The Ex-post performance evaluation of urban consolidation centers in the Netherlands

Faculty of Civil Engineering and Geosciences
Master of Science: Transport, Infrastructure and logistics (Policy) on the Delft University of Technology
To be defended in public on September 28Th 2023

by

Candidate: **Sem Sweere** (4968395),

Chairperson and first supervisor: **Dr. J.A. Annema**, TU Delft TPM

Second supervisor: **Dr.ir. A.J. van Binsbergen**, TU Delft CITG

Buck Consultants International supervisor: **Christiaan van Luik**

Buck Consultants International supervisor: **Erik Lubberding**

TU Delft

Summary

In recent years, urban freight logistics has rapidly grown and will continue to grow. This growing urban freight transport system is needed to satisfy the demands of the inhabitants, businesses, and visitors. Yet, this increasing transport within the city affects the sustainability of the cities by increasing congestion and pollution. This requires making choices for the municipalities to strike a balance between economic growth and livability in the city. The implementation of innovative solutions is needed to limit the increasing problems in the cities. Zero-emissions zones are seen as one of the solutions to stimulate the usage of electric vehicles in the cities. Yet, to limit the number of vehicles in the cities, consolidation is needed and urban consolidation centers (UCCs), positioned on the edges of urban areas, are seen as a promising approach to consolidate freight for the last-mile transport.

This research is aimed to compare the ex-ante and ex-post performance of UCCs in the Netherlands. The study combined both qualitative, quantitative insight from literature and insight from conducted interviews with UCC operators and municipalities. The ex-ante and ex-post performance evaluation was aimed at the UCC performance in the Netherlands focused on vehicle kilometer reduction, emission reduction, vehicle trip reduction, operational costs, and load factor improvement. However, UCC operators highlighted that they had limited data tracking methods, which is reducing the precise measurement of their UCC performance. Therefore, this research switched from establishing a quantitative ex-post evaluation to the qualitative ex-post evaluation, supplemented by quantitative data. Additionally, the investigated UCCs are the multi-client hubs which serve as a location for multiple parties. At the multi-client hubs, freight of different suppliers is consolidated before entering the city. The primary goal of an UCC is to reduce the number of trips made within the city, thus promoting efficiency and the sustainability of urban freight transport

Despite the very positive ex-ante expectations stated in the literature and by the UCC operators, the actual performance (ex-post) of the UCCs did not meet these expectations at the moment. From interviews and literature it is expected that significant changes in vehicle kilometers, vehicle trips, emissions and a small reduction in operational costs are established with the implementation of an UCC. However ex-post qualitative data from this research revealed that UCCs were not yet meeting these expectations. The only factor reaching its expectations is the increased load factor. Despite the small impact of the UCCs, its implementation still results in a vehicle trip reduction, vehicle kilometers reduction, and emission reduction, but less than expected and desired.

The ex-post performance not meeting the ex-ante expectations have arisen due to multiple challenges such as the lack of stakeholder cooperation. At the moment stakeholders, such as suppliers and carriers, continued to operate in a way that do not fully utilize the UCCs potential. Supplier and receiver involvement for utilizing the UCCs is low. Therefore the transported volume of the UCC is insufficient to have a significant effect on the vehicle kilometers, trips, emissions, and costs. Also, multiple carriers or suppliers are still entering the city center after delivering to an UCC. Resulting in extra vehicle kilometers within the city. One of the reasons for this limited stakeholder cooperation is the missing of proper pricing agreements and usage of cost allocation systems. The limited usage of transparent cost allocation systems results in various stakeholders being unable to gain a clear understanding of the places were cost savings can be achieved. Due to this lack of transparency, stakeholders are less inclined to utilize a UCC. Many stakeholders remain cost-oriented and are more likely to use a UCC if it offers cost benefits. Secondly, the limited availability of logistic space on the edges of cities often means that the desired locations are not available for the multi-client UCCs. As a result, they settle on the second-best locations, which affects the performance of the UCCs. Thirdly, some UCCs experience growth problems because they cannot be connected to the electricity grid. Therefore, some UCCs cannot expand their charging infrastructure for charging additional vehicles. This is essential for the growth of the UCCs. Fourthly, municipalities are not solely focused on UCCs but are more focused on stimulating consolidated zero-emission transport within the city. How the market manages facilitate this is up to them according to the municipalities. However, municipalities are still able to stimulate the utilization of UCCs with multiple policies to reduce the number of vehicles within the city. Lastly, the actual performance of the

UCCs in the Netherlands is limited measured by the operators, or the measurement is not transparent. This conclusion indicates that despite the effort of municipalities to stimulate the performance of UCCs, even with financial support, there are hardly any requirements for the monitoring of the desired results.

It is evident that the market is currently unable to optimize the performance of the UCCs on its own. If the UCCs serve a public interest for reducing the vehicle trips within the city, is it essential for the municipality to use policies for stimulating the UCCs. If no or very little cooperation among the stakeholders is established, utilization of UCCs will remain minimal until the implementation of the ZEZ. To ensure that UCCs are more widely adopted in the coming years and thus have a greater impact on urban freight logistics, recommendations for both UCC operators and municipalities are provided. First, the measurement of UCC performance by operators is something that must be required to gain a clear understanding of the social effects of the UCCs on the urban area or show if the allocated UCC subsidies achieve the desired goal of reducing the vehicle trips in the cities. So, the performance measurement model can serve as a validation tool for municipalities to state the effectiveness of the financial support to the urban consolidation centers. Secondly, municipalities can implement stricter access restrictions for small deliveries. Therefore, stimulating the consolidation of freight and increasing the utilization of UCCS. Yet, this implementation is complex and requires further investigation for its desired form. These access regulations are currently investigated by the municipality of Utrecht. Thirdly, municipalities can establish requirements for their purchase policies. Such as the requirement for consolidated transport of their purchased goods. Fourthly, the municipality can bring together multiple stakeholders for the creation of a coalition of the willing to improve UCC utilization. Lastly, municipality can include the necessity and relevance of an UCC, in the spatial planning and environment, to designate a plot of land for the purpose of multi-client hubs. However, each euro can be spent once, therefore it is recommended for the municipalities to focus on the requiring of consolidated transport in the procurement and for their own purchase policies. Together with requiring a performance measurement model for each UCC to estimate their social impact.

Additionally, UCC operators need to continue convincing suppliers, receivers, and carriers for utilizing their UCC. The cooperation of more stakeholders is essential for increasing the transported volume of the UCC. It is therefore recommended for UCC operators to use a cost allocation system to separate transportation costs from product costs in different phases, enabling a more effective allocation of transportation costs across various segments of the transport process. Which can be used as a tool for convincing stakeholders by showing the cost benefits.

Despite the differences between the expected and actual outcomes, the current effects of UCCs are still desired by municipalities. Eventually, the implementation of zero-emission zones is going to increase the utilization and performance of UCCs. For a better understanding of the desirability of UCCs, further research is recommended in 2025, when stricter access restrictions are implemented in 30 to 40 cities regarding the zero-emission zones. This would give better insight into the desirability and effectiveness of UCCs for multiple stakeholders in the Netherlands.

Contents

1

Introduction

Urban populations are growing rapidly. The projection is that in 2050, urban areas will host an additional 2,5 billion people compared to 2018 (Nations, 2018). As city's consumer demand increases, the need for a sustainable and livable environment becomes important for municipalities and inhabitants. The traditional urban freight transport with multiple individual deliveries has become increasingly unsuitable due to the increasing congestion, pollution, and safety. Therefore, innovative solutions to improve the future viability of cities are needed. Urban freight distribution is responsible for 34% of the CO_2-emissions (Buck Consultants International, 2020), which highlights that the last mile distribution is the most polluting part of the logistic chain. (Blokzijl, 2021).

Municipalities are seeking solutions to mitigate these negative environmental impacts of urban logistics, while ensuring that the economic growth is not hampered. This is done by implementing zero-emission zones and stimulating the use of electric vehicles (Quak et al., 2016). As of 1 January 2025, 30-40 municipalities in the Netherlands had agreed to the implementation of zero-emission zones (ZEZ)(Bolscher, 2023). The ZEZ aims to improve health, accessibility, quality of life, safety, and economic vitality in the cities and limit climate change. ZEZ can collectively save approximately 1 megaton of CO_2 annually. The ZEZ contributes to the long-term goal of completely zero-emission transport in 2050 (Zero Emissie Stadslogistiek, n.d.).

Another initiative to limit the environmental impact of urban freight transport, is the development of urban consolidation centers (UCCs) (Allen et al., 2014; Browne et al., 2005). The usage of an UCC is going under a lot of different names like, city hub, urban hub, Freight consolidation center, city logistic center, city logistic hub, and more. An UCC is located near a city center to consolidate inbound trucks and perform the last-mile transport in an environmentally friendly and efficient way (Quak, 2008). In this research, the focus is on the multi-client city hubs, which are being used to consolidate the goods of different logistic parties and perform the last-mile distribution.

The use of urban consolidation centers (UCCs) dates from the early 1970s (Allen et al., 2012). Since then, many UCCs are being developed in the Netherlands and abroad. At the moment, more than 300 city hubs are developed in the Netherlands. Mostly dominated by the dedicated hubs from PostNL and DHL. The amount of multi-client hubs is estimated on 50 (Bolscher, 2023). Multi-client hubs are established for manufacturers and suppliers to enhance consolidation and cost reduction. While dedicated hubs are established only for their own use, to deliver goods to the end customers efficiently.

Considering the implementation of Zero Emission Zones in 2025 in the Netherlands, UCCs might have a greater potential to change the urban freight distribution (Quak et al., 2020). With the performance of the UCCs, robust statements about the impact and desirability of UCCs in the Netherlands can be given. The outcomes of this study can be used to make recommendations for the UCC operators and municipalities to improve the actual performance of the UCCs.

While the theoretical advantages of UCCs are well documented, the actual performance and impact of these centers on various quantitative indicators require evaluation (Paddeu, 2021). UCCs can be essential for city

logistics, because local government is pursuing an active policy for emission reduction and improving the quality of life in cities. The goal of this research is to show the desirability and effectiveness of UCCs for sustainable urban logistics. However, currently limited comprehensive ex-post analyses are conducted for the existing UCCs in the Netherlands, making it challenging to measure the effectiveness and desirability of UCCs. Therefore, it is useful to carry out an ex-post evaluation of multiple UCCs, to find out whether they met their expectations or whether they are thought too positively and find the underlying reasons why. Therefore, the main question for this research is:

'To what extent do the ex-post effects of UCCs meet the ex-ante expectations from UCC operators?'

The main questions can be answered by researching the following sub-questions:

- **What were the UCC operators ex-ante evaluation expectations of the implementation of UCCs in the Netherlands?**
  - First, the expectations for the UCC implementation should be found and explored. Literature should be searched for expected effects and interviews with UCC operators should be conducted to get the important expected effects of the UCCs in the Netherlands.
- **What are the ex-post evaluation results of the implementation of the UCCs in the Netherlands?**
  - For the actual effects of the implemented UCCs in the Netherlands, different operational neutral multi-client hubs are being interviewed for quantitative and qualitative data to estimate the actual effects. The data consist of effects like vehicle kilometers, vehicle trips, emissions, load factor, and operational costs.
- **How can the differences between the ex-ante and ex-post performance evaluation be explained and what can we learn from it?**
  - Lastly, the differences in expected and actual performance should be explained with the help of literature, interviews, and expert meetings.

The sub-questions will be answered in this report, so statements can be made about the main question. Different methods are used for answering these questions, and will be explained in chapter 4.

2

Literature research

In this chapter, urban freight distribution is explained together with a more extensive explanation of the the urban consolidation center and involved stakeholders. This chapter will improve the understanding of the urban consolidation center concept and therefore increasing the possibility to understand differences between the ex-ante expectations and ex-post performance of operational UCCs in the Netherlands.

2.1. Urban freight transport

Urban freight flow is growing. It is expected that by 2040, there will be an increase of 1,5 million inhabitants (Stroosma, 2021). Consequently, urban freight transport is expected to grow with 5 till 27% (Stroosma, 2021). This has an impact on the last mile distribution, which is an inefficient and expensive part of the supply chain (Bosona, 2020; Nenni et al., 2019). The growth of the urban freight flow is caused by urbanization, increasing construction logistics, densification, growing population, and e-commerce in the urban areas(Nenni et al., 2019; Sheth et al., 2019). Urbanization will increase the economic activities and developments in the city, leading to an increase in urban freight flow(Nenni et al., 2019).

Urban freight distribution is mainly efficient for routing, number of deliveries, and load factor for larger operators which use economies of scale (MDS Transmodal, 2012). Therefore, large-scale distribution is more efficient than fragmented distribution services of small retailers and catering sectors, where just-in-time deliveries are desired (MDS Transmodal, 2012). Consolidation and collaboration between suppliers and receivers should lead to more sustainable urban freight distribution. The six major market segments of urban freight distribution are general cargo and retail, construction, facility and service logistics, parcels, and waste.

At the moment 34% of the CO_2 emissions of the total road transport is caused by urban freight distribution. In urban areas, freight flow is growing (Nenni et al., 2019). The distribution of CO_2 emission in the different segments is shown in figure 2.1. Construction and retail are within the urban distribution responsible for 50% of the emissions (Buck Consultants International, 2020).

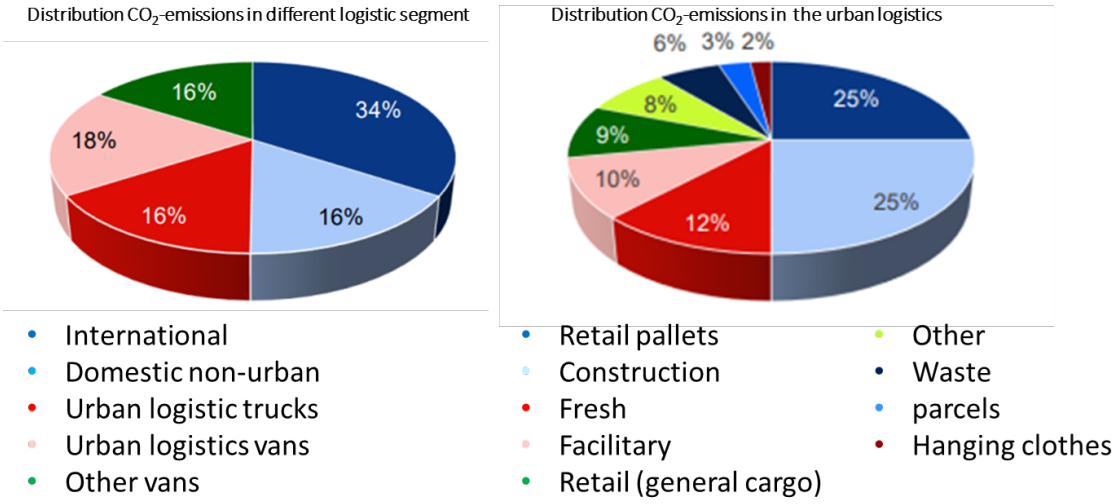


Figure 2.1: CO_2-emission distribution in the Netherlands (Source: Buck Consultants International, 2020)

Urban freight transport (UFT), especially the road transport sector is highly competitive. Additional costs created by new policy measures are passed onto customers and consumers. So, inappropriate policy steering will have an impact on the costs and efficiency of the local environment and economy (MDS Transmodal, 2012). To improve the urban freight distribution and address problems such as emissions, congestion, noise, and traffic accidents an alternative measure is investigated in this report. The impact of urban consolidation centers is investigated to show if an UCC is a desired alternative.

2.1.1. Urban freight contradiction

The growing populations and economy in cities are increasing the importance of urban freight transport (UFT) (Browne et al., 2012). Therefore, increasing the demand for urban freight transport. Cities heavily rely on efficient transportation to enhance the livability, economy, and attractiveness of the city. However, the increasing transport volumes raise concerns about its adverse environmental impact on urban areas. This contradiction leads to a situation where the increasing number of vehicles necessary for goods delivery causes undesirable effects such as congestion, greenhouse gas emissions, local air pollution, noise disturbance, and a decreased safety (Akgün et al., 2019; Browne et al., 2012; Mepparambath et al., 2021). To mitigate these undesirable effects, policymakers can implement different initiatives aimed at changing urban freight transport. Such as delivery time, truck size restrictions, and the implementation of urban consolidation centers (Mepparambath et al., 2021).

2.1.2. Urban freight transport policies

Urban freight transport (UFT) presents cities with advantages and challenges, requiring governmental organizations to balance their measures between economic growth and ensuring high quality of life for the residents (Akgün et al., 2019). Mitigating the environmental impact of UFT is necessary, requiring the implementation of sustainable measures. According to the papers of Filippi et al. (2010) and Agnün et al. (2019), policymakers can choose between the following range of urban freight transport measures.

- Freight traffic regulations: These measures include parking, access (ZEZ), loading and unloading regulations.
- Infrastructure measures: These measures are associated with the connection of urban transport networks, such as underground transport networks or specific locations, such as urban distribution centers.
- Intelligent transport systems: These are the measures related to traffic information and route optimization systems.
- Loading units and vehicles: Make use of unconventional vehicles like trams, electric vehicles, cargo boats, and railways for freight distribution.

Local authorities often face challenges in formulating policies that find a balance between the economic, environmental, and social interests of different stakeholders, especially when government support is lacking (Akgün et al., 2019). By establishing long-term objectives, local authorities should be mindful of the documents from the European Commission (Kiba-Janiak, 2017). The objectives within these documents include minimization of the environmental impact, reduce congestion, promote the integration of UFT into local policies and long-term planning, deploying transport intelligent systems in cities, and encouraging cooperation among different UFT stakeholders (Kiba-Janiak, 2017).

Time windows are freight traffic regulations, which allow vehicles to enter the city at certain times. As a result, flexibility and route options for vehicles are reduced. This can lead to vehicles with lower load factors because only a certain number of packages can be delivered within the time window. Therefore, additional vehicles are employed for good distribution, leading to higher operation costs. This situation can create an incentive for the carriers to utilize an UCC for transportation of the freight(van Duin et al., 2010).

2.1.3. Zero emission city logistics

Mitigating emissions caused by the increasing urban freight transport is a important policy goal for transportation planners (de Bok et al., 2022). In the Netherlands, 30-40 large cities signed the Green Deal Zero Emission City logistics, which stated that city centers should be emission-free in 2025 (de Bok et al., 2022). With this agreement, these parties were in front of the proposed European legislation that states that in 2050 only zero-emission vehicles can enter the city centers. Nevertheless, there is a transition rule which state that from 1 January 2025, all delivery vans and trucks that are registered must be emission-free at the exhaust. For existing vehicles, there will be transitional arrangements based on the Euro class and vehicle type. From 2030, all delivery vans and trucks must be zero-emission to comply with the regulations. It is estimated that a CO_2 reduction of 1 Mton a year is possible with the implementation of zero-emission zones in the Netherlands. To reach this reduction, great efforts need to be made to change the mileage to the city center. The municipalities with a ZEZ in 2025 are shown in figure 2.2.

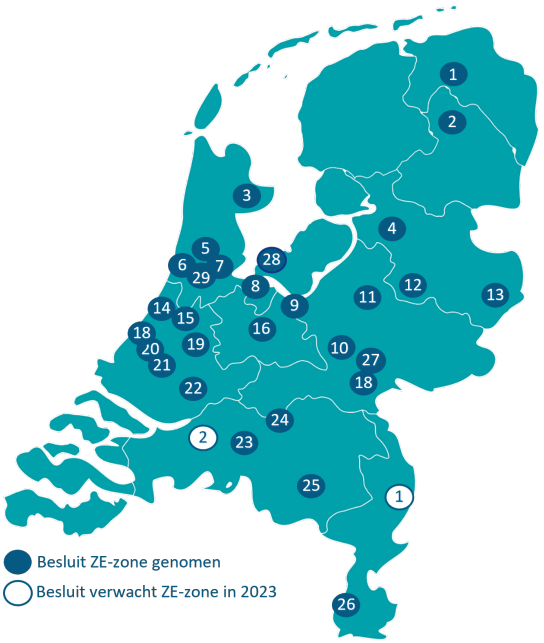


Figure 2.2: Zero emission zones the Netherlands (Zero Emissie Stadslogistiek, n.d.)

2.1.4. Urban freight bundling potentials

The usage of an UCC for urban freight logistics is done to supply different kinds of market segments. The segments differ in the potential for bundling, which affects the desirability of the UCC. Also, FTL and LTL deliveries are not eligible for bundling through multi-client hubs. Primarily, small deliveries, often by specialists and service deliveries, qualify for the utilization of an UCC. Buck Consultants International (2020) is differentiating six segments in urban freight transport. The bundling potentials for vans and trucks for different

segments are given in table 2.1. The average score applies to urban areas without extensive access restrictions.

Segment		Bundelingspotential van			Bundelingspotential truck		
		Low	Average	High	Low	Average	High
Fresh	Retail	3%	6%	8%	0%	0%	0%
	Catering and Specialists	3%	6%	8%	5%	8%	10%
	Home Deliveries	0%	0%	0%	0%	0%	0%
General cargo	Retail	5%	10%	15%	2%	4%	5%
	Specialists	5%	10%	15%	5%	8%	10%
	Two-person Deliveries	1%	2%	2%	1%	2%	2%
Waste	Consumers	0%	0%	0%	0%	0%	0%
	Businesses	0%	0%	0%	0%	0%	0%
Parcels	Express and Parcel	5%	5%	5%	5%	5%	5%
Facility/service	Maintenance and Service	1%	3%	5%	1%	2%	2%
	Supply	5%	10%	15%	5%	10%	15%
construction	Public Space	0%	0%	0%	0%	0%	0%
	Structure	0%	0%	0%	0%	0%	0%
	Finishing	3%	7%	10%	5%	13%	20%
	Personnel	3%	7%	10%	0%	0%	0%

Table 2.1: Bundling potential for different segments using an UCC (Buck Consultants International, 2020)

Fresh: The distribution of goods for catering is already performed by wholesalers which consolidate different kinds of products for catering. The impact of a multi-client UCC is therefore expected to have a bundling potential of 3% till 8% for vans and 5% till 10% for trucks. The frequency and volume of the deliveries are very unpredictable, meaning small deliveries are often needed. Larger organized businesses, such as big hotels can reach economies of scale through centralized procurement. Resulting in less frequent and more consolidated deliveries(MDS Transmodal, 2012).

General cargo and retail: The implementation of the ZEZ can stimulate the usage of the UCC for retail. Yet, the cooperation of the retailer is necessary. An UCC for this segment is used to consolidate the many small volumes of goods from small retailers, which requires cross-docking and only limited storage. The opportunities for bundling goods with a UCC are high in this segment. Expected is a bundling potential of 1-15% for the last-mile distribution with vans and 1-10% for trucks. The size of the hub ranges from 1.500-3000m^2 (Buck Consultants International, 2020). The higher volumes of large-scale retailers enable them to optimize their deliveries in are more efficient way. So, UCCs receive high benefits with fragmented retail markets or in areas where a lot of small or medium retail outlets are located alongside large chain stores (MDS Transmodal, 2012). Therefore, the highest bundling potential can be found with the small fragmented retailers.

Waste: Waste is seen as the segment with the lowest desirability for an UCC. Yet, it is seen as an opportunity for hubs to establish return flows. The collection of waste already implies a structure with different depots. Therefore, UCC operation will not increase the efficiency of the operation.

Parcels: Last-mile consolidated deliveries and collection tours are distributed from cross-dock locations close to the city center (MDS Transmodal, 2012). The operators in this segment have established hubs/ sorting centers around the cities themselves. Resulting in a low bundling potential of 5% for vans and trucks at the UCC. Most of the volume in this segment is distributed through dedicated hubs, leading to a low performance for a multi-client hub.

Facility and service logistics: A lot of opportunities are available for the bundling of facility goods. The use of a multi-client hub can consolidate the small orders and freight flow of offices, schools, and governmental buildings. The size of these hubs ranges from 500-1.500m^2. The expected bundling potential for the supplying of the facilities is 5-15% for vans and trucks. In contrast, maintenance and services experience lower

bundling potentials, varying from 1% to 5% for vans and 1% to 2% for trucks.

Construction: The construction deliveries involve a lot of different materials for construction sites located in city centers. These deliveries are not always optimized, which leads to extra usage of trucks. Large construction companies are more likely to reduce the impact on the environment by focusing on project design and planning. Which includes the consolidation of loads, reduction of waste, and reverse transport of goods (MDS Transmodal, 2012). The use of a construction hub is expected to offer big opportunities. Construction is responsible for 20-25% of the truck trips within the cities. Different deliveries for the day are consolidated and transported to the construction site to be used for the outfitting of the construction. Also, a park and ride is established for the staff to travel to the construction site together. The hub is established as an outdoor hub with small inside storage. The size ranges from 3.000-5.000m^2. The expected bundling potential in the finishing and personal part of the construction logistics is 3% to 10% for vans and 5% to 20% for trucks used for the outfitting of the construction.

It can be seen that most potential for bundling can be achieved within the facility supply and finishing of the constructions. The implementation of an UCC is not favorable for Waste, fresh home deliveries, structure construction, and site preparation of the public space.

2.2. Urban consolidation center

The concept of urban consolidation centers has been a topic of discussion in the literature for many years. The number of successful UCCs in this period is rare (Quak et al., 2020). Some of the UCCs can be successful after the subsidy of the government stops, but in the past, a lot of UCCs come to an end (Björklund & Johansson, 2018). Several papers identify the objectives for the development of an UCC. The papers and their objectives are shown in table 2.2.

Table 2.2: Literature papers about the objectives for the development of UCCs

Reference	Objectives
Allen et al. (2012)	Environmental, vehicle usage
Agrebi et al. (2015)	Environmental, vehicle usage, effectivity
Browne et al. (2005)	Environmental, vehicle usage, effectivity, turnover
Allen et al. (2012)	Environmental, vehicle usage, effectivity, turnover
Paddeu (2021)	Environmental, vehicle usage, effectivity
Quak et al. (2020)	Environmental and social advantages

Various objectives of the UCCs came forward after reading the papers. As cities become denser and e-commerce continues to grow, demand for urban freight transport is increasing. One commonly cited objective is the reduction of vehicle usage, which involves the number of trips and vehicle kilometers that are driven. Implementing UCCs is seen as an solution to achieve this objective and facilitate the transition from fuel-powered to electric vehicles for last-mile delivery.

The second objective, shown in many studies is the expected increase in freight transport effectiveness. At the moment, more than 30% of the national road kilometers are driven by empty vehicles in the Netherlands (Eurostat, 2021). This objective can be achieved by consolidating supplies into high load factor vehicles and optimizing the capacity. However, ineffective handling of goods may arise due to the additional loading process at the UCC. Improving the load factor of vehicles in UCCs can lead to a reduction in total vehicle distance traveled in urban areas, which positively impacts the environment. By optimizing the load factor, more freight will be transported in a trip. Resulting in fewer vehicles needed and lowering emissions. Furthermore, an increased load factor has financial advantages. It improves the value of additional goods transported and reduces the variable costs per order (Léonardi & Baumgartner, 2004).

However, requiring a high load factor is not always beneficial for the number of vehicle trips and total distance traveled. This is the case when some of the receivers are within the city center. In this case, consolidating at the edge of the city might not be the best option. Otherwise, suppliers and operators will drive longer distances than necessary with their freight.(Arvidsson, 2013). Secondly, the vehicle departed from the UCC is

empty when all goods have been delivered on its route. Resulting in a low load factor on the return to the consolidation center. Offering return logistics can increase the load factor of the vehicles from the UCC, increasing the positive transport experience for retailers (van Duin et al., 2016)

Third, all papers mentioned the expected environmental benefits of the UCCs, but quantitative empirical research was missed in most of the papers. Social cost due to pollution is expected to decrease with the implementation of an UCC. This is in line with the environmental objectives in the papers. However, it is important to note that not every UCC location would have positive environmental effects. The impact of an UCC is dependent on its location. Factors such as proximity to suppliers and customers, transportation infrastructure, and traffic patterns are playing a significant role in determining the environmental impact (Gogas & Nathanail, 2017).

From a political perspective, UCCs are developed to contribute to the concept of zero-emission zones by reducing vehicle kilometers and improving the environment (Quak et al., 2020). From the organizational view, UCCs offer the possibility to increase turnover and minimize transportation costs. By consolidating freight and optimizing transport, companies can improve their efficiency and achieve cost savings (Quak et al., 2020).

2.2.1. Consolidation

In this subsection, the functionality of consolidation at the UCC is explained. The supply chain without and with the implementation of an UCC is shown in figure 2.3

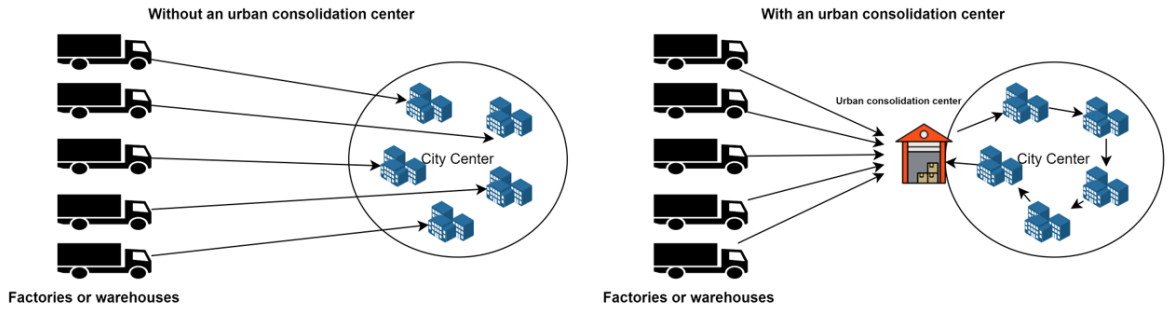


Figure 2.3: Supply chain goods without and with an UCC (Adapted from: Allen et al., 2014)

In the case without an UCC, all receivers are supplied directly from the factories and warehouses. This ensures that all vehicles are entering the city center separately for delivering the goods to their customers. But, with the implementation of the UCC, factories and warehouses can deliver their goods to the UCC near the city center from where freight is consolidated and last-mile distribution is performed. Not all goods need to be distributed through an UCC. Because a lot of freight is already efficiently distributed to the city in full truckload deliveries. These full truckloads cannot be profitably consolidated in an UCC and are therefore excluded from this research (Hezarkhani et al., 2019). The potential is at the suppliers who are having small deliveries and therefore a low load capacity. The goods of these different less-than-truckload deliveries can be consolidated in full truckloads. Also, an UCC can be used for only cross-docking as well. Where the goods from conventional fuel vehicles are cross-docked into electric vehicles for an environmental last-mile distribution. It can be seen that the implementation of an UCC includes an extra chain for the total supply chain. This extra chain consists of extra handling of the goods. Consequently, extra costs are involved for this extra handling. This is one of the disadvantages of the use of UCCs.

At the moment, insufficient electric vehicles are available for all carriers to distribute their goods independently in the cities when the Zero-emission zones (ZEZ) will be implemented (Kin et al., 2021). This will ensure that parties need to cooperate for the urban freight distribution under the ZEZ regulation. Therefore, stimulating the use of an UCC to get a higher degree of participation. An increase in consolidation will result in more environmental and social benefits compared to a high degree of electrification.

With the manufacturing of electric vehicles more CO_2 is emitted than by diesel vans, mainly because of the battery production (Andruetto, 2022). Also, it is important to consider the primary energy source that is used for electric vehicles. If the electricity is not very clean (i.e., a lot of conventional energy) CO_2 emission reduction is estimated at only 10%, while with clean energy a 90% reduction can occur. In the Netherlands, only 40% of the electricity was sustainable in 2022 (CBS, 2023). Therefore, more energy usage is still implying CO_2 emissions at the moment.

Consolidation can decrease the number of vehicle trips and therefore improve the safety, livability, and environment in the cities. Less energy is needed when a lot of freight is consolidated. Resulting in a decrease of energy usage and Co_2 emissions (Andruetto, 2022).

The sooner the ZEZ are implemented, the more cooperation is needed between different parties to consolidate their freight in the available electric vehicles. When the implementation of the ZEZ is rescheduled again, more electric vehicles will be available and many carriers are going to provide their own electric transport. As a result, more vehicles will supply the city compared to the situation with a lot of consolidation.

2.2.2. Cross-docking

Another functionality of the UCC is cross-docking, a process where freight is unloaded from incoming vehicles and directly loaded onto outgoing vehicles, without storing the freight (Goddefroy & Alexandrer, 2013). Cross-docking can serve different goals: support consolidation, shorter delivery load time, and cost reduction (Van Belle et al., 2012). Cross-docking eliminates the expensive order picking and storage costs (Galbreth et al., 2008). If the freight need to be stored temporally, should it be for a small period of less than 24 hours (Yan, 2014). Otherwise, it would not be considered as cross-docking but warehousing (Van Belle et al., 2012). Firstly, cross-docking enables faster and more frequent deliveries of smaller volumes of highly visible inventories (Cook et al., 2005). Secondly, cost reductions are the result of the eliminated storage of freight (Van Belle et al., 2012; Vis & Roodbergen, 2008; Yan, 2014). Large warehouses are not needed anymore and therefore reducing the costs for rent, labor, and inventory layout (Van Belle et al., 2012; Vis & Roodbergen, 2008). Yet, double handling is the result of the unloading and loading of the vehicles (Boysen & Fliedner, 2010). Thirdly, shorter delivery lead times are possible due to the faster order fulfillment (Van Belle et al., 2012). Fourthly, cross-docking minimizes handling and therefore reduces the risk of product damage or loss. Fifthly, cross-docking aligns very well with the just-in-time principle. Therefore, minimizing inventory and reducing overstocks (Galbreth et al., 2008; Van Belle et al., 2012). Environmental benefits can be achieved when the freight of conventional vehicles (Less than truckload) is distributed in consolidated electric vehicles to perform the last-mile distribution (Van Belle et al., 2012).

2.2.3. Service portfolio

The primary function of an UCC is to consolidate freight for the last mile distribution, optimizing the transport operation requires a maximum utilization of vehicles returning to the UCC (Allen et al., 2012). Several possibilities exist, including inter site-transfers, recycling of waste and damaged material, unsold inventory, and customer return orders (Allen et al., 2012). These value-added services mentioned above can not only increase revenue but also increase the load factor of the vehicles (Allen et al., 2014). Another major function of the UCC is to support cross-docking for retailers (Browne et al., 2005; Giampoldaki et al., 2021). Storage at the UCC is usually short-term and is moved within 24 hours. On top of these functions, UCCs offer a broader range of services. To increase revenue, UCC operators can provide other value-added services. These value-added services can improve the revenue for the UCC operators and reduce the costs for users (Pålsson, 2014). An example of a value-adding service is the provision of a buffer for the users, to reduce the delivery time and avoid shortage. The rest of the value-added services are shown in table 2.3.

