Case Studies on Transport Policy 10 (2022) 518–528

Contents lists available at ScienceDirect

Case Studies on Transport Policy

journal homepage: www.elsevier.com/locate/cstp

How Urban Consolidation Centres affect distribution networks: An empirical investigation from the perspective of suppliers

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ARTICLE INFO

Keywords:
Urban Consolidation Centre
Urban freight transport
Sustainable logistics

ABSTRACT

An Urban Consolidation Centre (UCC) can decrease the number of freight vehicles and their mileage in urban areas. In practice, however, UCCs often rely on subsidies and seldom make it past their starting period. Understanding about how UCCs affect urban freight transport is mostly based on mathematical models and on the opinions of stakeholders who do not actually use a UCC. The purpose of this paper is to study empirically how the introduction of a UCC influences the logistics processes, costs, and service levels of suppliers. In a multiple case study, we collect data about the distribution networks of nine suppliers (including their receivers, carriers, and the UCC). Analyses of these data show that introducing a UCC affects the logistics processes of many actors in a distribution network, and these effects differ strongly depending on how the distribution network was structured initially. Generally, a UCC does not result in lower logistics costs for suppliers, at least not in the short-term, and often requires new service level agreements with receivers. We hope our study provides stakeholders with a balanced view on the role UCCs can play in making urban freight transport more sustainable.

1. Introduction

Urban freight transport plays an important role in the commercial and residential functions of a city. At the same time, it also causes sustainability problems such as congestion, pollution and reduced safety (Demir et al., 2015). With sustainability issues high on the agenda, local authorities, companies, and scholars have initiated and investigated various policies and solutions to restructure urban freight flows in an attempt to address these problems (Dablanc, 2007; Holguín-Veras et al., 2020a; Taniguchi and Van Der Heijden, 2000). Yet, organizing urban freight transport in a sustainable manner is complex as measures taken are often not economically viable or do not actually solve the social and environmental issues caused by urban freight transport (Strale, 2019).

One often applied and studied initiative intended to make urban freight transport more sustainable is an Urban Consolidation Centre (UCC). A UCC is a facility at the edge of a city where freight from multiple suppliers can be consolidated and delivered into the city (Browne et al., 2005; Janjevic and Ndiaye, 2017a). In principle, a UCC can decrease the number of vehicles entering a city and make the transition toward zero-emission vehicles easier, which would alleviate congestion, pollution, and safety issues. Mathematical modeling studies indeed suggest that UCCs can have benefits such as reducing route length, pollution and costs (Escuín et al., 2012; Estrada et al., 2018; Simoni et al., 2018). However, these benefits are not confirmed by empirical research. In fact, only a few UCCs have made it past their starting period (Björklund et al., 2017; Quak et al., 2020). Given the limited use of UCCs in practice, empirical insight on the actual effects of a UCC on urban freight transport is scarce. Most empirical studies thus far had to rely on the opinions of actors, stakeholders, branch organizations, or industry experts with little or no first-hand experience of using a UCC themselves (Holguín-Veras et al., 2020a; Van Duin et al., 2018).

The purpose of this paper is hence to empirically study how the introduction of a UCC influences the logistics processes from the warehouses of suppliers to the end receivers, possibly involving third-party freight carriers. In our study, we take the perspective of the supplier, an often overlooked but important actor in the success of a UCC, as suppliers determine the delivery strategy of their products and bear the resulting distribution costs (Holguín-Veras et al., 2015; Van Duin et al., 2018). While our focus is on suppliers, we also consider other actors and stakeholders in their distribution network. Our aim to answer the following research question: *How does the introduction of a UCC influence logistics processes, costs, and service levels of suppliers?* In a multiple case study, we collect in-depth empirical data from nine suppliers that

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https://doi.org/10.1016/j.cstp.2022.01.012
Received 4 February 2021; Received in revised form 24 June 2021; Accepted 16 January 2022
Available online 20 January 2022

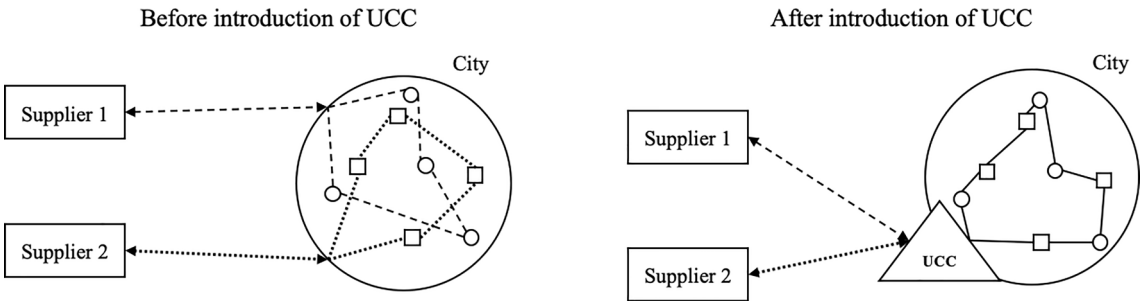


Fig. 1. Flow of goods before and after UCC introduction, based on Estrada and Roca-Riu (2017).

recently started making use of a UCC across two initiatives that were led by the receiver. Through interviews, we gained insight about the distribution network and logistics costs of these suppliers and about their stance on UCCs.

The contributions of our study are twofold. Firstly, it provides empirical insight into how a UCC affects the logistics processes, costs, and service levels of suppliers who actually use a UCC. Analysis of our data suggests that the effect of a UCC strongly depends on how the logistics processes were organized prior to introducing the UCC. Introducing a UCC did not reduce costs for all but one of the suppliers we interviewed – at least not in the short-term – and often required making changes in service level agreements between actors in the distribution network. Secondly, our study sheds light on how suppliers perceive the introduction of UCCs in their distribution network. The suppliers involved our study were generally positive about using a UCC, albeit they were motivated primarily by the receiver of their goods, who used their public procurement policy to encourage adopting a UCC. Furthermore, our findings suggest that the way in which costs and benefits are allocated across actors in the distribution network – and the transparency of the costs involved with the UCC – play an important role in stimulating suppliers to also use the UCC for other receivers.

2. Theoretical background

2.1. The urban consolidation Centre

A UCC is a logistics facility located in suburban and inner-city areas (Aljohani and Thompson, 2020a) where goods from different suppliers can be consolidated. From a UCC, the goods are often delivered in environmentally friendly vehicles into a specific geographic area, such as an entire city, a city center or a specific shopping center or construction site (Browne et al., 2005). The ultimate purpose of a UCC is often to reduce the total distance travelled in delivering goods to urban areas and to reduce the associated environmental impact (Allen et al., 2012) by increasing the load factor of vehicles that go into the city (Janjevic and Ndiaye, 2017a).

