11% in the carrier's dataset. As the number of routes and driven kilometres did decrease in both datasets, this share difference is probably the cause of the reduced network effects for the carrier. The marginal orders are more important for the UCC value proposition to the carrier than the distance to the orders. This confirms the proposition of Quak et al. (2014) that the proposition for the carrier would be less than the proposition for the shipper.

We can confirm that the first proposition is supported by this study. This was also expected from the results of previous studies. The UCC indeed creates value in the last-mile, although it can be lower than sometimes was suggested. The second proposition is also supported by this study, although the results varied between the carrier and the shipper. The last proposition is not fully supported by this study. Although we did determine the actual value an UCC can provide, we have not done enough to conclude that it also will be viable. The information we gathered does provide a solid basis for a business model to be tested.

7.3 Recommendations

Now that we have the actual calculated value for the shipper and the carrier we can make recommendations for the UCC concept. Both cases resulted in a direct last-mile value of 7 euro or more, with most only slightly higher. As the consolidation service is local, it is likely that this value can be used for revenue generation. The network effects are caused by how the firm uses the service in its network and hence are unlikely to be reimbursed. An UCC therefore can be viable of it can reduce its costs below 7 euro per order serviced. So when local delivery costs €4 per order, the UCC must limit their expenditure to €3 per order to break-even.

Other opportunities lie mainly in the construction sector. How much of the goods destined (or originating as waste) is suitable for an UCC is unknown. As Binnenstadservice is already active in multiple cities, we would recommend studies or pilot initiatives to determine whether construction sites are suitable. Additionally the added value of the UCC in regard to construction planning and reducing fail costs is promising enough to pursue.

Future research must mainly target the multitude of factors influencing the viability of the UCC. As we only studied two cases, more cases are needed to be able to confirm the results and to research the many variables involved in more detail. This thesis already had multiple assumptions for the distance to the centre from the UCC depots, the location picked, and the Utrecht Vector which all may be non-optimal. Additionally the properties of the shipper and carrier can influence the results. We found a difference between the shipper and the carrier, but it would be interesting to determine exactly how the marginal stops, the location of the national depots, and the vehicles used influence the optimal value gained from an UCC.

8 Reflection

This thesis provides knowledge where little existed; on the actual value an UCC creates. The subject is hard to research due to the small scale of projects, single cities, which leads to little knowledge being generated about the actual value of an UCC. An UCC can ultimately only be completely evaluated when the concept is introduced on a national scale. By doing simulations we have contributed greatly on this knowledge. By providing actual evaluations of the UCC, the business model of current UCCs can be adapted or confirmed. The value per order found in this study can explain the inviability of many UCCs in trial. However it also presents the opportunity to change the business model that they use and take a path that actually leads to a more viable concept. Additionally this research shows the network value of the UCC concept. This was not yet known in research and can be a crucial value for the customers approached. The value is not directly due to the UCC, it is due to the customer adapting to the UCC concept, and hence can not easily be a revenue for the UCC. However it does present valuable information to provide the customers, as the UCC provides additional value on top of not having to drive into a city.

The biggest obstacle within this research was the problems with the software used. First of all the algorithm seemed to be flawed as non-optimal results were found when releasing the fixed routes. This generated doubts in how close the results came to the actual optimum. For the carrier it presented additional questions to how the results were influenced by variance of the results. As it contained only a week of data in the calculations, these results would be vulnerable to deviations. The paper of ESRI® (2005) does provide the algorithm type used, but without benchmark results, the reliability is not checked. As the solver runs over street maps, the normal benchmarks for VRP algorithms could not be used.

Additionally it is unfortunate that the survey had insufficient results. Although in retrospect this is not surprising, as the time was simply too short to do all methods in high detail. The interviews could have been done in a more systematic way if there was no survey to rely on, although this did have the advantage that the interviews were broader in scope and contained more diverse information.

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Appendices

A Additional methodology

A few more methods must be described to support decisions made during the project. The actual locations of the UCC are described below, as this was done in a consistent way for all cities to reduce variance and bias. Additionally for the carrier the base VRP needed to be split to include all orders of a single day. Of course this included some bias against the baseline. However this split was done by using a software function, thereby reducing bias as much as possible.

Survey

The survey as generated based on the interviews is shown in figure 9. It contains the size of the deliveries, the prioritisation of the criteria, and the expected value per criteria. The last two values combined leads to a value that can be ranked, while the first subject can indicate what type of good flow the company has and whether these are compatible with UCC use.

Carrier's split baseline

The baseline of the carrier was split using the LocationAllocation function of ArcGIS®. This function allocates orders to facilities (or depots, depending on the nomenclature) according to certain rules. Since any reproducible method is better than arbitrary splitting of an order set, we chose to split the orders according to their closest depot. The function allocates the orders to the depot that is closest by (on time, not distance). This makes splitting more reliable, as the orders are most likely included in the routes from the closest depot. The results of this split can be seen in figure 8.