Table 2.3: UCC value-added services (Reyna López & Serrano Cáceres, 2020)

Value-added services	Explanation
Assembling	Assembling of different kinds of goods
Delivery flexibility	Let the customer choose the desired delivery time.
E-tailing	Support E-tailing
Freight pick-up	Enable businesses to pick up their freight at the UCC.
Inventory & Order Management	Performing inventory and order management for the suppliers.
Local Buffer	Local storage to reduce the delivery time and shortage for receivers.
Pre-retailing	Perform pre-retailing activities like unpacking and labeling.
Quality/Quantity Check	Provide notices of problems with a quality or quantity check.
Repackaging	Repackage the inbound goods, before delivery.
Return logistics	Handling the return of packages.
Support services at the receiver	Helping with tasks like unloading, unpacking, and placing of the goods.
Track & Trace	Support track and trace deliveries.
Training areas	Leave space available for the trainings

2.2.4. Location

The location of the urban consolidation center will dictate the level of environmental and traffic advantages than can be established (Allen et al., 2012). Urban consolidation centers are developed in different environments, having different impacts, which influence the performance of the consisting UCCs. This section can be used as an explanatory factor for the possible differences between the expected and actual performance of different UCCs.

Looking at the various literature, different factors for location selection were stated. The most important criteria for location selection are the economic, environmental, and social criteria. If the UCCs are not able establish a good economic conditions and attract sufficient participation, they will not be viable(Van Rooijen & Quak, 2010). Secondly, the UCC should have sustainable and social impact to generate more support under the authorities and stakeholders.

There are many economic factors, influencing the actual or future performance of an UCC. First, expensive prices can increase the investment cost of the UCC. (Gogas & Nathanail, 2017). Secondly, the possibility of expansion is important for future performance. Third, the transportation condition is important, such as the customer proximity Last, the paper of Yahyaei et al.(2014) indicated that the population is an important factor. When a city is denser because of the high population, more demand will occur in a small service area. This will improve the desirability of an UCC compared to a situation without an UCC. The development of the UCCs is to increase the sustainability in cities and deal with increasing problems such as safety, security, congestion and regulations.

2.2.5. Main barriers

The implementation of an UCC is seen as a solution to reduce CO_2-emission, reduce noise hindrance, improve effective land use and improve air quality. However, the development and performance of UCCs face challenges. A deeper understanding of the primary barriers encountered during their development and operation shows why many UCCs struggle. These obstacles involves practical, legal, and ecological aspects, all of which are significant not only for urban freight but also for the successful implementation of UCCs."(Tsiulin et al., 2017).

One of the reasons UCCs fail to be successful, is due to the lack of cooperation between stakeholders (carrier, authorities, and receivers) and their willingness to bear the costs of the urban consolidation center in exchange for the benefits they gain (Allen et al., 2012). The lack of cooperation between different stakeholders makes the implementation and successful operation of UCCs less smooth. According to Tsiulin et al.(2017). Each of the stakeholders independently assume their own costs and challenges. Addressing conflicts of interest is a challenging task, particularly when dealing with stakeholders who focus solely on potential losses rather than potential gains (Nordtømme et al., 2015). Several studies have also shown that the expected number of supliers utilizing UCCs exceeds the actual number of participants cooperating. (Olsson & Woxenius,

2014). This will result in a less transported volume of the UCCs than expected. Lastly, the location selection determines to a great extent the future incomes and costs for the UCCs.

2.2.6. Causal relations

The interdependence of the effects showed in table 3.1 are being explained in this subsection. Additionally, the causal diagram shows the impact of various policy measures and can serve as a tool for explaining various influences and measures, clarifying both the direct and indirect impact of these expected effects.
Together with all the found literature, the important variables for UFT are found and shown in table 2.4. These variables shown in the table are the most important variables which influence the performance of the UCCs. These variables were found after reading the literature shown in the bibliography.

Table 2.4: Important variables, UCC performance

Variable	**Unit**
Vehicle trips	[#/year]
Vehicle kilometres	[km/year]
Load factor	[%]
Fuel consumption	[Liter/year]
Pollution	[kg/year]
Electrification	[%]
Consolidation	[%]
Transportation costs	[€/year]
Bundling potential	[%]
Social costs	[€/year]
Traffic accidents	[fatalities/year]
Demand	[kg/year]
Business	[#]
Inhabitants	[#]
Labour	[Hours/year]
congestion	[km/year]
TCO	[€]
Fuel car costs	[€]
Fuel costs	[€/liter]
Energy costs	[€/Kwh]
Electric car costs	[€]

To improve the livability in cities, municipalities can look at the variables and display them in the causal diagram, to see the impact on the system of certain measures implemented for the urban freight transport.

The important dependent variables, together with the governmental policies and stakeholder participation are determining the performance of a certain UCC. A visual overview of the relations between the variables is given in the causal diagram, shown in figure 2.4. The goals for the municipality, inhabitants, and supplier/receiver are colored within the figure.

The change in one variable will change the effect of another variable. Figure 2.4 is showing the causal relations of all variables with the implementation of an UCC. The figure will be explained to get a better understanding of the current process when an UCC is implemented. The impact of an UCC on the society is shown in the blue dotted box. A green line in the figure means that an increase in the variable will increase the next variable. A red line means that the causal relation between the two variables is negative, meaning an increase in the first variable will decrease the value of the next variable. Also, the impact of certain policy measures is given with the red ellipses.

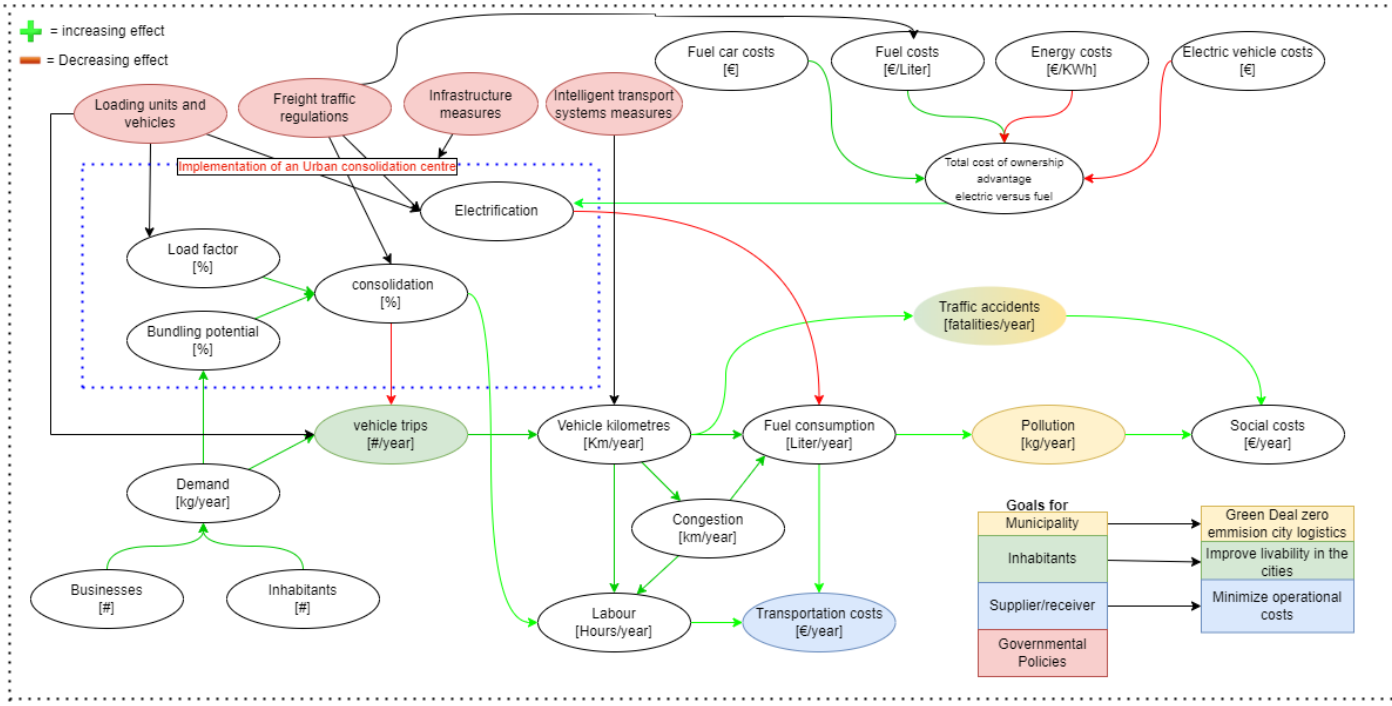


Figure 2.4: Causal diagram with implementation UCC

The number of businesses and inhabitants determines the demand for goods in the city center. The higher the number of businesses and inhabitants, the higher the demand in the city center will be. When the demand increases, vehicle trips will increase because a higher volume of goods needs to be transported. Therefore increasing the vehicle kilometers. Resulting in more congestion, more traffic accidents, more fuel consumption, and more driving hours (labour). When Labour hours and fuel consumption are increasing, transportation costs increase. Higher fuel consumption result in more pollution and therefore increasing the social costs. Social costs will also increase because of extra traffic fatalities.

Yet, when an urban consolidation center is implemented at the edge of a city, multiple effects will occur. The impact of an UCC can be seen from the blue dotted box to the other variables. The impact of an UCC is dependent on the bundling potential and the load factor at the UCCs. Together they form the consolidation rate. The higher the consolidation rate is, the more vehicle trips are saved. so, fewer vehicle trips are needed for the same amount of volume. Contrary, more consolidation will result in more labor hours for the handling of the goods. When fewer vehicle trips are needed for the delivery of the city center, fewer vehicle kilometers will occur. Resulting in less fuel consumption, congestion, driving hours (labor), and traffic accidents. The decrease in fuel consumption and labor hours will decrease transportation costs. The decrease in Fuel consumption will lead to less pollution and therefore less social costs. Also, the increased safety (traffic accidents) will result in a decrease of social costs.

Secondly, electrification of the fleet from an UCC will have an impact on the system. When more vehicles are electric, less fuel is needed. Consequently, improving the pollution and social costs. The electrification rate is dependent on the total costs of ownership between electric and fuel cars. The more beneficial electric cars are compared to fuel cars, the higher the electrification of the fleet will be.

The municipality can use some governmental measures to reach its goals. The municipality wants to achieve a sustainable, safe, and accessible city. The measures available to improve UFT are the loading unit and vehicles measures, freight traffic measures, infrastructure measures, and intelligent transport system measures. The impact of these measures on the UFT is also given in the causal diagram. This improves the understanding of how the policy measures impact the performance of UCCs. Firstly, the loading unit and vehicle measures aims at unconventional vehicles for freight transport like electric vehicles but also cargo boats or trams. Also, adapting the loading units of these vehicles. Therefore, these measurements are having an impact on the

load factor, electrification and vehicle trips when cargo boats or trams are used for the last-mile delivering of freight. Secondly, Freight traffic regulations include acces restrictions and loading or unloading regulations, which will have an impact on electrification when only electric vehicles are allowed in the city centers and on the consolidation degree. Thirdly, infrastructure measures, such as the the connection of urban transports networks or specific locations as UCCs will have an impact on the implementation of the UCCs and therefore the variables in the blue dotted box. Lastly, intelligent transport system measures will have an impact on the route optimization and therefore reducing the vehicle kilometers in the city center. These measures have direct effects as explained above, but they also lead to indirect effects, which can be easily observed in figure 2.4.

2.3. Stakeholders

A stakeholder analysis will be performed in this section to identify the power and interest of the different stakeholders related to urban consolidation centers. The different stakeholders are given in table 2.5. The insufficient volume that limits the performance of the UCCs is also related with the network of all stakeholders (Dreischerf & Buijs, 2022). All stakeholders must accept and participate in the implementation of the UCC for a successful operation. This analysis can be used to determine which important parties should be interviewed for getting the important data. Also, for the discussion on redesigning the regulatory framework, alternative market regulation on last-mile city logistics could be pursued. Is it important to know the stakeholders who are involved and their influence. The goal of alternating the regulatory framework could be to stimulate and foster the usage of UCC in the Netherlands.

Table 2.5: Stakeholder analyses

Stakeholders	Interest	Power	Interest
Municipality	The Municipalities wants to reduce the local air pollution in cities to improve the environment and livability in the city centers.	High	Very high
The operator of the UCC's	Realize logistics hubs from which consolidated, and zero-emission goods can be delivered to the cities. Strive for profit maximization	Low	Very high
Ministry of EZK	Is responsible for the national regulations to improve the environment. Can stimulate initiatives with subsidies	Medium	Medium
Ministry of I&W	Is responsible for the livability and accessibility of cities. Set framework for the ZEZ	Medium	Medium
European Commission	The European Commission monitors compliance with the Green deal whereby European countries must be climate neutral by 2050 and provides subsidies.	Medium	Medium
Suppliers	Products should be delivered in good condition, on the right place at the desired time with lowest costs.	Very high	High
Financiers	They stimulate the sustainable transition to a zero-emission zone. Making proposals for Sustainable and profitable business cases of the UCCs.	Very low	Very low
Energy supplier	Contributes to the roll-out of the public charging infrastructure. Which is needed for a good performance of the UCCs.	Low	Medium
Inhabitants	Interest in a safe, clean, and quiet environment.	Low	Low
Research agencies	Investigating the optimal implementation strategy for the UCCs. Which Creates revenue for the research company.	Low	Very low
Car/Truck manufacturers	Manufacturing of electric vehicles for the UCC's which can compete with fuel cars.	Low	Low
Carriers (3PL)	Distributing freight from the suppliers to the receivers with low costs	Low	Medium
Receivers	Want to have reliable, cheap and fast deliveries	Very high	High

The stakeholders given in table 2.5 are the important stakeholders regarding urban freight transport and the implementation of urban consolidation centers. The interest of the different stakeholders is also given in the table. Yet, it is useful to know which stakeholders are having power and interest in the actual performance of UCCs. The power-interest grid defines four groups of actors and is shown in figure 2.5. Power is defined as the actual impact the stakeholders have on influencing the performance of the UCC. The vertical axis represents the interest that different stakeholders have in the implementation of an UCC.

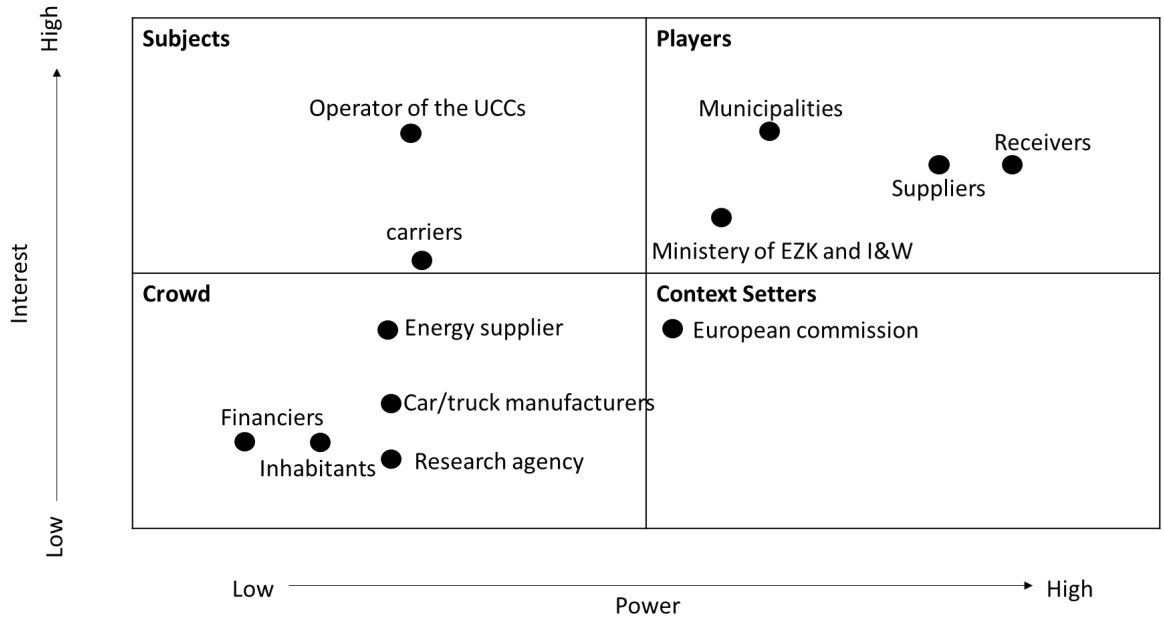


Figure 2.5: Power-interest grid of an urban consolidation center (Adapted from: Deloitte, n.d.)

2.3.1. Crowd

The crowd are bystanders with limited interest or power in the subject. It is important to monitor these stakeholders, but do not bother them with excessive communication (Deloitte, n.d.)

2.3.1.1. Research agency

The research agencies are mostly involved to consult about the desirability of an UCC in a certain area. The power of the agencies is low because they can only advise. Their interest is mainly based on the assignment they get from knowledge initiatives. Therefore, research agencies belong to the crowd.

2.3.1.2. Car/Truck manufacturers

The Car/truck manufacturers are responsible for the manufacturing of electric freight trucks and vehicles which are the most commonly used mode of transport for the last mile delivery through an UCC. Their interest is in the middle because UCC increases there demand but is not their main focus. They just want to sell as many vehicles as possible. Their power is also pretty low. Therefore, car/truck manufacturers belong to the crowd.

2.3.1.3. Financiers ($)

The banking sector doesn't have a lot of interest in UCCs, but they promote sustainable solutions like UCCs. Resulting in the financing of UCC projects. Their power is very low, and therefore belonging into the crowd.

2.3.1.4. Energy supplier

Energy suppliers contribute to the accelerated roll-out of public charging infrastructure through cooperation regions. They are responsible for the development of the loading infrastructure for the UCCs. The power of the Energy suppliers is limited and their interest is medium. Therefore, belonging to the group of crowd.

2.3.1.5. Inhabitants

Inhabitants have the power the vote for the board members of the governmental bodies. Therefore, able to influence the direction the government wants to take. So, the inhabitants are having indirect power to improve the stimulation of the UCCs by the governmental bodies. Yet, their direct interest is a bit lower. They want to have a sustainable environment but do not matter how it is going to be achieved. Overall, their power

is limited. Yet, with elections receiving more authority. Also, unsatisfied inhabitants can voice their concerns through protests, enabling them to wield some level of power. However, inhabitants are most of the time powerless and belong to the group of crowd. Nevertheless, inhabitants are a challenge to incorporate to fit in the power interest grid.

2.3.2. Subjects

These stakeholders show high interest but possess limited power. Ensure that these stakeholders are kept informed and regularly communicate with them to identify and address any significant issues. These stakeholders can provide valuable assistance in the initiatives (Deloitte, n.d.).

2.3.2.1. Operators of the UCCs

The operators of the multi-client hubs in the Netherlands are having low power and high interest. Yet, for optimal performance of the UCC, is dependent on the cooperation of suppliers and receivers. Consequently, having a lower power than the suppliers. The operators are not the owner of the goods or have perseverance toward the end customer. Therefore, the operators are belonging to the group of Subjects.

2.3.2.2. Carriers (3PL

For the carriers, only the trips from the suppliers to the UCC are considered. Because last-mile distribution is performed by the UCC operator. The main benefits for the carriers are expected to be the increased load factor and reduced vehicle kilometers (Isa et al., 2021). The carriers are dependent on the requirements of the supplier and or receivers. Therefore, power is limited but interest is moderate.

2.3.3. Context setters

These stakeholders have power, but low interest. These are the stakeholders who must be kept informed and satisfied throughout the project, even if they may not be interested, due to their significant influence. These stakeholders must be handled with care as they could potentially misuse their power if they become dissatisfied with the initiative (Deloitte, n.d.).

2.3.3.1. European Commission

Their interest is medium because of the financial support for projects and investigations for UCCs and their power is high. They mainly focus on the main goal to be climate neutral in 2050 in Europe. Their power is pretty high for making the rules but lower for national policies like the implementation of UCCs. Therefore, the European Commission is belonging to the group of context setters

2.3.4. Players

These stakeholders are having high interest and high power in the subject. These stakeholders are the decision makers, who are having the biggest impact on the project's success and it is therefore important to manage their expectations (Deloitte, n.d.)

2.3.4.1. Receivers

Together with the suppliers, they decide how and when the deliveries are made. Therefore, it can motivate different stakeholders to consolidate the goods. The receivers can stimulate the usage of the UCC by requiring supplies to be provided by a UCC. With the implementation of an UCC, the deliveries of different suppliers are consolidated in a single shipment. Resulting in a time and cost reduction for the receivers of the goods(Isa et al., 2021). Therefore having interest in the subject and having high power to influence the performance of the UCCs. Only some receivers can ensure that a great volume of freight is distributed through an UCC when they include this in the tendering process. Receivers therefore belong to the group of players.

2.3.4.2. Suppliers

The suppliers are the stakeholders which currently supply the goods to their customers in the city centers. Their goal is to have low delivery costs and a lot of satisfied customers (Dreischerf & Buijs, 2022). Some suppliers are using the UCC for improving their sustainable image, by reducing noise and environmental impact of their operation (Browne et al., 2011). The suppliers have high power to influence the performance of the UCCs. When a lot of suppliers are cooperating and supplying through a UCC, the performance of the UCC will increase. Therefore, belonging to the group of players.

2.3.4.3. Municipalities

The municipalities have the power to stimulate businesses and individuals to adopt UCCs by providing financial support, promoting awareness and establishing regulations that encourage sustainable transport. Moreover, municipalities can play a crucial role in developing of the necessary infrastructure to support UCCs, such as charging stations and bike parking facilities. By working closely with the other stakeholders, municipalities can ensure that the implementation of UCCs aligns with the overall goals of creating a more sustainable and livable community. Overall, cooperation and coordination between different players, including municipalities, will be essential for the successful implementation of UCCs as part of the ZEZ strategy. Yet, a lot of municipalities do not have policies for stimulating the usage of the UCC. So, some municipalities are acting as subjects, but they are still belonging to the group of players because they can stimulate the usage and performance of the UCC a lot.

2.3.4.4. Ministry of EZK

The Ministry of economic affairs and Climate is responsible for the national policies in the Netherlands, regarding economic affairs and climate. In recent years, the ministry has recognized the potential of UCCs to advance their goals of reducing greenhouse gas emissions and promoting sustainability. The implementation of UCCs is expected to improve the public health system, because of the vehicle kilometers traveled reduction. They are responsible to improve the livability and safety in the cities(Isa et al., 2021).

2.3.4.5. Ministry of I&W

The Ministry of I&W is responsible for the livability and accessibility of cities. Also, establishing a safe and sustainable environment for all inhabitants. The Ministry of I&W sets the framework for the municipalities in the Netherlands in which the Zero-emission zones can be introduced and is, therefore a stakeholder.

2.4. Governmental steering

An important factor for UCCs is the nature and extent of public involvement or intervention in this initiative (Giampoldaki et al., 2021). The action perspective can be different for each municipality. They can fulfill different kinds of steering to improve the sustainability of urban freight transport. The role of the municipality will be determined using the four forms of government steering (van den Biggelaar et al., 2021; Wondergem, 2018). Figure 2.6 is showing the different possible roles of the municipality. The vertical axis is differentiating between the steering on prerequisite or results. Meaning, government can emphasize reaching results or create the necessary prerequisites. The horizontal axis is differentiating in commitment of the society to the governmental objectives (Wondergem, 2018). On the left side of the scheme (top-down), government is making the rules. While on the right side (bottom-up), society is having more involvement. The different forms of government steering will be further explained below:

Legitimate government: This is the classical approach to governmental steering. Politics are making the policies and the municipalities develop rules and procedures to reach the desired effect on society (Wondergem, 2018).

New public management: The focus is on the performance of the government. When policies are effective and efficiently implemented, government is functioning optimally. Impact measurements serve as a tool for society to measure the performance of the government (Wondergem, 2018).

Societal resilience: The unstructured initiatives are established by society. Yet, government will join at a later stadium with the provision of subsidies or permits for the initiatives. The government must have the capacity to support, identify, remove obstacles, and if necessary, adjust these initiatives (Wondergem, 2018).

Networking government: The government is forced to cooperate with the initiatives and listen to the need of society. The government need to consider various interest of stakeholder in society for reaching its goals(Wondergem, 2018).

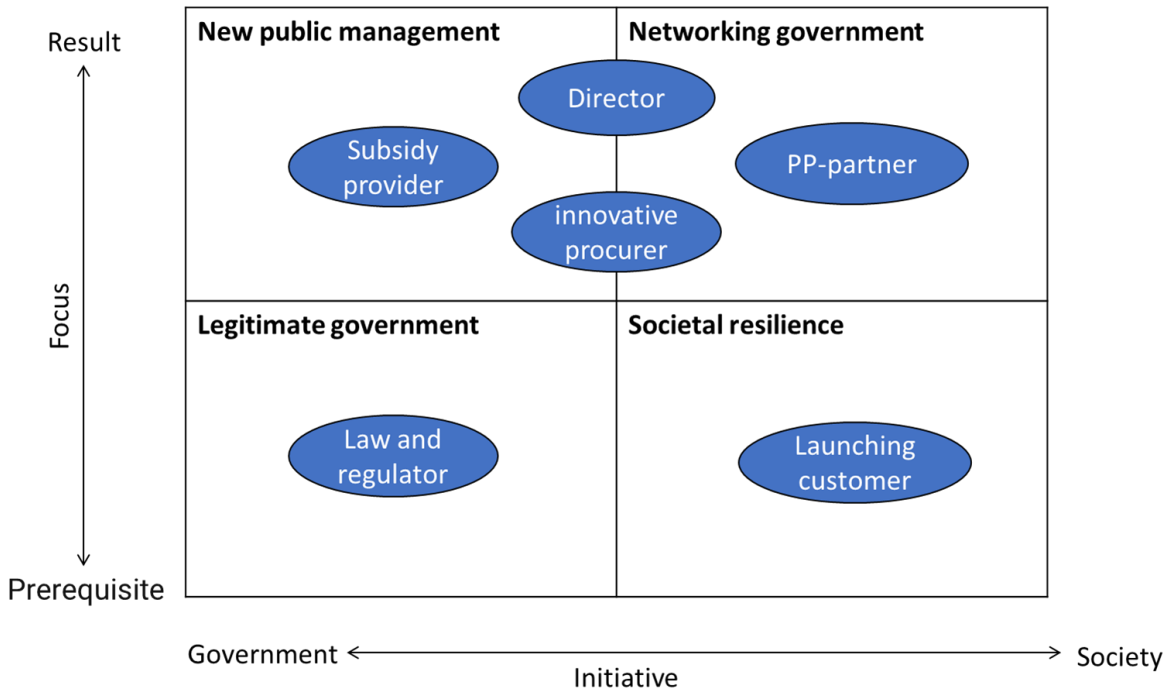


Figure 2.6: Action perspective government (Source: Buck Consultants International, 2020)

The different roles of the government on urban freight logistics and hub developments are explained by Buck Consultants International (2020) and based on their market expertise and a market consultation performed for the municipality of Leiden:

Law and regulator: The governmental body can use regulatory policy to stimulate the usage of the City hubs. An important example is the implementation of ZEZ in the Netherlands (Buck Consultants International, 2020).

Launching customer: The governmental body can set requirements for their purchasing policy. Such as deliveries of the parcels need to flow through an UCC. Therefore, stimulating the creation of volume for the UCC and new markets for sustainable urban freight logistics (Buck Consultants International, 2020).

Subsidy provider: The government can improve the financial resources of the enterprise by providing subsidies. The subsidies can be intended for the purchase of electric vehicles, wage subsidies, or the development of IT infrastructure (Buck Consultants International, 2020).

Innovative procurer: The government can stimulate the development of construction hubs by stating mandatory requirements in the tendering processes. These requirements may include the restriction on the number of deliveries. Also, these requirements can stimulate the use of cleaner or electric vehicles (Buck Consultants International, 2020).

Director: The government is responsible for the cooperation and dissemination of knowledge between various parties. This gives direction to the innovation process. The cooperation of different parties can stimulate the development of mutual principles. (Buck Consultants International, 2020).

Private Public Partnership The government can stimulate the initiatives of entrepreneurs by allocating a location for the city hub under favorable requirements.

3

Theoretical framework

The objective of the theoretical framework is to discuss the literature that fits the scope of this research. Firstly, the concept of the multi-client urban consolidation centers (hub) is being discussed. Secondly, the expected effects for the implementation of an urban consolidation centers are being discussed. Thirdly, the evaluation performance framework will be given. Fourthly, the ex-ante performance evaluation of urban consolidation centers is being explained. Lastly, the ex-post performance evaluation of urban consolidation centers is being explained.

3.1. Multi-client urban consolidation center

A lot of literature has been reviewed and showed that urban consolidation centers (UCCs) are having multiple synonyms like city logistic hub, city logistic center, urban distribution center, and city hub. Yet, in this research the aim is on the urban consolidation centers, because that is the name that is stated most of the time. The definition used for this research is provided by Browne et al. (2005), he defines urban consolidation centers as "a logistics facility that is situated in relative proximity to the geographic area that it serves be that a city center, an entire town or a specific site (e.g. shopping center), from which consolidated deliveries are carried out within that area, where a range of other value-added logistics and retail services can also be provided."

Most of the developed UCCs are dedicated hubs from companies like PostNL or DHL. In the Netherlands approximately 50 neutral Multi-client hubs are established (Bolscher, 2023). Different typologies of hubs are established based on the location-scale level. In figure 3.1, the different types of hubs are given with their location and size. The focus of this report will lay on the multi-client city hub.

	Type/ Scale level	Location	Size DC	Characteristics
1	Pick-up & Drop-off point	Shop at the edge of a residential area	100m^2	manned or unmanned deppot or parcel point
2	goods exchange point	Near city center or shopping street	1.000m^2	Small, flexible location for multiple receivers
3	CityHub	At the edge of the city near the center and residential areas	5.000-10.000m^2 (Single user from 1.000m^2)	Cross-dock and depot for multi- or single-user
4	City regional DC	At the edge of the city near regional acces	10.000-20.000m^2 (Single user from 1.000m2)	Cross-dock and depot for multi- or single-user
5	Regional DC	Central location between a few cities in the region	>20.000m^2	DC operation for region
6	National DC	Central location in the Netherlands	>20.000m^2	
7	E-fulfilment center	Freight corridor	>40.000m^2	
8	European DC	Freight corridor	>40.000m^2	
	Focuss of the report	National and international logistics	Urban logistics	

Figure 3.1: Characteristics of different hubs (Source: Buck Consultants International, 2020)

Four promising city hub concepts are developed for urban freight logistics under the different segments given in section 2.1. The four different kinds of UCCs are a construction hub, a dedicated regional hub, a multi-client hub, and a goods exchange hub. The focus of this research is on the multi-client city hub. The construction hub is used for the delivery of construction supplies to the hub in combination with temporary storage and just-in-time delivery from the construction hub to the construction site (Buck Consultants International, 2020). This hub is meant for just multiple construction operators. Secondly, the dedicated regional hub is a handling and storage location, which operates within the internal network of a single company. Mostly, used for the link between national distribution centers and destinations within the city. These dedicated hubs are used by parcel delivery companies like PostNL and DHL and by supermarkets like Albert Heijn and Jumbo, which are responsible for the whole process of receiving and supplying the goods (Buck Consultants International, 2023). A dedicated hub undertakes consolidation to improve the efficiency of the company's internal distribution network (Buck Consultants International, 2023). The small depots for the exchange of goods are unmanned or operated by a specialist and used for consolidated deliveries to the entrepreneurs in the city center. Yet, the focus of this report is on the multi-client hubs, were freight of different suppliers is consolidated before entering the city. In a multi-client hub, consolidation is performed to serve various suppliers. Yet, in this research this multi-client hub is stated as the urban consolidation center (UCC)

3.2. Expected effects of an urban consolidation centers

To improve sustainability in cities, UCC implementation is investigated. The implementation of an UCC will have an impact on the first and last-mile distribution of freight. First of all, goods are delivered at the UCC by a carrier. These goods are unloaded and afterward loaded in another (electric) vehicle to perform more efficient last-mile distribution with consolidated vehicles. See figure 2.3 for the systematic change after an UCC is implemented. Because of the more efficient transportation routes of the freight, an UCC is expected to reduce vehicle kilometers, trips, and travel time (Allen et al., 2012). Consequently, resulting in a congestion reduction, noise reduction, fossil fuel use reduction, and operational costs reduction (Allen et al., 2012). Because UCCs are used for storage, the receiving establishment can create additional space for more productive or profitable activities. This is advantageous, especially in areas where space is limited. Pre-retailing activities like inventory monitoring can help to improve product availability, service levels, processes in the shop, and free-up staff time (Allen et al., 2014). Yet, extra handling is needed during the process by unloading and loading the truck extra time at the UCC. However, the receiver will have fewer receiving moments, which can save them time. These expected effects are shown in 3.2, and then they are further elaborated for each stakeholder in table 3.1.

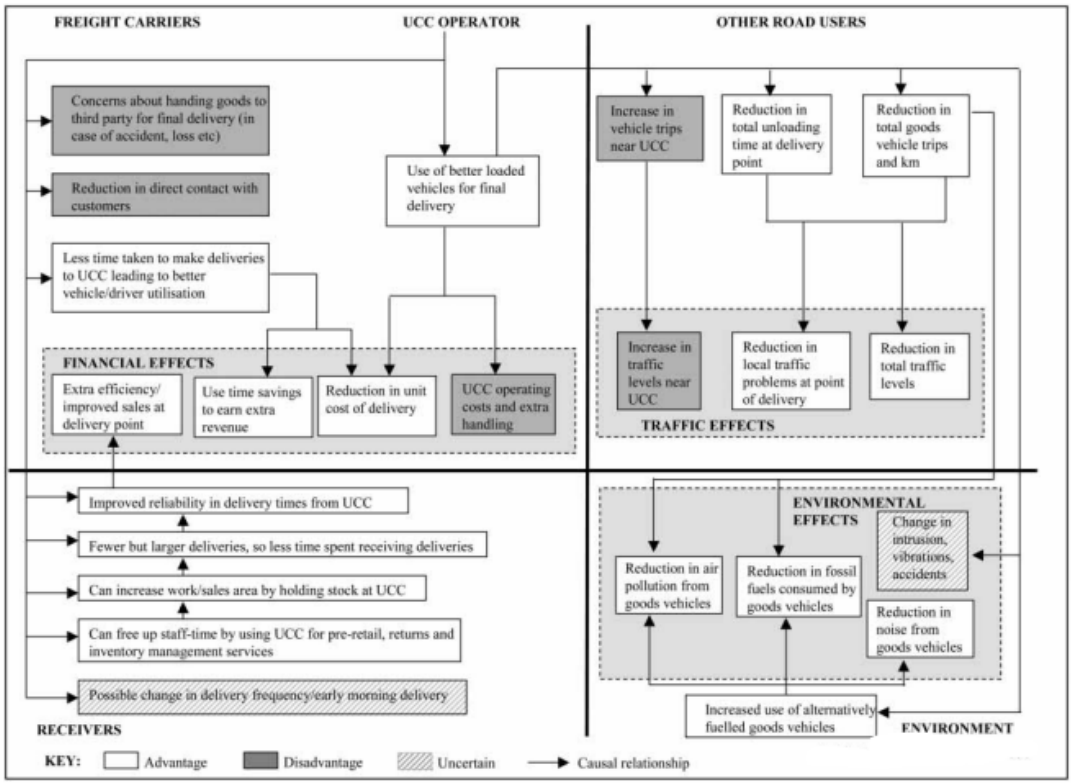


Figure 3.2: Effects of a UCC scheme with the implementation of an UCC (Source: Allen et al., 2012 adapted from Nemoto, 1997)

The implementation of UCCs offer advantages for the different participant in the supply chain. Suppliers will benefit from lower travel times, vehicle trips, and vehicle kilometers when these savings can be passed on to the carrier. Gaining a comprehensive understanding of cost savings across the supply chain is crucial. With proper cost allocation, operational costs are expected to decrease for the supplier.