It is important to note that while a UCC can accommodate the consolidation of urban goods flows, it is not the only solution. Consolidation can also be achieved through already existing local distribution centers, by changing the behavior of actors (e.g., changing delivery requirements by receivers), and through horizontal or vertical collaboration (Buijs and Wortmann, 2014; Pan et al., 2019). Interestingly, UCCs have notably been studied more in depth than these other forms of consolidation (Verlinde et al., 2012).

2.2. Cost and benefits of using a UCC

Several mathematical modeling studies have attempted to quantify the potential benefits of UCCs for urban freight transport by comparing two scenarios: one before the introduction of a UCC and one after the introduction of a UCC. In the before scenario, suppliers – or their carriers – often deliver directly to the receivers of their goods in the city. In the after scenario, they deliver all their goods to the UCC and do not enter the city anymore. Instead, the UCC now delivers goods from all suppliers to all receivers in the city, as shown in Fig. 1. The benefits computed in these studies are a route length reduction of 15–35% (Escuín et al., 2012) and a pollution reduction of 11–21% (Simoni et al., 2018). The resulting cost savings are estimated at between 2 and 24% when comparing scenario's before and after the introduction of a UCC, including the costs associated with the UCC (Estrada et al., 2018; Estrada and Roca-Riu, 2017; Roca-Riu et al., 2016; Simoni et al., 2018).

Thus far, empirical research has not confirmed the benefits suggested by mathematical modeling studies, however. Indeed, some empirical work shows that route lengths in the city center may even increase due to the often more restricting loading limits of environmentally friendly vehicles (Browne et al., 2011). What is more, many UCCs fail to become financially viable and depend on government funding (Allen et al., 2012). In some of the cases where UCCs have been considered viable – which does not always mean profitable (van Duin et al., 2016) – access restriction policies were needed to motivate stakeholders to actually use the UCC (Morganti and Gonzalez-Feliu, 2015). In other cases of viable UCCs, business models are continuously changing and many UCCs are still subsidized by local authorities (Björklund et al., 2017; Paddeu, 2017; Quak et al., 2020). These findings seem to be at odds with the generally positive results from modeling studies.

A UCC may reduce costs because of shorter routes in the last mile, but also involves additional costs, such as personnel costs, vehicle costs and material handling costs. For a UCC to become financially viable, it needs to create enough benefits from cost savings in the last mile to compensate for these additional costs. There are studies that estimate a UCC's break-even point to be at a throughput volume around 335 to 380 parcels per day (Janjevic and Ndiaye, 2017b; Kin et al., 2016; Lin et al., 2016). However, the break-even point of a UCC will depend on the specific setting as costs are determined by factors such as the location of the UCC, the labor costs, and the value adding services provided. Regardless of the exact break-even point, attracting a substantial volume is challenging as UCCs can create cost savings only for certain flows in urban freight transport. Prior research suggests UCCs create most benefits for routes with few deliveries to locations that are far apart from one another (Janjevic and Ndiaye, 2017a). Overall, there seems to be a strong tension between the limited number of deliveries that can benefit from a UCC and the need for large throughput volumes required to make a UCC financially viable. This is because, on the one hand, suppliers that would benefit the most from a UCC are those with relatively small freight volumes and doing their own transport. On the other hand, carriers who deliver the majority of urban freight are already rather efficient and thus less likely to benefit from using a UCC (Browne et al., 2005; Kin et al., 2016).

2.3. Actors and stakeholders involved in a UCC

The lack of volume that hampers the success of UCCs is also related to the complex network of actors (i.e., carriers, receivers, and suppliers) and other stakeholders (e.g., local government and NGOs) related to a

UCC. Prior research has shown that it is important to ensure all actors involved accept the UCC initiative, commit to it, and actively participate in it (Gammelgaard, 2015; Nordtømme et al., 2015; Österle et al., 2015). Studies consulting actors and stakeholders by Aljohani and Thompson (2019) and by Lebeau et al. (2018) have shown that the main objectives of different actor groups are related to costs and service levels, but these translate differently to specific expectations each actor group holds. Carriers, for example, aim to reduce the costs of picking up and delivering goods and to minimize the delivery time, while receivers want to reduce costs of receiving goods (e.g., the delivery fee and processing incoming goods), expect an on-time delivery, and would like to see reduced congestion in the urban area. As all actors involved in a UCC want to reduce costs, the allocation of costs and benefits related to a UCC is important to its success (Allen et al., 2014).

The main objectives of suppliers are to keep delivery costs low and to deliver successfully and on-time (Aljohani and Thompson, 2019; Lebeau et al., 2018). The perspectives of suppliers, their representatives (e.g., branch associations) and freight transport experts vary with regard to the potential outcomes of a UCC. Some anticipate that using a UCC has a negative impact on the logistics processes, costs, and service levels of suppliers (Holguín-Veras et al., 2020a), while others expect a positive impact assuming a UCC can improve efficiency (Van Duin et al., 2018). Besides costs and service levels, the use of a UCC can also be part of the corporate social responsibility strategy of a supplier, as it may reduce the environmental impact and noise pollution (Browne et al., 2011). However, a negative effect on service levels and costs will likely outweigh any positive contribution of using a UCC on a supplier's sustainable image (Van Duin et al., 2018).

Overall, the support of actors for a UCC is limited. Although freight transport experts expect a UCC to positively influence carriers (Holguín-Veras et al., 2020a), only 15% of carriers are supportive of a UCC in general – a figure that doubles to 30% if a UCC is introduced together with access restrictions into a city (Stathopoulos et al., 2012). Receivers seem to be somewhat more supportive of using a UCC, although the 35% favorability rate suggests that the majority of receivers still oppose using a UCC (Stathopoulos et al., 2012).

How actors perceive the introduction of a UCC may also depend on the specific actor taking the initiative. For example, when carriers lead a UCC initiative, they can influence which receivers are delivered through the UCC, which helps to achieve the desired cost savings (Estrada et al., 2018; Estrada and Roca-Riu, 2017). Receivers – together with suppliers – have the power to determine when and how deliveries are made and can therefore motivate other stakeholders to consolidate deliveries (Holguín-Veras and Sánchez-Díaz, 2016). Retail stores are a commonly addressed receiver group and their willingness to participate in a UCC initiative varies depending on their delivery experiences, their industry and the possible benefits from a UCC's storage and handling services (Aljohani and Thompson, 2020b; dell'Olio et al., 2017; Johansson and Björklund, 2017; Paddeu et al., 2018; Van Rooijen and Quak, 2010). Recently, Brettmo and Browne (2020) showed that business improvement districts, uniting receivers in one urban area, can effectively promote initiatives for sustainable urban freight transport, such as the use of UCCs. Public organizations are a particularly promising group of receivers to stimulate the use of a UCC among their suppliers, as they have buying power and are motivated by their publicness to contribute to more sustainable urban freight transport (Balm et al., 2016).