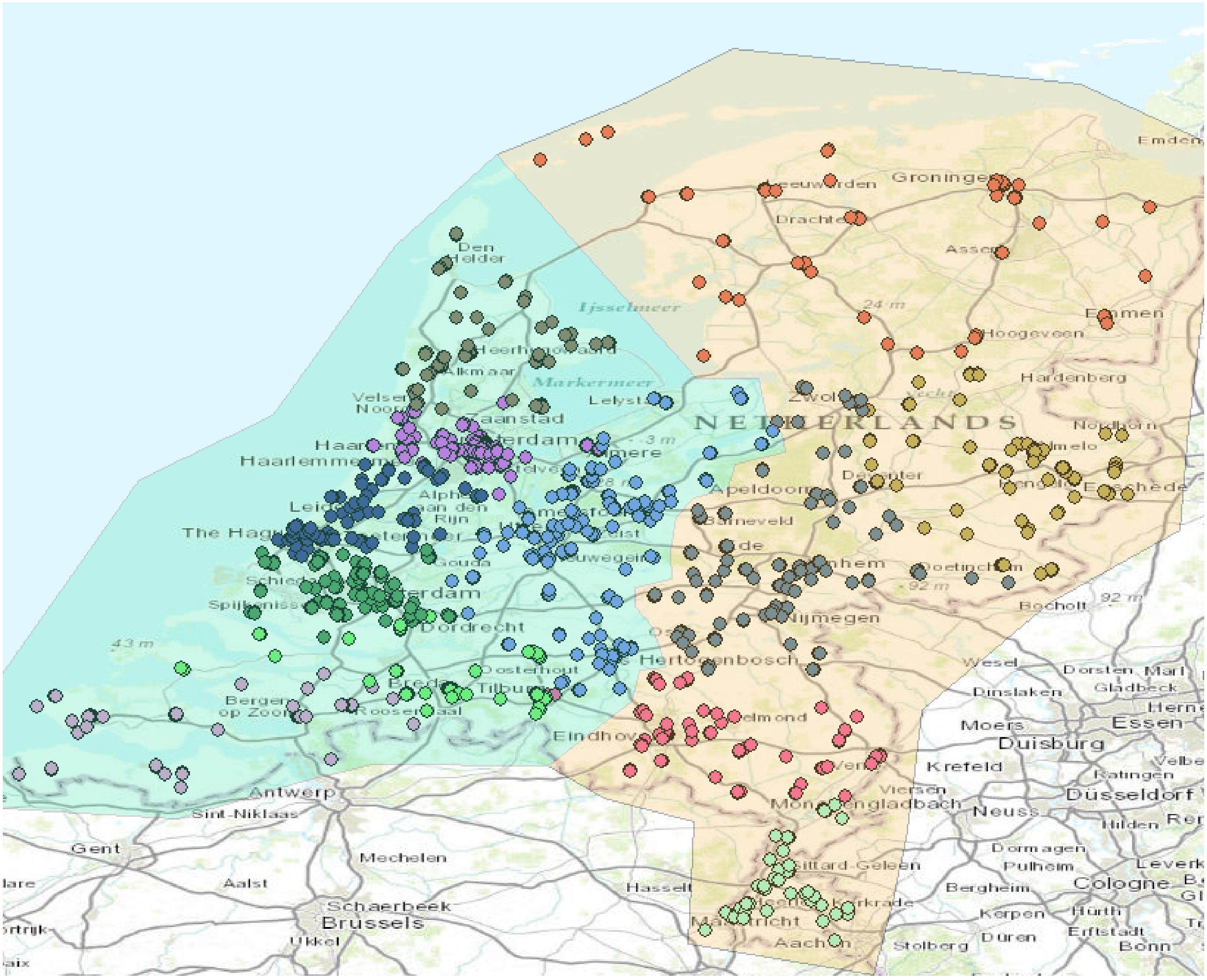

Figure 8: The result of the split VRP by LocationAllocation. The polygons are drawn to include all orders with their respective depots. As such a reliable split was done which is also reproducible.

1. Logistieke stromen

Volume / type	Vries	Koel	Ambient	Afval	Retour
Full-Truck Load (FTL)					
Hoog			80%		
Laag			10%		
Pakjes					10%

2. Beoordelingscriteria

	Weight (1-100)	Relative weight
Monetary Value	95	24%
Service Quality	90	23%
Strategic value	60	15%
Green Credentials	50	13%
Enforcement	60	15%
Visibility impact	10	3%
Overig: Werknemers	30	8%
Totaal	**395**	**100.0%**

3. Kwalitatieve beoordeling; diensten van een Stedelijk Distributie Centrum

Type dienst	Markt	Monetary value	Service Quality	Extra Services	Reliability	Strategic value	Environment	Visibility impact	Enforcement	Overig
Consolidatie	Kleine winkels									
	Grote winkels									
	Retail chain									
	Consument (pakket)									
	Bouwlogistiek									
	Koudlogistiek									
	Zorglogistiek									
	Platteland									
Afval retour	Papier / karton									
	Plastic									
	WEEE									
	klein chemisch									
Value added logistics	Off-site inventory									
	Avond-/Nachtbezorging									
	Eindproces									
	Servicepoint (pakket)									
Voorbeeld	Voorbeeld	+	+	-	0	0	++	0	–	Werknemers: Het verwijdert de prettige werkzaamheden => meer routine

N.B. Alle criteria worden beoordeeld met; Sterk negatief, negatief, neutraal, positief en Sterk positief (--/-/0/+/++)
Als een onderwerp niet van toepassing is, of alleen enkele delen niet, dan wordt het leeg gelaten.
De weights kunnen zelf gekozen worden. De relatieve weight wordt dan gebruikt om de waarde van de criteria te bepalen.

Monetary Value	De verwachte financiële waarde van de dienst; bijvoorbeeld door besparingen op kilometers, voorkomen van nieuwe investeringen (bijv. nieuwe trucks), etc.
Service Quality	De verwachte dienstverlening voordelen; bijvoorbeeld bezorgen/ontvangen op ruimere tijden of verminderen 'niet-thuis' returns.
Extra Services	Extra diensten die worden geleverd aan de klant; Het installeren van bezorgde apparatuur, verpakken, tweemansleveringen, etc.
Reliability	Betrouwbaarheid van leveringen en afspraken: op tijd en zonder beschadigingen bezorgd (OTIF)
Strategic value	De strategische waarde van de service: aanboren van een markt, afstoten van secundaire activiteiten, toekomstige EU/gemeente beperkingen, etc.
Environment	De waarde van het imago; duurzaamheid, (winkel)omgeving, ongelukken, etc.
Visibility impact	Het effect van eventuele verminderde zichtbaarheid op straat; minder reclame, niet zichtbaar als vervuilend, ongelukken, etc.
Enforcement	Hoe gemakkelijk het zal zijn om de service in te voeren; vooral in relatie tot andere partners, overheden, concurrenten, etc.
Overig	Factoren en overwegingen niet van toepassing onder de andere noemers. Deze kunnen in de lege tabel worden aangegeven.

Figure 9: The survey as build during the thesis. The results could have lead to rankable values which indicate the potential value of the UCC to the company.

Municipal name	Alternative1	Alternative2	Used term
Haarlemmermeer	Hoofddorp		Hoofddorp
Sittard-Geleen	Sittard	Geleen	Sittard-Geleen
Zaanstad	Zaandam		Zaanstad
's-Gravenhage	Den Haag	The Hague	The Hague
's-Hertogenbosch	Den Bosch		Den Bosch

Table 10: Names of municipalities and cities and how they are called in this thesis and the data

City names

As mentioned previously, some names of cities included in the study can be quite confusing. The exceptional names are explained here in more detail to make clear what the official names are and which are used in this thesis. They are also shown in table 10. The most common names for the cities are used in the Dutch equivalent. This does not have to coincide with the municipal name.

Another inconsistency is Sittard-Geleen; These are actually two cities which are so close together that they merged into a single municipality. Throughout the study Sittard-Geleen will be regarded as a single city with the centre in Sittard. The UCC location is therefore not focused with Geleen in mind. The urban area of Geleen is used by the UCC depot. This was done in this manner to preserve the method, even though aiming the vector between the cities would make sense in practice to get at both centres from the depot.

The municipality of Zaanstad is also an odd case; This is actually not a city (even though it contains city in the name; '-stad'), but a combination of multiple towns. The largest town is called Zaandam, but in this study the municipal name of Zaanstad is used, as this is how it appeared in the city centre search. For the same reason, the city of Hoofddorp is used, although it is not the municipal name, but it is used to denote the centre.

Two other, albeit smaller, exceptions are present in the study; Namely that there are two municipalities with an alternate spelling. These names are 's-Gravenhage (common name: Den Haag. English name: The Hague) and 's-Hertogenbosch (common name: Den Bosch). Both will be mentioned in their simple form; Den Haag and Den Bosch respectively.

City centres

The following table shows the references for the city centres. these sources were used to chart the centre area, after which the middlepoint was picked within the ArcMAP®environment. The sources are not all equally accurate as not all municipalities define their centre. Sometimes it was necessary to use proxy maps. For example the municipality of Emmen does not define their centre in a map, but it does have a map of ATMs near the city centre. The same is true for maps describing parking areas near the centre and so on. For some it was necessary to use more than one map to verify the centre or pinpoint a middlepoint. The nature of the sources mean that the middle-point is not necessarily the exact middle of the map, but has been chosen to represent the heart of the centre as accurate as possible in accordance with the municipals definition.

