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SOCIAL COST-BENEFIT ANALYSIS OF A PRIVATE URBAN CONSOLIDATION CENTRE IN ANTWERP

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Het Steunpunt Goederen- en personenvervoer doet beleidsrelevant onderzoek in het domein van transport en logistiek. Het is een samenwerkingsverband van het Departement Transport en Ruimtelijke Economie van de Universiteit Antwerpen en het Departement Business Technology and Operations (BUTO) van de Vrije Universiteit Brussel. Het Steunpunt Goederen- en personenvervoer wordt financieel ondersteund door de coördinerende minister Philippe Muyters, Vlaams minister voor Werk, Economie, Innovatie en Sport en Ben Weyts, Vlaams minister van Mobiliteit en Openbare Werken, de functioneel aansturende en functioneel bevoegde minister.

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De huidige wijze van stadsbevoorrading kan onder andere bijdragen aan luchtvervuiling, verminderde veiligheid, CO_2-emissies, schade aan infrastructuur en congestie (MDS Transmodal, 2012; Quak, 2008). Daarnaast is stadsbevoorrading vaak inefficiënt door een lage laadfactor en lege terugritten (Arvidsson, 2013; PORTAL, 2003). Ondanks de uitdagingen is stadsbevoorrading – het leveren van goederen en diensten binnen een stedelijke regio – belangrijk voor de leefbaarheid van een stad en daarom noodzakelijk (Mommens et al., 2014). Om steden leefbaar te houden voeren autoriteiten vaak restrictieve maatregelen in zoals lage emissie zones en venstertijden (Muñuzuri et al., 2005). Voor de transporteurs zelf compliceert dit alles hun activiteiten en veroorzaakt een additionele kost (Filippi et al., 2010; PORTAL, 2003). De genoemde uitdagingen voor stadsbevoorrading zijn ook van toepassing op Antwerpen waar dagelijks veel leveringen plaatsvinden (De Langhe et al., 2013). Zo is er een hoge mate van congestie met als gevolg dagelijkse vertragingen van 28% (INRIX, 2014). Voorts zijn er venstertijden en gewichtsbeperkingen in het centrum (Maes et al., 2012).

Duurzame stadsbevoorradingsconcepten, zoals een stedelijk distributiecentrum (SDC), beogen de huidige stadsbevoorrading te verduurzamen op zowel ecologisch, sociaal als economisch vlak (Mommens et al., 2014). Hoewel er niet één standaard voor een SDC is, heeft het verschillende kenmerken. In essentie is de bedoeling van een SDC om goederen van verschillende transporteurs, met bestemming in hetzelfde stedelijke gebied, te bundelen. Door deze bundeling kan bevoorrading efficiënter plaatsvinden (bijv. hogere consolidatiegraad), waardoor er minder voertuigbewegingen zijn (Huschebeck & Allen, 2005). De meeste consolidatiecentra leveren een positieve bijdrage aan ecologische en maatschappelijke duurzaamheid (Browne et al., 2005a). Het probleem blijft echter een duurzaam bedrijfsmodel omdat transporteurs, verladers en ontvangers vaak niet bereid zijn om voor de extra kost van consolidatie te betalen. Als gevolg zijn de meeste SDC afhankelijk van subsidies die vaak worden voorzien door lokale autoriteiten (Verlinde et al., 2012). In Antwerpen is City Logistics, als bedrijfsonderdeel van bpost, in 2014 een SDC gestart. City Logistics voert laatste mijl leveringen geconsolideerd uit waarvoor het een vergoeding aan transporteurs vraagt. In 2015 heeft bpost een meerderheidsaandeel genomen in CityDepot. City Logistics opereert sindsdien onder de noemer CityDepot. In deze studie is echter City Logistics gebruikt omdat dit de naam was ten tijde van de studie.