Besides the actors whose operations are directly influenced by using a UCC, local authorities are frequently addressed as important stakeholders in the urban freight transport system. To improve livability in cities, local authorities implement urban freight policies, such as limited traffic zones, time windows and parking policies (Holguín-Veras et al., 2020b; Holguín-Veras et al., 2020a). Such policies can, however, inadvertently reduce the efficiency of existing logistics processes (Eren Akyol and De Koster, 2018; Quak and de Koster, 2007; Vidal Vieira and Fransoo, 2015). Nonetheless, urban freight policies may form an extra stimulus for stakeholders to use a UCC when these policies increase the costs of entering the city with their own vehicles (Marcucci and Danielis, 2008; Morganti and Gonzalez-Feliu, 2015). In addition to stimulating the use of UCCs via public policy, local authorities can also directly support a UCC, either by leading a UCC initiative or becoming a launching customer of its services (Björklund et al., 2017). Marcucci et al. (2015) suggest that decision makers in cities or municipalities developing policies for more sustainable urban freight transport should consult the actors that are affected by these policies. Still, it is complicated to develop policies that balance sustainability and economic objectives as the interests of the actors and stakeholders involved are often conflicting and context-dependent (Buldeo Rai et al., 2017; Lebeau et al., 2018).

Although general perspectives of stakeholders and actors towards using a UCC are discussed in the academic literature, there is little empirical insight on the effect a UCC has on the logistics processes of actors that actually make use of one. In most studies, stakeholders and potential actors that do not yet use a UCC are asked if they would use a UCC. To our knowledge, Browne et al. (2011) is among the few studies that have empirically investigated how the actual use of a UCC affects logistics processes and costs. Their case study compares the logistics processes and costs of one supplier before and after the introduction of a UCC and shows that although the UCC did not reduce the distance driven in the city, it did reduce overall transportation costs and the total distance travelled. This dearth of empirical research comparing how the distribution networks of suppliers are affected by the introduction of a UCC is an important motivation for our study.

Table 1
Overview of cases.

Supplier	Product category	Own-account or outsourced transport network	Receiver	UCC
Paper 1	Paper and printed matter	Outsourced	Public 1	UCC Amsterdam
Office 1	Office supplies	Outsourced		
Furniture 1	Furniture	Outsourced		
Food 1	Food (non-perishable)	Own depots and partly outsourced (to dedicated carrier)	Public 1 and Public 2	
Hygiene 1	Hygienic products	Own transportation and partly outsourced	Public 2	
Office 2	Office supplies	Own transportation and partly outsourced (to dedicated carrier)		
Disposables 1	Disposables	Outsourced		
Food 2	Food (perishable and non-perishable)	Own transportation	Public 3	UCC Groningen
Office 3	Office supplies	Outsourced		

3. Method

We adopted a qualitative research approach based on a multiple case study with interviews as the main source of data collection. The focus in the case study was on the distribution network of nine suppliers that recently started using a UCC. A qualitative approach suits our research objectives well, because it allows for triangulating different sources of rich empirical data collected by means of interviews and documents (Barratt et al., 2011; Yin, 2009).

3.1. Case selection and context

As most UCC initiatives over the past years have failed to become financially viable, there were only a handful of UCCs in operation in the Netherlands, where we conducted our study, when we started selecting our cases in 2019. Moreover, there were not many suppliers that made use of a UCC, which limited the choice of suppliers that we could select for our case study. Still, we were able to study nine suppliers who deliver via one of two UCCs to multiple locations of one of the three receivers that were part of our study, as shown in Table 1. Four of these suppliers have their own transport network while five suppliers outsource transport, which can influence the possible benefits of a UCC for a supplier (Janjevic and Ndiaye, 2017a). Overall, this selection of cases enabled an in-depth analysis of the impact of introducing a UCC in the logistics processes of a supplier and to compare this impact across different suppliers.

Both of the UCCs in our study were initiated by the receivers – large public organizations with buying power to influence their supplier's delivery processes. In this sense, the use of a UCC in our cases can be described as receiver-led consolidation initiatives (Holguín-Veras and Sánchez-Díaz, 2016). The UCCs have throughput volumes between 50 and 350 orders per week which include a broad range of office supplies (e.g., printing paper, stationary, hygiene products, furniture, and food). Although they have not reached the hundreds of orders per day that would theoretically be needed to break even (Janjevic and Ndiaye, 2017b), the UCCs are operating independently. Since 2013, UCC Amsterdam operates as a commercial, white label UCC that collaborates with a large national carrier for the delivery of goods into the city. The two receivers involved in this UCC initiative allocate costs and benefits differently: Public 1 lets suppliers pay the costs of the UCC; Public 2 pays these costs. Paper 1, Office 1 and Furniture 1 are suppliers of Public 1 and Hygiene 1, Office 2 and Disposables 1 are suppliers of Public 2. Food 1 is a supplier of both Public 1 and Public 2. UCC Groningen is a private UCC, located on the premises of the receiver Public 3. In 2019, Public 3 expanded its internal goods receipt department to operate as a UCC for all incoming goods, which are mostly office supplies. At the time of the research, UCC Groningen exclusively delivered to the locations of Public 3, and Public 3 paid all costs involved in operating the UCC and the deliveries to the different locations. Food 2 and Office 3 are suppliers of Public 3.

3.2. Data collection

The data collected for this study consist mostly of data from semi-structured interviews with several actors involved in two UCC initiatives. We conducted a total of 17 interviews with nine suppliers, three receivers, two UCCs, and one carrier. Appendix A provides an overview of our interviews. In the interviews with suppliers, we spoke with logistics managers and/or sales managers about the effect of the UCC on their logistics process, costs, and service levels, about their decision to use a UCC, and discussed their general attitude towards UCCs. During the interviews, we drew out the logistics processes and validated with the interviewees if we interpreted the supplier's descriptions correctly. We had two follow-up interviews with a supplier doing its own transportation and a UCC operator to discuss how using the UCC for more receivers would influence the supplier's logistics costs. In interviews with other key actors, such as the receivers, the UCC operators, and the carrier of UCC Amsterdam, we discussed their reasons for introducing or starting a UCC, how they motivated their suppliers to use the UCC, the allocation of costs and benefits, service levels, and collaboration between the different actors. These interviews thus captured perspectives from all actors involved and enabled triangulation of the information shared by the suppliers about their use of the UCC. Through detailed accounts from the interviewees and by attending joint meetings between suppliers and the UCCs, we gained insight into the design and workings of the logistics processes from the suppliers' warehouses to the final

Table 2
Supplier analysis.