Municipality	**Population**	**Organisation**	**Distance**	**Middlepoint**	**5 minute UCC**	**10 minute UCC**	**Zoom level**	**In scenario:**
Alkmaar	94.269	G32	68,8	1811 JB 43	1814 HS 2	1812 LT 7	60.000	G4G32
Almelo	72.757	G32	119	7607 CE 4	7606 AN 65	7606 AN 65	60.000	G4G32
Almere	193.163	G32	28	1315 VJ 6	1326 RN 3	1358 BJ 10	60.000	G4G32
Amersfoort	148.250	G32	25,8	3811 CK 25	3811 NN 9	3832 RL 12	50.000	G14
Amsterdam	790.110	G4	33,7	1012 CR 4	1074 CJ 416	1096 CJ 6	50.000	G4
Apeldoorn	156.961	G32	57,6	7311 KD 50	7336 BC 4	7339 EL 60	60.000	G4G32
Arnhem	149.271	G32	66,2	6811 EJ 58	6814 GE 187	6816 VC 6	60.000	G4G32
Breda	176.401	G32	83,6	4811 XT 2	4818 AJ 61	4817 BL 1	50.000	G14
Delft	98.675	G32	83,5	2611 GW 87	2616 LN 1	2289 DG 29	60.000	G4G32
Den Bosch	141.893	G32	66	5211 JT 36	5231 XS 78	5231 DC 22	50.000	G14
Den Haag	502.055	G4	81	2512 CX 67	2595 AS 65	2632 BD 1	50.000	G4
Deventer	98.672	G32	75,8	7411 HJ 5	7418 AW 2	7384 AN 48	60.000	G4G32
Dordrecht	118.862	G32	70,9	3311 BV 241	3312 AP 1	3355 PP	50.000	G14
Ede	108.763	G32	44,6	6711 AC 10	6718 GT 203	3902 HP 2	80.000	G4G32
Eindhoven	217.225	G32	104	5611 DK 134	5613 AM 50	5628 WL 49	60.000	G4G32
Emmen	108.838	G32	153	7811 DH 10	7814 VM 170	7843 PX 2	80.000	G4G32
Enschede	158.048	G32	132	7511 HC 24	7543 EZ 120	7548 XA 1	60.000	G4G32
Gouda	71.235	G32	55,7	2801 JG 1	2801 SB 13	2811 MZ 201	60.000	G4G32
Groningen	193.127	G32	170	9711 JB 10	9727 AK 76	9744 TX 10	62.500	G4G32
Haarlem	151.818	G32	53,3	2011 RD 16	2032 SB 41	2141 BP 200	50.000	G14
Heerlen	89.016	G32	191	6411 LT 14	6411 ND 30	6365 EH 7	80.000	G4G32
Helmond	88.801	G32	114	5701 RK 2	5708 HN 1	5631 AD 23	80.000	G4G32
Hoofddorp	143.943	G32	49,4	2132 BG 200	2132 LZ 5	1118 CZ 378	80.000	G4G32
Leeuwarden	95.321	G32	145	8911 HJ 38	8934 AD 34	8941 ZZ 17	80.000	G4G32
Leiden	118.748	G32	70,8	2312 JB 1	2314 AH 164	2314 XZ 2	50.000	G14
Lelystad	75.312	G32	47,3	8232 ZX 2	8226 NA 58	8218 NJ 9	80.000	G4G32
Maastricht	121.050	G32	191	6211 GS 42	6224 LV 50	6225 XW 2	60.000	G4G32
Nijmegen	165.182	G32	89,7	6511 KA 3	6522 KK 82	6663 MA 322	40.000	G14
Oss	84.639	G32	80,7	5341 CV 7	5343 EC 51	5386 LD 12	60.000	G4G32
Rotterdam	616.260	G4	74,9	3012 KE 67	3038 LH 44	3065 PP 135	50.000	G4
Schiedam	76.244	G32	76	3111 EG 43	3042 NG 201	3045 LJ 567	63.360	G4G32
Sittard-Geleen	94.535	G32	171	6134 AC 271	6135 JE 39	6121 NW 5	80.000	G4G32
Tilburg	207.580	G32	94,3	5038 AE 24	5038 MA 40	5048 AN 9	50.000	G14
Utrecht	316.275	G4	28,4	3511 JN 59	3531 AH 500	3528 BJ 100	50.000	G4
Venlo	100.027	G32	151	5911 JL 13	5916 AD 370	5916 PT 90	50.000	G14
Zaanstad	148.281	G32	42,2	1506 CG 40	1505 HP 2	1511 MA 6	50.000	G14
Zoetermeer	122.331	G32	68,6	2711 AB 101	2729 NA 13	2665 MV 1	80.000	G4G32
Zwolle	121.527	G32	82,5	8011 RA 11	8011 BZ 2	8091 XK 86	62.500	G4G32

Table 11: List of the cities included in the study and their properties (Source population: CBS, Demografische kerncijfers per gemeente 2012)

Municipal name	Source
Alkmaar	http://www.alkmaarprachtstad.nl/plattegrond.aspx?selected=165BBADF-6FEE-4200-9656-C5EC6A0DA33C
Almelo	http://www.almelo.nl/Bestanden/ontdek%20almelo/Feiten%20en%20cijfers/Statistische%20informatie/Kortweg%20Almelo%202012.pdf
Almere	http://www.almerecentrum.nl/
Amersfoort	http://www.amersfoort.nl/Redacteuren/documenten/woonomgeving/wijken/startnotitie%20bp%20Binnenstad.pdf
Amsterdam	http://www.centrum.amsterdam.nl/publish/pages/515520/de_5_gebieden_in_centrum.pdf
Apeldoorn	http://www.shoppeninapeldoorn.nl/pages/winkels-apeldoorn/winkelcentra-in-apeldoorn.php
Arnhem	http://www.binnenstadarnhem.nl/uploads/files/93152824bb654adb21aafcd6c53415ee.pdf
Breda	http://www.bredavandaag.nl/breda/parkeren-in-breda
Delft	http://www.delft.nl/Toeristen/Toeristeninformatie/Plattegrond/CityMap_Delft_2014
Den Bosch	http://www.s-hertogenbosch.nl/inwoner/stad-en-wijken/wijken/
Den Haag	http://www.denhaag.nl/home/bewoners/den-haag-op-kaart.htm
Deventer	http://binnenstad.deventer.nl/documenten/2012-04-16-deventer-binnenstadsavond.pdf
Dordrecht	http://www.centrumdordrecht.nl/winkelen/pinautomaten
Ede	http://www.edecentrum.nl/centrum-info/ede-centrum-per-fiets/
Eindhoven	http://www.vvveindhoven.nl/cmslib/www.vvveindhoven.nl/vvvehv/files/citymap_Binnenstad.jpg
Emmen	http://emmencentrum.nl/parkeren-in-emmen
Enschede	http://www.enschede.nl/wonen/stadsdelen/stadsdeelcentrum/#.U_HIVzAcSHs
Gouda	http://www.gouda.nl/dsresource?objectid=5d9acca8-e2e1-4dcc-ba8a-3ac65223ec63&type=PDF
Groningen	http://toerisme.groningen.nl/over-groningen/groningen-op-de-kaart
Haarlem	https://www.haarlemmarketing.nl/zoeken_op_de_kaart/?theme=13&categories[]=52
Heerlen	http://www.cbs.nl/nl-NL/menu/_unique/_search/default.htm?cx=018020871965988641477:rvmzjpho2wq&cof=FORID:11&q=heerlen-centrum
Helmond	http://www.helmond.nl/Internet/feitenencijfers/Jaarcijfers-%28per-1-januari-2014%29/Buurten-in-cijfers
Hoofddorp	http://www.hoofddorpwinkelstad.nl/docs/Mijn%20documenten/Documenten/1platPDF.pdf
Leeuwarden	http://www.leeuwarden.nl/wijk/binnenstad
Leiden	http://binnenstad.leiden.nl/
Lelystad	http://www.lelystad.nl/mijnwijk
Maastricht	http://www.buurtplatformbinnenstadmaastricht.nl/stadsplattegrond
Nijmegen	http://www.ruimtelijkeplannen.nl/web-roo/roo/bestemmingsplannen?planidn=NL.IMRO.0268.BP5000-ON01
Oss	http://coo-oss.nl/index.php?option=com_content&view=article&id=10&Itemid=9
Rotterdam	http://www.rotterdam.nl/gebiedsplanrotterdamcentrum
”	http://www.rotterdam.nl/centrum
Schiedam	http://www.schiedam.nl/Docs/gemeente/archief/organisatie/cnor/wijken_en_buurten_kaart.pdf
Sittard-Geleen	http://www.ruimtelijkeplannen.nl/documents/NL.IMRO.1883.BPCentrumSittard-OW01/t_NL.IMRO.1883.BPCentrumSittard-OW01_2.4.html
”	http://www.centrummanagementsittard-geleen.nl/pagina_13.html
Tilburg	http://www.tilburg.nl/fileadmin/files/stad-bestuur/stad/overzicht-team-wijken-juni-25.pdf
Utrecht	http://route.andes.nl/utrecht/plan/van/
Venlo	http://www.venlo.nl/gemeente_en_beleid/feiten-en-cijfers/rapporten/Documents/2012%20Wijkanalyse%202011.pdf
Zaanstad	http://geo.zaanstad.nl/geointer/kaarten/fietsparkeren.html
Zoetermeer	http://www.zoetermeer.nl/centrum/
Zwolle	https://www.zwolle.nl/wijken