On the other hand, a decrease in transportation prices may affect the profitability of carriers. So, maybe lower travel times, vehicle trips, and vehicle kilometers are not desired for the carriers. However, carriers will benefit from a higher load factor, congestion reduction, and reduction in fossil fuel use when it is reducing operational costs.

Receivers and end users may benefit from operational cost savings achieved through UCCs if these savings are distributed throughout the supply chain. The receiver benefits from less vehicle trips and travel times. Orders are delivered faster and in fewer delivery moments, resulting in lower unloading times. Other services offered by an UCC are expected to increase work and sales area and free-up staff time.

Municipalities are expected to benefit from the environmental impact of an UCC. First, higher load factors due to consolidation will decrease vehicle trips and kilometers in the cities. As a result, livability in the cities is increasing because of a reduction in fossil fuel use, congestion, emissions, and noise. Also, the electrification of vehicles is contributing to a decrease in fossil fuel usage, resulting in reduced emissions.

Furthermore, inhabitants experience environmental and social benefits like improved safety, decreased pollution, and noise hindrance (Allen et al., 2012, 2014). These effects occur when less vehicle trips and kilometers are driven within the city.

The various stakeholders are having different expectations for the implementation of the UCC, and what may be an advantage for one can be a potential disadvantage for another. All possible expectations of an UCC are provided in table 3.1, along with the indications for each stakeholder whether this represents a desired or undesired effect. An X is indicating a benefit, - a disadvantage, and a +- indicates that the effects can go both ways for the stakeholder.

Table 3.1: Expected effects implementation UCC (Adapted from: Allen et al.,2012)

	Supplier	Freight carrier (3PL)	Receivers	Municipality	Inhabitants
Less travel time	X	+-	X		
Lower operational costs	X	X	X		
Vehicle trip reduction	X	+-	X	X	X
Vehicle kilometer reduction	X	+-		X	X
Increase load factor		X		X	
Congestion reduction		X		X	X
Reduction in unloading time			X		
Increase work/sales area			X		
Free-up staff-time by using value-added services of UCC.			X		
Emission reduction	X	X	X	X	X
Fossil fuel use reduction		X		X	
Noise reduction				X	X
Extra handling at Hub	-				

3.3. Urban consolidation centers evaluation methods

Typically, the evaluation of urban consolidation centers is performed by examining the UCC schemes implemented in different cities. Among these evaluations, the most comprehensive reviews of multiple UCC schemes are from Browne et al. (2005) and Allen et al. (2012, 2014). Another method for UCC evaluations is the ex-ante and ex-post evaluation of an UCC for a specific city. Ex-ante analyses involve a forward-looking evaluation that relies on predictions and probabilities to determine the future potential of an initiative. On the other hand, ex-post analyses is a backward-looking analysis that considers outcomes after they have occurred. The actual results of an ex-post evaluation are used to predict the likelihood of future results. However, ex-ante evaluations are dependent on forecasts, making their accuracy limited due to uncertainty (Bailey et al., 2002).

Paddeu (2021) presented a methodological framework for UCC performance evaluation, employing a multi-stakeholder multi-criteria approach to evaluate and compare alternatives. The model can be used for ex-post and ex-ante evaluations (Paddeu, 2021). Yet, in this research the key performance indicators are based on the objectives for the different stakeholders stated in table 2.2. These objectives are related to the environmental impacts like emission reduction, and vehicle kilometer reduction. Secondly, the productivity attribute is including the load factor and the number of vehicles reduction (trips reduction). Last, the operational costs are important to measure the UCC performance. The inclusion of the operational costs is crucial as they play an important role in convincing stakeholders to consider shifting from their current transportation to a system with the UCC. (Van Rooijen & Quak, 2010). Figure 3.3 is showing the framework to asses the ex-ante and ex-post UCC performance.

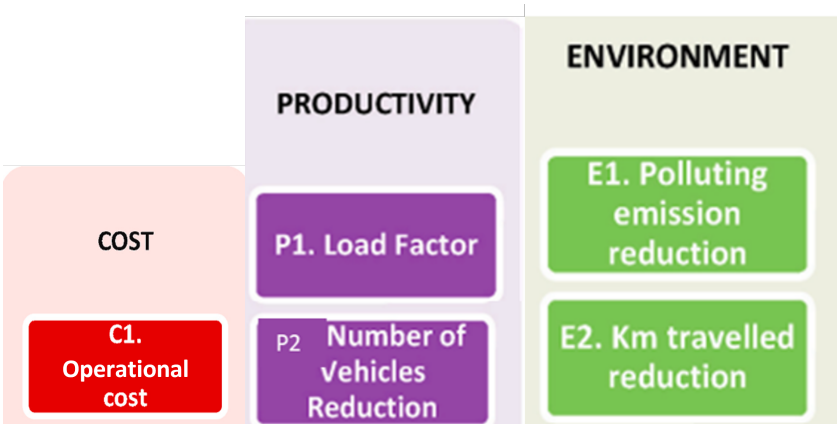


Figure 3.3: Framework with performance attributes and related metrics to asses UCC performance (Adapted from: Paddeu,2021)

The different approaches for measuring the expected performance of the UCCs is leading to a lot of different results. It is therefore important to understand the cause of the different results for evaluating the UCCs in

the Netherlands. The paper of Brown et al. 2005 is giving a lot of performance indicators but cannot be used for this research because a lot of the 17 UCCs stopped operating because of bad results. Therefore, indicating that the performance of the UCCs in some cases was not based on realistic estimates (van Duin et al., 2010).

The use of these indicators for estimating the performance of UCCs, is useful for decision making, estimating improvements as well as making comparisons (Egilmez et al., 2015). The evaluation of the indicators can improve the justification to implement UCCs (Björklund & Simm, 2019). These indicators were used for quantifying the impacts of an UCC in different research studies(Browne et al., 2005; Cerutti et al., 2016; Teo et al., 2015; Tozzi et al., 2014; Van Heeswijk et al., 2019). So, in total the following five indicators were established to measure to what extent the ex-post effects of UCCs meet the ex-ante expectations: load factor, operational costs, emissions, vehicle kilometers, and vehicle trips.

3.4. Ex-ante quantitative impact of an UCC

Ex-ante refers to a prediction before the event happens (Filippi et al., 2010). So, in this research, ex-ante performance expectations are the expectations stakeholders had before the UCC was implemented. Ex-ante evaluation is performed by Van Duin et al. (2010) where six UCCs in Europe were reviewed, to estimate the feasibility of an UCC in The Hague. Other, ex-ante evaluations are shown in the papers of Paddeu (2021), Simoni et al. (2018), Isa et al. (2021), Roca-Riu & Estrada (2012) and in the paper from Van Heeswijk et al. (2019). However, both the results of the conducted ex-ante and ex-post evaluations in the literature can be used as the ex-ante expectations for the UCCs in the Netherlands.

The different quantitative effects of the UCCs found in the literature will be given and explained in this subsection. Table 3.2 and 3.3 are showing the different effects mentioned in different literature. Additionally, an explanation of why certain literature are having different values for the same indicators is given. Hyperlinks are attached to the tables to go directly to Appendix A where the literature is explained and the applied method for reaching the effects is discussed.

Table 3.2: UCC effects in literature 1

	Browne et al., 2011	**Allen et al., 2012**	**Browne et al., 2005**	**Simoni et al., 2018**	**Escuín et al., 2012**
Operational costs				-2/-24%	+2,5/+5,8%
improve load factor		15-100%	55-68%		
vehicle kilometres reduction	20%	60-80%	30-45%		15-35%
Emission reduction	54%	25-80%	25-60%	11-21%	
Vehicle trip reduction			30-80%		
Explanation applied method in section	A.1	A.2	A.3	A.4	A.5

Table 3.3: UCC effects in literature 2

	Van Heeswijk et al., 2019	**Huijsmans and Wildeboer, 1997**	**Van Rooijen and Quak, 2010**	**Roca-Riu and Estrada, 2012**
Operational costs		-18/-25%		-12/-14%
improve load factor		15%		
vehicle kilometres reduction	65%		32%	
Emission reduction	70%			
Vehicle trip reduction			59%	
Explanation applied method in section	A.8	A.6	A.9	A.7

3.4.1. Operational costs

Throughout the literature, different operational cost savings are stated. looking at the effects found in four papers, it is apparent that the implementation of an UCC will lead to changes in the operational costs ranging from a reduction of 25% to an increase of 5,8%. This is in line with the investigation of Janjevic & Ndiaye (2017), about the theoretical cost-relationships of UCCs for their users. Within this paper, it is estimated that the suppliers can save up to 20% in operational costs when they have only one delivery stop within the city. Suppliers with 7 delivery stops are expected to reduce operational costs by 3% only. The break-even number of stops, for reducing the operational costs is estimated at 7.9 delivery stops (Janjevic & Ndiaye, 2017). This means that if a supplier has more than 7.9 stops within the city, the implementation of an UCC would result in higher costs for the supplier. So, the use of an UCC is more beneficial for suppliers with a small number of delivery stops in the city (Browne et al., 2005; Janjevic & Ndiaye, 2017). Figure 3.4 is showing the variations in

total costs and cost per shop for different numbers of delivery stops by a supplier.

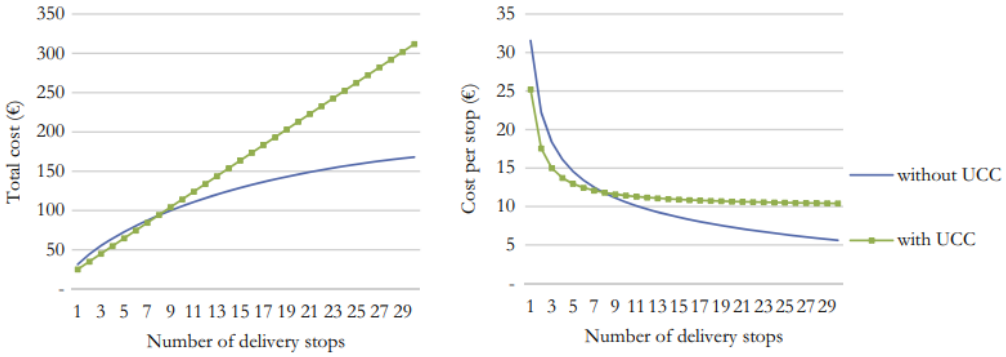


Figure 3.4: Total cost of a delivery route and (1) and cost per delivery stop (2) with and without the UCC. (Source: Janjevic & Ndiaye 2017)

To achieve cost benefits, suppliers must adapt their distribution networks, closing their depots with employees. Direct costs can only decrease when the UCC completely substitutes the carrier (Dreischerf & Buijs, 2022). Secondly, suppliers whose depots are located a long distance from the receivers will experience greater advantages by utilizing an UCC close to the receiver(Dreischerf & Buijs, 2022). Cost savings are expected to decrease with the number of delivery stops from one supplier. When only one stop needs to be made 20% costs saving can occur, while with 5 stops only 11% is expected, and with 7 stops only 3%

3.4.2. Improve load factor

In the found literature, improvements in load factor are stated. The effects in the literature were given different values for improvement and were ranging from 15-100%. However, it is hard to understand and measure the actual performance of the load factor in different UCCs. Mainly, due to the limited available evaluations of the short and long-term impact (Balm et al., 2014; Paddeu, 2021; Patier & Browne, 2010). Secondly, load factor can be measured in different loading units like weight or volume, the maximum number of trolleys, pallets, or collis. Therefore, certain load factor estimations may be estimates of different units. In the paper of Allen et al.(2012) the load factor improvement is evaluated at 15-100% in 24 UCC studies. But, the unit and explanation of the load factor in the different studies is not given. This makes it difficult to make proper statements about this improved load factor.

3.4.3. Vehicle kilometers reduction

The vehicle kilometers reduction is given by most of the found literature. Nevertheless, the results are very different. While Escuín et al.(2012) stated a decrease of 15-35%, is the source Allen et al. (2012) giving a decrease from 60-80%. The papers are indicating a reduction of vehicle kilometers in the range of 15-80%.

Yet, some suppliers of the UCC are still providing other customers with their goods through their original distribution. These suppliers are using the UCC when it is stated in the contract with the receiver. Therefore, some of these suppliers are still entering the city, resulting in inefficient use of the UCC(Dreischerf & Buijs, 2022).

3.4.4. Emission reduction

Emission reduction is one of the most important reasons for implementing of UCCs. Therefore, the effects on the environment are given in multiple sources. Also, this effect is estimated quite differently by different literature. Resulting in an estimated reduction range of 11-80%. Emissions can be reduced through various factors when utilizing an UCC, primarily by using zero-emission vehicles. Also, consolidation of goods can result in a decrease in vehicle trips, leading to emission reductions. Furthermore, the reduced number of vehicles can contribute to less traffic congestion, leading to emission reduction.

3.4.5. Vehicle trip reduction

The number of vehicle trips is estimated to decrease within the range of 30-80% when looking at the paper of Browne et al.2005, but when looking at the vehicle trip reduction for an UCC in the Netherlands a 59% reduction was found (Van Rooijen & Quak, 2010)

Looking at the results can it be concluded that the range of performance indicators is quite big and it is therefore hard to compare the relative results shown in table 3.2 and table 3.3. It is important to understand the differences between the results to increase the validity of the research. A few findings are shown next:

- Some cases are not based on realistic estimates, because these UCCs were not able to keep operating like in the paper of Browne et al.(2005)
- Relative calculation is dependent on the point of comparison
  - Is the reduction compared to the total vehicle kilometers in the supply chain or only looked at the difference for the last-mile distribution? The visual explanation for this is shown in figure 3.5
  - Is there checked for the vans or trucks which may enter the city after some goods are delivered to the UCC?
- The results are dependent on the unit of the indicator.
  - Loading factor can be explained by different units like volume of kg. This may result in biased results when trying to compare different loading factors.

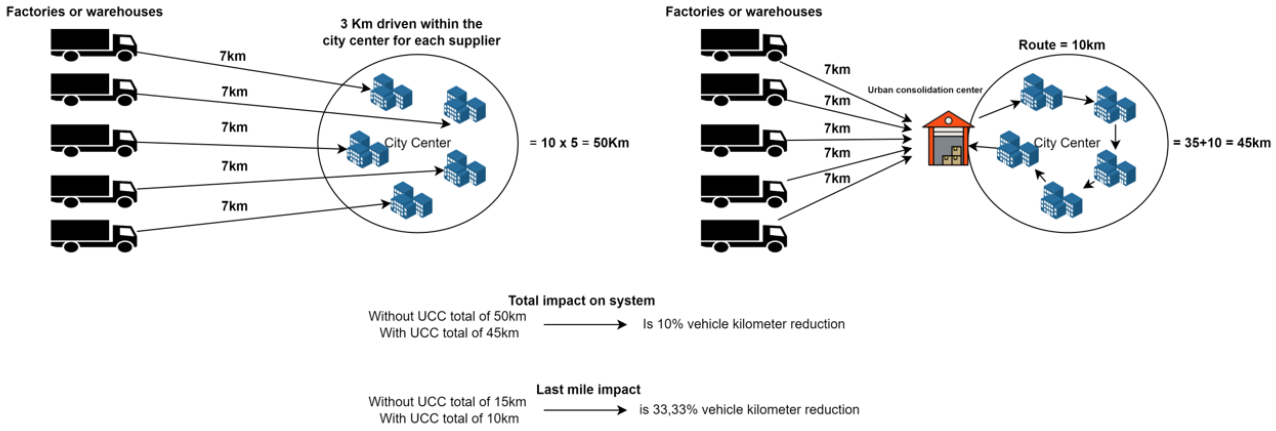


Figure 3.5: Calculation dependent from the point of comparison

When focusing on the last-mile impact of the UCC instead of the entire system, the performance will appear to be more favorable for the UCC implementation. Therefore, it is crucial to clearly define what has been measured with the ex-post performance of the UCCs.

3.5. Ex-post performance evaluation

The ex-post evaluation is used to evaluate the impact of an event after this event has taken place (Hubbard, 2008). So, in this research, the ex-post evaluation is used to estimate the actual impact of operational UCCs in the Netherlands. Ex-post evaluation was performed in multiple papers from Paddeu (2017, 2021), Browne et al.(2011), Kin et al. (2021 Van Rooijen and Quak (2010) and in the paper from Nordtømme et al. (2015). In the paper from Escuín et al. (2012) the vehicle routing problem for multiple hubs is evaluated. Additionally, Janjevic et al. (2017) established scenarios for freight distribution in Brussels, by using UCCs. The ex-post performance results of different UCCs investigated in the literature can be used as the ex-ante expectations for this research. However, the ex-post performance evaluation of UCCs in the Netherlands for this research is based on the performance framework shown in figure 3.3. The ex-post performance evaluation will be given in chapter 5 and will be stated in the conducted interviews with UCC operators. Both the qualitative as the quantitative performance of the operational UCCs in the Netherlands will be searched.

4

Methodology

in this chapter, the methodology used in this paper for answering the research questions will be explained. The research design, data collection and analyses method, reliability, and validity will be explained in this section to answer the following question:

'To what extent do the ex-post effects of UCCs meet the ex-ante expectations from UCC operators?'

4.1. Research design

The research mixed method design shows the structure of the research. It gives the elements of the research process, such as the research strategy, data collection methods, data analysis techniques, and the approach for interpreting the data (Van Thiel, 2014). The research design is important for organizing the study and addressing the research objectives effectively. It is a road map for the researchers, to guide you through the research process and establish valid and reliable findings. The research strategy involves the framework of the research design. Different methods can be used for gathering the data given a certain research strategy and the technique defines the method to analyze the data.(Van Thiel, 2014). The four main research strategies which are used in the book of Van Thiel (2014) are shown in table 4.1.

Strategy	*Research problem*	*Number of units*	*Number of variables*
Experiment	Explain, test, evaluate	Small	Small
Survey	Describe, test, diagnose	Large	Large
Case study	Explore, describe, diagnose, design, evaluate	Small	Large
Desk research	All	Varies	Varies

Table 4.1: Four main research strategies (Van Thiel, 2014)

This ex-post evaluation study involves a qualitative research based on multiple cases for different UCCs in the Netherlands, with interviews as the data collection method. The aim of the case studies was about the ex-ante expectations and ex-post performance of seven UCC operators that were operational. These multiple case studies are favored over a survey, experiment, and desk research because of the following reasons. Firstly, this research has limited number of studies explaining the ex-post performances of the UCCs. Therefore, surveys are not a good option as they require a large number of existing studies. Secondly, experiments are used to test a small number of variables. Given that this research evaluates multiple variables to define the performance and hypothesis, the experiment strategy is not the most viable option. Lastly, conducting desk research to collect data from previous research and excising documents is also not possible due to the absence of ex-post evaluation for multiple UCCs in the Netherlands. A case study is described as a systematic investigation of an individual, community, or group where the researcher examines data concerning multiple variables (Heale & Twycross, 2018). Case studies can use quantitative and qualitative information (Schell, 1992). The findings of an case study are specific to a case, making it challenging to generalize the results for all UCCs in the Netherlands, which is an disadvantage of case studies. (Heale & Twycross, 2018). To ensure that the results can still be generalized, multiple case studies for the ex-ante and ex-post performance of UCCs

were conducted.

These case studies will be used to establish a comprehensive understanding of the performances of the UCC. Therefore, being able to compare the ex-post performance with the ex-ante expectations. The case studies implies the cooperation of different interviewed multi-client hubs in the Netherlands. These interviewed hubs are chosen for the case study because they are operational multi-client hubs in the Netherlands. Also, accepted to participate in the research and were questioned about the performance of their UCC. With the results of the cooperating hubs, generalized conclusions will be made for the performance of all UCCs in the Netherlands. These results can contribute to the actual desirability of the UCCs for operators, inhabitants, or government.

Different methods and techniques can be applied for each chosen strategy (Van Thiel, 2014). For the chosen case study strategy, multiple methods are available, such as observation, questionnaire, interview, and content analysis method. Observations are probably the best method for estimating the actual performance of an UCC. However, In the time horizon of this research, observation of the UCC performance is not possible. Also, content analyses do not apply to this research as there are no relations that need to be proven. For this research, interviews were favored over the questionnaire, in this way, it allows for obtaining additional information beyond the questions. It also makes the process more personal, potentially stimulating respondents to participate.

4.2. Data collection and data analyses

The theoretical framework will be used for conducting the interviews and analyzing the data. All interviews required the cooperation of the interviewees. It is advised to use non-probability sampling instead of probability sampling for selecting the units of the study (Lucas, 2016). Units of study are selected randomly when using probability sampling. In contrast, non-probability sampling depends on a theoretical foundation for making the choices (Lucas, 2016). Due to the limited number of multi-client hub operators, approximately 20 in total, with a total of 50 UCCs, only a limited number of cases can be selected. Therefore, the non-probability sampling approach is used to choose interviewees based on theoretical considerations. Six UCC operators, two municipalities, and one project manager of an UCC are interviewed for this study and were selected out of an anonymous data base from Buck Consultants International with all operational urban consolidations centers in the Netherlands. Some UCC operators wanted to remain anonymous and were stated as UCC 1 to 7. The interviews are in-depth and focused on a specific topic. As a result, limited interviewees with high information power are preferred over a large number of interviewees with limited information power (Malterud et al., 2016).

Different types of interviews can be used in this research, each with its focus and objectives. The four different types of interviews are: structured, unstructured, semi-structured, and focus group interviews (Alsaawi, 2014). The structured interview is similar to a survey where the focus is on the questions, which limit in-depth conversations. (Alsaawi, 2014). Conversely, unstructured or open interviews may take an unpredictable direction, potentially ending up with a lot of unnecessary data. Focus group interviews, involve brainstorming among multiple interviewees. In this research individual interviews are being conducted with just one person (Alsaawi, 2014). So, for this research, the semi-structured interview is chosen to combine the structured and unstructured interviews. The questions are prepared in front and shown in Appendix B. yet, the interviewee has the opportunity to elaborate and provide insight due to open-ended questions (Alsaawi, 2014). The advantage of this interview, compared to an open interview, lies in its increased validity and reliability (Aung et al., 2021). As the interview is more structured, the data obtained becomes more consistent.

Each of the interviews will be conducted within 1 hour and the questions and results are shown in Appendix B. The interviews were conducted online and on location. The locations and timings of each interview are shown in table 4.3. The interviewees are the persons in the proper positions within the UCC or municipalities involved with UCCs. These operators and municipalities are chosen because of the informational power they have aimed at UCC operation and policies. Both the operators and municipalities are having very high interest for UCCs and will therefore have proper information about the subject. The interviewed municipalities of Utrecht and Rotterdam are chosen because they are both implementing zero-emission zones and multiple UCCs were implemented in these municipalities. Additionally, Utrecht is having the most implemented

multi-client hubs of all municipalities in the Netherlands and is therefore a useful municipality to interview. Not all municipalities with zero-emission zones and multi-client hubs are interviewed due to the lack of available time for this research. The chosen multi-client hub operators were selected out of a anonymous data base from Buck Consultant International which involves all the multi-client hubs in the Netherlands. Out of the approximately 20 multi-client hub operators, 6 were interviewed for this research. The sample includes different UCC operators to ensure that the finding can be generalized for all multi-client hubs.

The interviews are used to determine the qualitative and quantitative expectations and actual performance of the UCCs. It is important to know which performance expectations are reached and which ones are not. The interviewees were asked to state the expected impact of the implementation of their UCC on the following indicators: vehicle kilometers, vehicle trips, vehicle load factor, operational costs, and emissions in the city. They were able to choose between the five answers shown in table 4.2. So, first they needed to state the expected change in the performance indicators and secondly, they needed to state the actual change the implementation of their UCC had on these indicators.

Table 4.2: five-point likert-scale

Number	Likert-scale	Definition
5	Much higher	+30% and higher
4	Higher	0 t/m +30%
3	Equal	0%
2	Lower	0 t/m -30%
1	Much lower	-30% and lower

Additionally, the reasons for the varying outcomes were investigated within the interviews, focusing on the success factors and challenges during operations. Third, important measures and system changes to optimize the performance of the UCCs were explored. Based on this information, recommendations can be made to improve the current performance of the UCC and potentially meet the high expectations. The other stakeholders are left out of the interviews as they are not needed to estimate the qualitative impact of the UCC. The suppliers, carriers and receivers are important to be included in the interviews when the quantitative performance of the UCCs need to be measured. An overview of all the interviewed parties is shown in table 4.3.

Interviewee	Organization	function	Location	Time
1	Urban consolidation center 1	CEO	Teams meeting	11-7-2023 15:30
2	Urban consolidation center 2	CEO	On location	13-6-2023 11:00
3	Urban consolidation center 3	CEO	On location	11-7-2023 15:30
4	Urban consolidation center 4	CEO	On location	6-6-2023 10:00
5	Pilot hub Leiden (UCC 5)	Project manager	Leiden	27-7-2023 14:00
6	Urban consolidation center 6	CEO	Teams meeting	21-6-2023 14:00
7	Urban consolidation center 7	CEO	On location	27-6-2023 11:00
8	Municipality of Rotterdam	Advisor	Teams meeting	2-8-2023 16:00
9	Municipality of Utrecht	Advisor	Teams meeting	5-9-2023 14:30

Table 4.3: overview conducted interviews

Doing the interviews requires some techniques which should be used. To ensure that the interviewee can answer each question, the questions should be prepared properly and addressed to the interviewee before the interview takes place. At the start of the interview, a small introduction of myself and the subject is given to the interviewee. Also, make sure the interviewee knows that the interview is being recorded and ask if they want to remain anonymous. During the interview, ask clear and friendly questions and conclude the findings at the end of the interview (Swaen, 2022).

The interviews are transcribed and shown in Appendix B of this report. To facilitate easy referencing of statements from the interviewees, each interviewee is assigned a corresponding number, as illustrated in table 4.3. The interviews were conducted in Dutch but have been translated into English for this research.

4.3. Reliability and validity

Reliability and validity deal with the trust someone has in the accuracy and credibility of the findings and conclusions drawn from these findings (Motheral, 1998). The reliability of the interviews is received when similar results or findings are obtained. While the semi-structured interviews may not be completely reproducible, the focus on the specific topic increases their reliability. Therefore, repeating these interviews would result in consistent findings. By using standardized interview methods, the reliability of the interview data is improved. The semi-structured interviews were reviewed by two experts on urban consolidation centers and two supervisors from the Delft University of Technology. Additionally, the interview was updated after the first interview to ensure that all important information was obtained.

Validity of the research is dependent on internal and external validity (Motheral, 1998). There are several threats for internal validity: history, instrumentation, maturation, testing, statistical regression to the mean, selection bios, and experimental mortality (Motheral, 1998). The validity history threat refers to any new event occurring during the study period that could have an impact on the results. Since the focus is on the actual performance and some events are incorporated into the actual performance, this is not a threat to this research's validity. Regarding threats such as maturation, statistical regression, selection bias, and experimental mortality, they are not a threat to this ex-post analysis of a UCC either. However, the testing effect threat is addressed by not revealing the interview results of other respondents beforehand. This approach ensures that each interviewee elaborates on their findings without being influenced by the expectations of others. Last, to maintain internal validity, the instrumentation measures must remain consistent during the ex-ante and ex-post analyses. Therefore, they need to be clear and exclusively elaborated. The theoretical framework should define the urban consolidation centers and the performance indicators for the ex-ante and ex-post evaluation of the UCCs. To avoid missing any information during the interviews, they were recorded and transcribed and shown in appendix B.

The responses from the interviewees can be found in Appendix B. In order to accurately link the statements of the interviewees to their respective interviews within this report, each interview has been transcribed, assigned a unique number, and is referenced to in the text. Additionally, to generalize the results from the interviewed UCC operators to all UCC operations in the Netherlands, external validity should be guaranteed (Motheral, 1998). In this research, a relatively high number of multi-client hub operators are interviewed to define the generalized results. In total six hub operators were interviewed, while approximately 20 multi-client hub operators are active in the Netherlands at the moment. The sample is obtained through a non-probability sampling method founded on theoretical foundations (Lucas, 2016; Van Thiel, 2014). However, it is more difficult to generalize the results from the municipalities interview due to the low number of interviews conducted with municipalities and the fact that each municipality may have its unique policies regarding urban freight transport. Also, the interviewed UCC operators may have some biases for estimating the ex-ante and ex-post performance of the UCCs, as they have a possible stake in positive outcomes. Therefore, it is crucial to critically examine the responses provided by the interviewees and whether they may be given a more positive picture for their own interests.

Initially, the ex-post and ex-ante performance evaluation of the UCCs was focused on quantitative data. When it became apparent that the quantitative data from the literature ranged quite a lot and were difficult to compare, together with the absence of actual performance data from the UCCs, the focus of this research switched to a qualitative method, supplemented with the available quantitative data to achieve more reliable results. This approach eventually brought more dept into the research and increased the external validity, since both methods complemented and strengthened each other. To increase the validity and reliability of this research, multiple and different sources of information are used, a method names triangulation. These sources include a literature research and the conducted interviews shown in table 4.3. Both methods provide qualitative data and quantitative data about the UCC performance. The theoretical framework is established by searching the literature, quantitative data is received through interviews and literature, while qualitative data is sourced from the internal database of the operators. The integration of these different sources contributes to increasing the validity and reliability of the research (Golafshani, 2003).

5

Ex-ante and Ex-post performance of UCCs

The primary objective of this research is to assess the extent to which the UCC operations meet the expected performance found in the literature and interviews. Also, uncover the underlying challenges and factors that have influenced the differences in outcomes. By examining both the ex-ante performance expectations and the ex-post performance, we can gain a comprehensive understanding of the ex-post performance of urban consolidation centers (UCCs) and identify the drivers behind their success or challenges. Ultimately, these results will provide valuable knowledge to make recommendations for stakeholders and policymakers seeking to optimize UFT through UCC implementation. In this section, the ex-ante and ex-post performance of UCCs found in the interviews will be explained. table 5.1 is given the allocated number for each interviewee for easy referring in the text.

Interviewee	Organization
1	Urban consolidation center 1
2	Urban consolidation center 2
3	Urban consolidation center 3
4	Urban consolidation center 4
5	Pilot hub Leiden (UCC 5)
6	Urban consolidation center 6
7	Urban consolidation center 7
8	Municipality of Rotterdam
9	Municipality of Utrecht

Table 5.1: interviewee number allocation

5.1. Ex-ante performance expectations stated by UCC operators

After conducting the interviews, it was possible to determine whether UCC operators had any expectations before starting their operation. It became evident that during the initial phase, UCC operators did not conduct any kind of investigation to measure the social impact or expected impact of the UCC (1,2,3,4,5,6,7). They first wanted to focus on the current operation before worrying about measuring the impact of their operation. Despite the absence of the quantitative expected performance, they still had qualitative expectations. Eventually, four UCC operators (2,3,4,7) and one project manager of UCC (5) stated their qualitative expectations they had for the UCC operation. UCC 1 and 4 did not provided any qualitative performance data and are therefore not included in the ex-ante expectations and ex-post performance results.

The operators were asked about the expected ex-ante impact and the ex-post impact of their UCC on the vehicle kilometers, vehicle trips, emissions, operational costs and vehicle load factor for the urban freight logistics. So first, the UCC operators needed to state the expected change of these indicators before starting with the UCC and secondly they needed to state the actual change in these indicators reflecting the reality. They could choose between five answers based on the five-point likert scale. They had to choose between much lower (1), lower (2), equal (3), higher (4), and much higher (5). To ensure that the interviewees stated

the same meaning regarding the qualitative results, it is essential to accurately define the various potential answers of the likert-scale. The definition of qualitative effects can be found in table 5.2. The operators stated their expected performance for each indicator with the corresponding number in the table shown in Appendix B.

Table 5.2: five-point likert-scale

Number	Likert-scale	Definition
5	Much higher	+30% and higher
4	Higher	0 t/m +30%
3	Equal	0%
2	Lower	0 t/m -30%
1	Much lower	-30% and lower

After UCC operator 2,3,5,6, and 7 stated their expected impact of an UCC on the vehicle kilometers, vehicle trips, load factor, emissions, and operational costs , table 5.3 could be made to summarize these expected performance.

Table 5.3: Expected results stated by the UCC operators

Expected Performance :		UCC 2	UCC 3	UCC 5	UCC 6	UCC 7	Total
Vehicle kilometres	Much lower	X	X			X	3
	Lower			X	X		2
Vehicle trips	Much lower		X	X		X	3
	Lower	X			X		2
Load factor	Much higher		X		X		2
	Higher	X		X		X	3
Emissions	Much lower	X	X	X	X	X	5
Operational costs	Lower	X				X	2
	Equal		X	X	X		3

Although most operators initially stated they had little to zero expectations (2,4,6,7) questions related to the indicators brought these expectations to the surface for UCC 2,3,5,6, and 7. The expectations from the UCC operators were focused on the load factor, vehicle trips, vehicle kilometers, operational costs and emissions. The results shown in table 5.3 are being visualized and shown in figure 5.1.