Supplier	Paper 1	Office 1	Furniture 1	Food 1	Hygiene 1	Office 2	Disposables 1	Food 2	Office 3
Logistics process before UCC introduction	Delivery from national warehouse through large carrier using local depots	Delivery in boxes by large carrier using local depots	Delivery by dedicated carrier from own warehouse to receiver	Delivery by medium-sized carrier from national warehouse through own depots	Delivery by own vehicles and by medium-sized carrier from national warehouse through own depots	Delivery by dedicated subcontractors from international warehouse through own depots	Delivery by two medium-sized carriers from own warehouse to receiver	Delivery with own vehicles from own local depots	Delivery through large carrier using local depots
Logistics process after UCC introduction	Delivery in full truckloads from international factory to UCC, skipping national warehouse and local depot (Fig. 3b)	Delivery on pallets from local depot to UCC (Fig. 2b)	Delivery from own warehouse to UCC (Fig. 2a)	Delivery from national warehouse to UCC, skipping depot (Fig. 3a)	Delivery from national warehouse to UCC, skipping depot (Fig. 3a)	Delivery from own central depot to UCC (Fig. 3a)	Delivery from own warehouse to UCC (Fig. 2a)	Delivery from own depot to UCC (Fig. 2b)	Delivery from carrier depot to UCC (Fig. 2b)
Effect of UCC on total logistics costs	Expects cost reduction due to reduced distance travelled between warehouse and receiver	Cost increase due to UCC fee, cost reduction due to lower carrier costs, total costs remain even	Expects cost reduction, but no insight in costs yet	Cost increase due to UCC fee	No direct effect due to fixed costs	Cost reduction due to elimination of subcontractor costs	No effect due to receiver being the only customer in the city	Limited effect due to fixed costs, only saves fuel due to reduced distance and travel time	No effect due to carrier costs remaining the same
Allocation of costs and benefits	Supplier pays UCC costs	Supplier pays UCC costs and increases prices to receiver	Supplier pays UCC costs	Supplier or receiver pays UCC costs (depending on receiver)	Receiver pays UCC costs	Receiver pays UCC costs and supplier reduces prices	Receiver pays UCC costs	Receiver operates and pays UCC costs	Receiver operates and pays UCC costs
Effect of UCC on service levels	Limited effect (stock in UCC is closer to receiver)	Reduced delivery frequency (biweekly)	Reduced delivery frequency (weekly)	Reduced delivery frequency (delivery takes an extra day)	Other delivery method (delivery at the door instead of at the desk)	Reduced delivery frequency (weekly)	Not applicable (did not supply customer before using UCC)	Reduced delivery frequency (delivery takes a half to one extra day)	Reduced delivery frequency (delivery takes a half to one extra day)

a. Goods flow through UCC instead of directly from supplier to receiver (Furniture 1, Disposables 1)

b. Goods flow through CF and UCC, suppliers still enter city (Office 1, Food 2, Office 3)

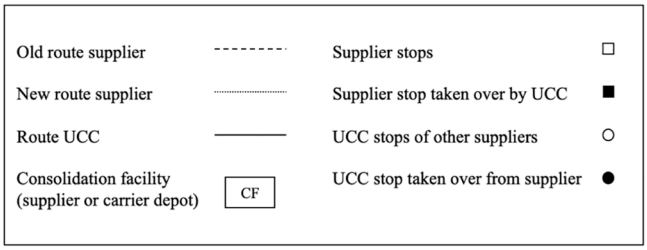


Fig. 2. UCC adds steps to the logistics process.

delivery at the receiver's locations, including line haul transport, transshipment, and last mile transportation.

In addition, we collected data on logistics costs from before and after the introduction of the UCC from three suppliers. The nature of the collected cost data differed per supplier, as each supplier calculated costs in a different way. For one supplier, the difference in costs before and after introducing the UCC was simply the cost difference per parcel charged by its carrier, while another supplier also had to calculate the savings on the line haul, including fuel, personnel, and vehicle costs. Besides the data collected during interviews and on logistics costs, we had several informal conversations with different actors in the logistics networks and received documents from suppliers and other actors, which were used to further triangulate our findings. An overview of our case study protocol is presented in Appendix B.

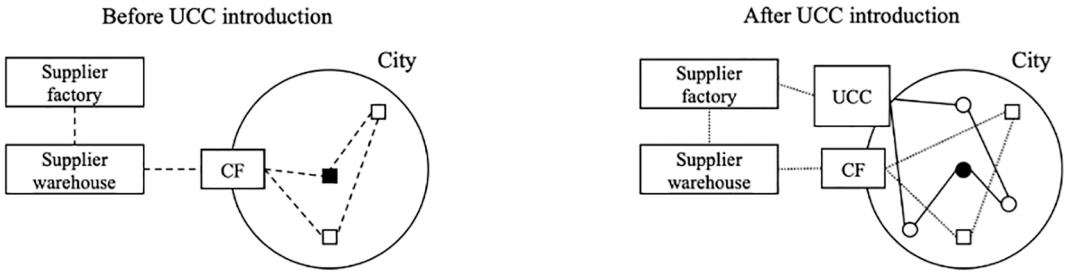
3.3. Data analysis

All interviews were recorded with permission of the interviewees and later transcribed. After we transcribed the interview recordings, we conducted a within-case analysis of the distribution network of each supplier. To this end, we developed a template, which we filled for each supplier with information about their logistics processes, costs, service levels and the impact of the UCC thereon. In these templates, we summarized the information shared by suppliers and other actors supported by quotes. Condensed parts of these templates can be found in Table 2. For each supplier, we made a graphical representation of the logistics processes from the warehouse – and in one case the factory – to the receiver, before and after the introduction of the UCC. These graphs were based on the supplier's description of the processes and the drawing of the processes made during the interview. To determine how the UCCs influenced logistics costs, we analyzed suppliers' ideas about how the UCC influenced costs and when possible, compared this to the objective cost data. After we filled the template for each supplier, we conducted a cross-case analysis to compare the suppliers on the different aspects from our research question (Eisenhardt, 1989). First, we looked for similarities and differences in the logistics processes and later divided these into types. We then compared how costs and service levels changed after the introduction of the UCC for the different suppliers and if there were underlying factors that explained differences and similarities. Finally, we looked for overarching themes that could contribute to our understanding of how the introduction of a UCC affects the distribution network of suppliers.