Table 12: The sources for the city centre determination of the cities

G14 assignment

For an intermediate sized scenario we needed to choose several cities from the total list. It makes sense to pick the cities which are most likely to profit the most from an UCC. The concept would most likely be started at the most lucrative and expanding to the less lucrative cities over time. The G4 cities are the largest and experience most problems and hence are a suitable minimum of services cities. The G4 combined with the G32 was the current expected end scenario according to the spokesman of the UCC in question. Therefore an intermediate 'G14' scenario, as we dubbed it, should mimic the phase in between the minimum spread of UCCs and the maximum spread.

To get an approximate measure of the total accessibility of the city from all sides, the zoom level within ArcMAP®at which the whole 10-minute polygon of a city is on-screen is used. So the larger the 10 minute drive distance, the further must be zoomed out to get the whole polygon in view and the larger the zoom level. The level value is the distance 1 centimetre in ArcMAP®represents in reality and is taken from the value shown in the ArcMAP®interface. This is definitely a crude way of measuring accessibility, but it has some advantages. Firstly this method does not measure a single point of entry, if the city has only one point of entry, the center of view shifts to that side of the city and does not necessarily lead to a larger zoom level. Hence cities with mediocre access points on all sides do not necessarily score lower than a city with a single good access point. Secondly, this method is very objective. As long as the polygon cannot be positioned in full view, the program is set to a higher level. This is repeated until the whole polygon is in view. Thirdly, this method is an efficient measure as it does not take much additional time since the polygons are already present.

Due to the alternative last-mile calculations for the carrier's dataset, we actually have a second method of ranking the city to check whether this subset would be the same when other selection methods are used. In this method two VRPs were solved which included respectively all city centre middle-points and all UCC depots. This generated actual time and distance savings for all cities on which a selection can be made. Figure 10 shows that the selection would be very different when this method is used. Whether this method would be better suited is not known, as this method has the flaw that it only measures savings from one side of the city and hence is specific for the depot used. This is apparent from the second VRP ranking based on the carrier's depots. This again results in a different set of cities and hence show that this VRP method is not suitable to determine what selection of cities would be most suitable.

City name	Zoom	VRP costs	Δ Distance	Δ Time	Δ Distance (costs)	Δ Time (costs)	Δ Total costs
Apeldoorn	G4G32	G14	6,41	12,32	€ 1,73	€ 7,06	€ 8,79
Schiedam	G4G32	G14	7,44	10,02	€ 2,01	€ 5,74	€ 7,75
Arnhem	G4G32	G14	5,71	10,61	€ 1,54	€ 6,08	€ 7,62
Emmen	G4G32	G14	9,83	8,43	€ 2,65	€ 4,83	€ 7,49
Zaanstad	G14	G14	7,56	8,81	€ 2,04	€ 5,05	€ 7,09
Dordrecht	G14	G14	4,16	9,93	€ 1,12	€ 5,69	€ 6,81
Deventer	G4G32	G14	4,65	9,57	€ 1,26	€ 5,48	€ 6,74
Sittard-Geleen	G4G32	G14	7,87	7,68	€ 2,13	€ 4,40	€ 6,53
Leeuwarden	G4G32	G14	4,54	9,10	€ 1,23	€ 5,22	€ 6,44
Alkmaar	G4G32	G14	3,85	9,35	€ 1,04	€ 5,36	€ 6,40
Den Bosch	G14	G14	4,28	8,85	€ 1,16	€ 5,07	€ 6,23
Oss	G4G32	G14	5,04	8,47	€ 1,36	€ 4,85	€ 6,22
Leiden	G14	G14	5,58	7,99	€ 1,51	€ 4,58	€ 6,09
Gouda	G4G32	G14	4,68	8,38	€ 1,26	€ 4,80	€ 6,06
Breda	G14	G4G32	2,97	8,89	€ 0,80	€ 5,09	€ 5,90
Ede	G4G32	G4G32	5,17	7,52	€ 1,40	€ 4,31	€ 5,71
Venlo	G14	G4G32	3,10	7,91	€ 0,84	€ 4,53	€ 5,37
Almere	G4G32	G4G32	1,20	8,56	€ 0,32	€ 4,90	€ 5,23
Lelystad	G4G32	G4G32	4,72	6,79	€ 1,28	€ 3,89	€ 5,17
Heerlen	G4G32	G4G32	3,97	6,99	€ 1,07	€ 4,01	€ 5,08
Zwolle	G4G32	G4G32	2,71	7,33	€ 0,73	€ 4,20	€ 4,93
Haarlem	G14	G4G32	3,18	6,75	€ 0,86	€ 3,87	€ 4,72
Nijmegen	G14	G4G32	1,51	7,34	€ 0,41	€ 4,20	€ 4,61
Groningen	G4G32	G4G32	2,48	6,84	€ 0,67	€ 3,92	€ 4,59
Zoetermeer	G4G32	G4G32	4,28	5,21	€ 1,16	€ 2,99	€ 4,14
Maastricht	G4G32	G4G32	3,93	5,27	€ 1,06	€ 3,02	€ 4,08
Amersfoort	G14	G4G32	6,89	3,25	€ 1,86	€ 1,86	€ 3,72
Almelo	G4G32	G4G32	1,83	5,16	€ 0,50	€ 2,95	€ 3,45
Eindhoven	G4G32	G4G32	2,30	4,89	€ 0,62	€ 2,80	€ 3,42
Hoofddorp	G4G32	G4G32	3,54	3,90	€ 0,96	€ 2,24	€ 3,19
Enschede	G4G32	G4G32	0,34	5,34	€ 0,09	€ 3,06	€ 3,15
Tilburg	G14	G4G32	-4,14	5,81	-€ 1,12	€ 3,33	€ 2,21
Delft	G4G32	G4G32	-1,05	1,63	-€ 0,28	€ 0,93	€ 0,65
Helmond	G4G32	G4G32	-11,01	0,92	-€ 2,97	€ 0,52	-€ 2,45

Figure 10: The difference between the two methods with which the cities could be ranked in the study. The VRP methods has been done on both datasets, showing the variance when using that method.