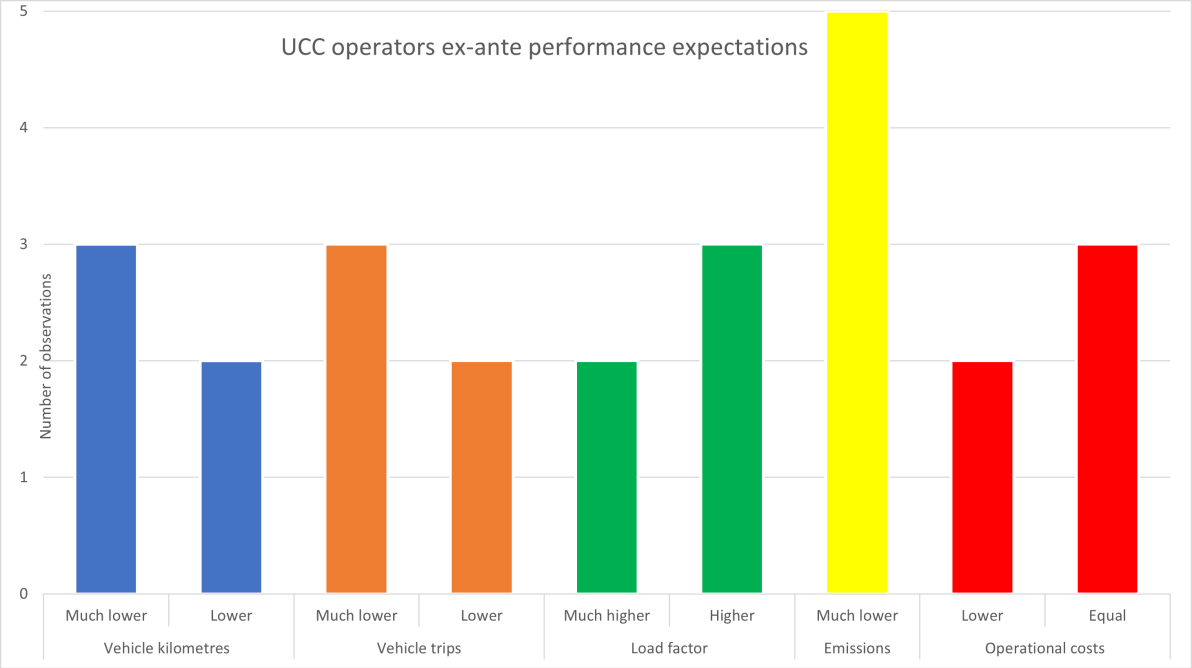


Figure 5.1: UCC ex-ante performance expectations from UCC operators

Vehicle kilometers: While UCC 5 and 6 expected a small reduction in vehicle kilometers, UCC 2, 3, and 7 expected a significant reduction (Much lower) in vehicles kilometers due to the consolidation at the UCC.

Vehicle trips: UCC 3, 5, and 7 expected the vehicle trips to decrease significantly when using an UCC to consolidate the freight. Additionally, UCC 2 and 6 suggested that trips were expected to be slightly lower, due to the unloading of large trucks into smaller vans.

Load factor: UCC operators 2, 5, and 7 expected the load factor to be higher, UCC 3 and 5 expected the load factor to increase significantly when using an UCC. They expected that consolidation of freight would result in better utilization of the vehicle capacity, resulting in higher load factors.

Emissions: All hub operators (2,3,5,6,7) expected that the implementation of an UCC could lead to a significant (much lower) decrease in emissions. They believe that the consolidation of freight and the use of electric vehicles within the UCC could have a positive impact on emissions.

Operational costs: The costs were expected to remain equal after the implementation of an UCC for suppliers and receivers stated by UCC 3, 5, and 6. However, UCC operator 2, and 7 proposed that the operational costs could be lower when proper pricing agreements were developed with the stakeholders.

Overall, hub operators (2,3,5,6,7) showed positive expectations regarding the implementation of an UCC, including emission reduction, higher load factors, decreased vehicle trips, and fewer vehicle kilometers. An optimal-performing UCC has the expected potential to positively impact the UFT.

These findings are in line with the qualitative findings in the literature, which also stated these expectations. Overall, expectations for UCCs are positive, with much potential for improving the UFT and stimulating sustainability.

In conclusion, after investigating the different papers and performing interviews with the hub operators, it is possible to give the overall performance expectations for the implementation of a hub. Both methods emphasize the potential benefits that UCCs can achieve in the UFT.

From the interviews with the hub operators (UCC 2,3,5,6,7) it was evident that they expected significant emis-

sion reductions, higher load factors, reduced vehicle trips and kilometers. Additionally, operators expected the operational costs to be equal to the current operation (3,5,6), with the possibility to even lower operational costs with proper pricing agreements (2,7). These expectations are similar to the findings from the literature, which also stated the expected emission reduction, higher load factor, less vehicle trips and kilometers as shown in table 3.1. The literature states that an UCC has high potential to improve the UFT and address some of the rising problems within the city. In addition to the interview results, the quantitative findings from the literature also play a crucial role in this study. The literature's quantitative results showed a wide range of values, making them challenging to use. However, the direction of these values aligns well with the qualitative expectations obtained from the hub operators and literature. While the specific values from the literature may vary, the trends and patterns are consistent with the expected performance of the hub operators. This similarity between qualitative and quantitative expectations improves the reliability of the conclusions drawn. The mixed methods of information is providing a proper understanding of the expected performance of UCCs.

5.2. Ex-post performance stated by UCC operators

In this section, the key findings and results of the interviews, focusing on the anticipated actual performance of UCCs by the UCC operators will be presented. The following subsections will explain the outcomes and insights found with the interviews conducted at the hub operators. By seeking qualitative and quantitative data, the research seeks to gain a good understanding of the actual performance of the UCC operations and to identify factors that contribute to the success or challenges of the operation.

5.2.1. Ex-post qualitative performance

During the interviews with the UCC operators, it was found that most of the interviewed operators have limited data tracking practices (1, 3, 5, 6, 7), which makes it challenging to measure the actual performance accurately. The main focus of the UCC operators has been on ensuring an operational business before showing their actual performance. Therefore, the actual performance is stated as the estimated performance of the current UCC operation. These estimations are based on the estimates from UCC 2,3,6, and 7. Despite, the missing of quantitative data by most of the operators (1,4,6,7), some operators were still able to provide valuable insights into the estimated performance of their current UCC operation(2,3,6,7). The results are shown in table 5.4

Table 5.4: Estimated ex-post performance of UCCs

Estimated current performance:		UCC 2	UCC 3	UCC 6	UCC 7	Total
Vehicle kilometres	Lower	X	X			2
	Equal			X	X	2
Vehicle trips	Higher			X		1
	Equal				X	1
	Lower	X	X			2
Load factor	Much higher		X	X		2
	Higher	X			X	2
Emissions	Much lower	X				1
	Lower			X		1
	Equal		X		X	2
Operational costs	Lower			X		1
	Equal	X	X		X	3

UCC 1 and 4 did not provided any qualitative performance data and are therefore not included in table 5.4. Secondly, the interviewees were asked to provide the estimated current performance that represents the reality closely. However, UCC 5 instead provided the best-case scenario results of the UCC for the actual performance. Assumptions were made that all incoming vehicles at the hub no longer entered the city. However,

UCC 5 did not know how the inbound vehicles acted in reality. Therefore, the results of UCC 5 cannot be included in the table on the estimated current performance. Figure 5.2 is showing the visualization of the current performance stated by the included UCC operators.

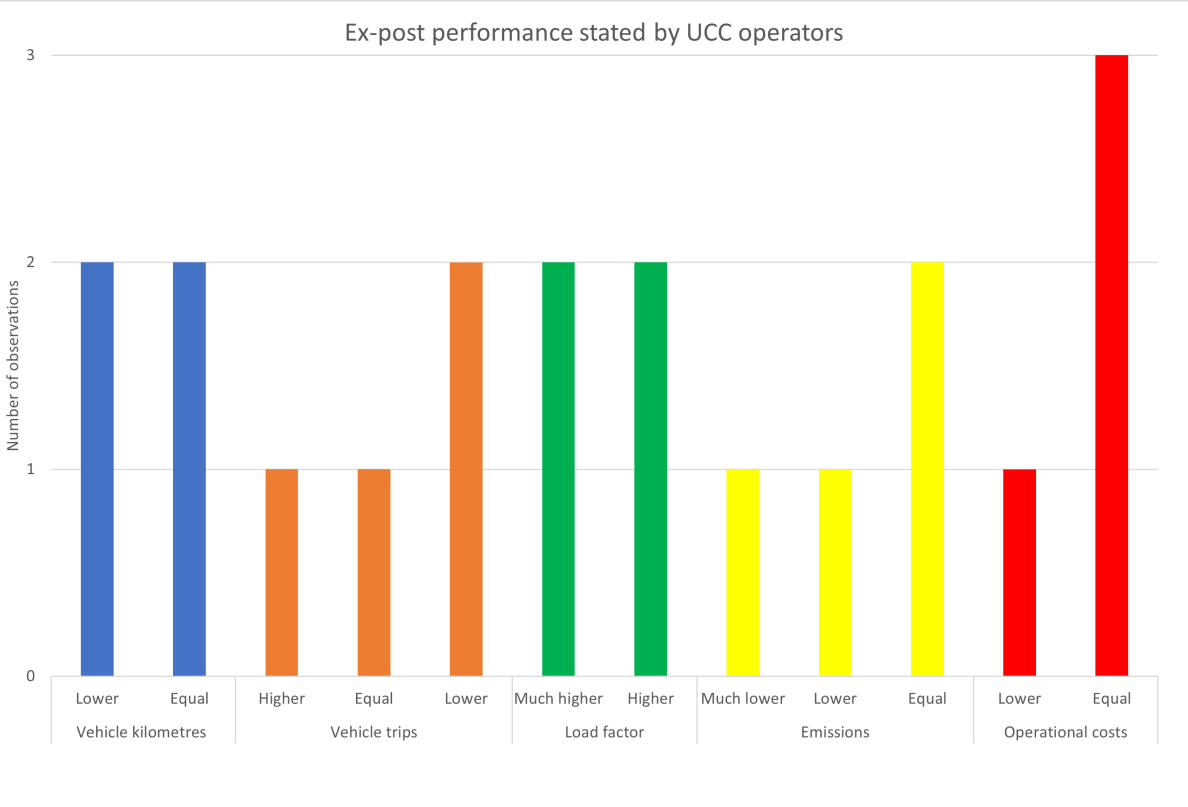


Figure 5.2: UCC ex-post performace stated by UCC operators

Vehicle kilometers: The results showed that two UCC operator (6,7) experienced the vehicle kilometers to be equal, and two UCC operators showed lower vehicle kilometers (2, 3) after the implementation of the UCC.

Vehicle trips: The number of vehicle trips showed varying outcomes, with one operator experiencing higher vehicle trips (6), one with equal trips (7), and two witnessing lower vehicle trips after implementing an UCC (2, 3).

Load factor: The utilization of the vehicles was reported to be higher (2, 7) and much higher in the other two cases (3, 6) . So, consolidation of freight with an UCC can lead to more efficient use of vehicles and increase the load factor.

Emissions: In one case the emissions were lower with the implementation of the UCCs (6). The findings that emissions stayed the same in two of the cases (3, 7) was because some suppliers still entered the city after delivering goods to the UCC. As a result, the UCCs emission reduction is obstructed by these suppliers. The last operator experienced a significant reduction in emissions for the delivering of certain goods (2).

Operational costs: The results show that in one case , costs were lower compared to previous operations (7), while in the other three instances, costs remained the same (2, 3, 6). The implementation of an UCC can lead to cost savings in certain scenarios, but the reduction is dependent on the pricing arrangements between different stakeholders and the operational context.

5.2.2. Ex-post quantitative performance

Even though most of the interviewed operators did not have any quantitative data, UCC 2, UCC 3 and UCC 5 provided some quantitative data about the UCC performance. The quantitative data of UCC 5 showed how a UCC for catering could perform when suppliers avoid entering the city after delivering to the UCC. It is important to note that UCC 5 was excluded from the qualitative results in previous section, but the quantitative results of UCC 5 are still useful, for showing the potential performance of the UCC in the best-case scenario. Figure 5.5 is showing the results of UCC 5 after four months of operating. However, these results do not reflect the actual performance of the hub, as they show the best-case scenario performance under the assumption that suppliers do not enter the city after delivering goods to the UCC. Yet, this assumption has not been investigated by UCC 5, and these results are therefore not reflecting the actual performance of the UCC.

Table 5.5: Results Hub Leiden (Retrieved from: (Hub Leiden, 2023)

Variable	Result	Explanation
Combined kilometers	3,541 km	Kilometers that would be driven by suppliers
Bundled kilometers	1,523 km	Kilometers driven by the hub
Saved kilometers	2,018 km	Kilometers saved (combined minus bundled)
Supplier deliveries	400	Deliveries made to the hub
Bundled stops	302	Bundled deliveries made to restaurants
Bundled trips	101	Times driven through the city by the hub
Average stops per trip	3	Deliveries made to restaurants per trip

However, these results can still be used to get a better view of the potential performance of a hub used for the consolidation of fresh goods and products need for catering. These results were obtained by consolidating the freight of sixteen suppliers near the city of Leiden. In the end, 2018 kilometers (57%) were saved because the vehicles of the suppliers did not need to individually enter the city to reach each customer. Freight was delivered to the UCC, which then uses electric vehicles to efficiently distribute the freight through the city using optimized routes. Furthermore, the use of the UCC enabled the consolidation of the original 400 inbound deliveries into 101 deliveries to the city, which corresponds to a 75% vehicle trip reduction.

Additionally, the study conducted by Buck Consultants International using BigMile presented the environmental impact of UCC 2 in six months. The analysis includes examining the CO_2 reduction, trips savings, kilometer reduction, and cost saving per ton of transported freight. within this research, two scenarios were developed to estimate the environmental impact of an UCC. The first scenario is the reference scenario were the UCC was not yet implemented and orders were directly transported to the customers by various suppliers . Yet, with the implementation of UCC 2, suppliers are currently delivering their goods to UCC 2 and the freight is distributed to the city with electric vehicles (scenario 2). The results obtained from this research are useful as these results are very recently estimated and are reflecting the actual performance of an implemented UCC, were suppliers did not enter the city after delivering at the UCC.

Table 5.6: Actual performance UCC 2 in six months(Buck Consultants International, 2023)

	Scenario 1 without UCC	Scenario 2 with UCC			
	customer	hub	customer	Total	Change
Total CO_2 emissions (Kg)	49.107	33.502	4.236	37.738	-23,2%
Average emissions (kg) per ton freight	49	33,4	4,23	-	
Number of City Trips	446	0	239	239	-46,4%
Number of Trips Outside City	446	435	0	435	-2,5%
Total kilometers	52.892	36.604	8.119	44.723	-15,4%
costs per ton transported*	4,9	1,17	0,85	2,02	-58,8%
Cost per ton transported* (Based on ETS tariff 100 euro)					

The implementation of UCC 2 has some positive environmental impact. CO_2 emissions are decreased with almost 12000Kg and 23,2%. Electric driving reduces CO_2 significantly, but is also important to identify the

impact of consolidation at the UCC to reduce the kilometers traveled and number of trips in the city. Furthermore, the consolidation of deliveries at UCC 2 has established a great reduction for vehicle trips made within the city. First, there were 446 individual deliveries to the receivers in the city, but this number of trips decreased to 239 after consolidation at UCC 2. This is representing a 46,4% reduction in vehicle trips compared to the situation without an UCC. This vehicle trip reduction due to consolidation at the UCC has also led to a decrease in the total kilometers traveled for delivering the goods. The total kilometers traveled reduced from 52892km to 44724 km, corresponding to a 15,4% reduction for the total supply chain. When focusing on the last-mile distribution a reduction of 50% can be witnessed. It is important to note that the calculated reductions for the last-mile distribution are based on certain assumptions. This 50% reduction calculation assumes that all the efficiency gains are solely obtained in the last-mile distribution and that the first-mile distribution to the hub remains constant under both scenarios. However, this assumption may not hold entirely true, as the absence of the hub would mean that suppliers would have to individually enter the city from different locations. When using the same calculation for the Last-mile CO_2 emission savings, a 73% reduction in emission can be found for the Last-mile delivery with an UCC instead of the 23% for emissions from supplier to receiver. In Europe, an emissions trading system (ETS) is established to discourage CO_2 emissions by companies. Companies are required to pay €60,78 for the extra emission of 1-ton CO_2 when they exceed their dispensation rights(DPRs) (Nederlandse Emissieautoriteit, 2022). When the ETS tariff reaches €100,- per ton CO_2, the costs per ton freight transported are much cheaper when using an UCC for the last mile delivery. Therefore, the implementation of an UCC can potentially decrease the operational costs for different stakeholders.

The last operator which provided data about the actual performance was urban consolidation center 3. However, most data are estimates based on the total vehicle kilometers driven by this UCC from 1-1-2023 till 30-6-2023. Therefore, results will not be 100% accurate with the actual performance of the UCC, but will still give useful estimates. Results and estimates are shown in figure 5.7.

Table 5.7: Estimated actual performance UCC 3

Urban consolidation center 3	
Vehicle kilometers (km)	316.875
CO_2-emissions (kg)	67.496
Consolidation (%)	66%
Load factor (%)	60%
Kilometers reduction (km)	633.750
Travel time reduction (Hours)	28.042
Fossil fuel reduction (Liter)	190.125

During the first 6 months of operating in 2023, 316.875 kilometers were driven with zero-emission vehicles by this UCC. Resulting in a CO_2 emission of 67.495Kg. For the following data, estimations were made by the operator to assign value to the factors such as consolidation degree, load factor, kilometer reduction, travel time reduction, and fuel reduction. These estimations were made to gain a certain level of insight into the impact of this UCC. Consolidation was estimated at 66% with one vehicle needed to consolidate three inbound vehicles. Therefore, a kilometer reduction of 633.750 was estimated with help from the consolidation rate. This operator estimated that otherwise three vehicles would have driven the actual vehicle kilometers. This value is a rough estimate, as the actual number of kilometers reduction would have been different. All vehicles would have taken different routes and did not start from the UCC location. The same account for the travel time reduction of 28.042 hours and fossil fuel reduction of 190.125 liters.

The results of UCC 2 are the most reliable to consider, as they represent the actual calculated impact of the UCC without any estimations or assumptions, which were present in the other two cases.

6
Analyses

The sub-questions stated in chapter 1 will be answered in this analysis. Therefore, the findings and theoretical framework will be used to answer these questions. first, the ex-ante evaluation expectations will be given, followed by the ex-post evaluation results. Eventually, the differences between expected and actual performance is being elaborated in the third section.

6.1. Ex-ante expectations evaluation

First, the following sub-question is being answered in this section: What were the UCC operators ex-ante evaluation expectations of the implementation of UCCs in the Netherlands. This question consists of three kinds of findings within this research. First, the qualitative expected performance in the literature will be given, followed by some quantitative findings. Eventually, these findings will be compared with the qualitative expectations of the interviewed UCC operators.

The implementation of an UCC is expected to have a positive impact on the sustainability of cities. UCCs are expected to improve the UFT by consolidating freight, resulting in reduced vehicle kilometers, trips, travel time, congestion, noise, fossil fuel use, and operational costs. The implementation of an UCC can also free up space for more productive activities for the receivers. Additionally, value-added services, such as inventory monitoring can improve the services of the UCCs. However, an extra handling step during unloading and loading at the UCC is established. These expected performances can be seen in figure 3.2 and table 3.1, which shows the benefits for the different stakeholders.

A range of quantitative effects are expected in the different literature, such as operational cost reduction, load factor improvement, vehicle kilometers reduction, emission reduction, and vehicle trip reduction. Yet, these impacts vary across the different literature, making it challenging to compare the relative results. Certain expectations in the literature lack realistic estimates, leading to unsuccessful UCC implementation and unsatisfactory outcomes for the UCC operator. Also, relative calculations are dependent form the chosen comparison point. Is the entire supply chain being considered, or only the last part of the distribution from the UCC? Additionally, not all post-UCC movements might be included, such as vans entering the city after delivering goods to the UCC. Last, the results are dependent on the chosen unit of the indicator. Load factor, for example, can be expressed in different units, such as volume or weight. This could results in different results when comparing the load factors. These factors highlight that comparing the quantitative data in the literature relies on various variables and considerations. It is therefore important that the context and methodology behind this data are stated accurately within these papers. This will improve the understanding of the expected and actual performance of the UCCs within the literature.

Additionally, interviews are conducted with UCC operators to understand their expectations before initiating their operations. Initially, operators did not conduct any investigation into the social or expected impact of their operation. Instead, their focus was on running their operation. Despite the absence of quantitative expectations, they still had qualitative expectations. The expectations were centered around five indicators

such as emissions, load factor, vehicle trips, vehicle kilometers, and operational costs. Firstly, the operators expected a significant emission reduction when implementing an UCC (2,3,5,6,7). The consolidation of freight together with electric vehicles was expected to reduce emissions. Secondly, the load factor was expected to be higher (2,5,7) or much higher (3,6). Consolidating freight was expected to optimize vehicle capacity utilization. Thirdly, most of the operators expected a significant reduction in vehicle trips (3,5,7). The other two operators expected a small reduction in vehicle trips (2,6). Fourthly, vehicle kilometers are expected to decrease significantly by UCC operator 2,3,7 and a small reduction in vehicle kilometers is expected by operator 5 and 6. Lastly, operational costs are expected to remain unchanged after UCC implementation (3,5,6). However, two operators (4,7) suggested that these costs might decrease if proper pricing agreements were established with the stakeholders.

In conclusion, the interviewed UCC operators showed positive expectations for the UCC implementations. Their expectations are in line with the expected benefits highlighted in the literature, which also stated the emission reduction, higher load factors, reduced vehicle trips and kilometers, and the change in operational costs for both the qualitative as quantitative data. These expected performances showed the potential of UCCs for improving the UFT.

6.2. Ex-post expectations evaluation

The second sub-question that needs to be answered is: What are the ex-post evaluation results of the implementation of the UCCs in the Netherlands? By looking at the insights gathered from the interviews with the UCC operators, the answer to this question can be given. Due to limited data tracking practices, the accurate measurement of the actual performance was a challenge for most operators (1,3,6,7). Despite the lack of quantitative data, operators provided valuable qualitative findings for the actual performance of UCCs. However, these qualitative results are considered as the operators expected actual performance, as they did not precisely measure the performance of their operation. In only three of the seven cases (2,3,5), quantitative performance data is given.

Results indicate that the operational costs either remain the same (2,3,6) or were lower (7) in one case compared to the situation without an UCC. While UCC implementation can lead to cost savings in certain scenarios, the reduction is dependent on proper pricing agreements with different stakeholders. Secondly, emissions were lower (2,6) or equal in both two cases (3,7). The emission staying equal in some cases was due to suppliers still entering the city after delivering freight at the UCC. Thirdly, the load factor was higher (2,7) or much higher (3,6) for the other two UCC operators. So, UCC implementation and consolidating freight resulted in better vehicle utilization and increased load factors. Fourthly, the number of vehicle trips varied among the operators. While one experienced more vehicle trips (6), one equal number of trips (7), and two operators experienced a lower number of vehicle trips (2,3). Lastly, vehicle kilometers were reduced in two of the cases (2,3) and remained equal in the other two cases (6,7). These results are shown in figure 5.2.

The actual quantitative performance is given by the pilot UCC 5, UCC 2, and UCC 3. The results provided by UCC 5 do not reflect the actual performance due to some assumptions, which do not reflect the reality. Because they do not account for trucks and vans entering the city after delivering to the UCC. These calculations are primarily focused on the best-case performance of UCC 5. However, the results of UCC 5 can still be useful to see the potential of UCCs. Also, the results of UCC 3 do not reflect the actual performance of the UCC due to same assumptions made by UCC 5. These assumptions include uncertainties that will influence the results. The results of UCC 2 are the most valuable performance data for estimating the UCC performance. In this specific UCC, suppliers did not enter the city after delivering to the UCC. So, the data shown by this UCC are the actual performances of the UCC. However, relying on these single measurements might not be sufficient to make robust conclusions for other UCCs in the Netherlands. Different operational conditions in the other UCCs could significantly influence the performance of their operation. While it is not possible to generalizing these findings for all UCCs in the Netherlands, these results can still provide a comprehensive overview of the performance or best-case performance of the UCCs. Table 6.1 is showing the quantitative results of UCC 2, UCC 3 and UCC 5 for the last-mile delivery of their freight.

Table 6.1: Quantitative results of UCC 2, UCC 3 and UCC 5

Last-mile	UCC 5	UCC 2	UCC 3
Vehicle kilometers reduction	57%	50%	66%
Vehicle trips reduction	75%	46%	66%
Vehicle emissions reduction	57%	73%	66%

The results presented above are the simplified representations of the outcomes provided in section 5.2.2. The results demonstrate that consolidation of freight through an UCC could lead to a significant reduction in vehicle kilometers, trips and emissions for last-mile delivery in a best-case scenario for UCC 3 and 5. However, the results of UCC 2 still showed that with the right utilization of an UCC by stakeholders, the performance will indeed be very high. With a reduction in the number of trips by about 46%, the number of kilometers driven by about 50%, and emissions for last-mile transport reduced by approximately 75% for the last-mile transport. It is also evident that the outcomes of the three UCCs in the Netherlands have a narrower range compared to the quantitative data showed in the literature.

From this section, it can be concluded that the qualitative impact of an UCC is not reflecting the optimal performance of an UCC at the moment. However, quantitative results of UCC 2 show that the impact of an UCC can be big for the last-mile delivery of freight. The results of UCC 2 are the most reliable results for showing the actual performance of an UCC in the Netherlands. To get a better understanding of the differences in expected and actual performance, challenges and success factors are sought and explained in the next section.

6.3. Comparison of the ex-ante and ex-post evaluation

After the ex-ante and ex-post performance has been elaborated in previous sections is it important to see and understand the differences in performance. Therefore, this section will be answering the following sub-question: How can the differences between the ex-ante and ex-post performance evaluation be explained and what can we learn from it? To address this sub-question, it is important to compare the ex-ante and ex-post performance results and carefully compare the differences as shown in table 6.2.

Table 6.2: Operators expected performance and estimated current performance

Indicator	Change	Expected performance	Estimated performance of current UCC operation
Vehicle kilometres	Much lower	3 --> (UCC 2,3,7)	0
	Lower	1 --> (UCC 6)	2-->(UCC 2,3)
	Equal	0	2-->(UCC 6,7)
Vehicle trips	Much lower	2 --> (UCC 3,7)	0
	Lower	2 -->(UCC 2,6)	2-->(UCC 2,3)
	Equal	0	1-->(UCC 7)
	Higher	0	1-->(UCC 6)
Load factor	Much higher	2-->(UCC 3,6)	2-->(UCC 3,6)
	Higher	2-->(UCC 2,7)	2-->(UCC 2,7)
Emissions	Much lower	4-->(UCC 2,3,6,7)	1-->(UCC 2)
	Lower	0	1-->(UCC 6)
	Equal	0	2-->(UCC 3,7)
Operational costs	Lower	2-->(UCC 2,7)	1-->(UCC 7)
	Equal	2-->(UCC 3,6)	3-->(UCC 2,3,6)

Eventually, reasons for these deviations in results can be explored. The explanation for the differences in performances will be found in the interviews and the theoretical framework in chapter 3. First, the visualisation of the ex-ante and ex-post performance of the UCC is given in figure 6.1. These are the UCC qualitative ex-post performance stated by four UCC operators. Out of the seven interviewed operators, UCC 5 is excluded from the comparison because the ex-post performance of the UCC was aimed at the best-case scenario instead of the actual situation, and two interviewed parties (UCC 1, UCC 4) did not stated any of the requested performance indicators. The results shown in figure 6.1 are based on the estimations of UCC operator 2,3,6, and 7.

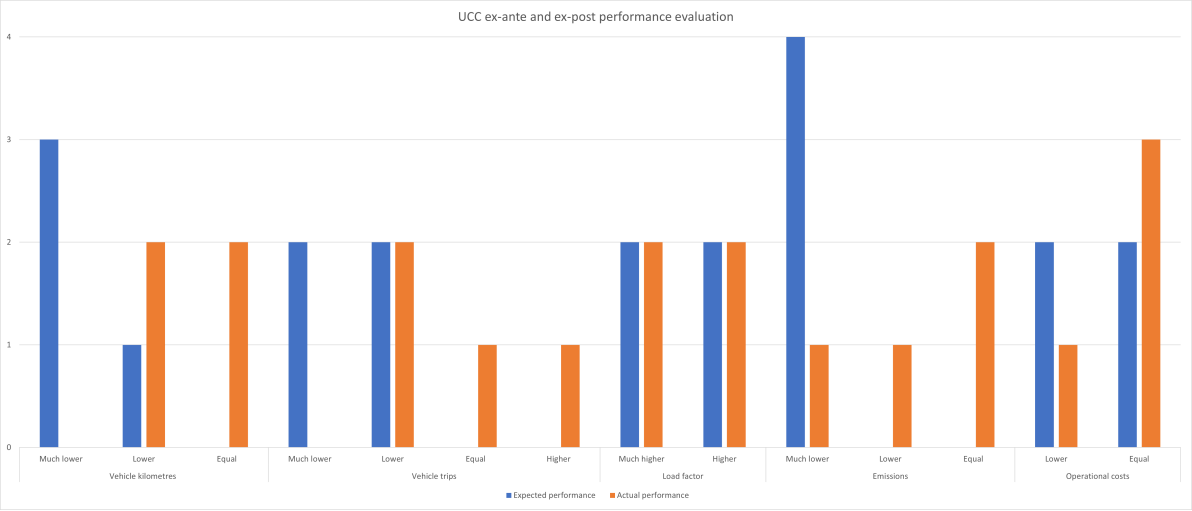


Figure 6.1: ex-ante and ex-post performance of UCCs stated by the UCC operators

When looking at the comparison of the ex-ante and ex-post performance of the current UCC operation, the following differences can be seen for vehicle kilometers, vehicle trips, load factor, emissions, and operational costs. The changes in these indicators are in the range as given in table 6.3.

Table 6.3: five-point likert-scale

Likert-scale	**Definition**
Much higher (5)	+30% and higher
Higher (4)	0 to +30%
Equal (3)	0%
Lower (2)	0 to -30%
Much lower (1)	-30% and lower

Vehicle kilometers: It can be seen that the initial expectations (ex-ante) for vehicle kilometer reduction with the implementation of an UCC were optimistic. However, actual reduction (ex-post) in vehicle kilometers is showing a more nuanced picture. The differences between expected and actual performance suggest that the implementation of UCCs did not lead to the amount of vehicle kilometers reduction that was originally expected. The differences between the expected and actual results can be explained by multiple factors. First, some carriers (3PL) still enter the city after delivering to the UCC (2). Second, the volume of transported freight through an UCC is not big enough to have an impact (6). Third, cooperation among stakeholders is low, resulting in limited utilization of an UCC (3). Last, high rental prices for UCCs create an uneven playing field, consequently limiting their utilization (7).

Vehicle trips: Also vehicle trips are performing less than expected. Were an UCC was expected to reduce the vehicle trips significantly (3,5,7) or lower (2,6), actual results revealed a different and varied picture. One operator reported an increase in the number of trips but a decrease in distance per trip (6). Another operator noted the number of trips to remain unchanged (7), while the last two operators experienced a reduction in the number of trips due to the implementation of the UCC (2,3). The differences between the expected and actual results can be explained by multiple factors. First, some carriers (3PL) still enter the city after delivering to the UCC (2). Secondly, the number of trips was expected to increase because the volume of trucks is consolidated into smaller vans. Yet, the trip length is reduced (6).

Load factor: This is the only indicator that is performing as expected by the UCC operators (2,3,5,6,7). By consolidating the freight, the load factor of the vehicles is higher or even much higher than in a situation without the UCC. Consolidation of freight will improve the load factor because 50% of the trips within the city are for one address (6). Also, vehicles of the UCC are driving with FTL, while the suppliers of the UCC deliver with LTL shipments (2,5). Therefore, improvements for the load factor are made by consolidating at

the UCC.

Emissions: Looking at the expected and actual reduction in emissions can it be seen that the actual reduction is less positive than initially expected. A significant reduction in CO_2 emissions was expected (2,3,5,6,7). Yet, in only one of the cases a significant reduction of emission occurred (2). In one case a emission reduction was found (6) and in two cases no change of emissions was shown (3,7). An emission reduction is established due to the shift to electric vehicles and due to the fact of consolidation. However, the actual performance of the UCC is less favorable than expected and this can be explained by the fact that the transport industry is reluctant for rapid changes. As a result, the adoption of consolidation practices at an UCC decreases, thereby limiting the significant changes in emissions (7). The reduction in emissions is primarily attributed to the utilization of electric vehicles (2,5,6).

Operational costs: It is expected that the operational costs can decrease when pricing agreements are made amongst all stakeholders (3,5,7). Yet, at the moment, no pricing agreements are made and it is still very difficult. Therefore, the actual operational costs for using an UCC are not lower in most of the cases (2,3,6). These operational costs were not lower because suppliers did not supply all of their receivers through the UCC (2). However, the actual operational costs among different stakeholders can remain the same compared to a situation without an UCC. This improves the desirability of an UCC for stakeholders, particularly due to the reason that most of the suppliers and receivers prioritize cost-effectiveness.

6.4. Explanation for differences in the ex-ante and ex-post performance evaluation

In this subsection, the challenges and factors that are crucial for a successful operation of an UCC are explained. The insights retrieved from the interviews will be explored to state the different challenges and successes for the UCC operation. An overview of these challenges and success factors is presented in figure 6.4. The corresponding numbers in the text are associated with the operators mentioned below the table.

Table 6.4: Challenges and success factors for UCC operators (Adapted from Dreischerf et al., 2023

Stage	Challenges	Succes factors
Preparation	Cooperation among stakeholders (1,2,3,4,5,7), Location avalibility (1,4,5,6,7)	UCC as the secondary business case (2,3,4,7)
Start	Cooperation among stakeholders (1,2,3,4,5,7), Organised costs allocation (3,5,7)	Offering multiple services(1,2,3,4,6,7) Launching customer (1,2,7)
Growth	Cooperation among stakeholders (1,2,3,4,5,7), Charging infrastructure (1,2,4,6), fundings to scale up (6)	Implementation of ZEZ (1,2,3,4,5,6,7)
1: Consolidation center 1, 2: Consolidation center 2, 3: Consolidation center 3, 4: Consolidation center 4, 5: PHL (UCC 5), 6: Consolidation center 6, 7: Consolidation center 7		

6.4.1. Challenges

First of all, lack of collaboration and coordination among stakeholders, influencing the operation of an UCC is one of the biggest challenge. This is the main challenge during the preparation, start, and growth stage of an UCC. Each stakeholder point to others for solving the situation, while it can only be successful if everyone collaborates. The cooperation is lacking because of the reluctance of the UFT sector to change. A lot of companies are resistant to adopting new initiatives which can slow down the adoption of UCCs (1,2,3,4,5,7). Also, the cooperation of municipalities may be lacking, even if it could lead to improved performance and sustainability of the city (3,4,5,6). The limited cooperation is established due to the limited awareness and understanding of the advantages of UCCs for stakeholders, which limits their adaption (1,2,3,4,5,6,7). Informing and establishing the participation of various stakeholders to use an UCC is necessary to create sufficient volume and receive a successful operation(1,2,3,4,6,7). The lack of cooperation will lead to struggles for attracting enough volume for operating efficiently. Without a sufficient volume of goods to consolidate, the UCCs may not reach the economies of scale needed for optimal performance.