4. Results

A key finding from our study is that the introduction of a UCC does not have a singular effect on the logistics processes, costs, and service levels of suppliers. This effect depends on several factors, such as the

a. Goods flow through UCC instead of CF, suppliers still enter city (Food 1, Hygiene 1, Office 2)



b. Goods flow through UCC instead of supplier warehouse and CF, supplier still enters city (Paper 1)

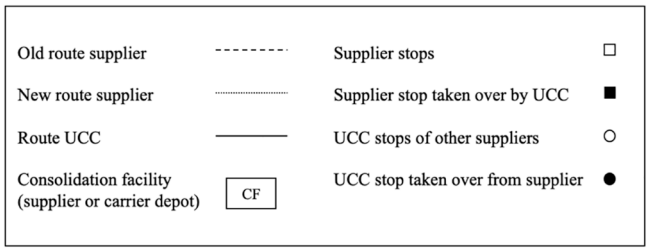


Fig. 3. UCC partly replaces steps in the logistics process.

existing logistics processes and agreements between the actors in the supply chain. In the following sections, we describe what the results from our study tell about the effect of introducing a UCC on logistics processes, costs, and service levels. Additionally, we discuss the role of public policy, as during our data analysis this turned out to be a critical element in motivating suppliers to use a UCC.

4.1. Impact of UCCs on logistics processes

The collected data reveal that the distribution network of each supplier is structured differently. The implications of introducing a UCC thus differ per supplier, as described in Table 2 and shown in Figs. 2 and 3. We spoke to large, nationally operating suppliers belonging to the largest suppliers in their category (e.g., Office 1, 2 and 3 are three of the largest office suppliers in the Netherlands). These suppliers usually deliver to multiple receivers in the same city and already used consolidation facilities (i.e., depots) – in some cases of their carriers – located closely to receivers in the city. At the depots, trucks bring large volumes of goods that are sometimes stored for a period and then bundled before being delivered to the receiver, usually in smaller vehicles with average loading rates of 70 to 100%. Only Disposables 1 and Furniture 1 do not use a depot and delivered directly from their national warehouse to the receiver. These two suppliers deliver larger volumes per shipment, ranging between full pallets and full truckloads.

When comparing how the introduction of a UCC affects the logistics processes of suppliers, we identified two overall categories. In the first category, shown in Fig. 2, the UCC adds an extra step to the logistics processes. Furniture 1, Disposables 1, Office 1, Food 2, and Office 3 fall into this category. In those cases where goods went through a depot before the introduction of the UCC, the goods still go through the depot of the supplier or carrier now that the UCC is introduced. Two suppliers have concerns about the UCC as an extra step in the process, as it creates inefficiencies and complicates the control of lost goods. "*So that means more labor, more vehicles, and goods are handled another time*" (Food 2). "*It is about responsibility, you need to arrange who is responsible*" (Office 1). Office 3, on the other hand, does not have such concerns as they do not see the UCC as an extra step: "*It is not an extra step for us, because it [the UCC] is our final step*".

In the second category, shown in Fig. 3, the UCC partly replaces steps in the logistics processes. In the cases of Food 1, Hygiene 1, and Office 2, the UCC replaces the step of the supplier or carrier's depot as their goods go directly from the central warehouse to the UCC (Fig. 3a). Skipping the depot has benefits, Hygiene 1 for instance needs less storage space in the depot and fewer trips are driven from the depot to the city. In the case of Paper 1, the UCC replaces two steps in the process, as shown in Fig. 3b. Paper 1 delivers directly from the factory of their supplier to the UCC,

hereby skipping both the central warehouse and the carrier's depot.

We note that Figs. 2 and 3 give a simplified representation of the goods flows from a supplier's warehouse or factory to the end receiver. For example, Fig. 2b shows only three supplier stops, while in reality there could be up to 60 stops.

Except for Food 1, suppliers we interviewed use the UCC only for one of their customers, as their other customers are not involved in the UCC initiative. And, all suppliers, except for Disposables 1, have more customers in the city than only those associated with the UCC. Suppliers provide other customers with goods via their original distribution network and logistics processes – thus, without the UCC – and therefore still enter the city. In these cases, the UCC does not reduce the actual distance travelled, especially when other customers are located closely to the receiver using the UCC. Food 2: "*We have more [customers] in this area, so we still drive past old locations. […] So, when you start with a UCC, everyone must be involved to make it very interesting, to reduce vehicle movements*". This holds especially for private UCCs that only serve one receiver, such as UCC Groningen, as suppliers cannot use this UCC for other receivers. The openness of a UCC toward including other receivers is a key factor determining if the UCC can actually reduce distances driven in the city.

Few suppliers consider using the UCC for other customers in the city as well, due to organizational barriers and delivery agreements. Office 2 explained: "*We cannot just say, we deliver to a UCC. That does not work, that is contractual. […] You should also look at how contracts are made up with customers, what does the end user expect, is he organized for that? We had that in the case of one city, that was so much work, to organize it all*". Only Food 1 uses the UCC for multiple customers who are located closely together: "*Not for all customers, but for those in that area, it is good to have synergy so you deliver everything at the same time*". Paper 1 and Hygiene 1 are investigating the possibilities of using the UCC for other customers, because they expect it will create efficiency and cost benefits. Although Paper 1 uses the UCC only for Public 1, the supplier sees potential to deliver paper to more receivers in the same city using the UCC: "*We talk to other receivers [about using a UCC], but it is not common yet […]. What holds us back is that these receivers are not our customers yet*". Hygiene 1 discusses the use of a UCC with four customers located closely to one another and talks to these customers about using the UCC, because the supplier expects costs of using the UCC will decrease when more customers are supplied through the UCC.

4.2. Impact of UCCs on logistics costs

Our data show that the impact of introducing a UCC also affects logistics costs of suppliers differently. The effect on costs depends not only on how a UCC changes the logistics processes, but also on the allocation of costs and benefits across suppliers and receivers. Five suppliers said that the introduction of a UCC has had no (direct) effect on their logistics costs (Hygiene 1, Office 1, Disposables 1, Food 2, Office 3). Two suppliers had no insight in the costs of the UCC or did not calculate the effect, but assume a cost reduction (Paper 1, Furniture 1). Only Office 2 was certain that the introduction of a UCC reduced their logistics costs. Food 1 was the only supplier who said with certainty that the introduction of the UCC increased their costs.

When taking a network perspective, the introduction of a UCC often did not result in cost reductions, at least not in the short-term. Firstly, last mile transportation distances and costs do not decrease because suppliers still enter the city, as Office 3 explained: "*If the truck only drove for Public 1, then we would have cost reductions, but a truck is filled efficiently. It drives to Groningen and perhaps past Public 1 to deliver to the neighbor, so [our] costs remain the same*". The limited number of suppliers using the UCC also prevents cost decreases, which may change in the future, as Food 1 expects that: "*In a few years, things may look differently, when more companies use the UCC it becomes interesting, synergy takes place and costs decrease*".