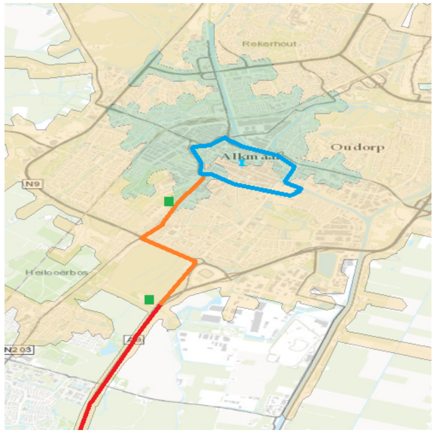

Figure 11: Alkmaar

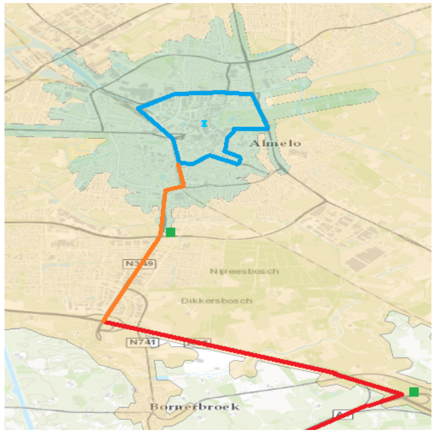

Figure 12: Almelo

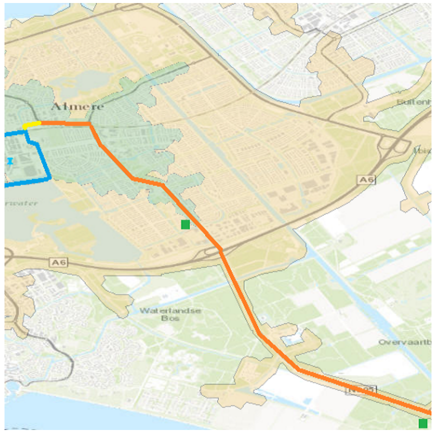

Figure 13: Almere

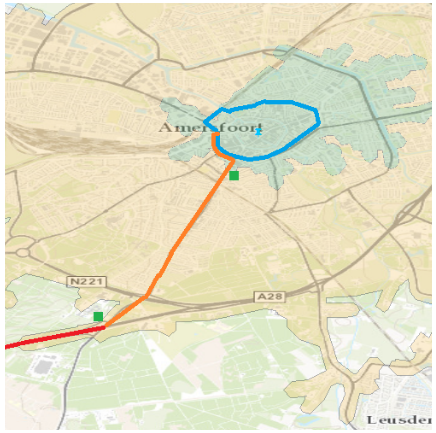

Figure 14: Amersfoort

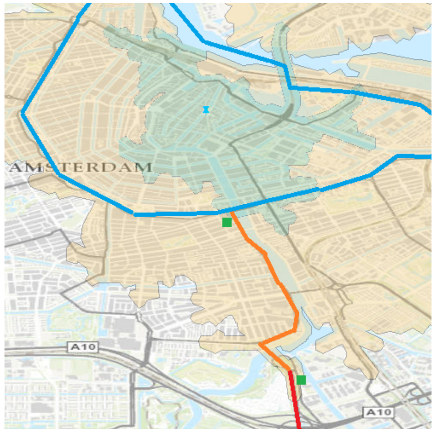

Figure 15: Amsterdam

Figure 16: Apeldoorn

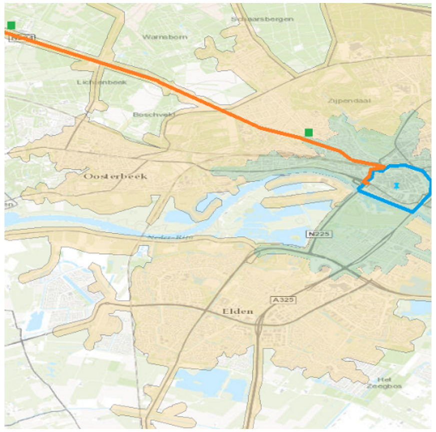

Figure 17: Arnhem

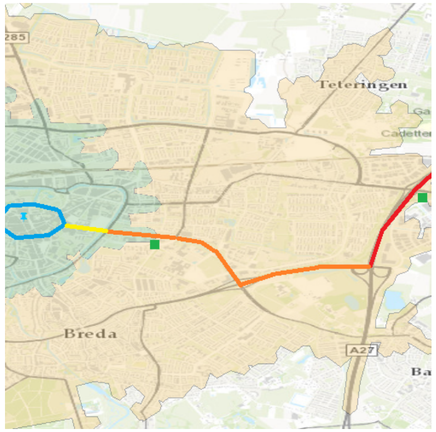

Figure 18: Breda

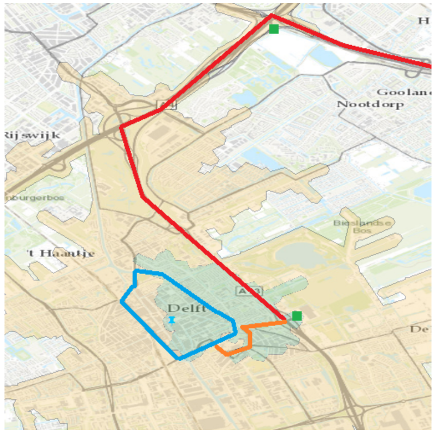

Figure 19: Delft

Figure 20: Den Haag

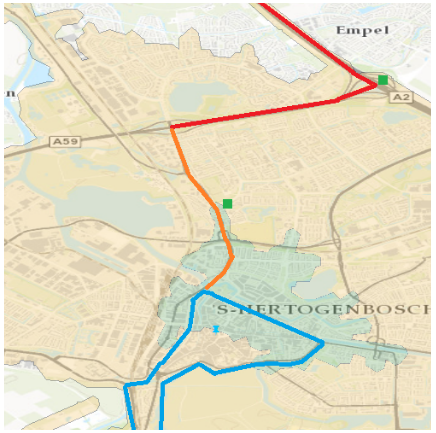

Figure 21: Den Bosch

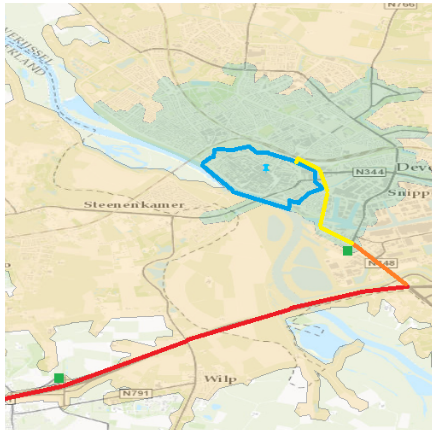

Figure 22: Deventer

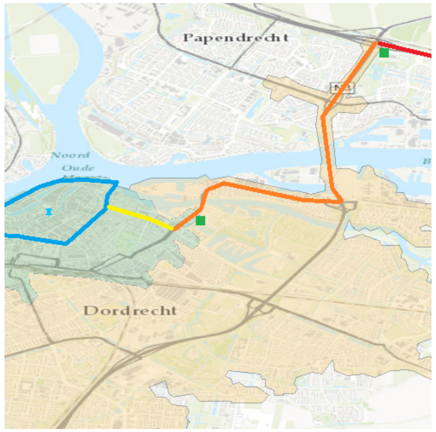

Figure 23: Dordrecht

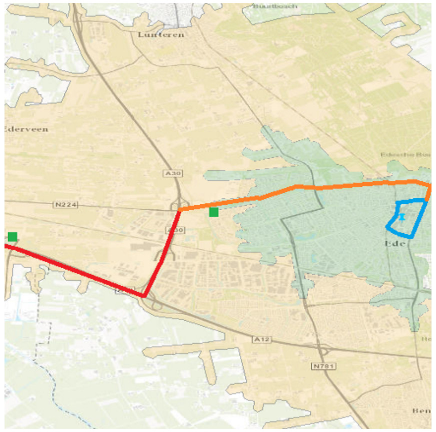

Figure 24: Ede

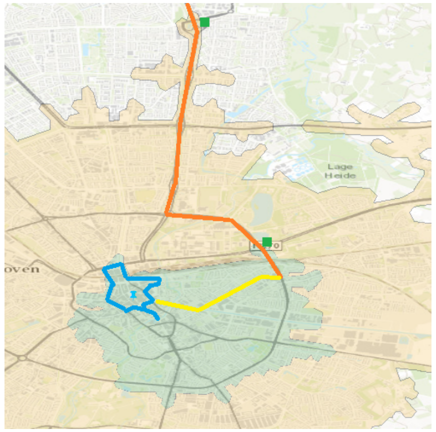

Figure 25: Eindhoven

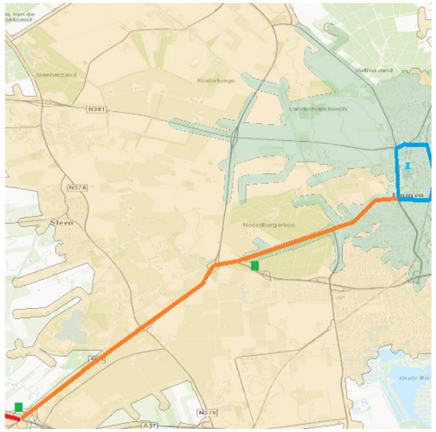

Figure 26: Emmen

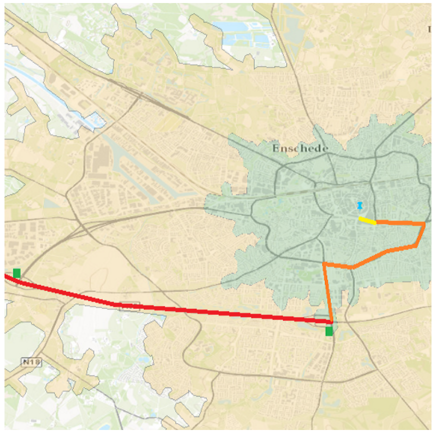

Figure 27: Enschede

Figure 28: Gouda

Figure 29: Groningen

Figure 30: Haarlem

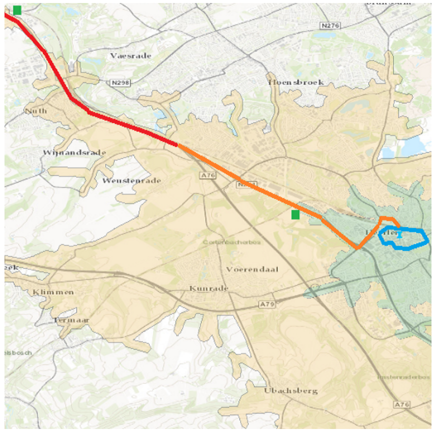

Figure 31: Heerlen

Figure 32: Helmond

Figure 33: Hoofddorp

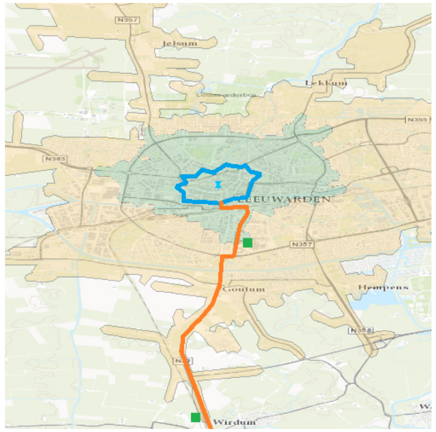

Figure 34: Leeuwarden

Figure 35: Leiden

Figure 36: Lelystad

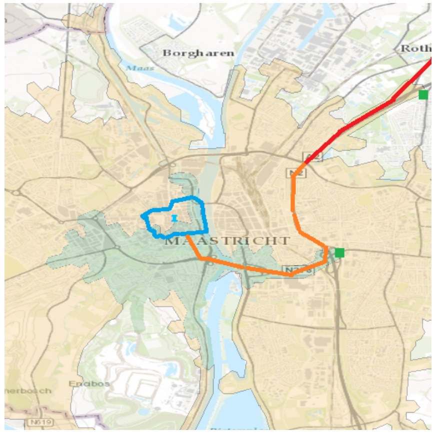

Figure 37: Maastricht

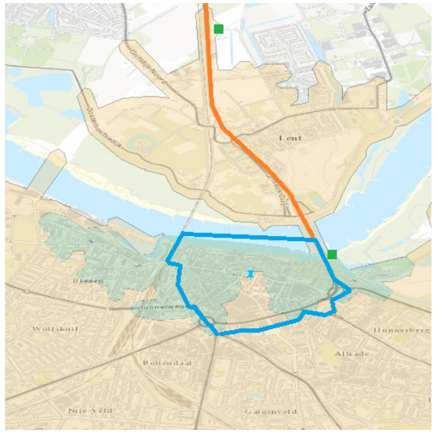

Figure 38: Nijmegen

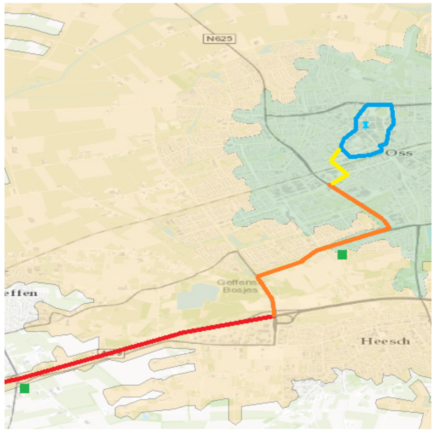

Figure 39: Oss

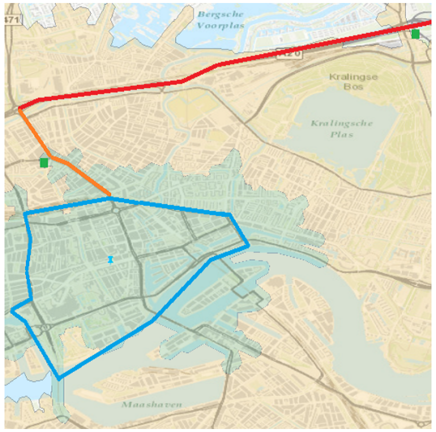

Figure 40: Rotterdam

Figure 41: Schiedam

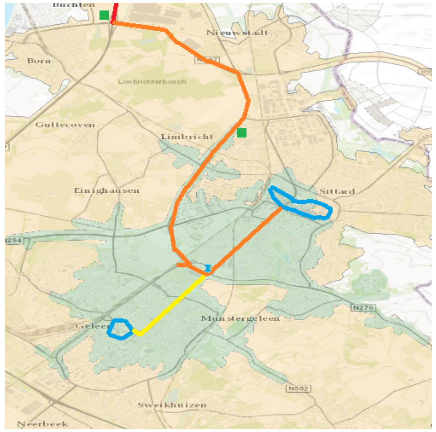

Figure 42: Sittard-Geleen (Update, this was not the location used

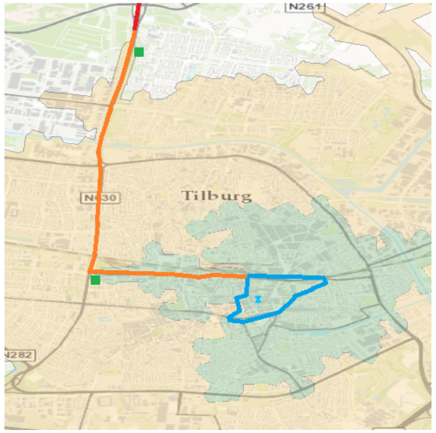

Figure 43: Tilburg

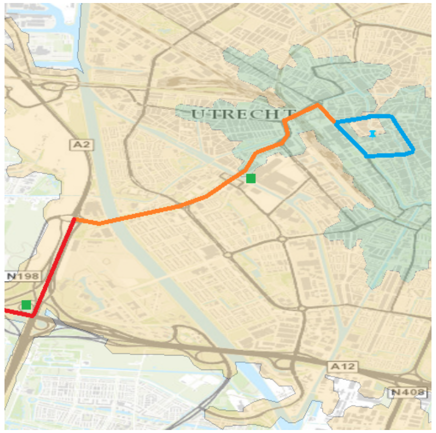

Figure 44: Utrecht

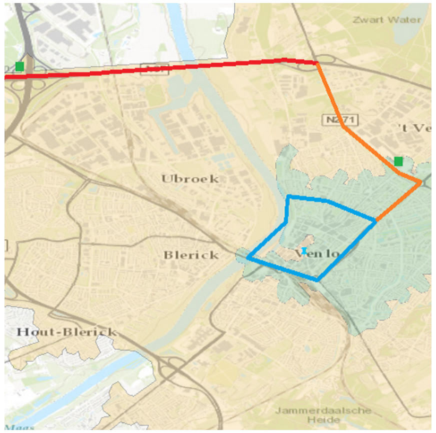

Figure 45: Venlo

Figure 46: Zaanstad

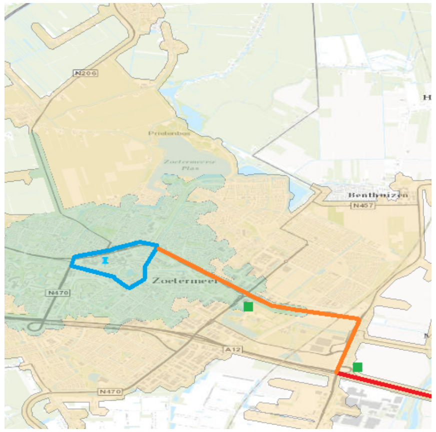

Figure 47: Zoetermeer

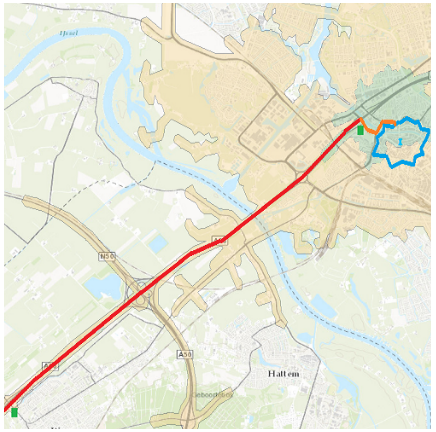

Figure 48: Zwolle

B ArcGIS details

ArcGIS tool: Solve Vehicle Routing Problem