Secondly, Insufficient or poorly developed locations can lead to inefficiencies within the UCCs (1,2,3,4,5,7). If

the facilities are not properly equipped or located, it can reduce performance and prevent the UCCs from reaching their full potential. Therefore, it's important to allocate different significant locations for UCCs (1,4,5,7). However, if all the prime locations are bought by real estate developers, they might require high rental prices from hub operators for these locations. These high costs will be passed on, which could hurt the attractiveness of city hubs (7). UCCs performance needs to be operating in suitable locations at reasonable prices. This will eventually increase the performance and attractiveness of UCCs. Also, the absence of sufficient charging infrastructure at some locations is hindering the desired growth of UCCs (1,2,4,6). The insufficiency emerges because some of the UCC operators are tenants, relying on the owners for developing their charging infrastructure, using solar panels and batteries (2,6). Additionally, there is currently a shortage of capacity on the power grid, leading to delays in developing charging infrastructure at the UCC. Many UCCs desire to be self-sufficient in electricity to ensure all electric vehicles can be charged when desired (1,2,3,4,6,7).

Thirdly, a lack of Financial or cost-sharing mechanisms among stakeholders may discourage participation in UCCs (3,5,7). Without clear financial benefits and pricing agreements, some parties may be less motivated to actively cooperate in the UCC operations. Implementing a smart costs model is needed to attract both suppliers and receivers and ensure that the costs are properly distributed (7).

Lastly, the lack of sufficient funding for the UCC to reach the required growth was a challenge (6). This limited their ability to scale up their operation. Addressing these challenges and implementing strategies to deal with these challenges can help UCCs to improve their performance and move closer to achieving their intended goals of improving UFT, reducing environmental impacts, and optimizing logistics efficiency.

6.4.2. Success factors

The UCC operators also experienced some success factors during the operation. First of all, a lot of UCCs took the business as a secondary business case. Initially being relocation companies or other service providers (2,3,4,7). In this way, they ensured a steady income from their existing operation, allowing them to experiment with consolidated zero-emission urban logistic services. However, it is important to state that currently, the UFT add a small portion of the overall revenue for these companies (2,3,7). Because the UCCs serve as a secondary business case, this provides a higher level of certainty and investment opportunities for the development of the UCC.

Secondly, value-added services provide advantages for UCCs next to their core function of consolidated transport. These services increase the attractiveness of the UCC for the stakeholders. The value-added services of the interviewed UCC operators in the Netherlands are given in table 2.3. UCC 5 has been excluded from the table as the interviewee was the project manager and not the UCC operator. Additionally, UCC 5 only focused on assessing the impact of consolidation and electric transportation for the UFT.

Table 6.5: Value-added services

Value-added services	UCC 1	UCC 2	UCC 3	UCC 4	UCC 6	UCC 7	Total
Assembling	X		X	X	X	X	5
Delivery flexibility	X		X	X	X	X	5
E-tailing	X		X				2
Freight pick up	X		X	X	X	X	5
Inventory & Order Management	X		X	X	X	X	5
Local Buffer	X		X		X	X	4
Pre-retailing	X		X	X	X	X	5
Quality/Quantity Check	X		X	X	X	X	5
Repackaging	X	X	X	X	X	X	6
Return logistics	X	X	X	X	X	X	6
Support services at the receiver	X	X	X	X	X	X	6
Track & Trace	X		X	X	X		4
Training areas	X			X			2

Table 6.5 shows that a lot of different value-added services are provided by the UCC operators to improve

the operation. These services come with certain advantages like the generation of additional revenue next to the consolidation services. This can improve the financial stability of the UCC. Secondly, services such as packaging, quality and quantity checks can improve customer satisfaction and therefore foster stronger, long-term agreements. Thirdly, increasing the efficiency of UFT by repackaging and reducing waste. Fourthly, value-added services often have higher margins compared to consolidated transport. This can improve the profitability of the UCCs. Fifthly, it can improve the flexibility of the company and increase the utilization of the available resources. So, eventually, value-added services provide advantages for both the operator and the customers.

6.4.3. Governmental influence

Many municipalities are not very clear regarding their UCC policies (3,4,5,7). These municipalities are looking for an effective method to implement the zero-emission zones and simultaneously reduce the number of vehicles. Each municipality is having its regulations for the UFT. The various influence the municipalities have on the different UCC operators is given in table 6.6. The first column is indicating the actual influence of the municipalities, while the second column illustrates the governmental influence desired by the UCC operators.

Table 6.6: Governmental influence

Governmental actual influence	**Governmental influence desired by the UCC operators**
market consolation for a pilot project (1,5)	Strict Access restrictions or stimulation's (1,5)
Vehicle subsidy (1,2,3,4,6,7)	Governmental market regulations (3,4,5,7)
Launching customer(1,2,7)	launching customer (1,2,3,4,6,7)
Additional hours to enter time window (6)	Improve charging infrastructure (1,2,4)
Access restrictions (ZEZ) (1,2,3,4,5,6,7)	Enough vehicle subsidies (2)
	UCC location allocation (1,4,5,7)

The influence of municipalities on the current operation of the UCCs takes various forms. A market consultation was conducted in two cities and these consultations were won by the UCC operators, granting them the opportunity to perform the pilot project (1,5). All operators received subsidies, not only for purchasing electric vehicles (1,2,3,4,6,7) but also for conducting research aimed at improving the operation(3,5,6). This financial support is not directly aimed at improving the performance of the UCCs, but rather at stimulating zero-emission transport within the city. Some municipalities play a role by becoming the launching customers for the UCCs, securing volume for the UCC operations (1,2,7). Despite UCC operators offering their services to the municipalities, it was stated that some municipalities were reluctant to use the UCC for the supplying of their public buildings (3,4,6,7). Additionally, UCC 6 was granted permission to enter the city outside of the specified time windows due to its utilization of consolidated and electric transport (6). Furthermore, municipalities impose certain levels of access restrictions for heavy or polluting vehicles and define time windows for city deliveries (1,2,3,4,5,6,7). These measures are implemented to reduce the environmental impact of the UFT. Looking ahead, the implementation of the zero-emission zones is expected to bring significant changes to UCCs operations.

However, insights from the interview with the operators revealed that they actively seek greater governmental influence in certain areas. They stated the governmental desired influence of the municipalities as shown in table 6.6. These desired influences of the government are first explained and afterwards looked at the feasibility of these implications. First, two operators mentioned that the municipality should adopt stricter access restrictions (5,7) or subsidize entrepreneurs for consolidating their freight at an UCC(1). An uneven playing field will arise when the dedicated hubs with more investment possibilities to occupy the desired locations early. This will, in turn, prevent multi-client hubs from securing these desired locations. Therefore, UCC operators highlighted the need for clearer and more supportive governmental regulations that stimulate the usage of UCCs, ensuring a level playing field and promoting the efficiency of the UCCs. Thirdly, operators wanted the municipalities to act as the launching customer, ensuring significant volume to make the start-up and development easier (1,2,3,4,6,7). Fourthly, some operators experienced difficulties with the connection to the grid and expressed the importance for UCCs that these developments are improved(1,2,4,6). The charging infrastructure is crucial for the UCC operators to perform zero-emission last-mile logistics. Fifthly,

it is important to take a closer look at the role of subsidies and their influence on UCC usage. UCC 2 mentioned that subsidies should be extended to subsidize a broader range of operators for purchasing an electric truck or van (2). However, an interesting perspective is presented by UCC 3, stating that subsidies for electric vehicles can have a counterproductive effect on the utilization of UCCs (3). Such subsidies are expected to create a lower threshold for third-party logistic firms and suppliers to independently perform the last-mile distribution using their own electric fleet. Lastly, UCC operators suggested that the government could play an active role in allocating suitable locations for UCCs (1,4,5,7).

However, to what extent are the desired actions of municipalities actually legally possible? During the interview with the municipality of Rotterdam, these desired governmental influences were discussed, and they will be explained in the following subsection

6.4.3.1. Municipal policy

However, to approach the findings of the operators with a different perspective, two interviews were conducted with the municipality of Rotterdam (8) and Utrecht (9). The vision and guidance of these municipalities can be different from the municipalities in which a few of the UCCs are located. The interviews are shown in appendix B and the main findings will be given in this subsection.

The municipalities are trying to find a balance between overstimulating urban consolidation centers (UCCs) and leaving it solely to the market (8,9). Finding this equilibrium is crucial and might currently lean towards allowing the sector to make the decisions (8,9). By leveraging the expertise of the logistics sector, the best approaches can be chosen for optimal UCC performance, including location selection, vehicle types, and strategies (8,9). The municipality's role is to step in where sector limitations exist and to facilitate measures like the implementation of zero-emission zones (8,9).

Multiple interviews with UCC operators has led to insights for the desired needs. UCC operators encounter challenges and desire the municipality to intervene a bit more. The UCC operators want the municipalities to make stricter access regulation (1,5), increase subsidies (2), act as the launching customer (1,2,3,4,6,7), and allocate locations (1,4,5,7). However, the municipality of Rotterdam allocated 2 million euros in subsidies for innovative logistics concepts such as UCC development and the municipality of Utrecht is giving subsidies to receivers to experiment with the utilization of UCCs. Secondly, establishing access restriction for high load factor requires a lot of cargo verification, which is stated as a complex and unrealistic process by the municipality of Rotterdam(8). Despite the complexity, the municipality of Utrecht is trying to establish these access restriction by requiring a minimum load factor and minimum number of delivery addresses before a vehicle can enter the city (9). Thirdly, While the municipality of Rotterdam is working on designating certain location for UCCs (8), the municipality of Utrecht is not designating certain locations for UCCs (9). The municipality of Utrecht is primarily focused on efficient and sustainable transport, with the efficiency aimed at reducing the number of vehicles and increasing the load factor of the vehicles in the city. UCCs are seen as an alternative to reduce the number of trips in the city, but the municipality also encourages other alternatives and cooperation among stakeholders (9). The focus of the municipalities is on consolidated, electric, and efficient transport, not solely on UCCs (8,9). For designating certain location for UCCs, delicate considerations must be made between different desired functionalities at the locations that serve the city's needs (8). To prioritize city logistics with urban consolidation centers, the municipality can incorporate regulations in the environmental planning to enforce specific functions on these locations(8). Lastly, The municipality is not acting as a launching customer due to the decentralized location of offices in Rotterdam (9). Nonetheless, contracts encourage and require consolidated zero-emission transport to government buildings, boosting the attractiveness of UCCs indirectly in the tendering process (8,9). The municipality of Utrecht has implemented urban freight transport privileges for UCCs, such as driving on bus lanes, no delivery time-window restrictions, and a C1 closed declaration (9).

Despite their potential, the impact of UCCs remains modest, but even a 10-15% reduction in certain segments could contribute to the city's livability (8). Transparent benefits of the UCCs are essential, requiring comprehensive cost analyses and pricing agreements to attract stakeholders (8,9). Addressing the transparency of last-mile costs is a challenge (8,9). Each supplier or carrier has its own cost model, making transportation costs less transparent. Therefore, costs savings of an UCC are difficult to measure accurately (9). As UCCs are still in their starting phases, desired volumes have not yet been reached due to limited cooperation

(8). Achieving optimal UCC performance remains a goal, and the implementation of zero-emission zones is expected to drive greater collaboration and increase the performance of the UCCs (8). The municipality of Utrecht is not aware of the current performance of the UCCs. However, they plan to collect more data, including the number of trips and load factors, by incorporating these metrics into the requirements for obtaining exemptions (9).

7

Discussion, conclusion and recommendations

The limitations of the research will be given in the discussion. Secondly, the results of this research will be concluded and discussed to answer the main question. Lastly, recommendations to improve the performance of UCCs will be made together with recommendations for further investigations.

7.1. Discussion

The missing consistency in the quantitative data for UCCs in the literature had a negative impact on the validity of the research. Initially, the ex-post and ex-ante performance evaluation of the UCCs was focused on quantitative data. When it became apparent that the quantitative data from the literature ranged quite a lot and were difficult to compare, together with the absence of actual performance data from the UCCs, the focus of this research switched to a qualitative method, supplemented with the available quantitative data to achieve more reliable results. This approach eventually brought more dept into the research and increased the external validity, since both methods complemented and strengthened each other. It should be noted that the ex-post performance is based on the expectations from UCC operators and not on data. This may introduce some biases into the results because these UCC operators have significant stakes in the performance of UCCs, and they may prefer highly positive outcomes. However, the UCC operators do indicate that their UCCs are not performing as initially expected. This conclusion, to some extent, reflects the honesty of the UCC operators. To obtain the quantitative data nonetheless, it would have been possible to conduct quantitative performance measurements for each UCC, similar to the research conducted for UCC 2. However, due to time constraints, these quantitative measurements were not carried out for each UCC in this study.

Additionally, quantitative data of UCC 3 and UCC 5 do not accurately reflect the actual performance of these UCCs. The results stated by these operators were estimated based on the number of inbound vehicles versus outbound vehicles. So, when the goods of four vehicles were consolidated in one vehicle at the UCC, a 75% vehicle trip reduction would occur. However, this assumption does not take the actual actions of the suppliers or freight carriers into account. It is possible that the suppliers, after delivering to these UCCs, still enter the city for their other products. This could have a significant impact on the estimated reduction in vehicle kilometers, vehicle trips, and emissions. Because the measurement model for UCC performance is not clear or not present, it is very difficult to compare the various performances of the UCCs in the Netherlands. Currently, there is no consistency among the different UCCs for measuring data. However, to make valid statements about the performance of UCCs in the Netherlands, it is important to establish requirements for UCCs when measuring performance data. In this way, UCCs will collect the desired data and be more transparent when presenting this data. This will allow the performances of different UCCs to be compared effectively.

Despite the positive expectations in the literature for UCCs. This research showed that the impact of an UCC is not reaching it's expected performance. Mainly due to the limited stakeholder cooperation for utilizing an UCC. The municipalities believe that the market should address this issue independently. However, it is evident that the market is currently unable to optimize the performance of the UCCs on its own. If the UCCs

serve a public interest for reducing the vehicle trips within the city, is it essential for the municipality to use policies for stimulating the UCCs. If no or very little cooperation among the stakeholders is established, utilization of UCCs will remain minimal until the implementation of the ZEZ. To ensure that UCCs are more widely adopted in the coming years and thus have a greater impact on urban freight logistics, recommendations for both UCC operators and municipalities are provided in the recommendations section.
To gain a better understanding of the current varying policies of municipalities, it would be beneficial to interview more municipalities that are planning to implement zero-emission zones. Currently, two municipalities have been interviewed that already have active policies regarding consolidated and electric transport within the city. These two municipalities share a similar perspective on the desired policies and what to achieve with these policies. However, interviewing a municipality with limited policy regarding city hubs or consolidated transport would make the results more reliable for all municipalities.

Additionally, for this research, the decision was made to only interview municipalities and UCC operators. These stakeholders have the highest interest in the subject, and are therefore highly informative. Suppliers and freight carriers would be interesting parties to interview if quantitative data on the current UCC performance needs to be collected. Since this research primarily focuses on the extent to which UCC operators expectations regarding UCCs are being met by current performance, the interview results from UCC operators and municipalities are most important. However, when interviewing the suppliers, carriers and receivers, the lack of cooperation with the UCCs could have been researched more. Also, this study might have been conducted prematurely to draw comprehensive conclusions about the effectiveness of urban consolidation centers. The expected performance of the UCCs in the literature and interviews are focused on the optimal performance an UCC can achieve in a certain city. However, the actual performance has not yet reached these optimal expectations stated in the literature. Nevertheless, the implementation of the zero-emission zones will improve the future urban consolidation center performances.

7.2. Conclusion

Urban freight transport is growing due to population growth and e-commerce. This has led to an increasing urge for sustainability and livability in cities, a priority for both municipalities and inhabitants. Therefore, 30 to 40 municipalities in the Netherlands are implementing zero-emission zones in their cities. However, reducing the number of vehicle movements is also important to preserve a livable and accessible city in the future. This is one of the reasons urban consolidation centers (UCC) are developed to consolidate freight at the edge of the city center and deliver the city center with electric vehicles. This research shows to what extent the ex-post effects of UCCs meets the ex-ante expectations from the UCC operators. However, even after 50 years of UCC operation and research, a lot of UCCs are still not using the proper data measurement models at the UCCs to measure the performance, which limited the availability of quantitative data. This conclusion indicates that despite the effort of municipalities to stimulate the performance of UCCs, even with financial support, there are hardly any requirements for the monitoring of the desired results. The measurement of UCC performance by operators is something that must be required to gain a clear understanding of the social effects of the UCCs on the urban area or show if the allocated UCC subsidies achieve the desired goal of reducing the vehicle trips in the cities. The performance measurement model also serves as a validation tool for municipalities to state the effectiveness of the financial support to the urban consolidation centers.

Because of the missing of quantitative performance data of the UCCs, this research switched to qualitative performance data for comparing the ex-ante and ex-post performance of the UCCs. However, the ex-ante and ex-post performance were both stated by the UCC operators which may include some biases. Yet, the findings indicated that the actual effects of the urban consolidation centers do not yet align with the ex-ante expectations for the degree of kilometer reduction, trip reduction, emission reduction, operational costs reduction. The only indicator meeting its expectation is the increased load factor. This, to some extent, reflects a certain level of reliable statements made by the UCC operators.

Despite the disappointing performances, the expectation is that the UCCs still improve the sustainability of the city. So, the implementation of the UCCs is still reducing the number of vehicle trips, vehicle kilometers, and vehicle emissions, but not as much as initially expected. The performance of the UCCs is expected to improve when the utilization of UCCs is increasing with the implementation of the ZEZ, together with the throughput of freight. However, the slow increase in volume is primarily caused by many suppliers and re-

ceivers not yet seeing the benefits of utilizing an UCCs for the last-mile transport. The process of convincing different stakeholders progresses slowly and a lot of discussions are needed before these parties are seeing the potential of UCCs and are willing to cooperate. However, this factor will be crucial in achieving better performances when the zero-emission zones are implemented. Also, the behavior of suppliers and carriers (3PL) who still entered the city after delivering goods to an UCC is a barrier for achieving better performance. The incentive for these stakeholders by using an UCC is based on the contractual agreements with the receiver. As a result, the expected reduction in vehicle kilometers and trips has not been realized.

Additionally, the lack of proper pricing agreements and usage of the available pricing allocation models is limiting the cooperation of the suppliers and receivers. It important to improve the willingness for cooperation among the suppliers and receivers by using cost allocation models for the UCCs. Many stakeholders are under the impression that an UCC will lead to additional operational costs because of the extra handling time. However, a well-structured cost allocation and clear pricing agreements can result in cost savings. Last, the limited electricity grid capacity in the Netherlands poses challenges to the growth of certain urban consolidation centers. As a result, they desire to become self-sufficient by installing solar panels and batteries. However, some urban consolidation centers are rented warehouses, and therefore dependent on the tenant for the charging infrastructure. This limited flexibility to increase the charging infrastructure when needed impacts the desired growth and performance of some UCCs. Overcoming these barriers will improve the societal value of UCCs for the cities.

Municipalities are seeking solutions to promote both electrification and consolidation to reduce to number of trips and emissions in the city. Yet, at the moment the reduction in vehicle trips is less than expected with the implementation of an UCC. Therefore, the environmental impact is mainly caused by the electrification of the vehicles for the last-mile distribution, with consolidation having a smaller impact. Given the societal value of consolidated transport to create a sustainable city with less vehicles, it is essential for municipalities that consolidated transport in the city is improved. Still, UCC operators experience the lack of specific policies tailored to urban consolidation centers. It is partly correct that there is a lack of specific policies regarding UCCs. This is because the municipalities do not directly promote UCCs but are more focused on stimulating consolidated transport. How the market manages to facilitate this is up to them according to the municipalities. UCCs are not seen as the only solution to improve consolidation. So, the stimulation of consolidated transport indirectly lead to the increased utilization of UCCs. However, if the UCC operators provide valuable recommendations to improve the performance of the UCCs, the municipality is open for such suggestions.

Additionally, the operators want the municipalities to be more involved as the launching customer and in the allocation of proper locations. UCC operators, desire municipalities to regulate the market more to create a level playing field for urban consolidation centers by finding desired locations. Otherwise, dedicated hubs with better financial resources are buying all the desired locations, leaving little space for the multi-client hubs. However, the municipality of Rotterdam and Utrecht says that the market is responsible for the UCC operation and they prefer to use limited market regulation.

So, 'To what extent do the actual effects of UCCs meet the ex-ante expectations?'. Interviews showed that the ex-post performance of the urban consolidation centers did not meet the ex-ante expectations. These differences are mainly caused by the limited stakeholder cooperation for utilizing an UCC. As a results, low volumes are transported through the UCCs and some suppliers are still entering the city, which will have an negative impact on the expected vehicle kilometers, vehicle trips, emissions, and operational costs. Cost allocation systems need to be used by the UCC operators for convincing multiple receivers and carriers for cooperating with the UCCs. Additionally, municipalities need to stimulate consolidated transport in their contracts and allocate good locations for UCCs to increase the cooperation and performance of UCCs. However, the implementation of the zero-emission zones is expected to bring significant changes and an increased urgency for suppliers and receivers to cooperate with UCCs, thereby increasing the volume of freight and improving the actual performance of the UCCs.

7.3. Recommendations

Three kinds of recommendations will be made in this section. First of all, recommendations for further investigation will be made. Secondly, recommendations for municipalities are made to stimulate the desired

consolidated transport. Lastly, recommendations for UCC operators will be made to improve their performance.

For further investigations, it is good to include more municipalities in the interviews to make better statements about the municipalities involvement for UCCs in the different cities. At the moment only two municipalities are interviewed and each municipality can have very different policies from each other. Therefore, it is important to investigate the different policies of each municipality were a UCC is located. Secondly, it is recommended to conduct in-depth research 2025 to gain more quantitative data on the actual performance of multiple UCCs across different cities in the Netherlands when the ZEZ are implemented. This will provide a more accurate understanding of the performance of UCCs on different indicators such as vehicle kilometers, vehicle trips, emissions, load factor, and operational costs. Especially, because the implementation of the ZEZ is going to have a big impact on the utilization and actual performance of the UCCs. Lastly, investigate the reasons for the lack of cooperation with an UCC using in-depth interviews with suppliers,carriers, and receivers.

Even after 50 years of UCC operation and research, it is still not the case that every UCC has effectively captured its ex-ante and ex-post performance using desired measurement models. Despite the high amount of invested money in researching and enhancing the performance of UCCs by the municipalities. It is therefore recommended to make requirements for the UCC operators before they start operating and receive any form of subsidies. The measurement model should include the following requirement:

- Calculations of the initial route of all carriers or suppliers from start to receiver.
  - With separately estimates for the distance to the city and distance within the city. (vehicle kilometers, trips, load factor, costs, transported volume, and emissions)
- Calculation of the the driven kilometers,trips,load factor, costs, transported volume, and emissions when using an UCC.
  - So, for both the trip from suppliers to UCC and trip from UCC to the receivers.
- Ask the suppliers if they still enter the city after supplying goods to the UCC.
- Measure inbound vs outbound vehicles.
- Measure the fuel or energy use of the inbound and outbound vehicles.
- Calculate the last-mile impact as well as the impact from supplier to receiver.

When each UCC operator is measuring these data, better statements and monitoring can be done for stimulating the UCC performance by operators and municipalities. It is crucial to accurately describe the part of the operation being measured in order to effectively compare the the results. Ideally, both the last-mile impact and the impact on the entire operation should be indicated and well-described for accurate measurement. It is the responsibility of the UCC operators to implement these measurement models, but the municipalities can stimulate the adaption of these models by requiring it in tenders or before subsidies are provided.

The Municipalities can adapt various policies in relation to the sustainability of urban logistics. For each of the desired policies, an recommendation is made for improving the urban consolidation centers performance.

Law and regulator:

- Municipalities need to adapt transparent urban freight policies for UCC operators, so they know what to expect from the municipalities.
  - Transparent regulations will ensure that UCC operators understand what to expect, enabling them to operate more confidently, and potentially improving performance of the operation. Uncertainties from the municipalities leads to hesitant decision from the UCC operators and other stakeholders.

- Implementation of Zero emission zones (ZEZ)
  - The implementation of ZEZ is stimulating the utilization of UCCs when multiple vehicles are not allowed to enter the city.
- Implement access restrictions for small deliveries.
  - By requiring vehicles with higher load factors and not allowing single deliveries in the city. A higher load factor is achieved and fewer trips will be made within the city center. Therefore, stimulating the utilization of UCCs. The municipality of Utrecht is currently investigating the possible implementation of this complex access restriction with requirements aimed at a minimum load factor and minimum number of delivery addresses within the city.

Launching customer: Municipalities need to require the consolidation of freight in their purchase policy.

- Which will result in the direct or indirect stimulation of UCC utilization by suppliers.
- Which effects the throughput of freight for an UCC, making it easier for them to start and remain operational.

Subsidy provider: Before providing subsidy to UCC operators, require the adaption of the measurement model explained above.

- The usage of measurement models by the UCCs makes it possible to monitor the performance of different UCCs in the Netherlands. As a results, it us possible to determine quickly whether certain goals or expectations are being met.

Innovative procurer: Municipalities need to encourage the utilization of construction UCCs in the construction tenders.

- Stricter requirements can include a limited number of trips or the usage of cleaner or electric vehicles.

Director: The municipality can bring multiple stakeholders together for the creation of common principles.

- Especially, to improve the cooperation of multiple stakeholders for utilizing an UCC.

Private Public Partnership: Include the significance and essence of UCCs in the spatial planning and environment.

- So, a plot of land can be designed for the purpose of multi-client hubs. Otherwise, dedicated hubs with better financial resources will buy the desired locations, leaving little space for the multi-client hub.
- However, it remains essential for municipalities to collaborate with operators in identifying suitable locations, as the operators are the experts in this field of operation.
- It is important that the UCCs do not face high rental costs. Otherwise, these costs are being passed on to customers, resulting in a reduced utilization of the UCCs.

However, every euro spent by the municipality can only be spent once. Therefore, it is recommended that the municipality primarily focus on requiring consolidation in procurement's and in their own purchase policies, along with the requirement of transparent performance measurement model of the UCCs. Together with the implementation of the ZEZ, this will lead to better performance of the UCCs in the future. Ultimately, stakeholders themselves need to recognize the importance and utility of the UCCs.

To improve the performance of the UCCs, recommendations for UCC operators are made. The first recommendations for UCC operators is to use the available cost allocation models for improving the transparency and show the operational cost reductions for using an UCC. The limited usage of transparent cost allocation systems results in various stakeholders being unable to gain a clear understanding of where cost savings can be achieved. Due to this lack of transparency, stakeholders may be less inclined to utilize a UCC. Many stakeholders remain cost-oriented and are more likely to use a UCC if it offers cost benefits. Therefore, it is crucial to separate transportation costs from the total product costs in different phases, enabling a more effective allocation of transportation costs across various segments of the transport process. Secondly, being energy

self-sufficient with solar panels and batteries to secure the availability of charging infrastructure for future fleet growth. This will ensure that the UCCs are able to grow their fleet and charge the cars when needed. Thirdly, provide different value-added services to increase the revenue of the UCC operation. These value-added services provide different advantages like the improved customer satisfaction, revenue growth, more market opportunities, and higher efficiency. Fourthly, keep in touch with the municipalities to improve the level playing field for UCCs by finding proper locations. Fifthly, continue engaging suppliers, receivers, and carriers (3PL). Inform them about the upcoming zero-emission zones and the benefits of delegating the last-mile distribution to the UCC. This is the most important task for the UCC operators to increase the volume of the freight and increase the performance. Lastly, use the requirements for the measurement model mentioned above for monitoring and evaluating the UCC performance to adapt strategies based on these findings.

Additionally, it is recommended for Buck Consultants International (BCI) to develop a multi-client hub concept. Including the location selection, location requirements, multiple services, storage space, a performance measurement model, and a recommended cost-allocation model. This ideal-multi client hub concept, together with the desired policies of municipalities for improving the UCC performance can be used for advising various municipalities and UCC operators on the desired implementation of a multi-client hub for reducing the number of vehicle trips in a city and improving the business case of the UCCs. This concept is developed to limit some of the challenges faced by multiple UCC operators and improve the performance of the UCCs.

Bibliography

Agrebi, M., Abed, M., & Omri, M. N. (2015). Urban distribution centers' location selection's problem: A survey. *2015 4th International Conference on Advanced Logistics and Transport (ICALT)*, 246–251.

Akgün, E. Z., Monios, J., Rye, T., & Fonzone, A. (2019). Influences on urban freight transport policy choice by local authorities. *Transport Policy*, *75*, 88–98. https://doi.org/https://doi.org/10.1016/j.tranpol.2019.01.009

Allen, J., Browne, M., Woodburn, A. G., & Leonardi, J. (2012). The Role of Urban Consolidation Centres in Sustainable Freight Transport. *Transport Reviews*, *32*(4), 473–490. https://doi.org/10.1080/01441647.2012.688074

Allen, J., Browne, M., Woodburn, A. G., & Leonardi, J. (2014). A Review of Urban Consolidation Centres in the Supply Chain Based on a Case Study Approach. *Supply chain forum*, *15*(4), 100–112. https://doi.org/10.1080/16258312.2014.11517361

Alsaawi, A. (2014). A critical review of qualitative interviews. *European Journal of Business and Social Sciences*, *3*(4).

Andruetto, C. (2022). Exploring electrification, consolidation, cargo bikes and automation using a sustainability performance assessment framework.

Arvidsson, N. (2013). The milk run revisited: A load factor paradox with economic and environmental implications for urban freight transport. *Transportation Research Part A: Policy and Practice*, *51*, 56–62. https://doi.org/https://doi.org/10.1016/j.tra.2013.04.001

Aung, K. T., Razak, R. A., & Nazry, N. N. M. (2021). Establishing validity and reliability of semi-structured interview questionnaire in developing risk communication module: A pilot study. *Edunesia: Jurnal Ilmiah Pendidikan*, *2*(3), 600–606.

Bailey, P. D., Haq, G., & Gouldson, A. (2002). Mind the gap! comparing ex ante and ex post assessments of the costs of complying with environmental regulation. *European Environment*, *12*(5), 245–256.

Balm, S., Browne, M., Leonardi, J., & Quak, H. (2014). Developing an evaluation framework for innovative urban and interurban freight transport solutions. *Procedia-Social and Behavioral Sciences*, *125*, 386–397.

Björklund, M., & Johansson, H. (2018). Urban consolidation centre – a literature review, categorisation, and a future research agenda. *International Journal of Physical Distribution & Logistics Management*, *48*(8), 745–764. https://doi.org/10.1108/ijpdlm-01-2017-0050

Björklund, M., & Simm, N. (2019). Roles and perspectives when estimating energy and environmental potentials of urban consolidation. *Energies*, *12*(24), 4811.

Blokzijl, M. (2021). Urban distribution hub policy design. combining hub user requirements with municipal distribution visions.

Bolscher, D. (2023). Schaarse ruimte dwingt tot delen van stadshubs. https://www.abnamro.nl/nl/zakelijk/insights/sectoren-en-trends/logistiek/schaarse-ruimte-dwingt-tot-delen-van-stadshubs.html

Bosona, T. (2020). Urban Freight Last Mile Logistics—Challenges and Opportunities to Improve Sustainability: A Literature Review. *Sustainability*, *12*(21), 8769. https://doi.org/10.3390/su12218769

Boysen, N., & Fliedner, M. (2010). Cross dock scheduling: Classification, literature review and research agenda. *Omega*, *38*(6), 413–422. https://doi.org/https://doi.org/10.1016/j.omega.2009.10.008

Browne, M., Allen, J., & Leonardi, J. (2011). Evaluating the use of an urban consolidation centre and electric vehicles in central london. *IATSS Research*, *35*(1), 1–6. https://doi.org/https://doi.org/10.1016/j.iatssr.2011.06.002

Browne, M., Allen, J., Nemoto, T., Patier, D., & Visser, J. (2012). Reducing social and environmental impacts of urban freight transport: A review of some major cities [Seventh International Conference on City Logistics which was held on June 7- 9,2011, Mallorca, Spain]. *Procedia - Social and Behavioral Sciences*, *39*, 19–33. https://doi.org/https://doi.org/10.1016/j.sbspro.2012.03.088

Browne, M., Sweet, M., Woodburn, A., & Allen, J. (2005). Urban freight consolidation centres final report. *Transport Studies Group, University of Westminster*, *10*.

Buck Consultants International. (2020). Onderzoek naar mogelijkheden en kansen stedelijke distributie Den Haag.

Buck Consultants International. (2023). Onderzoek marktkansen Stadslogistiek.

CBS. (2023). Aandeel hernieuwbare elektriciteit met 20 procent gestegen in 2022. https://www.cbs.nl/nl-nl/nieuws/2023/10/aandeel-hernieuwbare-elektriciteit-met-20-procent-gestegen-in-2022

Cerutti, A. K., Contu, S., Ardente, F., Donno, D., & Beccaro, G. L. (2016). Carbon footprint in green public procurement: Policy evaluation from a case study in the food sector. *Food Policy*, *58*, 82–93. https://doi.org/https://doi.org/10.1016/j.foodpol.2015.12.001

Cook, R. L., Gibson, B. J., & MacCurdy, D. (2005). A lean approach to cross docking.

de Bok, M., Tavasszy, L., & Sebastiaan Thoen. (2022). Application of an empirical multi-agent model for urban goods transport to analyze impacts of zero emission zones in the netherlands. *Transport Policy*, *124*, 119–127. https://doi.org/https://doi.org/10.1016/j.tranpol.2020.07.010

Deloitte. (n.d.). Power and Interest Grids - Making Governance Fun. https://www2.deloitte.com/mt/en/pages/risk/articles/mt-risk-article-power-and-interest-grids.html

Dreischerf, A. J., & Buijs, P. (2022). How urban consolidation centres affect distribution networks: An empirical investigation from the perspective of suppliers. *Case Studies on Transport Policy*, *10*(1), 518–528. https://doi.org/https://doi.org/10.1016/j.cstp.2022.01.012

Dreischerf, A. J., Buijs, P., & Balm, S. (2023). Exploring the setup and development of receiver-led urban consolidation centres in the netherlands [manuscript submitted for publication]. *Faculty of Economics and Business, University of Groningen*.

Egilmez, G., Gumus, S., & Kucukvar, M. (2015). Environmental sustainability benchmarking of the u.s. and canada metropoles: An expert judgment-based multi-criteria decision making approach. *Cities*, *42*, 31–41. https://doi.org/https://doi.org/10.1016/j.cities.2014.08.006

Escuín, D., Millán, C., & Larrodé, E. (2012). Modelization of Time-Dependent Urban Freight Problems by Using a Multiple Number of Distribution Centers. *Networks and Spatial Economics*, *12*(3), 321–336. https://doi.org/10.1007/s11067-009-9099-6

Eurostat. (2021). A fifth of road freight kilometres by empty vehicles. https://ec.europa.eu/eurostat/en/web/products-eurostat-news/-/ddn-20211210-1

Filippi, F., Nuzzolo, A., Comi, A., & Site, P. D. (2010). Ex-ante assessment of urban freight transport policies [The Sixth International Conference on City Logistics]. *Procedia - Social and Behavioral Sciences*, *2*(3), 6332–6342. https://doi.org/https://doi.org/10.1016/j.sbspro.2010.04.042

Galbreth, M. R., Hill, J. A., & Handley, S. (2008). An investigation of the value of cross-docking for supply chain management. *Journal of business logistics*, *29*(1), 225–239.