Even if introducing a UCC would result in benefits in the last mile, these benefits would not directly materialize due to long term contracts between suppliers and the owners of existing logistics facilities and – for suppliers with own transportation – vehicle lease companies and personnel. Even when a depot is skipped and the UCC replaces a step in the logistics processes, the use of a UCC does not directly reduce costs. Hygiene 1: "*When you have existing customers, existing vehicles, existing rent [of warehouses/depots], you do not save costs. Only when new contracts can be negotiated, which usually happens every three to five years, the number of vehicles and facilities can be reduced*". Thus, to reap the cost benefits of using a UCC, suppliers with their own transportation need to change the structure of their entire distribution network, for example by closing depots and laying off staff. Furthermore, carriers usually quote a fixed price per parcel to the supplier, which does not change when the carrier must drop the parcel at a UCC instead of a receiver. Direct costs can only reduce when the UCC fully replaces a carrier's depot and the carrier's services are no longer used, as shown in the cases of Office 2 and Paper 1.

Our data suggest that the introduction of a UCC may decrease suppliers' transport costs because of factors other than reducing last mile transportation distances. First, the costs of using a UCC may be lower than the costs charged by the carrier for the last mile, such as in the case of Office 2. Second, when the introduction of a UCC reduces steps in the logistics process, such as the line haul transportation of a carrier, this may save costs. Paper 1, for example, has a cost reduction because there is no line haul transportation from the central warehouse to the carrier's depot anymore. Third, a supplier with its own transport, and whose depot is located far from the receiver, may benefit from using a UCC if it is located closer to the receiver. Hygiene 1 compared the effect of using a UCC in Amsterdam – 30 km from their nearest depot – to using a UCC in Maastricht – 120 km from their nearest depot: "*The volume is now so big that I could look for a depot there [in Maastricht], but I don't want to because it costs time and money. So, using a UCC, there would be beneficial*".

Except for Food 1, the introduction of a UCC did not increase logistics costs for any of the suppliers either – even when the UCC adds a step to the logistics processes. However, this is due to the way costs and benefits are allocated across receivers and suppliers in our cases. Receivers Public 2 and Public 3 effectively bear the costs of the UCC and therefore logistics costs for the suppliers in these cases do not increase. These receivers pay the cost of the UCC as they expect it removes the main – or only – barrier for suppliers to use the UCC. Public 1 lets the supplier pay for the UCC because they do not want to subsidize the use of a UCC and find it more sustainable and cost-effective in the long run when suppliers bear the costs. To compensate for any losses in the short-term, however, Public 1 did change their price agreement with Office 1 to partly offset the supplier's cost increase associated with introducing a UCC.

An effect of the cost-benefit allocation scheme where receivers pay for the UCC, is that suppliers do not know the actual costs of using the UCC. How the use of a UCC is priced is often not transparent and differs from how supplier's traditional logistics costs are structured. To consider using the UCC for more customers, suppliers want to know how much using a UCC would cost. Hygiene 1: "*I do not know the costs that the UCC invoices. […] When that information is known, I can calculate the savings*".

While all suppliers consider costs to be an important factor when reflecting on the use of UCCs, few suppliers had actually calculated the precise effects of the introduction of the UCC on their logistics costs. Together with some suppliers, we tried to calculate this effect, taking into account the costs for storage, line haul transport, and last mile transportation. In the case of Hygiene 1, it took multiple follow-up interviews to compare how these costs changed exactly after a UCC was introduced. During these interviews, it became clear that introducing a UCC affects more than only the direct costs of one delivery, but can impact a supplier's entire cost structure, which makes it complex to evaluate the effect precisely. Suppliers with their own transportation often determine one overall logistics cost per unit by simply adding up all logistics costs and dividing it by the total number of units. What is

more, while each delivery has a different cost, depending on distance and time driven, suppliers often do not differentiate costs across deliveries – rather, they work with an average cost. When a UCC is introduced in a large city with high density, the overall logistics cost per unit can increase, as UCC Amsterdam explained to a supplier: "*If you take out Amsterdam [from your own transport] you do not compensate for [a rural area] anymore, so you need to take that into account [as] you don't know if the density you had is still the same*". Additionally, because the volume going through a supplier's own depot decreases when more volume goes to the UCC, the costs of running the depot will likely increase per unit.

4.3. Impact of UCCs on service levels

Our results show that introducing a UCC affects service levels in different ways, both positively and negatively. First, a UCC may apply other delivery methods than the supplier used to do. For instance, a UCC may only offer to drop off goods at the door, while a supplier delivers at a desk or in a stockroom. Such differences can impact the receiver, as Hygiene 1 explained: "*You see that in the whole process, the project with receiver, UCC and supplier, people do not quickly accept change. There is a lot of resistance when a driver is replaced and is not willing to put goods in a stockroom, but puts it at the entrance and makes it the receiver's responsibility to put it in the stockroom*". Second, the introduction of a UCC can be coupled with a change in delivery time. Food 1: "*When you use a UCC, the delivery takes an extra day*". In some cases, receivers and suppliers decided to reduce the delivery frequency to make the logistics processes after the introduction of the UCC more efficient and avoid a cost increase. For instance, Office 1 went from delivering the next day to delivering once a week after the introduction of the UCC: "*Of course, it is more efficient to deliver one time compared to five times per week at the customer*". This supplier bundles orders in their warehouse, which are delivered on pallets to the UCC. The UCC unstacks the pallets and distributes individual orders to customers. Fewer delivery moments can also benefit the receiver and can be a reason to let suppliers use a UCC, as it minimizes handling of incoming goods. Public 1: "*There are so many moments a package is delivered, and each time someone, a security guard for example, needs to find out for who it is, and leave their spot. That aspect plays a role*". Third, a UCC can offer services that a supplier or its carrier previously did not offer. For instance, UCC Amsterdam offers storage services which benefit suppliers as it allows them to quickly respond to urgent demand requests without the need of operating an own depot in the city. Material handling and temporary storage services offered by a UCC also facilitate delivery changes such as the reduction of delivery frequency.

The potential benefits of a UCC also depend on the service level required by receivers. UCC Amsterdam explained how delivery requirements of a receiver can influence the potential efficiency benefits that they can create: "*fixed [weekly] delivery moments are out of the question there, while that is where we can benefit the most. All goods need to enter the city within eight hours, that leaves very little flexibility*". Still, receivers usually adapt well to the reduced delivery frequency. Public 1: "*In general, people may have become a bit more patient*". Hygiene 1 discusses changing the delivery moment with other customers who consider using the UCC in the future: "*In the beginning there was resistance, especially with such products, frequency is often mentioned. But what does it matter that one receiver orders on Monday and the other on Thursday? I need to explain that they will receive their delivery. That can be scary in the beginning, but people will soon trust in it*". Another key factor is the product variety a supplier delivers to a receiver. UCC Amsterdam: "*The [business] case with Paper 1 was easily made, but somewhere else with many different types of paper it was very complicated. You need four times as much stock and planning*".