The settings used in the ArcGIS tool SolveVehicleRoutingProblem are mentioned in figures 13 and 14. The first table coincides with the shipper's dataset calculations and the second table shows the settings for the carrier's dataset calculations. The difference was caused by an update of the tool (server-side), which prevented the same settings to be used from that moment on. All options not mentioned were left at their default value.

Service Areas

Table 15 sums the settings for the ServiceArea tool in ArcMap, as used in this thesis. All options not mentioned were left at their default value.

Location Allocation

Table 16 sums the settings for the ServiceArea tool in ArcMap, as used in this thesis. All options not mentioned were left at their default value.

Name	Setting	Notes
Time units		
Distance units		
Analysis region	Europe	
Default date	Day only	
Spatially cluster route	Unchecked	
U-turn policy	Allow dead ends and intersection only	
Use hierarchy in analysis	Unchecked	
Restrictions	Avoid gates, Avoid private roads, Avoid unpaved roads, Driving a delivery vehicle, Through traffic prohibited	

Table 13: The settings as used in SolveVehicleRoutingProblem for the shipper's dataset

Name	Setting	Notes
Time units		
Distance units		
Travel mode	Trucking	
Analysis region	Europe	
Default date	Day only	
Spatially cluster route	Checked	
U-turn policy	Travel mode determined	
Use hierarchy in analysis	Travel mode determined	
Restrictions	Travel mode determined	

Table 14: The settings as used in SolveVehicleRoutingProblem for the carrier's dataset

Name	Setting	Notes
Break values	5 10 15 20	
Break units	minutes	
Travel mode	Custom	
Analysis region	Europe	
Travel direction	Towards facility	
Time of day	Day only	Same function as 'Default date' for traffic
Restrictions	Avoid gates, Avoid private roads, Avoid unpaved roads, Driving a delivery vehicle, Through traffic prohibited	
Impedance	Truck time	
Polygons for multiple facilities	Overlapping	
Polygon overlap type	Rings	

Table 15: The settings as used in ServiceArea tool

Name	Setting	Notes
Measurement units	minutes	
Travel mode	Custom	
Analysis region	Europe	
Travel direction	Facility to demand	