Giampoldaki, E., Madas, M., Zeimpekis, V., & Vlachopoulou, M. (2021). A state-of-practice review of urban consolidation centres: Practical insights and future challenges. *International Journal of Logistics Research and Applications*, 1–32.

Goddefroy, N., & Alexandrer, M. (2013). Optimizing the dock door assignment problem in cross-docking warehouses. *Universiteit Gent Faculteit Economie En Bedrijfskunde*.

Gogas, M., & Nathanail, E. (2017). Evaluation of Urban Consolidation Centers: A Methodological Framework. *Procedia Engineering*, *178*, 461–471. https://doi.org/10.1016/j.proeng.2017.01.089

Golafshani, N. (2003). Understanding reliability and validity in qualitative research. *The qualitative report*, *8*(4), 597–607.

Heale, R., & Twycross, A. (2018). What is a case study? evidence-based nursing 21.1: 7-8.

Hezarkhani, B., Slikker, M., & Van Woensel, T. (2019). Gain-sharing in urban consolidation centers. *European Journal of Operational Research*, *279*(2), 380–392. https://doi.org/https://doi.org/10.1016/j.ejor.2019.05.028

Hub Leiden. (2023). Gebundeld & Zero-emissie unieke pilot Leidse horeca. https://hub-leiden.nl/

Hubbard, W. R. (2008). Efficient definition and communication of patent rights: The importance of ex post delineation. *Santa Clara Computer & High Tech. LJ*, *25*, 327.

Huijsmans, J., & Wildeboer, Y. (1997). Freight distribution into large european cities. *Freight and*.

Isa, S. S., Lima, O. F., & Vidal Vieira, J. G. (2021). Urban consolidation centers: Impact analysis by stakeholder. *Research in Transportation Economics*, *90*, 101045. https://doi.org/https://doi.org/10.1016/j.retrec.2021.101045

Janjevic, M., & Ndiaye, A. (2017). Investigating the theoretical cost-relationships of urban consolidation centres for their users [SI: Freight Behavior Research]. *Transportation Research Part A: Policy and Practice*, *102*, 98–118. https://doi.org/https://doi.org/10.1016/j.tra.2016.10.027

Kiba-Janiak, M. (2017). Urban freight transport in city strategic planning [Sustainable efficiency and management issues in urban goods transport: new trends and applications]. *Research in Transportation Business & Management*, *24*, 4–16. https://doi.org/https://doi.org/10.1016/j.rtbm.2017.05.003

Kin, B., Hopman, M., & Quak, H. (2021). Different Charging Strategies for Electric Vehicle Fleets in Urban Freight Transport. *Sustainability*, *13*(23), 13080. https://doi.org/10.3390/su132313080

Léonardi, J., & Baumgartner, M. (2004). Co2 efficiency in road freight transportation: Status quo, measures and potential. *Transportation Research Part D: Transport and Environment*, *9*(6), 451–464. https://doi.org/https://doi.org/10.1016/j.trd.2004.08.004

Lucas, S. R. (2016). Where the rubber meets the road: Probability and nonprobability moments in experiment, interview, archival, administrative, and ethnographic data collection. *Socius*, *2*, 2378023116634709.

Malterud, K., Siersma, V. D., & Guassora, A. D. (2016). Sample size in qualitative interview studies: Guided by information power [PMID: 26613970]. *Qualitative Health Research*, *26*(13), 1753–1760. https://doi.org/10.1177/1049732315617444

MDS Transmodal. (2012). Dg move european commission: Study on urban freight transport. *Final report. Chester, UK: MDS Transmodal Limited*.

Mepparambath, R. M., Cheah, L., & Courcoubetis, C. (2021). A theoretical framework to evaluate the traffic impact of urban freight consolidation centres. *Transportation Research Part E: Logistics and Transportation Review*, *145*, 102134. https://doi.org/https://doi.org/10.1016/j.tre.2020.102134

Motheral, B. R. (1998). Research methodology: Hypotheses, measurement, reliability, and validity. *Journal of Managed Care Pharmacy*, *4*(4), 382–390.

Nations, U. (2018). World's population increasingly urban with more than half living in urban areas. https://www.un.org/development/desa/en/news/population/world-urbanization-prospects.html

Nederlandse Emissieautoriteit. (2022). CO2-heffing algemeen. https://www.emissieautoriteit.nl/onderwerpen/co2-heffing-algemeen

Nemoto, T. (1997). Area-wide inter-carrier consolidation of freight in urban areas, 1997. 5. *Transport Logistics*.

Nenni, M. E., Sforza, A., & Sterle, C. (2019). Sustainability-based review of urban freight models. *Soft Computing*, *23*, 2899–2909.

Nordtømme, M. E., Bjerkan, K. Y., & Sund, A. B. (2015). Barriers to urban freight policy implementation: The case of urban consolidation center in oslo. *Transport Policy*, *44*, 179–186.

Olsson, J., & Woxenius, J. (2014). Localisation of freight consolidation centres serving small road hauliers in a wider urban area: Barriers for more efficient freight deliveries in gothenburg. *Journal of Transport Geography*, *34*, 25–33.

Paddeu, D. (2017). The bristol-bath urban freight consolidation centre from the perspective of its users. *Case Studies on Transport Policy*, *5*(3), 483–491. https://doi.org/https://doi.org/10.1016/j.cstp.2017.06.001

Paddeu, D. (2021). The Five Attribute Performance Assessment (FAPA) model to evaluate the performance of an urban consolidation centre. *Research in Transportation Economics*, *90*, 101065. https://doi.org/10.1016/j.retrec.2021.101065

Pålsson, H. (2014). Diversified service offerings in city logistics-understanding the need for different groups of users. *26th Annual NOFOMA Conference, 2014*, 329–345.

Patier, D., & Browne, M. (2010). A methodology for the evaluation of urban logistics innovations. *Procedia-Social and Behavioral Sciences*, *2*(3), 6229–6241.

Quak, H. (2008). Sustainability of Urban Freight Transport: Retail Distribution and Local Regulations in Cities. https://hdl.handle.net/1765/11990

Quak, H., Nesterova, N., van Rooijen, T., & Dong, Y. (2016). Zero emission city logistics: Current practices in freight electromobility and feasibility in the near future [Transport Research Arena TRA2016]. *Transportation Research Procedia*, *14*, 1506–1515. https://doi.org/https://doi.org/10.1016/j.trpro.2016.05.115

Quak, H., Van Duin, R., & Hendriks, B. (2020). Running an urban consolidation centre: Binnenstadservice 10 years back and forth. *Transportation research procedia*, *46*, 45–52. https://doi.org/10.1016/j.trpro.2020.03.162

Reyna López, A., & Serrano Cáceres, D. (2020). Defining the concept of city hub in urban consolidation schemes a case study in the city of gothenburg.

Roca-Riu, M., & Estrada, M. (2012). An evaluation of urban consolidation centers through logistics systems analysis in circumstances where companies have equal market shares [Seventh International Con-

ference on City Logistics which was held on June 7- 9,2011, Mallorca, Spain]. *Procedia - Social and Behavioral Sciences*, *39*, 796–806. https://doi.org/https://doi.org/10.1016/j.sbspro.2012.03.148

Schell, C. (1992). The value of the case study as a research strategy. *Manchester Business School*, *2*(1), 1–15.

Sheth, M., Butrina, P., Goodchild, A., & McCormack, E. (2019). Measuring delivery route cost trade-offs between electric-assist cargo bicycles and delivery trucks in dense urban areas. *European transport research review*, *11*, 1–12.

Simoni, M. D., Bujanovic, P., Boyles, S. D., & Kutanoglu, E. (2018). Urban consolidation solutions for parcel delivery considering location, fleet and route choice. *Case Studies on Transport Policy*, *6*(1), 112–124. https://doi.org/https://doi.org/10.1016/j.cstp.2017.11.002

Stroosma, E. (2021). 'Infrastructuur heeft tot 2040 € 60 miljard extra nodig'. *Transport & Logistiek*. https://transportlogistiek.nl/branche/infrastructuur/infrastructuur-heeft-tot-2040-e-60-miljard-extra-nodig/

Swaen, B. (2022). Interviewtechnieken voor een succesvol interview: Tips en voorbeelden. *Scribbr*. https://www.scribbr.nl/onderzoeksmethoden/interviewtechnieken/

Teo, J. S., Taniguchi, E., & Qureshi, A. G. (2015). Evaluation of Urban Distribution Centers Using Multiagent Modeling with Geographic Information Systems. *Transportation Research Record*, *2478*(1), 35–47. https://doi.org/10.3141/2478-05

Tozzi, M., Corazza, M. V., & Musso, A. (2014). Urban goods movements in a sensitive context: The case of parma. *Research in Transportation Business & Management*, *11*, 134–141.

Tsiulin, S., Hilmola, O.-P., & Goryaev, N. (2017). Barriers towards development of urban consolidation centres and their implementation: Literature review. *World Review of Intermodal Transportation Research*, *6*(3), 251–272.

Van Belle, J., Valckenaers, P., & Cattrysse, D. (2012). Cross-docking: State of the art. *Omega*, *40*(6), 827–846.

van den Biggelaar, T., van den Heuvel, J., & Kerseboom, J. (2021). No more Mr.SMART- guy? *Nederlandse Vereniging van Rekenkamers & Rekenkamercommissies*. https://www.nvrr.nl/bibliotheek/rekenkamerrapporten/

van Duin, J., Quak, H., & Muñuzuri, J. (2010). New challenges for urban consolidation centres: A case study in the hague [The Sixth International Conference on City Logistics]. *Procedia - Social and Behavioral Sciences*, *2*(3), 6177–6188. https://doi.org/https://doi.org/10.1016/j.sbspro.2010.04.029

Van Heeswijk, W., Larsen, R. B., & Larsen, A. (2019). An urban consolidation center in the city of Copenhagen: A simulation study. *International Journal of Sustainable Transportation*, *13*(9), 675–691. https://doi.org/10.1080/15568318.2018.1503380

Van Rooijen, T., & Quak, H. (2010). Local impacts of a new urban consolidation centre–the case of binnenstadservice. nl. *Procedia-Social and Behavioral Sciences*, *2*(3), 5967–5979.

Van Thiel, S. (2014). *Research methods in public administration and public management: An introduction*. Routledge.

van Duin, J., van Dam, T., Wiegmans, B., & Tavasszy, L. (2016). Understanding financial viability of urban consolidation centres: Regent street (london), bristol/bath & nijmegen [The 2nd International Conference "Green Cities - Green Logistics for Greener Cities", 2-3 March 2016, Szczecin, Poland]. *Transportation Research Procedia*, *16*, 61–80. https://doi.org/https://doi.org/10.1016/j.trpro.2016.11.008

Vis, I. F., & Roodbergen, K. J. (2008). Positioning of goods in a cross-docking environment. *Computers & Industrial Engineering*, *54*(3), 677–689.

Wondergem, R. (2018). Verschillende perspectieven op overheidssturing - Audit Magazine. https://auditmagazine.nl/artikelen/verschillende-perspectieven-op-overheidssturing/

Yahyaei, M., Bashiri, M., & Garmeyi, Y. (2014). Multi-criteria logistic hub location by network segmentation under criteria weights uncertainty. *International Journal of Engineering*, *27*(8), 1205–1214.

Yan, W. (2014). *Heuristics for truck scheduling at cross docking terminals* (Doctoral dissertation). Concordia University.

Zero Emissie Stadslogistiek. (n.d.). Waarom Zero-Emissiezones? https://www.opwegnaarzes.nl/over-zes/doel

Appendices

A

Applied method in the papers

Although, a lot of data is found, results are difficult to compare. Mainly, because of the different used methods for estimating the effects of UCCs. In this section, the used methods in the papers are explained to give a better understanding of the found effects in previous section 3.4

A.1. Browne et al.(2011)

This ex-post performance evaluation was aimed at a trial with an urban micro consolidation centre started in London 2009. Electrically-assisted cargo tricycles and electric vans were used for the delivery. The customers were located in the City of London with an area of 2.9 km^2.

The original transport system involved using 7 diesel vans that were operating from a warehouse located 29km away. Each van drove around 15.000 km a year and made 20-25 stops per journey. The capacity of the vans was 1.3-1.6 tonnes and 9-10m^3.

The implemented micro consolidation centre was only 160m^2. The delivery of the UCC was done at night with a 18-tonne diesel vehicle. The delivery of goods to the consumers was done by 6 electrically-assisted cargo vehicles which were able to load up to 180kg or 1.5m^3 and the 3 mega electric vans with an capacity of 445kg or 3m^3. This resulted in an decrease of 20% in the total distance travelled in all of London and in a reduction of 54% CO_2-emission. Due to the implementation of the UCC, multiple costs components changed as well. These changes are shown in figure A.1.

Cost component	Effect of new system on delivery costs
Total distribution centre operating costs (including micro-consolidation centre buildings and staffing)	Increase
Total vehicle capital costs	Reduction
Total vehicle fuel costs	Reduction
Total vehicle insurance costs	Reduction
Total vehicle excise duty costs	Reduction
Total vehicle maintenance costs	Reduction
Total vehicle driver costs (number of drivers increased but hourly wage rates decreased)	Slight increase

Figure A.1: Change in cost components as a result of the new distribution system in London (Source:Browne et al., 2011)

A.2. Allen et al.(2012)

This review identified the ex-post performance evaluation of 114 UCC schemes in 17 countries worldwide. Yet, only 24 UCC schemes stated the quantification of vehicle kilometres and greenhouse gas emissions. These 24 UCCs were trial or fully operational. The results and lessons learned were evaluated, classified, and allocated to the main impacted UCC stakeholders. The reduction for the vehicle kilometres travelled

ranged from 60-80% and the Greenhouse gas emissions reduction from 25% to 80%. These improvements refer to the improvements for the last-mile distribution with the implementation of an UCC.

A.3. Browne et al.(2005)

In this paper multiple ex-post performances of different UCCs in Europe were investigated. The results were founded by looking at the operational schemes of UCCs all around the world. Only 17 evaluated UCCs schemes were giving quantified impacts. However, the source does not provide clarity on whether these outcomes are based on actual measurements and data collection or based on estimations. The results only refer to the changes in transport activities associated with goods handled by the UCC compared to a situation were an UCC is not implemented. The fact that a lot of the 17 UCCs stopped operating because of bad results indicates that the performance of the UCCs in some cases were not based on realistic estimates (van Duin et al., 2010).

The improvement in load factor in Freiburg was estimated at 55%. This was calculated because the load factor went from 45% to 70%. This is an increase of 55,5%. The improvement in load factor in Basle was estimated at 68%. This UCC was located at the biggest transport company's depot in Basle, 2 km south of the city center. Deliveries were made from the UCC using a gas, an eco-diesel, and an electric vehicle. However, due to generating lower than expected users and goods throughput, the UCC was closed after a few years. Also, the reduction in vehicle kilometres ranged from 30% to 45% in the UCCs schemes and the vehicle emissions reduction ranged from 25-60%. In the case of Basle, the reduction in vehicles was estimated at 45%. These results were retrieved from the No.of consignments per day per vehicle without and with an UCC. Lastly, the reduction in vehicle trips was estimated to range from 30-80%.

A.4. Simoni et al.(2018)

This discusses the ex-ante evaluation of the implementation of an UCC for supplying the Austin central business district (CBD). The evaluation is performed with an optimization model that determines were to locate the UCCs, the type of vehicle to use and the optimal route in order to minimize costs and emissions. The total demand has been estimated at 7450 deliveries/day. The UCC is located at seven miles from the CBD with an handling capacity of 13400 deliveries a day. The operational costs were expected to decrease with 2-24% in the different scenarios and emissions to reduce with 11-21%.

A.5. Escuín et al.(2012)

This ex-ante performance expectation was based on a hypothetical UCC case which was simulated based on a real case of pharmaceutical distribution to 211 pharmacies in Zaragoza. The UCCs would contain the route with high density of pharmacies with similar time windows. Six UCCs have been established in this research, covering 139 customers (around 65% of the total). The other 35% is distributed through the conventional distribution method. The results were obtained by testing over 2 days of operation and comparing the results with the traditional way of operating. Day 1 involves 57 customers, including 6 DCs, and Day 2 has 60 customers, also including 6 DCs. Hybrid vehicles are used to serve the customers from the UCCs. The method used involves extending the Vehicle Routing problem Time window (VRPTW) to consider total delivery costs and the impact of arrival times at each UCC.

A.6. Huijsmans & Wildeboer(1997)

The ex-ante performance expectations simulation study in Munich included the developing of distribution centers for consolidation, creation of telematic networks, usage of electric vehicles and the development of efficient systems for transshipment.

A.7. Roca-Riu & Estrada(2012)

The ex-ante effects found in this paper were aimed for UCCs with a service area between 4km^2 and 50 km^2 and a stores density between 1 and 250 stores/km^2. An continuous approximation model is used to com-

pare the usual system with an system were an consolidation center in implemented. In order to simplify the service area, they assume that several factors are uniform, like zone size, demand, truck capacity, depot proximity, and associated costs. They, also presume that the central hub will not double as a storage facility and thus goods will be processed daily. The last assumption is, market competing carriers can construct and operate an urban Cargo Consolidation center with public funding

A.8. Van Heeswijk et al.(2019)

An ex-ante agent-based simulation is performed for this evaluation of an UCC in Copenhagen, with the following variable values, the access time is between 9.00-11.00am, UCC subsidies 20% of prices charged, 7-20€/m3 for handling costs and 20% value-adding services. Subsidies and regulations were used to promote the adoption of UCC during the startup phase and several measures are tested to provide support in this regard. The subsidies were provided for a two-year period and the simulation lasts for five years, with the last two years providing insight into whether the UCC meets its performance goals. Resulting in an reduction of truck kilometres driven by 65% and an emission reduction of 70%.

A.9. Van Rooijen & Quak(2010)

This ex-post performance evaluation research focused om the logistical results for Binnenstadservice (BSS) in Nijmegen under different scenario's in 2010. In the most promising scenario, vehicle kilometres could be reduced with 32% , travel time with 25% and number of trucks with 59%. These results were found by simulations in a few models of TNO like the RESPONSE^{TM}, Urban Strategy and environmental model. In this artificial scenario, the maximimum local impact of BSS is examined. All deliveries smaller than 9 roll contrainer equivalents are sent to the UCC of BSS. Meaning 632 stores joined BSS instead of the 98 stores which joined after one year of operating. After one year of operating the number of truck kilometres was reduced with 5%, travel time with 5,4% and the number of trucks in the city centre with 2%.

B

Interviews

In this chapter, interview results are given. In total 6 hub operators were interviewed, 1 project manager and 1 municipality.

B.1. Interview questions UCC operators

The interview questions which were asked were in Dutch and are given in this section. Table B.1 is showing the table which UCC 2, UCC 3, UCC 4, pilot hub Leiden, and UCC 7 have filled in to identify the expected and actual performance of the UCCs looking at the vehicle kilometers, vehicle trips, load factor, emissions, and operational costs.

Huidige operatie

- Hoe loopt de huidige operatie van uw Hub?
- Is er overheidssteun geweest bij de realisatie en exploitatie van de hub? (volume kan ook)
  - Op welke manier heeft u steun ontvangen?
  - Welke voorwaarden werden gesteld aan de ondersteuning?
  - Door welke overheidsinstantie werden deze voorwaarde gesteld?
- Is er een PVA, Businessplan gemaakt of KPI's opgesteld om de prestaties te kunnen meten?
  - Zo ja, zou u dit document mogelijk met mij kunnen delen?

Verwachtingen

- Wat waren de verwachte prestaties van de hub vooraf?
  - Is hier een onderzoek voor uitgevoerd?
  - Zo ja, doe wie is dit onderzoek uitgevoerd
  - Zou u dit document mogelijk met mij kunnen delen?
- Wat is er uitgekomen van de verwachtingen en wat niet?
  - Wat was hiervoor de reden?
- Wat voor ontwikkelingen verwacht u verder de komende jaren?

Leveranciers en consumenten

- In welk gebied worden de goederen bezorgd?
- Wie ontvangen de goederen? (B2B of B2C)

- Hebben jullie te maken met regulatie bij het bezorgen?
  - Zo ja, welke regels?
- Wie leveren de goederen aan de Hub?
  - Hoe worden de goederen geleverd?
  - Hoe ver zitten de leveranciers van de Hub vandaan?
  - Hoeveel leveranciers zijn er aangesloten bij de Hub?
  - Wat is de reden dat leveranciers zich bij jullie aansloten?
- Wie betaalt er voor de extra dienst ontvanger of leverancier?

Type voertuigen en goederen

- Welk type goederen worden er vervoerd?
- Naar welke ladingseenheid wordt gekeken bij het vervoeren van de goederen?
  - Het aantal kg, m3 of naar het aantal colli ,rolcontainers, pakketten, pallets?
- Welke voertuigen worden er gebruikt?
- Wat is de capaciteit van een voertuig?
- Wat is het energie/brandstof gebruik van de voertuigen?

Laadinfrastructuur

- Is er laadinfra aanwezig op jullie stadshub(s)?
  - Zo ja, hoeveel laadpalen en wat is het vermogen?
  - Zo nee, hoe worden dan de zero-emissie zones beleverd? Waar laden de voertuigen op?
- Wordt de laadinfra voornamelijk gebruikt voor het vervoer naar de stad of voor vrachtverkeer tussen steden?
- Wat is de algemene ervaring met laadinfra op city hubs?
- Wat zijn de verwachte ontwikkelingen met blik op de toekomst?

Verdien model

- Voorheen zijn veel stadshubs niet in staat geweest om economisch levensvatbaar te zijn, wat is de reden dat dit bij deze stadshub wel gelukt is?
- Wat waren de succesfactor en challenges, tijdens voorbereiding, start en bij de groei fase.?
- Welke value-added services worden er ook uitgevoerd door de stadshub? (Zie tabel 2.3
- Zijn er nog andere value-added services waar jullie gebruik van maken?

Key performance Indicators

- Hoeveel in en uitgaande voertuigen zijn er per jaar?
- Hoeveel trips en kilometers rijdt een voertuig gemiddeld per jaar?
- Hoeveel stops zijn er gemiddeld per trip?
- Hoeveel kg/m3 wordt er totaal vervoerd per jaar per type ladingseenheid?
- Wat is de gemiddelde beladingsfactor van de voertuigen?

Afsluitende vragen

- Wat is de grootste uitdaging geweest in de operatie van de hub?
  - Is deze uitdaging verholpen?
  - Zo ja, hoe is dit verholpen?
- Wat zou de prestaties van neutrale hubs stimuleren?
  - Welke rol speelt de overheid hierbij?
- Welke mobiliteitsmaatregelen of ruimtelijke maatregelen zouden getroffen kunnen worden om het speelveld voor stadshubs te verbeteren?
- Welke regels en randvoorwaarde heeft de gemeente de laatste jaren opgesteld die invloed hebben op de prestaties van de hub.

Table B.1: Expected and actual performance indicated by the UCC operators

	Verwacht	Werkelijk	Verschil
	1/tm 5 (Volgens legenda)	1/tm 5 (Volgens legenda)	Belangrijkste redenen voor verschil
Voertuig kilometers			
Voertuig ritten			
Beladingsgraad			
Emissies			
Operationele kosten			
	1 = Veel lager (-30% en lager)		
	2 = Lager (0 t/m -30%)		
	3 = Geen verandering (0%)		
	4 = Hoger (0 t/m 30%)		
	5 = Veel hoger (30% en hoger)		

B.2. Urban consolidation center 1

This operator is performing the last mile distribution in five cities in the Netherlands. They cooperate with other parties to facilitate the delivery of products to the city center. Since 2018, the UCC operator is also using its own vehicle and personnel for the last-mile delivery. Livability in the city can increase most with consolidation instead of electrification. Yet, consolidating full truck loads at the UCC is not efficient and should not be done. Also, a lot of opportunities lay on different transport modes like the electric boat, resulting in less vehicle movements on the already busy roads. Despite a lot literature is written about the social impact of the UCCs, the operator did not measured the expected impact of its UCCs. It was to premature to perform these measurements. Nevertheless, the operation is performing as expected for the operator, which is earning money in the first place.

When the operator starts with a new location, requirements are established to ensure enough revenue will be made. The requirements include the surface size, cross-docking capacity, storage places, office space, parking, loading docks and energy infrastructure. These services are determining the revenue of the UCCs. Therefore a lot of value-added services are offered to stimulate diversification of the services and improve the revenue model of the UCC. The operator is offering all the value-added services in table 2.3 and providing office rental and charging infrastructure for third parties. The lease of spaces within the UCC is going better than expected.

In the start-up phase of the operation these UCCs did not get any public financial support, only a loan during the COVID period. However, in one city, this operator successfully secured the tender for supplying (semi) governmental buildings. But, this was not during the start-up stage. In another city, assistance was provided as the municipality started a market consolation for a pilot project. So, the UCC operator successfully secured the tender and started operating in this city. In most of the operating cities, operator is experiencing regulations like time-windows and axle weight limits. The capacity of the vehicles is measured with looking at the maximum places for collis, pallets or roll containers.

Some barriers were experienced during the the eight years of operating. The main barrier for successful operating of the UCCs was the willingness to cooperate for different parties. A lot of suppliers and receivers are not seeing the advantages of cooperating. This traditional attitude of transport is reducing the performance of the operation. Secondly, the power supply is not sufficient for a proper operation or growth of the UCC at a few locations. Third, The optimal locations are often not available and therefore is the operator using the

second best locations.

To redress these barriers some recommendations were given. First, put a lot of effort into convincing more suppliers and receivers for cooperating. The government can play a role in this by subsidizing entrepreneurs for delivering their freight at an UCC. Second, more suitable locations should be made available for the urban consolidation centers by the municipalities. Third, governmental buildings should be supplied by an UCC to attract more volume for the UCCs. Last, it is crucial to consider logistics when developing new buildings, specifically examining how these buildings are supplied in the future. By taking this aspect into consideration, contribution to reduce traffic congestion in the city can be achieved.

B.3. Urban consolidation center 2

This UCC did not original started as a Logistic service provider. 50/60% of the business is aimed at relocating of different companies or individuals and the other business is aimed at urban logistics and real estate services. This operator is transporting facility goods on pallets, roll container or parcels to business (B2B) with high volumes. A full electric truck is driving on average 1,5/2 trips with 15 till 20 stops a day. The electric truck is having an capacity of 18 pallets and can drive up to 212km (accu capacity of 265kwh and 0,8km per kwh). Yet, at the end of the day battery is still for 70% full because of the regenerating braking. The price of an zero-emission electric truck is expensive compared to the conventional trucks. An investment of €300.000 was made to purchase the truck. However, the government had a subsidy pot of €30.000.000 to subsidies the purchase of these trucks. This operator received €90.000 for the investment. The subsidy was only provided by "rijksdienst voor ondernemend nederland" for a zero-emission truck with a non final purchase agreement. The subsidy pot of €30.000.000 is not enough for all requests because for €100.000.000 subsidy was requested by all companies in the Netherlands. Therefore, it should remain possible for companies to withdraw from the purchase if they did not obtain the subsidy. Without the subsidy, the electric truck would be a to big of investment for multiple companies. Small and medium-sized enterprises (sMEs) were receiving more subsidy than the big companies.

At the moment twelve suppliers are delivering goods to this UCC. From the UCC goods are delivered to businesses like offices, hospital and colleges and government buildings. The hospital wields a time window from 07:00-12:00. These time windows cannot work when every party wants to be delivered on the same part of the day. Another stimulating development is the requirement within the tendering processes to use an UCC for the last mile distribution of goods to the (semi)governmental buildings. These tendering contract gives certainty to the winning party to be able to supply goods for four years. Yet, some suppliers do not deliver all their goods to the UCC. These parties are still entering the city to perform the other deliveries themselves. They are not obliged to deliver all their goods to the UCC, so they often don't.

The function of the hub is to consolidate the goods. So, not useful to handle full truck loads at an UCC. It is important to check the remaining load of the inbound vehicles and investigate the delivery addresses of these goods. Maybe the goods of another supplier can also be delivered at the same route of the UCC vehicles. So, useful to ask the supplier if they also want to deliver their goods at the UCC. In this way, more suppliers will join the UCC and a more efficient transport network can be formed.

This UCC has the advantage to be the only one in their city. The target area is stimulating sustainable innovations and this is improving the performance of the UCC and therefore the possibility to remain operational. The start-up phase was really difficult to create enough volume to be transported. Necessary to talk a lot with suppliers and convince them to deliver their goods to the UCC.

Yet, no performance indicators are established within the company because not a specific business plan for the company was established. Expected performance was only measured in terms of revenue goals for this hub when the where collaboration with PostNL. Expected performance for social effects is not being investigated by sMEs, for these investigations dependent from governmental bodies or colleges. Collaboration with PostNL stopped because of the different approaches for urban logistics and conveying the concept. To improve the revenue of the company different Value added services are offered like reverse logistics, repackaging and support services at the receiver

Zero-emission zones need to stimulate suppliers to think about the future. Are they going to invest in an electric fleet or cooperate with an local hub for the last mile distribution. At the moment electric is special but later on consolidation will be the main focus. For the total need of 16.000 only 500 electric truck are available and even now there is a shortage of charging points. At the moment they cannot charge an second electric truck at their location because of the overloaded electricity network. The solution is to generate the electricity at the hub with solar panels and store the power in battery containers. So, the UCCs should be self-sufficient for the electricity. At the moment they are renting the warehouse and it is therefore difficult to install solar panels. So, they are dependent from owner and possibility to be connected to the electricity grid. This is an undesired situation when the goal is to perform zero-emission distribution. Consolidation is going to be the USP in the future. Because vehicles will increasingly be banned from inner cities and this will free up more space for pedestrians and cyclists. When no space is available for a lot of trucks and vans and cooperation and consolidation is needed.
At the moment no data is collected to measure the social impact of the UCC. But, they want to measure this in the future. At the moment focusing on the operation.

Including the use of an UCC in the tendering process can stimulate the performance of the UCC and the government should ensure that the charging infrastructure is sufficient for UCC to be connected. Also enough subsidy should be available for the purchase of trucks. In total for €100.000.000 in subsidies was requested and only €30.000.000 was available.

Table B.2: Expected and actual performance indicated by UCC 2

	Verwacht	Werkelijk	Verschil
UCC2	1/tm 5 (Volgens legenda)	1/tm 5 (Volgens legenda)	Belangrijkste redenen voor verschil
Voertuig kilometers	1	2	door de consolidatie worden er minder kilometers gereden
Voertuig ritten	2	2	Sommigen transporteurs rijden nog steeds de stad in, wellicht voor andere klanten
Beladingsgraad	4	4	Als hub rijden wij veel met volle vrachten, terwijl de leveranciers hier komen aanleveren met minder volle vrachtwagen
Emissies	1	1	Doordat de hub zero-emissie rijdt is de uitstoot heel erg laag
Operationele kosten	2	3	In veel gevallen zijn de kosten niet lager of gelijk aan, dat heeft er mee te maken dat sommigen leveranciers ervoor kiezen om niet alle klanten via de hub te laten verlopen.
	1 = Veel lager (-30% en lager)		
	2 = Lager (0 t/m -30%)		
	3 = Geen verandering (0%)		
	4 = Hoger (0 t/m 30%)		
	5 = Veel hoger (30% en hoger)		

B.4. Urban consolidation center 3

UCC 3 is using 3500m2 warehouse for their hub operation and expansion with the same volume is planned for 2024. At UCC 3 all segments are bundled into vehicles for the last mile distribution of the city. The vision of this operator is to look at an integral approach for urban logistics. At the moment only 30/40% of the possible capacity is used. The business model is performing best when it is implemented across all supply chains. This hub is created with sufficient charging infrastructure and solar panels for future growth.

The primary goal is to add value to the surrounding environment, it should contribute to a reduction of vehicle trips and kilometers in the city, while ensuring predictable costs for every stakeholder without increasing them. Additionally, it should contribute to the improvement of accessibility and livability of the city. The added value that UCCs bring lies in space optimization, transportation, cross-docking and supporting services. These aspects are taken into account when developing the business case.

Recently, subsidies where received for developing fresh distribution. However, 90% of the subsidy was allocated to research and exploratory initiatives and only 10% for operational costs. It is not possible to rely on financing based on potential future revenue without clarity and certainty. After, three year of of pre-financing investments, it is now time to look at the actual societal impact of the UCCs and learn from the results.

To optimize the performance of the UCCs, all incentives in the supply chain should be organised differently. New norms and awareness should be created together, to realize the added value of UCCs. Currently, the impact of an UCC is small, but the potential impact of an UCC is much higher. At the moment, not a lot of business wants to make the sacrifices to achieve this larger impact. The subsidy for zero-emission transport, intended to stimulate change, has had a counterproductive effect. The threshold for 1 on 1 electrification has been lowered without implementing measures to reduce the overall footprint. In the past, focus was on elec-

trification and emission reduction instead of reducing the overall footprint. With urban densification, logistic footprint increases. If we don't start changing the system, costs and complexity will continue to rise in urban areas. At the moment we lack resilience to change the system, while other countries have taken more drastic measures.

Most stakeholders recognizes the challenges and benefits of UCCs, but still have their own interests and goals which are being an obstacle. To achieve successful consolidation, multiple stakeholders need to be brought together to be integrated into the hub model and compelling value propositions should be offered. It is clear that the customers and their motivations for using an UCC is different than initially expected. The ideal customer, who is using different services of an UCC is really small. Depending on the hub process as a whole discourages companies from fully embracing the concept, especially for new markets. Building the future solely on the idea of an UCC carries a lot of uncertainties. Companies like PostNL, DHL or Jumbo and Albert Heijn determine market standards. If we convince traditional carriers to incorporate multiple segments into their routes, they wouldn't need to individually handle their logistics within the city.

It is important to use the UCCs and actually implementing changes. Validation of UCCs is necessary, but decision-making is slow rather than fast. A collective awareness or regulation could drive change. Also, an urgency for implementing alternative measures is needed. At the moment, focus of the municipalities is to implement zero emission zones. Ultimately, zero-emission policies are only contributing to zero-emission logistics and not to a reduction in vehicle kilometers and trips. To enhance the broader added-value of UCCs, new policy instrument need to be developed. Market regulation lies with the government as the market is to fragmented to change on its own. However, governmental interventions often lead to increased regulation, administrative burdens and costs.

It is a challenge to measure and manage expectations. The operator aims to reduce vehicle kilometers by 80% for freight distributed through the UCC compared to the situation were each supplier is performing the last mile distribution independently. While they achieve this for some of the routes, is it not applicable to all of the routes. Currently performing at 60% of their ambition in term of vehicle kilometers and trips reduction. The loading factor has significantly improved, with a target of full to full operations, although it is not always achievable due to bundling operations across different segments. Sometimes, return streams are lower than the inbound flow of goods. Resulting in lower load factors for returning vehicles. Containerization is necessary within urban logistics, using uniform loading units. So, vehicles can be adjusted to the uniform loading units and perform efficient transport. The differences between expectations and performance lies in the order interchangeability and bundling rates, which have not yet reached the desired level. Fragmented availability and lack of validation hinder the technical progress.