4.4. How public policy can motivate suppliers to use a UCC

After analyzing the collected data and answering our initial research questions, we were triggered by the important role the receivers played in motivating and guiding suppliers to use a UCC in our study. Accordingly, we further analyzed our interview data on the role of public policy. Public authorities have several means to improve sustainability, such as by restricting access of urban freight actors through regulations, but they can also use their power as a large buyer. The receivers in our cases did the latter and thereby played an important role in motivating suppliers to use a UCC. The aim of the receivers was to reduce their impact on the environment, thereby promoting their own green efforts and act as an example for other (private) organizations, to reduce internal work for receiving goods, and to reduce nuisance from delivery vehicles around their locations. In most cases, suppliers only use the UCC for one receiver because that receiver asked them to, or simply required it when tendering their services. Office 2: "*It was part of the contract, a sort of requirement*". Furniture 1: "*I got involved through Public 1. I was invited and went there because I found it interesting. And from there we started in Amsterdam*".

A requirement from a receiver can also positively affect a supplier's view on UCCs in general, as Paper 1 explained: "*It was a requirement from the tender. [..] One of the requirements was: you collaborate with the UCC. […] It was not voluntary, we just had to. We had no choice. And it is not bad at all, because it has been quite a learning experience*". Suppliers however remain skeptical about the actual benefits of using a UCC. Office 1: "*But you still see that the neighbors of Public 1 are still being delivered by DHL/GLS/PostNL. That is the biggest problem*". Receivers are aware that suppliers often still enter the city for other customers and that only few suppliers deliver to other customers via the UCC. Therefore, Public 2 considers using incentives in their future tenders that would benefit suppliers when also using the UCC for other customers. Public 3 does not have this possibility as it operates its UCC in-house, but they discuss the possibility of opening their UCC to receive goods for another receiver.

Despite their doubts about the benefits of UCCs for last mile transportation, suppliers do have a positive stance towards the idea of consolidation and see potential societal benefits of using a UCC. Office 2: "*I fully understand the idea, to keep vehicles from large cities, to bundle goods*". Hygiene 1: "*If we consolidate with each other and create space and the UCC is paid by that, I applaud that*". Additionally, some suppliers are positive towards using a UCC when it is communicated externally, because it improves their sustainable image.

All suppliers deem public policy regulations, such as access and vehicle restrictions, a crucial aspect in the development and use of UCCs. At the same time, they do not know how these policies will develop in the future and worry about public policy leading to unnecessary inefficiencies in their logistics processes. This holds especially for suppliers with their own transport, who need to change their distribution network when such policies are implemented. These changes can be complex and time-consuming, due to the restricted capacity of electric vehicles and the need to make investments and contracts several years ahead, while future restrictions and technological developments are unsure. Hygiene 1: "*We can do logistics, but I just get the transition from fossil fuel to electric on my plate, it is not my world*". Using a UCC can shift the burden of these uncertainties and complexities away from the supplier to the UCC.

5. Discussion

Our study provides four important insights with implications for scholars, managers, and policy makers with an interest in UCCs and sustainable urban freight transport.

5.1. Effect of UCCs on logistics processes

A first important insight from our study is that distribution networks

of suppliers are structured differently across cases and that these differences have strong implications on how the introduction of a UCC affects the logistics processes, costs, and service levels. For example, for some suppliers a UCC forms an additional step in their logistics processes. Often, the logistics processes were relatively efficient before introducing the UCC, with full vehicles driving from a supplier's existing depot to multiple receivers in the city. For other suppliers, the UCC replaces or reduces a step in their logistics processes. Overall, introducing a UCC has negative effects for some suppliers and positive effects for others. From a theory-building perspective, this may help clarify why previous studies found contrasting opinions when suppliers were asked to reflect on the potential effects of a UCC (Holguín-Veras et al., 2020a; Van Duin et al., 2018). Additionally, our study confirms that the existing dynamics in an urban freight transport network change after a green initiative is introduced (Perboli and Rosano, 2019). Finally, this has key implications for policy makers, who need to consider how urban freight policies influence the existing logistics processes of key actors and stakeholders in their city and need to determine if those policies actually make logistics processes more sustainable.

5.2. Effect of UCCs on logistics costs

Secondly, our study includes mostly suppliers for whom logistics costs did not change considerably after introducing a UCC – even, and especially, when the receiver also pays for the costs of using the UCC. On the one hand, a decrease in logistics costs that could be expected based on prior research (Estrada and Roca-Riu, 2017; Simoni et al., 2018) does not seem to materialize for most suppliers – at least not in the short-term. For some suppliers in our case study this was due to the fact that they still enter the city to deliver goods to other customers. The UCC then does not reduce the overall distance travelled. Indeed, we observed cases where the number of vehicles entering the city has likely increased due to the last mile transportation from the UCC and the suppliers' depots running in parallel. In cases where the introduction of a UCC does enable some efficiency benefits, suppliers could not always reap those benefits because of long-term contracts for their depots, vehicles, and personnel. On the other hand, due to the role of the receiver, who in most of our cases paid the cost of the UCC to motivate suppliers to make use of it, we also do not find empirical support for the much feared cost increase that could stem from a UCC (Aljohani and Thompson, 2019).

Generally, prior research recognized that for a UCC to be financially beneficial, the cost of operating the UCC needs to be offset by cost savings in the last mile (Janjevic and Ndiaye, 2017b). The insights from our study suggest that this break-even point is difficult to obtain in the short-term, which holds implications for managers and policy makers. If policy makers focus on the potential cost benefits when communicating the introduction of a UCC, this may well disappoint suppliers in the early stages of the initiative – when they realize there are in fact no cost reductions in the short-term. Rather, policy makers could communicate about the longer-term possibilities with a UCC to structurally change a supplier's distribution network. Furthermore, when funding new UCC initiatives that have no existing customers providing revenue, policy makers should be aware of how difficult it is for a UCC to realize a break-even point without subsidies – let alone become profitable.