Time of day	Day only	Same function as 'Default date' for traffic
U-turn policy	Allow dead ends and intersection only	
Use hierarchy in analysis	Unchecked	
Restrictions	Avoid gates, Avoid private roads, Avoid unpaved roads, Driving a delivery vehicle, Through traffic prohibited	
Impedance	Truck time	
Problem type	Minimize impedance	
Number of facilities to find	12	

Table 16: The settings as used in LocationAllocation tool

C Result details

Reduction in kilometres

For municipalities it would be interesting to see exactly how many kilometres were not driven due to the implementation of the UCC. This is shown in table 17.

Case	Scenario	Calculation	Driven km	Reduction
Shipper	Baseline	-	38.183	-
Shipper	G4	SS	37.765	419
Shipper	G14	SS	37.439	744
Shipper	G4G32	SS	36.681	1.502
Shipper	G4	FO	37.765	419
Shipper	G14	FO	37.435	748
Shipper	G4G32	FO	33.749	4.434
Carrier	Baseline	-	165.639	-
Carrier	G4	FO	160.149	5.490
Carrier	G14	FO	153.129	12.510
Carrier	G4G32	FO	146.570	19.069

Table 17: This table lists the kilometre reductions in absolute values instead of ratios. This can be useful for municipalities or higher authorities. These values are over one entire month.

Overlapping service areas

The areas of Rotterdam, Eindhoven, and The Hague have interesting variables not found in the other cities. These have certainly not been mentioned in the literature and hence could present interesting subjects for future research. In this thesis there was a fixed one depot per city (with the exception of Sittard-Geleen), however in the randstad the cities are so close together, their 10-minute areas overlap. Is a combined UCC preferable with overlapping service areas? Which service area distance (e.g. 10 minutes to the centre) is most efficient and is this correlated (inversely) with combinations? Should the overlapping area be located at the (Utrecht) vector or is the efficiency so great that it is always beneficial to use overlapping areas to create a single depot; even when the best access point is somewhere else?

The overlapping areas noted in the study results are shown in figure 49, 50, and 51.