Energy infrastructure is expected to be decentralized. Requiring smarter energy management for building and mobility related operations. Eventually, self-sufficiency is key to success and adding-value to UCCs, serving as a secondary business case. These UCCs are located on strategic locations, suitable for energy distribution and storage.

Table B.3: Expected and actual performance indicated by the UCC 3

UCC 3	Verwacht	Werkelijk
	1/tm 5 (Volgens legenda)	1/tm 5 (Volgens legenda)
Voertuig kilometers	1	2
Voertuig ritten	1	2
Beladingsgraad	5	5
emissie	1	3
Operationele kosten	3	3
	1 = Veel lager (-30% en lager)	
	2 = Lager (0 t/m -30%)	
	3 = Geen verandering (0%)	
	4 = Hoger (0 t/m 30%)	
	5 = Veel hoger (30% en hoger)	

B.5. Urban consolidation center 4

This UCC operator is specialized in consumer logistics. They choose the hub structure because of the limited range of electric vehicles "proximity logistics". In the morning a truck is unloaded at the UCC and distributed with electric vans to the city. At the moment 25% of the deliveries are transported with electric vans. One of the limiting factor is the availability of charging infrastructure. So, this UCC is going to invest in their own solar park and batteries to ensure enough charging infrastructure is available. 3200 solar panels are already installed at one location and they only need to install the battery to remain self-sufficient.
UCC 4 is first focusing on the operation before measuring the social impact of the UCC. By making the city ring road completely emission-free, we can reduce CO2 emissions by about 70%. Currently, limited progress is being made due to the reluctant transport companies. It is good to know what actual impact is , so at the moment working on a measurement for the CO2 reduction. They started with using electric vehicles for urban logistics because they want to be ahead of the coming problems with the ZEZ. This is expected to be the business model of the future so this UCC already started with it.

At the moment, they strive to have a national network in 2025 with an electric fleet and charging infrastructure to share with other companies. The national fleet consist of 60 vans for the delivery of retail. Transport between the UCCs is done with trailers. But, want to use electric or hydrogen trucks in the future. Due to the quality and innovative approach to sustainability, thirty big retailers from all over the world are using the UCC for the last mile distribution.

Most of the goods arrive in the port of Antwerp and Rotterdam and are transported in containers to the UCC. The goods are than loaded into vans with the range of 120km and distributed to the city. The total costs of ownership of the electric vehicle is almost similar than a fossil fuel vehicle. The investment costs are higher but the operational costs are lower. For charging the electric vehicles 25 double Ac and 4 double Dc are available at one of the locations. Due to the limited availability of connection to the electricity grid, UCCs need to invest in solar panels and batteries, to become self-sufficient. Also, companies should start cooperating with sharing charging infrastructure.

In the past a lot of initiatives stopped operating because no position is taken by the municipality, regarding the actual implementation of the ZEZ and promotion of UCCs. Therefore a lot of uncertainty and limited decisiveness will occur. Yet, this UCC has their own business and is adding the function of consolidation and electrification , instead of starting the UCC for the goals of the government. Despite the enthusiasm from the government, they have not provided any active involvement or stimulation for this operation. However, this operation is open to perform the last-mile distribution for governmental bodies, but they are still not coopering. Recently wanted to start a pilot with the municipality but even then they did not cooperate. However, the municipality has the power the stimulate the performance of the UCC. This operator suggest that the municipality should act as a launching customer, improve the charging infrastructure in the Netherlands and develop new locations for urban logistics.

To increase the revenue of the business, multiple value-added services are being offered like: assembling, delivery flexibility, freight pick-up, inventory and order management, local buffer, pre-retailing, quality and quantity check, repackaging, return logistics, support services at the receiver, track and trace, training areas.

B.6. Pilot hub Leiden (UCC 5)

The zero-emission zone is going to change the transport system in Leiden. The pilot to consolidate urban freight transport for catering in Leiden, is carried out to improve the future implementation of these zero emission zone. In this pilot which ran for four months, five restaurants were participating. These five restaurant are supplied by sixty unique suppliers. 40% of these suppliers do not utilize the Hub Leiden. This is mainly due to fact that they are wholesalers who already consolidate freight. Additionally, a few of these suppliers can use the bicycle for the last-mile distribution. At the end sixteen suppliers cooperate in this pilot. The pilot ran from November 2022 till April 2023 and Logiconnekt was responsible for the Last-mile distribution.

It was expected that the pilot was able to reduce the vehicle kilometers and trips with 50%. For that purpose,

there was looked at the trip length the supplier would have driven when the hub wasn't used, compared to the situation with the use of an hub. The extent of cost savings was not clear beforehand in this study and unfortunately not clear afterwards either. Actually, costs of the pilot were paid with a received fund.

After four months of operating, results were published for the pilot study on Hub Leiden (2023). In the best week, a 69% vehicle kilometer reduction was shown. Yet, on average a 57% vehicle kilometer reduction was found in these four months of operating. Resulting in an CO_2 emission reduction of 57% due to consolidation. Additionally, a 75% reduction in vehicle trips was the result in this pilot study. Because, all goods are delivered within one delivery moment, is it possible for the receiver to save up to 24% of their handling time at the receiving moment. The results of the pilot study are shown in table B.4.

Table B.4: Results Hub Leiden (Retrieved from: (Hub Leiden, 2023)

Variable	Result	Explanation
Combined kilometers	3,541 km	Kilometers that would be driven by suppliers
Bundled kilometers	1,523 km	Kilometers driven by the hub
Saved kilometers	2,018 km	Kilometers saved (combined minus bundled)
Supplier deliveries	400	Deliveries made to the hub
Bundled stops	302	Bundled deliveries made to restaurants
Bundled trips	101	Times driven through the city by the hub
Average stops per trip	3	Deliveries made to restaurants per trip

During the pilot some obstacles emerged. It can be useful to link ordering platforms to the hub, resulting in costs saving throughout the supply chain. A reduced order frequency can reduce the transportation costs for suppliers. Resulting in a greater margin available for the suppliers to pay for the services of Hub Leiden (2023). Additionally, the contact between receiver and supplier vanished. Important to develop a communication system for the suppliers and receivers. Third, the administration of emballage is difficult if there is an extra link withing the supply chain (Hub Leiden, 2023). A solution for the hub can be to offer their own crates to the supplier and receiver. Last, the different stakeholders are not aware of the main goal they need to achieve and are acting as individuals instead of working together.

The municipality of Leiden was not really cooperating in this pilot. This pilot was subsidized by the Leids stimulation fund, but not a lot of requirements were set to receive this subsidy. At the moment we are electrifying 1 on 1 , which has the effect that the vehicle numbers and trips in the city center will not decrease. Therefore, the importance lays on consolidation at UCCs. To stimulate this, municipalities should provide affordable land and develop strict regulations requiring other parties to deliver their goods to a hub, with exceptions only granted for situations were a hub cannot be used. If the municipality continues to adhere to the rules of the old system, the desired new system with the UCCs will not be successful. The hub operator is facing a lot of risks when changing the transport system, so the rules from the government must be clear. At the moment the municipalities are not clear and resolute. Moreover, the purchase of 50 diesel trucks just before 2025 is not setting a good example.

To have a successful operation, all stakeholders should participate in the project. A lot of time is needed to convince a lot of suppliers and receivers to use an UCC. An independent instigator is needed for looking at the overall goal of the city. Otherwise, different interests will clash with each other. Biggest challenge is to get everyone on the same page. Also, the cost allocation needs to be well organized and clearly researched. However, the implementation of the ZEZ is possible not gaining traction effectively when the opposition lobby advocates for a postponement of the ZEZ in later stages

Table B.5: Expected and actual performance indicated by Pilot hub Leiden

Pilot hub leiden	Verwacht	Werkelijk	Verschil
UCC 5	1/tm 5 (Volgens legenda)	1/tm 5 (Volgens legenda)	Belangrijkste redenen voor verschil
Voertuig kilometers	2	1	Belangrijkste reden voor verschil is dat relatief veel kleine leveranciers naar hetzelfde restaurant rijden. Nu is dat gebundeld in 1 ZE-rit.
Voertuig ritten	1	1	
Beladingsgraad	4	4	Veel kleine bestelbussen rijden in de 0-situatie niet volledig beladen de stad in. In de pilot reedt 1 kleine vrachtwagen.
Emissies	1	3	Alleen de CO-2 is berekend: die is beduidend lager door de bundeling. Het ZE-vervoer levert nog een extra bijdrage.
Operationele kosten	3	?	De pilot was te beperkt (o.a. door de beperkte betrokkenheid van de lokale overheid) om hier goed onderbouwde uitspraken over te doen.
	1 = Veel lager (-30% en lager)		
	2 = Lager (0 t/m -30%)		
	3 = Geen verandering (0%)		
	4 = Hoger (0 t/m 30%)		
	5 = Veel hoger (30% en hoger)		

B.7. Urban consolidation center 6

Urban consolidation center 6 strive to perform zero-emission transport and consolidate as much as possible. They are responsible for less than 1% of the transported volume to Arnhem. So, a lot of room and place is available for other companies to start with UCCs as well. Finding a suitable location for the hub was a challenge during preparation phase. Additionally, aligning the amount of staff en equipment during the start-up proved to be a challenge. Yet, in all stages, flexibility was important, because each day is different. Getting proper funding to scale up is also a big challenge.

At the moment, operation is generating enough revenue to break-even with performing the first, last and local mile distribution with electric vehicles to Arnhem, Nijmegen, Ede-Wageningen and Doetinchem. The Fleet consists of seven bicycles, two Carla cargo, a electric Toyota van , a Zolution, a maxus 9 and a cargolev. Yet, only 240volt sockets are available at the hub as charging infrastructure. The Maxus is even charged at a location nearby. UCC 6 wants to have own charging infrastructure, but they are tenants and therefore dependent from the landlord. The distributed goods include food, clothes,cosmetics and books. Before the goods are transported, the preferred mode of transport for the load carrier is chose and the volume and route of all vehicles are checked. This means that sometimes, a small package is delivered using a van if that van needs to be in close distance to another customer.

Dutch suppliers are delivering their goods to the UCC because of the sustainable image and cost reduction. Most costs reduction are reached because of more efficient transport and lower wages per hour. While a truck with driver will costs around €100 per hour a cyclist costs €40 per hour. At the end the services of the UCC are paid by the suppliers.

This operator offered multiple times to perform the last-mile distribution for the public buildings, but the municipality was not cooperating. However, the municipality is able to stimulate the process of the UCCs, but are still very reluctant. To stimulate the process, they can act as the launching customer and change the infrastructure. For example, close the city with poles and do not allow all vans and trucks, only allow sustainable vehicles to enter the city. Also, take control of the establishment of different white label UCCs, where each party is going to perform the last mile distribution with their own fleet. Nevertheless, the municipality has implemented certain measures to stimulate the UCCs. Like, allowing UCC 6 to enter the city for two additional hours after the time window, due to the electric consolidated transport.

During the operation UCC 6 received a subsidy of €100.000 by the province to perform a research. The research was aimed to compare "Industriepark Kleefse Waard" (IPKW) with the city center of Arnhem and estimating the impact of closing the city center of Arnhem similar to the situation at IPKW. Also, receiving a subsidy for the electric vehicles.

The interest and investment for UCCs improved the last 10 years, due to a change in mindset. More and more companies are changing their transport policies to use UCCs for the supplying of their goods. This will increase the performance of new UCCs. Also, advancing technique (vehicles and software) is stimulating the performance of the UCCs. Nevertheless, Green deal zero emission is expected to be delayed one last time, which would be highly disadvantageous.

To increase the revenue of the business, multiple value-added services are being offered like: assembling, de-

livery flexibility, freight pick-up, inventory en order management, pre-retailing, quality and quantity check, repackaging, return logistics, support services at the receiver and track and trace.

Table B.6: Expected and actual performance indicated by UCC 6

UCC 6	Verwacht	Werkelijk	Verschil
	1/tm 5 (Volgens legenda)	1/tm 5 (Volgens legenda)	Belangrijkste redenen voor verschil
Voertuig kilometers	2	3	Door ritten te combineren zou het aantal km lager moeten worden maar de 'massa' is nog niet genoeg om deze impact te hebben.
Voertuig ritten	2	4	Het aantal ritten neemt toe, de lengte per rit neemt af
Beladingsgraad	5	5	Door ladingen te combineren is onze beladingsgraad zeer hoog. Omdat 50% van alle leveringen in de stad maar één adres betreft is hier een groot voordeel te behalen.
Emissies	1	2	Niet meetbaar voor ons maar de emissie in de stad moet flink lager zijn van een elektrisch voertuig tov een vrachtwagen (met koeling)
Operationele kosten	3	3	Al met al ongeveer gelijk schatten wij in en krijgen wij terug van onze klanten.
	1 = Veel lager (-30% en lager)		
	2 = Lager (0 t/m -30%)		
	3 = Geen verandering (0%)		
	4 = Hoger (0 t/m 30%)		
	5 = Veel hoger (30% en hoger)		

B.8. Urban consolidation center 7

Urban consolidation center 7 started 8/9 years ago with the purchase of their first electric truck. In the following years multiple vehicles were electrified. The expectations were very high for UCCs. It was expected to save money for the supplier in the case he doesn't need to drive to the city center. However, to realize these costs saving, good arrangements should be made with the carrier who is driving less kilometres. This is the case for all phases within the process were cost savings can be achieved, including construction logistics. When carpenter,plumber,plasterer, painter and electrician all consider the use of UCCs, they can collectively save a lot of money and improve efficiency. Currently, these individuals still prefer having their own vehicle with equipment parked in front of the building. When the extra costs are properly distributed, it does not have to be more expensive for everyone. Implementing a smart model is needed to attract both suppliers and receivers. Freight distribution through an UCC will not occur when extra costs are involved for the receiver or supplier. Therefore, it is important for suppliers and receivers to have proper negotiations about the prices.

UCC 7 expected that the use of an UCC would improve the efficiency of the route, improve the load factor, less kilometres would be driven and lower operational costs would occur. However, to achieve these results, regulations from the municipality are necessary. Currently, the impact of the UCC is small, although their potential is high. As the municipality is the key stakeholder of the city, taking control of the situation is necessary when trying to improve the sustainability in the city. Relying on market forces, is unlikely to have significant progress and the desired outcome.

The core business of UCC 7 is offering relocating services and storage. Yet, UCC 7 is also offering Zero-emission last mile distribution for different parties, including the University of Amsterdam (UVA). The UVA is making requirement for the suppliers and carriers to use the UCC for the distribution of their purchases. They are experiencing the benefit of receiving deliveries on one moment instead of eight. UCC 7 hoped to obtain even more volume through cooperating with these suppliers. Nevertheless, this UCC is mainly used when it is stated in a contract. Suppliers and carriers are reluctant for using the UCC when they are not obliged to.

Transport is performed with electric trucks, three electric box trucks and a few fossil fuel trucks. To charge these electric vehicles, own charging infrastructure is available at the warehouse. In total sixteen 11kw chargers and two 125kw chargers are established. By Starting really early with connecting to the grid, enough connections are available at the moment and for the future. Unfortunately, the warehouse is not suitable for installing solar panels with a lot of weight. However, with future developments such as panel gluing techniques, should it be possible to limit the pressure on the roof.

At the moment a lot of places are bought by big real estate companies. Resulting in increasing prices and rents for the UCCs. These high rents need to be paid by the UCC operator who is charging the suppliers and receivers for this. With the high rents of these locations, a bad competitors position will be established for the UCCs. It is important that a level playing field is established when solely relying on market forces. Yet, this is not going to succeed when the city is still open for everyone with electric vehicles. Resulting in less

consolidation and a lot of electrification.

The municipality need the make regulations, so not all locations are bought and rented for high prices. Second, to improve the competitors position of an UCC, infrastructure should be adapted to create small advantages for the UCC operators. Restrictions for other vans or trucks will improve the usage of the UCCs. For example demarcated places like a construction area's or hotels are having high bundling potential because the landlord is determining if you can enter the place or not. Third, municipality should be the launching customer and in this situation everyone needs to cooperate. So, make sure not a few purchasers still bypass the hub.

To increase the revenue of the business, multiple value-added services are being offered like: Assembling, delivery flexibility, freight pick-up, inventory and order management, local buffer, pre-retailing, quality and quantity check, repackaging, return logistics, support services at the receiver.

Table B.7: Expected and actual performance indicated by UCC 7

UCC 7	Verwacht	Werkelijk	Verschil
	1/tm 5 (Volgens legenda)	1/tm 5 (Volgens legenda)	Belangrijkste redenen voor verschil
Voertuig kilometers	1	3	Stad blijft open voor alle voertuigen, hierdoor ongelijk speelveld (hoge huurprijzen), wat het gebruik van de hub beperkt.
Voertuig ritten	1	3	
Beladingsgraad	4	4	
Emissies	1	3	Transport sector stugge markt die niet snel veranderd. Waardoor niet snel gebruik gemaakt wordt van het consolideren bij een hub
Operationele kosten	2	2	Alleen als vooraf al wordt gekeken naar de kostenverdeling
	1 = Veel lager (-30% en lager)		
	2 = Lager (0 t/m -30%)		
	3 = Geen verandering (0%)		
	4 = Hoger (0 t/m 30%)		
	5 = Veel hoger (30% en hoger)		

B.9. Interview questions municipality

Huidige operatie

- Heeft de gemeente beleid t.a.v stadshubs of richt dit zich vooral op ZEZ?
- Hoe loopt de huidige operatie van de neutrale stadshubs zoals Cycloon, hub010 en Hubbel in Rotterdam?
- Is er overheidssteun geweest bij de realisatie en exploitatie van de hub? (volume kan ook)
  - Op welke manier hebben ze steun ontvangen?
  - Welke voorwaarden werden gesteld aan de ondersteuning?
- Welke regels en randvoorwaarden heeft de gemeente de laatste jaren opgesteld die invloed hebben op de prestaties van de hubs?
- Wat zou de prestaties van neutrale hubs stimuleren?
  - Welke rol speelt de overheid hierbij?
- Welke mobiliteitsmaatregelen of ruimtelijke maatregelen zouden getroffen kunnen worden om het speelveld voor stadshubs te verbeteren? (locations, toegangsbeperkingen)
- Verschillende stadshubs gaven aan dat de gemeentes meer het heft in handen moeten nemen en het niet helemaal overlaten aan de markt omdat dit niet het optimale resultaat zal geven, hoe kijkt u daar tegenaan?

Verwachtingen

- Wat waren de verwachte prestaties van de hub vooraf?
  - Is hier een onderzoek voor uitgevoerd en kunt u dit document met mij delen?
  - Wat is er uitgekomen van de verwachtingen en wat niet?

    - ◇ Wat was hiervoor de reden?

- Wat voor ontwikkelingen verwacht u verder de komende jaren?
- Voorheen zijn veel stadshubs niet in staat geweest om economisch levensvatbaar te zijn, wat is hier de reden voor denkt u?

B.10. Municipality of Rotterdam

The municipality of Rotterdam has various policy documents in which urban consolidation centers (UCCs) are addressed. For instance, in the road map for zero-emission city logistics, efficient logistics innovations are explored. The Rotterdam Spatial Vision also includes a section about logistics UCCs, identifying strategic locations that align with the needs for urban consolidation centers. While these locations are currently identified as suitable for urban consolidation centers, they have not been specifically designated solely for these UCCs. However, the municipality is working on allocating certain location for UCCs. Yet, delicate considerations must be made between different desired functionalities at the locations that serve the city's needs. To prioritize city logistics with urban consolidation centers, the municipality can incorporate regulations in the environmental planning to enforce specific functions on these locations.

However, the municipality needs to seek a balance between overstimulating urban consolidation centers (UCCs) like purchasing locations and allocating them to UCCs to enhance performance or completely leaving matters to the market. Both of these options represent extremes and are unlikely to be fully pursued. Therefore, a well-considered middle ground must be established. At the moment, it is tried to lean slightly more towards leaving decisions in the hands of the sector. They could take a larger role in determining the best approach.

An increasing number of parties are seeking locations due to growing urgency, caused by the implementation of the ZEZ. As there are limited greenfield locations around Rotterdam, existing buildings are often utilized, which isn't ideal for the UCCs. This sense of urgency encourages more parties to invest more money in suitable locations. However, high costs made by logistics real estate developers might make these UCCs financially unsustainable, posing a challenge to the entire logistics system.

The transparency of last-mile costs remains a challenge. While most vehicle delays occur within the city, establishing a hub could mitigate these costs by eliminating these delays. Given that the logistics sector excels in its field, they should choose the best locations, vehicles, and strategies for reaching the optimal UCC performance. The municipality's role lies where limitations for this sector exist, or when facilitation is required, such as the implementation of zero-emission zones.

Multiple sessions with logistics partners were conducted to identify what the sector requires from the municipality. Despite these efforts, the sector faces difficulties, including the reluctance of some parties to utilize the UCC as desired. The logistics sector is open to make recommendations for the municipality if it helps to improve the performance of the UCCs.

The challenges faced by operators are numerous. However, subsidies totaling 2 million euros were secured to initiate innovative logistics concepts, including the establishment of UCCs. The UCCs in Rotterdam could obtain subsidies up to €100.000 for the development of the UCC. However, a viable business case was required. After two years, the UCCs had to be self-sustainable. Establishing access restriction for high load factor requires a lot of cargo verification, which is a complex and unrealistic process. The municipality can assist through market regulation, when the UCCs operators are having good suggestions. However, the exact desired regulations by the UCC operators are not entirely clear. The sector is increasingly recognizing the advantages of the UCCs. As the benefits become clearer, more parties might join the UCCs. The municipality of Rotterdam is not acting as launching customer due to the dispersed locations of the offices. However, contracts do promote consolidated transport to the governmental buildings. The municipality does not dictate which UCC should be used, but still stimulate efficient last-mile transport. Fewer trips within the city leads to a better score in the procurement. This encourages parties to collaborate with UCCs for improving their scores in the tendering process.

Over the years, several measures have been taken to improve hub performance, including the implementation of zero-emission zones and policy documents aimed at refining logistics. Prioritizing pedestrians and cyclists over vehicles indirectly fosters a sense of urgency for bundling logistics through UCCs. Similar to Amsterdam, where driving trucks in the city is unfavorable, the desirability to drop off freight at the city's edge is increasing. In Rotterdam, although trucks are still allowed throughout, they will be considered "guests" in the coming years.

UCCs have been seen as the solution, but their actual impact remains relatively modest. The potential for reduction is not overwhelming, yet it remains worthwhile. Even a 10-15% reduction could contribute to maintaining the city's accessibility and livability for the growing demand. However, significant volume is required, and until the benefits of UCCs are clearly and transparent, the business case may not be watertight. Comprehensive cost analysis and pricing agreements are necessary to attract multiple stakeholders.

At the moment UCCs are still in their early stages, and since not enough parties have fully embraced them, the desired volumes of goods flowing through the UCCs have not been realized yet. It's important to state that the optimal performance levels for UCCs have not yet been fully achieved. The implementation of the zero-emission zones will likely attract more companies to collaborate with the UCCs and improve the performance.

B.11. Municipality of Utrecht

The urban freight policy of the municipalities of Utrecht focuses primarily on efficient and sustainable transport, with the efficiency aimed at reducing the number of vehicles and increasing the load factor of the vehicles in the city. UCCs are seen as an alternative to reduce the number of trips in the city, but the municipality also encourages other alternatives and cooperation among stakeholders. The focus of the municipality is on consolidated, electric, and efficient transport, not solely on UCCs. The municipality did not provide direct financial support for the developments of UCCs, as research showed that this approach would not work. The municipality believes that the market should adapt to the changes while the municipality is focused on minimizing the environmental impact by setting regulations. An entrepreneur will then figure out how to make this business model profitable. Whether it's a multi-client hubs or national logistics service providers it doesn't matter for the municipality as long as they use suitable vehicles with as little impact on the city as possible. This way, the goals of the municipality will be achieved.

At the moment, the municipality of Utrecht has granted urban freight transport privileges for UCCs, such as driving on bus lanes, no delivery time-window restrictions, and a C1 closed declaration. For receivers, there are subsidies available to experiment with UCCs, if they choose to have their goods delivered sustainably and efficient through these UCCs. The municipality does not specifically allocate locations for UCCs. However, they do stimulate modal shifts to reduce the number of vehicle movements in the city. The cooperation of stakeholders can only be encouraged by the municipality if they increase the urgency of bundling through access restrictions. The market will have to find its own innovative solutions for this.

The future access restriction requirements for consolidated transport is being explored, and there are investigations into its implementation and control. The access restrictions will be implemented in small phases. To encourage cooperation and bundling, the municipality aims for an access restriction for vehicles with for example a minimum of 5 or 6 delivery addresses. Currently, logistics companies already consolidate freight to reduce last-mile costs. The majority of companies are logistics experts, and if they delve deeper, they might come up with other innovative solutions. The ideal access restriction is an access fee, where every vehicle entering the city pays a certain amount, discouraging small shipments. Research shows that this is the easiest way for achieving the goals, which is equal for everyone. Right now, the municipality can only achieve the goals by taking much more difficult and complex measures. These access restrictions will lead to more cooperation and consolidated transport, resulting in fewer trips in the city. Yet, this access fee is legally not possible at the moment in the Netherlands.

Regarding the current performance of the UCCs in Utrecht, the municipality does not have complete overview of these performances. At the moment there is only looked at the number of delivery addresses in the city. However, the municipality plans to collect more data, including the number of trips and load factors, by

incorporating these metrics into the requirements for obtaining exemptions. Currently, this information is primarily gathered through conversations and not on a micro-level but more likely on a half-yearly or quarterly basis. The desired data collected will determine whether carriers are operating more efficiently, and if so, whether other trips are reduced within the city. The change in number of trips in the city can eventually be found in CBS data.

C

Scientific paper

The ex-post performance evaluation of urban consolidation centers in the Netherlands

S.W. Sweere
Faculty of Civil Engineering and Geosciences
MSC: Transport, Infrastructure and logistics
on the Delft University of Technology

***Abstract*— As the population in the cities increase, so does the urban freight transport. A solution to make urban freight logistics more sustainable to limit problems like congestion and emissions, is the implementation of urban consolidation centers (UCCs). The concept of urban consolidation centers are initiated to consolidate the freight of multiple inbound vehicles into less electric vehicles for the last-mile distribution of the freight. In this paper the ex-post performance of urban consolidation centers is evaluated and compared to the ex-ante expectation from urban consolidation center operators. The results of this research show that the performance of urban consolidation centers is not yet reaching its expected performance for the reduction in vehicle trips, vehicle kilometers, emissions and operational costs. It is recommended for UCC operators to improve stakeholder engagement by implementing transparent cost allocation models and municipalities need to stimulate the consolidation of freight in contracts to improve the performance of UCCs and require performance measurement models for UCC operators.**

I. Introduction

Urban populations are growing rapidly. The projection is that in 2050, urban areas will host an additional 2,5 billion people compared to 2018 (Nations, 2018). As city's consumer demand increases, the need for a sustainable and livable environment becomes important for municipalities and inhabitants. The traditional urban freight transport with multiple individual deliveries has become increasingly unsuitable due to the increasing congestion, pollution, and safety. Therefore, innovative solutions to improve the future viability of cities are needed.

Municipalities are seeking solutions to mitigate these negative environmental impacts of urban logistics, while ensuring that the economic growth is not hampered. This is done by implementing zero-emission zones and stimulating the use of electric vehicles (Quak et al.,2016). Another initiative to limit the environmental impact of urban freight transport is to implement urban consolidation centers to reduce the number of vehicles in the city center. Freight of multiple vehicles is consolidated in less (electric) vehicles to perform the last-mile distribution. The implementation of UCCs is expected to reduce the vehicle trips, kilometers, emissions, and operational costs of the urban freight logistics and improve the load factor of the vehicles. The situation with and without an UCC is shown in *Figure 1***.** This research is focused on the Multi-client UCCs where flows from multiple parties converge and are consolidated before supplying the city, with the aim of reducing the number of trips within the urban area.

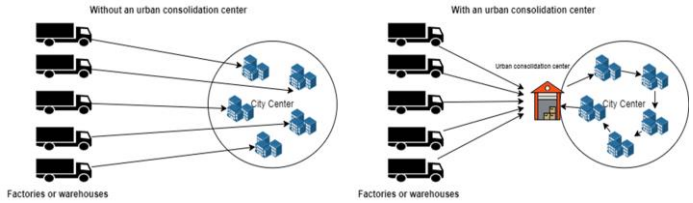


Figure 1: Freight transport without and with an UCC (Adapted from: Allen et al., 2014)

In this paper the ex-ante expectations and the ex-post performance evaluation of UCCs in the Netherlands is researched in the literature and by conducting interviews with UCC operators and municipalities. The main question of this research is: *'To what extent do the ex-post effects of UCCs meet the ex-ante expectations from the UCC operators*?'. In section II the literature summery is explained. Section III is proving the methodology. In section IV the interview results of this paper are presented. In the last section V the conclusions of the research is given.

II. Literature research

Within the literature research, multiple studies related to urban consolidation centers is investigated such as the urban freight transport, Multi-client urban consolidation centers, expected effects of the implementation of an UCC, Ex-ante performance expectations and the Ex-post performance evaluation of UCCs .

A. Urban freight transport

At the moment 34% of the CO2 emissions of the total road transport is caused by urban freight distribution. In urban areas, freight flow is growing (Nenni et al., 2019). Urban freight transport (UFT), especially the road transport sector is highly competitive. Additional costs created by new policy measures are passed onto customers and consumers. So, inappropriate policy steering will have an impact on the costs and efficiency of the local environment and economy (MDS Transmodal, 2012). The usage of an UCC for urban freight transport is done to supply different kinds of market segments. The segments differ in the potential for bundling, which affects the desirability of the UCC. Also, FTL and LTL deliveries are not eligible for bundling through multi-client hubs. Primarily, small deliveries,

often by specialists and service deliveries, qualify for the utilization of an UCC. The bundling potentials for vans and trucks for different segments are given in *Table 1*. The average score applies to urban areas without extensive access restrictions. It can be seen from the table that especially cargo for retail, facility goods and construction finishing freight is having the highest potential for bundling through an UCC.

Table 1: Bundling potential for different segments using an UCC.

Segment		Bundelingspotential van			Bundelingspotential truck		
		Low	Average	High	Low	Average	High
Fresh	Retail	3%	6%	8%	0%	0%	0%
	Catering and Specialists	3%	6%	8%	5%	8%	10%
	Home Deliveries	0%	0%	0%	0%	0%	0%
General cargo	Retail	5%	10%	15%	2%	4%	5%
	Specialists	5%	10%	15%	5%	8%	10%
	Two-person Deliveries	1%	2%	2%	1%	2%	2%
Waste	Consumers	0%	0%	0%	0%	0%	0%
	Businesses	0%	0%	0%	0%	0%	0%
Parcels	Express and Parcel	5%	5%	5%	5%	5%	5%
Facility/service	Maintenance and Service	1%	3%	5%	1%	2%	2%
	Supply	5%	10%	15%	5%	10%	15%
construction	Public Space	0%	0%	0%	0%	0%	0%
	Structure	0%	0%	0%	0%	0%	0%
	Finishing	3%	7%	10%	5%	13%	20%
	Personnel	3%	7%	10%	0%	0%	0%

B. Multi-client urban consolidation centers

The use of urban consolidation centers (UCCs) dates from the early 1970s (Allen et al., 2012). Since then, many UCCs are being developed in the Netherlands and abroad. At the moment, more than 300 city hubs are developed in the Netherlands. Mostly dominated by the dedicated hubs from PostNL and DHL. The amount of multi-client hubs is estimated on 50 (Bolscher, 2023). The focus of this research is on the multi-client hubs, which are established for manufacturers and suppliers to enhance consolidation and cost reduction. Implementing urban consolidation centers is seen as an solution to reduce the number of vehicle trips in cities and facilitate the transition from fuel-powered to electric vehicles for last-mile delivery. Consolidation of freight can decrease the number of vehicle trips needed for the last-mile transport and therefore improve the safety, livability, and environment in the cities. When a lot of freight is consolidated less energy is needed for the transport. Resulting in a decrease of energy usage and CO_2-emissions (Andruetto, 2022). Additionally, UCCs are used for cross-docking of the freight without the temporary storage of goods. On top of these functions, UCCs offer a broader range of services to increase revenue of the business. These value-added services include services like assembling, delivery flexibility, freight pick-up, inventory management, local buffer, pre-retailing, quality and quantity check, repackaging, return logistics, support services at the receiver and track and trace.

To achieve a successful operation, cooperation of all stakeholders is needed. Therefore, it is important to know which stakeholders are having interest and power for the UCC performance. An power-interest grid is shown in *Figure 2* to show which stakeholders are having power and interest in the actual performance of UCCs. Power is defined as the actual impact the stakeholders have on influencing the performance of the UCC. The vertical axis represents the interest that different stakeholders have in the implementation of an UCC.

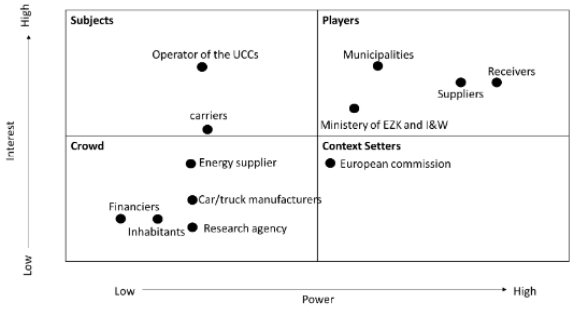


Figure 2: Power-interest grid of an UCC (adapted from: Deloitte,n.d.)

It can be concluded from the Pi-grid that the receivers, suppliers and municipalities are the most important stakeholders to influence the performance of the UCC. The UCC operators are dependent from the policies of the municipality and from the cooperation of receivers and suppliers for improving the performance of their UCC.

C. Expected effects of the implementation UCC.

The efficient transportation routes and increased vehicle load factors with the implementation of an UCC is expected to reduce vehicle kilometers, trips, and travel time (Allen et al., 2012). Consequently, resulting in a congestion reduction, noise reduction, fossil fuel use reduction, and operational costs reduction (Allen et al., 2012). Because UCCs are used for storage, the receiving establishment can create additional space for more productive or profitable activities. This is advantageous, especially in areas where space is limited. Pre-retailing activities like inventory monitoring can help to improve product availability, service levels, processes in the shop, and free-up staff time (Allen et al., 2014). Yet, extra handling is needed during the process by unloading and loading the truck extra time at the UCC. However, the receiver will have fewer receiving moments, which can save them time.