5.3. Allocation of costs and benefits related to a UCC

Thirdly, our study shows that there are multiple ways of allocating costs and benefits when using a UCC. Receivers can motivate suppliers or their carriers to use a UCC by paying for it. Yet, by paying a part of the financial burden, receivers may inadvertently impede suppliers from using the UCC for other customers, which is needed to achieve efficiency and sustainability benefits. Until now, scholars have paid little attention to the allocation of costs and benefits across actors and stakeholders involved in a UCC initiative (Björklund and Johansson, 2018), which is a missed opportunity given that financial concerns often impede stakeholders from using a UCC. Our findings on allocating costs and benefits also have implications for policy makers, who should be aware of the potential side-effects of their subsidies. While subsidies may help to stimulate the use of a UCC in the beginning – when potential cost decreases do not materialize immediately – these subsidies may also obscure the potential benefits for suppliers, which in turn may demotivate suppliers to initiate the use of a UCC for other customers.

5.4. Effect of UCCs on service levels

Fourthly, our study extends prior research that has suggested the importance of considering service levels when analyzing UCC initiatives (Lebeau et al., 2018). In almost all of our cases, new service level agreements were made during the introduction of the UCC. In some cases, suppliers changed service levels in consultation with their receivers to ensure that introducing the UCC did not increase costs, for example by reducing delivery frequency, which also benefits the receiver as it minimizes the handling of incoming goods. In other cases, service levels changed because the UCC offers a different service than the supplier or its carrier did before, which can be positive (e.g., offering storage and handling services) or negative (e.g., delivering goods to the door instead of at the desk). Generally, existing delivery agreements may hold suppliers from introducing a UCC to other customers.

6. Conclusions

In this study, we evaluated how the introduction of a UCC affects the distribution of goods from a supplier's warehouse(s) to receivers in the city, including changes in logistics processes, costs and service levels. In collecting and analyzing empirical data, our focus was on suppliers, but we also included perspectives from other actors in the distribution network. Our study confirms that suppliers are important actors for the development of UCCs, as their distribution strategy affects the potential benefits a UCC can provide. Furthermore, the insights derived from our study help understand why successfully introducing a UCC can be a great challenge.

A UCC is far from a panacea for creating sustainable urban freight transport as one cannot simply introduce a UCC and start reaping the benefits. Despite the lack of successful UCC initiatives, the notion that UCCs can make urban freight transport more sustainable is still popular. This applies to academia, where a vast amount of studies examine how UCCs can become successful (Björklund and Johansson, 2018; Verlinde et al., 2012), and to practice, where many public authorities act as initiator, enabler, or customer of a UCC (Björklund et al., 2017).

By studying suppliers that recently started using a UCC, we show the importance of suppliers for the success of we hope that our study will contribute to a more nuanced understanding of the role UCCs may play in making urban freight transport more sustainable. Introducing a UCC has major implications for existing logistics processes involving many different actors, changes the allocation of costs and benefits, and impacts service levels. Driven by competition, suppliers have established distribution networks with efficient logistics processes, or rely on the infrastructure and processes of third-party freight carriers, driving with full vehicles driving into a city for multiple customers. This makes it hard for a UCC to bring immediate benefits to the supplier, both in terms of costs and service levels. From a sustainability perspective, the use of zero-emission vehicles can distinguish a UCC from other consolidation solutions, as most suppliers and carriers often still rely on fossil fuel vehicles. This is rapidly changing, however, as regulations become increasingly stringent, subsidies for less polluting vehicles abound, and technological developments drive down the costs of zero-emission vehicles. For future research, it will be interesting to study what the introduction of zero-emission zones in cities does to the added value of UCCs for suppliers.

A limitation of our study is that we only included suppliers operating in the Netherlands, where transport distances are relatively short,

Table A1
Interviews held.

Actor	*Organization*	*Interviews held*	*Explanation*
Supplier	Paper 1	1	
Supplier	Office 1	1	
Supplier	Furniture 1	1	
Supplier	Food 1	1	
Supplier	Hygiene 1	3	Two extra interviews together with UCC, focused on costs
Supplier	Office 2	1	
Supplier	Disposables 1	1	
Supplier	Food 2	1	
Supplier	Office 3	1	
Receiver	Public 1	2	An extra interview to include those involved in the introduction of the UCC
Receiver and UCC	Public 2 and UCC Amsterdam	1	We spoke to receiver Public 2 and UCC Amsterdam together in one interview
Receiver and UCC	Public 3 and UCC Groningen	1	As UCC Groningen is the in-house UCC of receiver Public 3, we captured the receiver and UCC in one interview
UCC	UCC Amsterdam	1	
Carrier	Carrier of UCC Amsterdam	1	

population density is high, and many cities have historic city centers. We selected suppliers with different distribution network structures, but the geographic specificity may limit the transferability of our findings to regions outside North-Western Europe. Still, we expect that some findings, such as that suppliers have optimized their logistics processes – in many cases by relying on efficient third-party carriers – are applicable to other regions. Another limitation is that, despite our successful efforts to involve actors linked to the suppliers in our study (i.e., receivers, carriers, and UCCs), our study does not even come close to fully covering the entire the urban freight transportation system of a city. To show the true impact of introducing a UCC on the urban freight transport system, it would be highly valuable – albeit complex – to also include other actors linked to receivers and carriers. That is, for example, not only a single receiver of a supplier, but also its other receivers in a city, or all suppliers of the same receiver. Other interesting topics for future research could be the role of public organizations and procurement in stimulating UCCs, and how the interaction between receivers and suppliers could motivate carriers to use UCCs.

Funding

This research was supported by research funding from the Province of Drenthe, The Netherlands through the Interreg North Sea Region project Surflogh. The funding source had no involvement in study design, data collection and analysis or publication.

CRediT authorship contribution statement

Anna J. Dreischerf: Conceptualization, Data curation, Investigation, Methodology, Project administration, Validation, Visualization, Writing – original draft, Writing – review & editing. **Paul Buijs:** Conceptualization, Methodology, Project administration, Validation, Visualization, Writing – review & editing, Supervision, Funding acquisition.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A

Table A1

Appendix B

Interview protocol for suppliers, receivers, UCC and carrier.
B.1. Supplier's interview protocol

(a) General information (e.g.: job description, company description)
(b) Logistics process and costs without the use of a UCC (e.g.: process description)
(c) Logistics process and costs with the use of a UCC (e.g.: difference with 'before' process, cost structure, effect on service)
(d) Use of a UCC (e.g.: reason why UCC is used, introducing UCC to other customers)

B.2. Receiver's interview protocol

(a) General information (e.g.: job description, company description)
(b) Use of a UCC (e.g.: goods delivered through UCC, reason why UCC is used, effect of UCC on receiving incoming goods, costs associated with using UCC)

B.3. UCC's interview protocol

(a) General information (e.g.: job description, company description)
(b) Processes, service and costs (e.g.: process description, services offered, pricing of costs)

B.4. Carrier's interview protocol

(a) General information (e.g.: job description, company description)
(b) Collaboration with UCC (e.g.: process description)

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