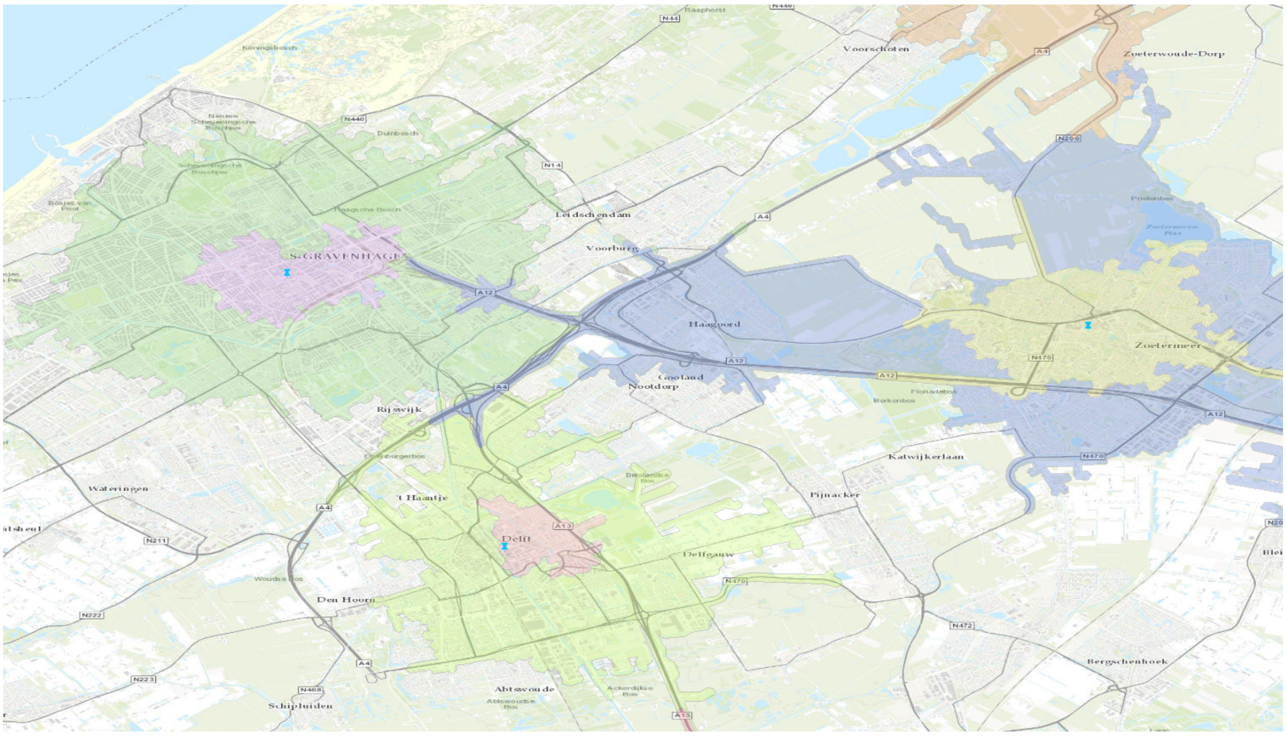

Figure 49: The Hague area

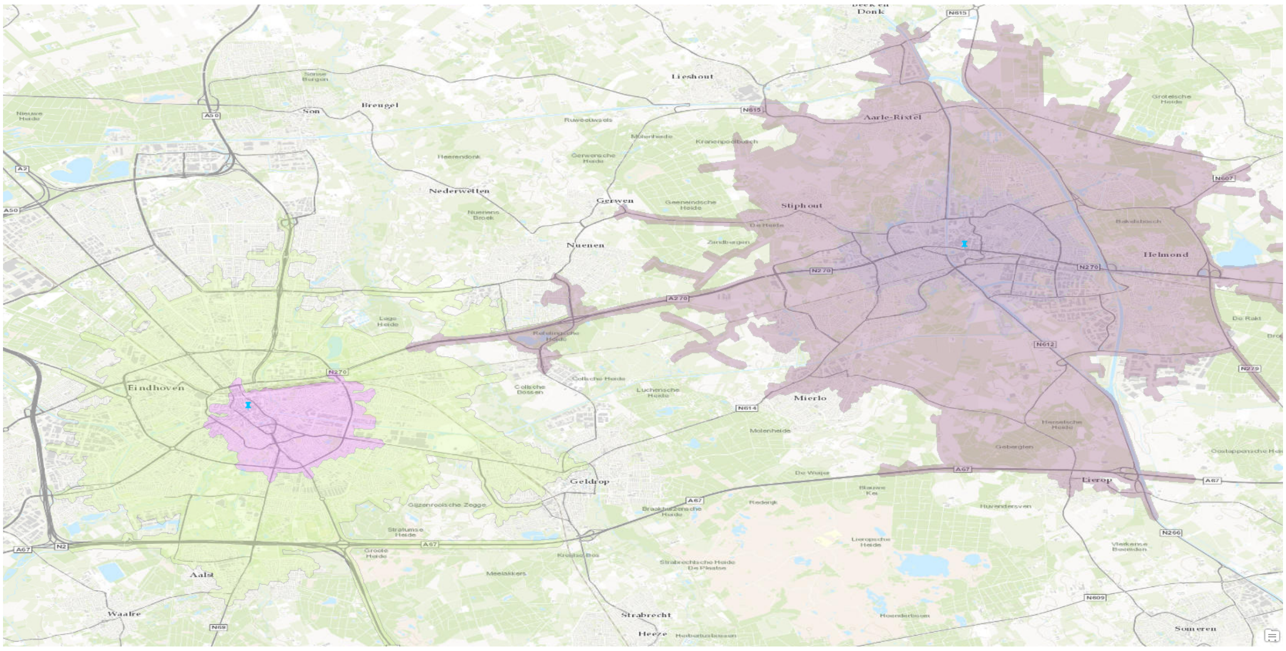

Figure 50: Eindhoven area

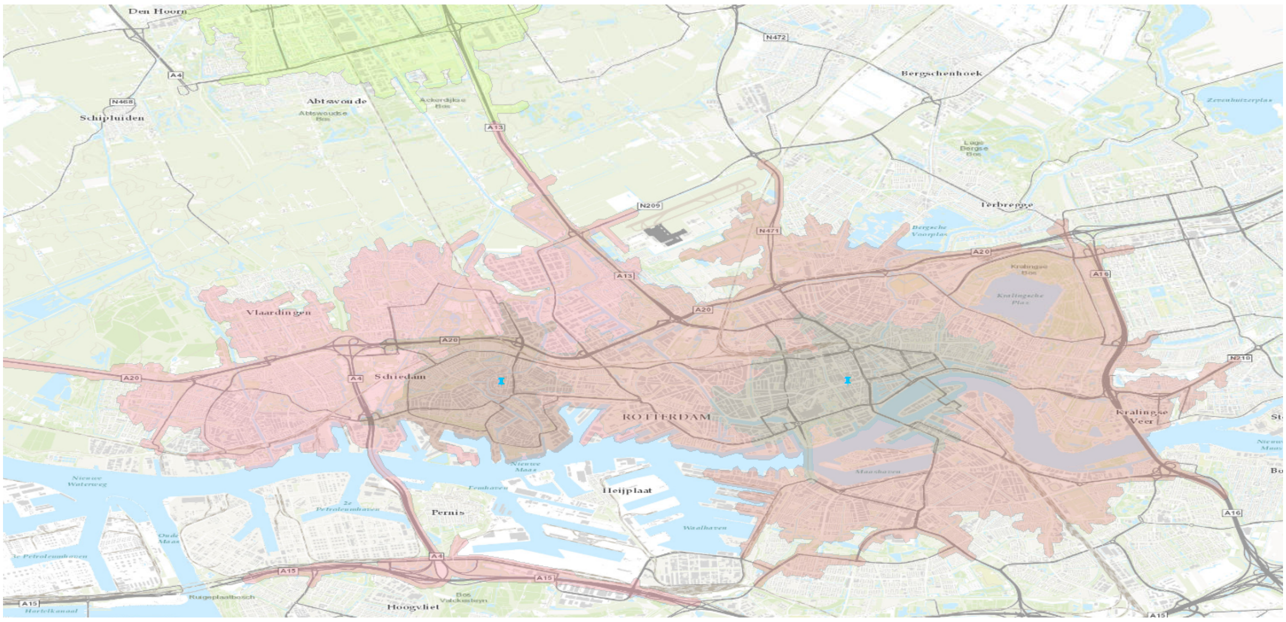

Figure 51: Rotterdam area

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