The various stakeholders are having different expectations for the implementation of the UCC, and what may be an advantage for one can be a potential disadvantage for another. All possible expectations of an UCC are provided in *Table 2* , along with the indications for each stakeholder whether this represents a desired or undesired effect. An X is indicating a benefit, - a disadvantage, and a +- indicates that the effects can go both ways for the stakeholder.

Table 2: Expected effects implementation of an UCC

	Supplier	Freight carrier	Receivers	Municipality	Inhabitants
Less travel time	X	+-	X		
Lower operational costs	X	X	X		
Vehicle trip reduction	X	+-	X	X	X
Vehicle kilometer reduction	X	+-		X	X
Increase load factor		X		X	
Congestion reduction		X		X	X
Reduction in unloading time			X		
Increase work/sales area			X		
Free-up staff-time by using value-added services of UCC.			X		
Emission reduction	X	X	X	X	X
Fossil fuel use reduction		X		X	
Noise reduction				X	X
Extra handling at Hub	-				

D. Urban consolidation centers evaluation method

Ex-ante analyses involve a forward-looking evaluation that relies on predictions and probabilities to determine the future potential of an initiative. On the other hand, ex-post analyses is a backward-looking analysis that considers outcomes after they have occurred. The actual results of an ex-post evaluation are used to predict the likelihood of future results. However, ex-ante evaluations are dependent on forecasts, making their accuracy limited due to uncertainty (Bailey et al., 2002). Paddeu (2021) presented a methodological framework for UCC performance evaluation, employing a multi stakeholder multi-criteria approach to evaluate and compare alternatives. The model can be used for ex-post and ex-ante evaluations (Paddeu, 2021). Yet, in this research the key performance indicators are based on the objectives of UCCs. These objectives are related to the environmental impacts like emission reduction, and vehicle kilometer reduction. Secondly, the productivity attribute is including the load factor and the number of vehicles reduction (trips reduction). Last, the operational costs are important to measure the UCC performance. The inclusion of the operational costs is crucial as they play an important role in convincing stakeholders to consider shifting from their current transportation to a system with the UCC. (Van Rooijen & Quak, 2010). The use of these indicators for estimating the performance of UCCs, is useful for decision making, estimating improvements as well as making comparisons (Egilmez et al., 2015). So, in total the following five indicators were established to measure to what extent the ex-post effects of UCCs meet the ex-ante expectations for the change in load factor, operational costs, emissions, vehicle kilometers, and vehicle trips.

E. Ex-ante performance expectations

Ex-ante refers to a prediction before the event happens (Filippi et al., 2010). So, in this research, ex-ante performance expectations are the expectations stakeholders had before the UCC was implemented. However, both the results of the conducted ex-ante and ex-post evaluations in the literature can be used as the ex-ante expectations for the UCCs in the Netherlands. The results within table 3 are showing the different effects mentioned in different literature. Looking at the results can it be concluded that the range of performance indicators is quite big and it is therefore hard to compare the relative results. It is important to understand the differences between the results to increase the validity of the research. A few findings are shown next:

- Some cases are not based on realistic estimates, because these UCCs were not able to keep operating like in the paper of Browne et al.(2005)
- Relative calculation is dependent on the point of comparison
    - Calculate for impact on last mile or on the total transport of first and last mile.
- Missing transparency for the measured performances
    - Is there checked for the vans or trucks which may enter the city after some goods are delivered to the UCC?
- The results are dependent on the unit of the indicator. (different units possible for estimation)

Table 3: Ex-ante performance expectations

	Browne et al., 2011	Allen et al., 2012	Browne et al., 2005	Simoni et al., 2018	Escuín et al., 2012
Operational costs				-2/-24%	+2,5/+5,8%
improve load factor		15-100%	55-68%		
vehicle kilometres reduction	20%	60-80%	30-45%		15-35%
Emission reduction	54%	25-80%	25-60%	11-21%	
Vehicle trip reduction			30-80%		

	Van Heeswijk et al., 2019	Huijsmans and Wildeboer, 1997	Van Rooijen and Quak, 2010	Roca-Riu and Estrada, 2012
Operational costs		-18/-25%		-12/-14%
improve load factor		15%		
vehicle kilometres reduction	65%		32%	
Emission reduction	70%			
Vehicle trip reduction			59%	

E. Ex-post performance evaluation UCCs

The ex-post evaluation is used to evaluate the impact of an event after this event has taken place (Hubbard, 2008). So, in this research, the ex-post evaluation is used to estimate the actual impact of operational UCCs in the Netherlands. The ex-post performance results of different UCCs investigated in the literature can be used as the ex-ante expectations for this research. The ex-post performance evaluation will be stated in the conducted interviews with UCC operators. Both the qualitative as the quantitative performance of the operational UCCs will be searched

III. Methodology

In this chapter, the methodology used in this paper for answering the research questions will be explained. The research design, data collection and analyses method, reliability, and validity will be explained in this section to answer the following question: 'To what extent do the ex-post effects of UCCs meet the ex-ante expectations from UCC operators?'

A. Research design

The research mixed method design shows the structure of the research. It gives the elements of the research process, such as the research strategy, data collection methods, data analysis techniques, and the approach for interpreting the data (Van Thiel, 2014). This ex-post evaluation study involves a qualitative research based on multiple cases for different UCCs in the Netherlands, with interviews as the data collection method. The aim of the case studies was about the ex-ante expectations and ex-post performance of seven UCC operators that were operational. Case studies can use quantitative and qualitative information (Schell,1992). The findings of an case study are specific to a case, making it challenging to generalize the results for all UCCs in the Netherlands, which is an disadvantage of case studies. (Heale & Twycross, 2018). To ensure that the results can still be generalized, multiple case studies for the ex-ante and ex-post performance of UCCs were conducted. These case studies will be used to establish a comprehensive understanding of the performances of the UCC. Therefore, being able to compare the ex-post performance with the ex-ante expectations. The case studies implies the cooperation of different interviewed multi-client hubs in the Netherlands.

These interviewed hubs are chosen for the case study because they are operational multi-client hubs in the Netherlands. Also, accepted to participate in the research and were questioned about the performance of their UCC. With the results of the cooperating hubs, generalized conclusions will be made for the performance of all UCCs in the Netherlands. These results can contribute to the actual desirability of the UCCs for operators, inhabitants, or government. For this research, interviews were favored over the questionnaire, in this way, it allows for obtaining additional information beyond the questions. It also makes the process more personal, potentially stimulating respondents to participate.

B. Data collection and data analysis

The theoretical framework will be used for conducting the interviews and analyzing the data. All interviews required the cooperation of the interviewees. It is advised to use non-probability sampling instead of the probability sampling for selecting the units of the study (Lucas, 2016). Due to the limited number of multi-client hub operators, approximately 20 in total, with a total of 50 UCCs, only a limited number of cases can be selected. Therefore, the non-probability sampling approach is used to choose interviewees based on theoretical considerations. Six UCC operators, two municipalities, and one project manager of an UCC are interviewed for this study. Some UCC operators wanted to remain anonymous and were stated as UCC 1 to 7. The interviews are in-depth and focused on a specific topic. As a result, limited interviewees with high information power are preferred over a large number of interviewees with limited information power (Malterud et al., 2016). For this research, the semi-structured interview is chosen to combine the structured and unstructured interviews. The questions were prepared in front. Yet, the interviewee has the opportunity to elaborate and provide insight due to open-ended questions (Alsaawi, 2014). The advantage of this interview, compared to an open interview, lies in its increased validity and reliability (Aunget al., 2021). As the interview is more structured, the data obtained becomes more consistent. The interviews were conducted online and on location as shown in table 4. The interviewees in the proper positions within the UCC or municipalities involved with UCCs. These operators and municipalities are chosen because of the informational power they have aimed at UCC operation and policies. Both the operators and municipalities are having very high interest for UCCs and will therefore have proper information about the subject. The interviewed municipalities of Utrecht and Rotterdam are chosen because they are both implementing zero-emission zones and multiple UCCs were implemented in these municipalities. Additionally, Utrecht is having the most implemented multi-client hubs of all municipalities in the Netherlands and is therefore a useful municipality to interview. Not all municipalities with zero-emission zones and multi-client hubs are interviewed due to the lack of available time for this research. The chosen multi-client hub operators were selected out of an anonymous data base from Buck Consultant International which involves all the multi-client hubs in the Netherlands. Out of the approximately 20 multi-client hub operators, 6 were interviewed for this research. The sample includes different UCC operators to ensure that the finding can be generalized for all multi-client hubs.

Table 4: Overview conducted interviews.

Interviewee	Organization	function	Location	Time
1	Urban consolidation center 1	CEO	Teams meeting	11-7-2023 15:30
2	Urban consolidation center 2	CEO	On location	13-6-2023 11:00
3	Urban consolidation center 3	CEO	On location	11-7-2023 15:30
4	Urban consolidation center 4	CEO	On location	6-6-2023 10:00
5	Pilot hub Leiden (UCC 5)	Project manager	Leiden	27-7-2023 14:00
6	Urban consolidation center 6	CEO	Teams meeting	21-6-2023 14:00
7	Urban consolidation center 7	CEO	On location	27-6-2023 11:00
8	Municipality of Rotterdam	Advisor	Teams meeting	2-8-2023 16:00
9	Municipality of Utrecht	Advisor	Teams meeting	5-9-2023 14:30

The interviews are used to determine the qualitative and quantitative expectations and actual performance of the UCCs. It is important to know which performance expectations are reached and which ones are not. Secondly, the primary reasons behind the varying outcomes were investigated within the interviews, focusing on the success factors and challenges during operations. Third, important measures and system changes to optimize the performance of the UCCs were explored. Based on this information, recommendations can be made to improve the current performance of the UCC and potentially meet high expectations. Other stakeholders are left out of the interviews as they are not needed to estimate the qualitative impact of the UCC. The suppliers, carriers and receivers are important to be included in the interviews when the quantitative performance of the UCCs need to be measured.

C. Reliability and validity

Reliability and validity deal with the trust someone has in the accuracy and credibility of the findings and conclusions drawn from these findings (Motheral, 1998). The reliability of the interviews is received when similar results or findings are obtained. While the semi-structured interviews may not be completely reproducible, the focus on the specific topic increases their reliability. Therefore, repeating these interviews would result in consistent findings. By using standardized interview methods, the reliability of the interview data is improved. The semi-structured interviews were reviewed by two experts on urban consolidation centers and two supervisors from the Delft University of Technology. Additionally, the interview was updated after the first interview to ensure that all important information was obtained. Validity of the research is dependent on internal and external validity (Motheral, 1998). There are several threats for internal validity: history, instrumentation, maturation, testing, statistical regression to the mean, selection bios, and experimental mortality (Motheral, 1998). The validity history threat refers to any new event occurring during the study period that could have an impact on the results. Since the focus is on the actual performance and some events are incorporated into the actual performance, this is not a threat to this research's validity. Regarding threats such as maturation, statistical regression, selection bias, and experimental mortality, they are not a threat to this ex-post analysis of a UCC either. However, the testing effect

threat is addressed by not revealing the interview results of other respondents beforehand. This approach ensures that each interviewee elaborates on their findings without being influenced by the expectations of others.
Last, to maintain internal validity, the instrumentation measures must remain consistent during the ex-ante and ex-post analyses. Therefore, they need to be clear and exclusively elaborated. The theoretical framework should define the urban consolidation centers and the performance indicators for the ex-ante and ex-post evaluation of the UCCs. To avoid missing any information during the interviews, they were recorded and transcribed. In order to accurately link the statements of the interviewees to their respective interviews within this report, each interview has been transcribed, assigned a unique number, and is referenced to in the text.

Additionally, to generalize the results from the interviewed UCC operators to all UCC operations in the Netherlands, external validity should be guaranteed (Motheral, 1998). In this research, a relatively high number of multi-client hub operators are interviewed to define the generalized results. In total six hub operators were interviewed, while approximately 20 multi-client hub operators are active in the Netherlands at the moment. However, it is more difficult to generalize the results from the municipalities interview due to the low number of interviews conducted with municipalities and the fact that each municipality may have its unique policies regarding urban freight transport. Also, the interviewed UCC operators may have some biases for estimating the
ex-ante and ex-post performance of the UCCs, as they have a possible stake in positive outcomes. Therefore, it is crucial to critically examine the responses provided by the interviewees and whether they may be given a more positive picture for their own interests. Initially, the ex-post and ex-ante performance evaluation of the UCCs was focused on quantitative data. When it became apparent that the quantitative data from the literature ranged quite a lot and were difficult to compare, together with the absence of actual performance data from the UCCs, the focus of this research switched to a qualitative method, supplemented with the available quantitative data to achieve more reliable results. This approach eventually brought more dept into the research and increased the external validity, since both methods complemented and strengthened each other. To increase the validity and reliability of this research, multiple and different sources of information are used, a method names triangulation. These sources include a literature research and the conducted interviews shown in table 4. Both methods provide qualitative data and quantitative data about the UCC performance.

IV. RESULTS

The primary objective of this research is to assess the extent to which the hub operations achieve the expected performance found in the literature and interviews. By examining both the ex-ante performance expectations and the ex-post performance, we can gain a comprehensive understanding of the ex-post performance of urban consolidation centers (UCCs) and identify the drivers behind their success or challenges. Ultimately, these results will provide valuable knowledge to make recommendations for stakeholders and policymakers seeking to optimize UFT through UCC implementation. In this section, the ex-ante and ex-post performance of UCCs found in the interviews will be explained. The numbers stated in the following text refer to the interviewee showed in table 4.

A. Ex-ante performance expectations from UCC operators

After conducting the interviews, it was possible to determine whether UCC operators had any expectations before starting their operation. It became evident that during the initial phase, UCC operators did not conduct any kind of investigation to measure the social impact or expected impact of the UCC (1,2,3,4,5,6,7). The UCC operators first wanted to focus on the current operation before worrying about measuring the impact of their operation. Despite the absence of the quantitative expected performance, they still had qualitative expectations. Eventually, four UCC operators (2,3,4,7) and one project manager of UCC 5 stated their qualitative expectations they had for the UCC operation. UCC 1 and 4 did not provided any qualitative performance data and are therefore not included in expected and actual results. The operators were asked about the expected ex-ante impact and the ex-post impact of their UCC on the vehicle kilometers, vehicle trips, emissions, operational costs and vehicle load factor for the urban freight logistics. So first, the UCC operators needed to state the expected change of these indicators before starting with the UCC and secondly they needed to state the actual change in these indicators reflecting the reality. They could choose between five answers based on the five-point likert scale. They had to choose between much lower (1), lower (2), equal (3), higher (4), and much higher (5). To ensure that the interviewees stated the same meaning regarding the qualitative results, it is essential to accurately define the various potential answers of the likert-scale as shown in table 5.

Table 5: Likert scale definitions.

Number	Likert-scale	Definition
5	Much higher	+30% and higher
4	Higher	0 t/m +30%
3	Equal	0%
2	Lower	0 t/m -30%
1	Much lower	-30% and lower

After UCC operator 2,3,5,6, and 7 stated their expected impact of an UCC on the vehicle kilometers, vehicle trips, load factor, emissions, and operational costs, table 6 could be made to summarize these expected performance .

Table 6: Expected results stated by the UCC operators.

Expected Performance :		UCC 2	UCC 3	UCC 5	UCC 6	UCC 7	Total
Vehicle kilometres	Much lower	X	X			X	3
	Lower			X	X		2
Vehicle trips	Much lower		X	X		X	3
	Lower	X			X		2
Load factor	Much higher		X		X		2
	Higher	X		X		X	3
Emissions	Much lower	X	X	X	X	X	5
Operational costs	Lower	X				X	2
	Equal		X	X	X		3

Vehicle kilometers: UCC 5 and 6 expected a small reduction in vehicle kilometers, UCC 2, 3, and 7 expected a significant reduction (Much lower) in vehicles kilometers due to the consolidation at the UCC.

Vehicle trips: UCC 3, 5, and 7 expected the vehicle trips to decrease significantly when using an UCC to consolidate the freight. Additionally, UCC 2 and 6 suggested that trips were expected to be slightly lower, due to the unloading of large trucks into smaller vans.

Load factor: UCC operators 2, 5, and 7 expected the load factor to be higher, UCC 3 and 5 expected the load factor to increase significantly when using an UCC. They expected that consolidation of freight would result in better utilization of the vehicle capacity, resulting in higher load factors.

Emissions: All hub operators (2,3,5,6,7) expected that the implementation of an UCC could lead to a significant (much lower) decrease in emissions. They believe that the consolidation of freight and the use of electric vehicles within the UCC could have a positive impact on emissions.

Operational costs: The costs were expected to remain equal after the implementation of an UCC for suppliers and receivers stated by UCC 3, 5, and 6. However, UCC operator 2, and 7 proposed that the operational costs could be lower when proper pricing agreements were developed with the stakeholders.

Overall, hub operators (2,3,5,6,7) showed positive expectations regarding the implementation of an UCC, including emission reduction, higher load factors, decreased vehicle trips, and fewer vehicle kilometers. An optimal-performing UCC has the expected potential to positively impact the UFT. These findings are in line with the qualitative findings in the literature, which also stated these expectations. Overall, expectations for UCCs are positive, with much potential for improving the UFT and stimulating sustainability.

B. Ex-post performance stated by UCC operators

During the interviews with the UCC operators, it was found that most of the interviewed operators have limited data tracking practices (1, 3, 5, 6, 7), which makes it challenging to measure the actual performance accurately. The main focus of the UCC operators has been on ensuring an operational business before showing their actual performance. Therefore, the actual performance is stated as the estimated performance of the current UCC operation.

These estimations are based on the estimates from UCC 2,3,6, and 7. Despite, the missing of quantitative data by most of the operators (1,4,6,7), some operators were still able to provide valuable insights into the estimated performance of their current UCC operation(2,3,6,7). UCC 1 and 4 did not provided any qualitative performance data and are therefore not included in table 7. Secondly, the interviewees were asked to provide the estimated current performance that represents the reality closely. However, UCC 5 instead provided the best-case scenario results of the UCC for the actual performance. Assumptions were made that all incoming vehicles at the hub no longer entered the city. However, UCC 5 did not know how the inbound vehicles acted in reality. Therefore, the results of UCC 5 cannot be included in table 7 on the estimated current performance.

Table 7: Ex-post performance stated by UCC operators

Estimated current performance:		UCC 2	UCC 3	UCC 6	UCC 7	Total
Vehicle kilometres	Lower	X	X			2
	Equal			X	X	2
Vehicle trips	Higher			X		1
	Equal				X	1
	Lower	X	X			2
Load factor	Much higher		X	X		2
	Higher	X			X	2
Emissions	Much lower	X				1
	Lower			X		1
	Equal		X		X	2
Operational costs	Lower			X		1
	Equal	X	X		X	3

Vehicle kilometers: The results in table 7 showed that two UCC operator (6,7) experienced the vehicle kilometers to be equal, and two UCC operators showed lower vehicle kilometers (2, 3) after the implementation of the UCC.

Vehicle trips: The number of vehicle trips showed varying outcomes, with one operator experiencing higher vehicle trips (6), one with equal trips (7), and two witnessing lower vehicle trips after implementing an UCC (2, 3).

Load factor: The utilization of the vehicles was reported to be higher (2, 7) and much higher in the other two cases(3, 6). So, consolidation of freight with an UCC can lead to more efficient use of vehicles and increase the load factor.

Emissions: In one case the emissions were lower with the implementation of the UCCs (6). The findings that emissions stayed the same in two of the cases (3, 7) was because some suppliers still entered the city after delivering goods to the UCC. As a result, the UCCs emission reduction is obstructed by these suppliers. The last operator experienced a significant reduction in emissions for the delivering of certain goods (2).

Operational costs: The results show that in one case , costs were lower compared to previous operations (7), while in the other three instances, costs remained the same (2, 3, 6). The implementation of an UCC can lead to cost savings in certain scenarios, but the reduction is dependent on the pricing arrangements between different stakeholders and the operational context.

Additionally to the qualitative data stated by the UCC operators, a study conducted by Buck Consultants International using BigMile presented the actual performance of UCC 2 in six months. The analysis includes examining the emission reduction, vehicle trip reductions, kilometer reduction, and cost saving per ton of transported freight. Within that research, two scenarios were developed to estimate the environmental impact of an UCC. The first scenario is the reference scenario were the UCC was not yet implemented and orders were directly transported to the customers by various suppliers . Yet, with the implementation of UCC 2, suppliers are delivering their goods to UCC 2 and the freight is distributed to the city with electric vehicles (scenario 2). The results obtained from this research are useful as these results are recently culculated and are reflecting the actual performance of an implemented UCC, were suppliers did not enter the city after delivering at the UCC.

Table 8: Actual performance UCC 2 (Buck Consultans international, 2023)

	Scenario 1 without UCC	Scenario 2 with UCC			
	customer	hub	customer	Total	Change
Total CO_2 emissions (Kg)	49.107	33.502	4.236	37.738	-23,2%
Average emissions (kg) per ton freight	49	33,4	4,23	-	
Number of City Trips	446	0	239	239	-46,4%
Number of Trips Outside City	446	435	0	435	-2,5%
Total kilometers	52.892	36.604	8.119	44.723	-15,4%
costs per ton transported*	4,9	1,17	0,85	2,02	-58,8%

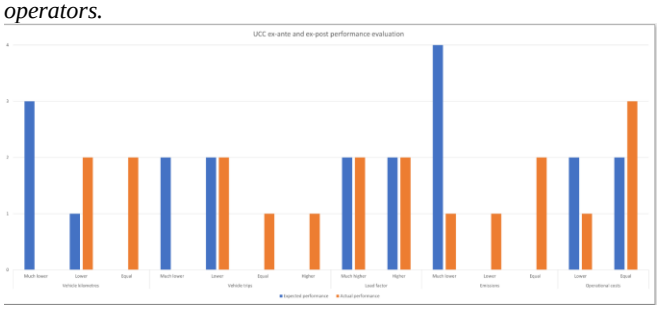
Cost per ton transported* (Based on ETS tariff 100 euro)

The actual results shown in table 8 are the changes for the total system of the freight transported (First+last-mile). When only estimating the last-mile impact of UCC 2, a 50% vehicle kilometer reduction, 46% vehicle trips and 73% vehicles emissions are established with the implementation of UCC 2. This shows the impact an UCC can have when it is used by the stakeholders as intended. The suppliers did not enter the city after delivering freight to the UCC. So, al freight of these suppliers for the city is transported to the UCC and after being consolidated into electric vehicles transported to the receivers.

C. Comparison of the ex-ante and ex-post evaluation

After both the ex-ante and ex-post performance has been stated by the UCC operators, it was possible to visualize the differences between these two performances. These differences are shown in figure 3.

Figure 3: Ex-ante and ex-post performance of UCC stated by the operators.



Vehicle kilometers: It can be seen that the ex-ante expectations for vehicle kilometer reduction with the implementation of an UCC were too optimistic. However, the actual reduction in vehicle kilometers is showing a more nuanced picture. The differences between expected (ex-ante) and actual performance (ex-post) suggest that the implementation of UCCs did not lead to the amount of vehicle kilometers reduction that was originally expected. The differences between the expected and actual results can be explained by multiple factors. First, some carriers (3PL) still enter the city after delivering to the UCC (2). Second, the volume of transported freight through an UCC is not big enough to have an impact (6). Third, cooperation among stakeholders is low, resulting in limited utilization of an UCC (3). Last, high rental prices for UCCs create an higher operational costs for operators and users, consequently limiting their utilization (7).

Vehicle trips: Also vehicle trips are performing less than expected. Were an UCC was expected to reduce the vehicle trips significantly (3,5,7) or lower (2,6), actual results revealed a different and varied picture. One operator reported an increase in the number of trips but a decrease in distance per trip (6). Another operator noted the number of trips to remain unchanged (7), while the last two operators experienced a reduction in the number of trips due to the implementation of the UCC (2,3). The differences between the expected and actual results can be explained by multiple factors. First, some carriers (3PL) still enter the city after delivering to the UCC (2). Secondly, the number of trips was expected to increase because the volume of trucks is consolidated into smaller vans. Yet, the trip length is reduced (6).

Load factor: This is the only indicator that is performing as expected by the UCC operators (2,3,5,6,7). By consolidating the freight, the load factor of the vehicles is higher or even much higher than in a situation without the UCC. Consolidation of freight will improve the load factor because 50% of the trips within the city are for one address (6). Also, vehicles of the UCC are driving with FTL, while the suppliers of the UCC deliver with LTL shipments (2,5). Therefore, improvements for the load factor are made by consolidating at the UCC.

Emissions: Looking at the expected (ex-ante) and actual reduction (ex-post) in emissions can it be seen that the actual reduction is less positive than initially expected. A significant reduction in CO2 emissions was expected (2,3,5,6,7). Yet, in only one of the cases a significant reduction of emission occurred (2). In one case a emission reduction was found (6) and in two cases no change of emissions was shown (3,7). An emission reduction is established due to the shift to electric vehicles and due to the fact of consolidation. However, the actual performance of the UCC is less favorable than expected and this can be explained by the fact that the transport industry is

reluctant for rapid changes. As a result, the adoption of consolidation practices at an UCC decreases, thereby limiting the significant changes in emissions (7). The reduction in emissions is primarily attributed to the utilization of electric vehicles (2,5,6).

Operational costs: It is expected that the operational costs can decrease when pricing agreements are made amongst all stakeholders (3,5,7). Yet, at the moment, no pricing agreements are made and it is still very difficult. Therefore, the actual operational costs for using an UCC are not lower in most of the cases (2,3,6). These operational costs were not lower because suppliers did not supply all of their receivers through the UCC (2). However, the actual operational costs among different stakeholders can remain the same compared to a situation without an UCC. This improves the desirability of an UCC for stakeholders, particularly due to the reason that most of the suppliers and receivers prioritize cost-effectiveness

V. CONCLUSION

Despite the very positive ex-ante expectations stated in the literature and by the UCC operators, the actual performance (ex-post) of the UCCs did not meet these expectations at the moment. UCC operators highlighted in the interviews that they had limited data tracking methods, which is reducing the precise measurement of their UCC performance. Therefore, this research switched from establishing a quantitative ex-post evaluation to the qualitative ex-post evaluation, supplemented by quantitative data. From interviews and literature it is expected that significant changes in vehicle kilometers, vehicle trips, emissions and a small reduction in operation costs can be established with the implementation of an UCC. However ex-post qualitative data from this research revealed that UCCs were not yet meeting these expectations. The only factor reaching its expectations is the increased load factor. Despite the small impact of the UCCs, its implementation still results in a vehicle trip reduction, vehicle kilometers reduction, and emission reduction. So, the actual performance of UCCs is changing the UFT less than expected and desired.

The ex-post performance not meeting its ex-ante expectation is because of the following challenges during the UCC operation. First, limited stakeholder cooperation with the UCCs is reducing the estimated throughput of freight for the UCCs. Therefore, reducing the volume of consolidated freight. One of the reasons for this limited stakeholder cooperation is because of the missing of proper pricing agreements and usage of cost allocation systems. The limited usage of transparent cost allocation systems results in various stakeholders being unable to gain a clear understanding of the places where cost savings can be achieved. Due to this lack of transparency, stakeholders are less inclined to utilize a UCC. Many stakeholders remain cost-oriented and are more likely to use a UCC if it offers cost benefits. Therefore, it is crucial to separate transportation costs from product costs in different phases, enabling a more effective allocation of transportation costs across various segments of the transport process. Secondly, the scarcity of logistic space on the edges of cities often means that the desired locations are not available for the multi-client UCCs. As a result, they settle on the second-best locations, which affects the performance of the UCCs. Thirdly, some UCCs experience growth problems because they cannot be connected to the electricity grid. Therefore, some UCCs cannot expand their charging infrastructure for charging additional vehicles. This is essential for the growth of the UCCs. Fourthly, municipalities are not solely focused on UCCs but are more focused on stimulating consolidated zero-emission transport within the city. How the market manages facilitate this is up to them according to the municipalities. However, municipalities are still able to stimulate the utilization of UCCs with multiple policies to reduce the number of vehicles within the city. Lastly, the actual performance of the UCCs in the Netherlands is limited measured by the operators, or the measurement is not transparent. This conclusion indicates that despite the effort of municipalities to stimulate the performance of UCCs, even with financial support, there are hardly any requirements for the monitoring of the desired results

It is evident that the market is currently unable to optimize the performance of the UCCs on its own. If the UCCs serve a public interest for reducing the vehicle trips within the city, is it essential for the municipality to use policies for stimulating the UCCs. If no or very little cooperation among the stakeholders is established, utilization of UCCs will remain minimal until the implementation of the ZEZ. To ensure that UCCs are more widely adopted in the coming years and thus have a greater impact on urban freight logistics, recommendations for both UCC operators and municipalities are provided. First, the measurement of UCC performance by operators is something that must be required to gain a clear understanding of the social effects of the UCCs on the urban area or show if the allocated UCC subsidies achieve the desired goal of reducing the vehicle trips in the cities. The performance measurement model also serves as a validation tool for municipalities to state the effectiveness of the financial support to the urban consolidation centers. Secondly, municipalities can implement stricter access restrictions for small deliveries. Therefore, stimulating the consolidation of freight and increasing the utilization of UCCS. Yet, this implementation is complex and requires further investigation for its desired form. These access regulations are currently investigated by the municipality of Utrecht. Thirdly, municipalities can establish requirements for their procurements and purchase policies. Such as the requirement for consolidated transport of their purchased goods. Fourthly, the municipality can bring together multiple stakeholders for the creation of a coalition of the willing to improve UCC utilization. Lastly, municipality can include the necessity and relevance of an UCC, in the spatial planning and environment, to designate a plot of land for the purpose of multi-client hubs. However, each euro can be spent once, therefore it is recommended for the

municipalities to focus on the requiring of consolidated transport in the procurements and for their own purchase policies. Together with requiring a performance measurement model for each UCC to estimate their social impact.

Additionally, UCC operators need to continue convincing suppliers, receivers, and carriers for utilizing their UCC. The cooperation of more stakeholders is essential for increasing the transported volume of the UCC. Despite the differences between the expected and actual outcomes, the current effects of UCCs are still desired by municipalities. Secondly, the UCC operators need to use a cost-allocation model for convincing more stakeholders and be transparent about the performance of the UCC with a UCC performance measurement model. Eventually, the implementation of zero-emission zones is going to increase the utilization of UCC. For a better understanding of the desirability of UCCs, further research is recommended in 2025, when stricter access restrictions are implemented in 30 to 40 cities with to the zero-emission zones. This would give better insight into the desirability of UCCs for multiple stakeholders in the Netherlands.

REFERENCES

[1] Allen, J., Browne, M., Woodburn, A. G., & Leonardi, J. (2012). The Role of Urban Consolidation Centres in Sustainable Freight Transport. Transport Reviews, 32(4), 473–490. https://doi.org/10.1080/01441647.2012.688074

[2] Allen, J., Browne, M., Woodburn, A. G., & Leonardi, J. (2014). A Review of Urban Consolidation Centres in the Supply Chain Based on a Case Study Approach. Supply chain forum, 15(4), 100–112. https://doi.org/10.1080/16258312.2014.11517361

[3] Andruetto, C. (2022). Exploring electrification, consolidation, cargo bikes and automation using a sustainability performance assessment framework

[4] Alsaawi, A. (2014). A critical review of qualitative interviews. European Journal of Business and Social Sciences, 3(4).

[5] Bailey, P. D., Haq, G., & Gouldson, A. (2002). Mind the gap! comparing ex ante and ex post assessments of the costs of complying with environmental regulation. European Environment, 12(5), 245–256

[6] Aung, K. T., Razak, R. A., & Nazry, N. N. M. (2021). Establishing validity and reliability of semi-structured interview questionnaire in developing risk communication module: A pilot study. Edunesia: Jurnal Ilmiah Pendidikan, 2(3), 600–606

[7] Bolscher, D. (2023). Schaarse ruimte dwingt tot delen van stadshubs. https://www.abnamro.nl/nl/zakelijk/insights/sectoren-en-trends/logistiek/schaarse-ruimte-dwingt-tot-delen-van-stadshubs.html

[8] Browne, M., Sweet, M., Woodburn, A., & Allen, J. (2005). Urban freight consolidation centres final report. Transport Studies Group, University of Westminster, 10.

[9] Egilmez, G., Gumus, S., & Kucukvar, M. (2015). Environmental sustainability benchmarking of the u.s. and canada metropoles: An expert judgment-based multi-criteria decision making approach. Cities, https://doi.org/https://doi.org/10.1016/j.cities.2014.08.006

[10] Filippi, F., Nuzzolo, A., Comi, A., & Site, P. D. (2010). Ex-ante assessment of urban freight transport policies[The Sixth International Conference on City Logistics]. Procedia - Social and Behavioral Sciences, https://doi.org/https://doi.org/10.1016/j.sbspro.2010.04.042

[11] Heale, R., & Twycross, A. (2018). What is a case study? *Evidence-based nursing* 21.1: 7-8.

[12] Lucas, S. R. (2016). Where the rubber meets the road: Probability and nonprobability moments in experiment, interview, archival, administrative, and ethnographic data collection. Socius, 2, 2378023116634709

[13] Nations, U. (2018). World's population increasingly urban with more than half living in urban areas. https://www.un.org/development/desa/en/news/population/world-urbanization-prospects.html

[14] Malterud, K., Siersma, V. D., & Guassora, A. D. (2016). Sample size in qualitative interview studies: Guided by information power [PMID: 26613970]. Qualitative Health Research, 26(13), 1753–1760. https://doi.org/10.1177/1049732315617444

[15] MDS Transmodal. (2012). Dg move european commission: Study on urban freight transport. Final report. Chester, UK: MDS Transmodal Limited.

[16] Motheral, B. R. (1998). Research methodology: Hypotheses, measurement, reliability, and validity. Journal of Managed Care Pharmacy, 4(4), 382–390

[17] Nations, U. (2018). World's population increasingly urban with more than half living in urban areas. https://www.un.org/development/desa/en/news/population/world-urbanization-prospects.html

[18] Nenni, M. E., Sforza, A., & Sterle, C. (2019). Sustainability-based review of urban freight models. Soft Computing, 23, 2899–2909.

[19] Paddeu, D. (2021). The Five Attribute Performance Assessment (FAPA) model to evaluate the performance of an urban consolidation centre. Research in Transportation Economics, 90, 101065. https://doi.org/10.1016/j.retrec.2021.101065

[20] Quak, H., Nesterova, N., van Rooijen, T., & Dong, Y. (2016). Zero emission city logistics: Current practices in freight electromobility and feasibility in the near future [Transport Research Arena TRA2016]. Transportation Research Procedia, 14, 1506–1515. https://doi.org/https://doi.org/10.1016/j.trpro.2016.05.115

[21] Schell, C. (1992). The value of the case study as a research strategy. Manchester Business School, 2(1), 1–15

[22] Van Rooijen, T., & Quak, H. (2010). Local impacts of a new urban consolidation centre–the case of binnen-stadservice. nl. Procedia-Social and Behavioral Sciences, 2(3), 5967–5979

[23] Van Thiel, S. (2014). Research methods in public administration and public management: An introduction. Routledge