Dit SDC wordt geëvalueerd met een sociale kosten-baten analyse (SKBA) waarbij alle effecten (direct, indirect en extern) worden gemonetariseerd. Dit is gedaan door de huidige situatie met het SDC te vergelijken met de situatie waarin de transporteurs, welke aan het SDC leveren, de leveringen zelf uitvoerden. De ritten die de transporteurs zonder SDC hadden uitgevoerd worden gesimuleerd met behulp van simulatiesoftware. Op deze manier is er een voor-na analyse uitgevoerd. Gedurende de simulatieperiode van 4 weken (november-december 2014) werden er door 4 transporteurs dagelijks gemiddeld 75 leveringen bij het SDC afgeleverd. Dit aantal is relatief laag doordat het enerzijds de pilootperiode betrof en er anderzijds gedurende deze periode (regionale) stakingen waren. De transporteurs gebruikten gemiddeld 5,95 truck trailers per dag en het SDC 6,21 voertuigen (bakwagens en een minibus). Met het SDC nam het aantal kilometers voor alle leveringen af van 358 tot 279 en de gemiddelde tijd van 38 tot 35 uur per dag. De consolidatiegraad (leveringen per stop) nam toe van 1,12 tot 1,17. Een combinatie van kleinere voertuigen en minder gereden kilometers veroorzaakte een vermindering van het brandstofverbruik van 36%. Dezelfde redenering geldt voor een verminderde uitstoot van CO_2, PM, SO_2 en NOx. Mede op basis van deze data is de SKBA uitgevoerd. Voor de berekening van de externe effecten zijn verschillende assumpties gebruikt met behulp van Gibson et al. (2014).

De SKBA leidt tot een baten/kosten-ratio van 0,42. Dit betekent dat voor iedere geïnvesteerde € in het SDC, €0,42 wordt teruggegeven aan de maatschappij. In overeenstemming met andere consolidatiecentra levert het geëvalueerde SDC een baat op voor de maatschappij en het milieu (externe effecten). De directe effecten zorgen echter voor een hoge kost wat er toe leidt dat het concept financieel niet rendabel is. Met andere woorden, op basis van het volume gedurende de studieperiode worden de investeringen in het SDC niet terugverdiend. Wanneer het aantal geconsolideerde leveringen met 80% stijgt van 75 naar 135 wordt er een baten/kosten-ratio van 1 bereikt. Het break-even volume om financieel rendabel te zijn waarbij de externe effecten buiten beschouwing worden gelaten (kritische massa), ligt op 335 leveringen per dag, ofwel 4,47 keer het volume uit de studieperiode. Bij deze berekening zijn de assumpties uit de simulatieperiode gebruikt en het volume kan lager zijn doordat: 1) meer goederen betekent een hogere dropdensiteit (meer leveringen in hetzelfde gebied) en consolidatiegraad welke leiden tot relatief minder voertuig(kilometers), 2) het in de toekomst aanbieden van extra diensten (bijv. opslag voor ontvangers en pick-ups voor transporteurs) leidt tot extra inkomsten waarvoor geen extra volume nodig is en 3) er is infrastructuur beschikbaar om leveringen per binnenvaart te ontvangen.

Om een SDC te starten zijn er aanzienlijke investeringen nodig, waardoor het concept vaak afhankelijk is subsidies. De huidige constructie waarbij een privaat bedrijf voorziet in startkapitaal is daarom raadzaam. Indien de kritische massa niet wordt bereikt gaat het concept in tegenstelling tot veel andere SDC niet ten koste van publiek geld. De vraag is of dit SDC een duurzaam bedrijfsmodel heeft? Het concept richt zich in de eerste plaats op transporteurs om tegen een vergoeding laatste mijl leveringen uit te voeren. In hoeverre dit een baat oplevert, is afhankelijk van de kosten per transporteur wanneer de leveringen in de stedelijke regio zelf uitgevoerd worden ten opzichte van de vergoeding die betaald moet worden aan het SDC. De kritische massa ligt relatief hoog maar de combinatie van vertragingen van 28% door congestie, beperkingen in het centrum en de omvang van het gebied bieden potentieel om dit volume te bereiken. Uitbesteding van leveringen in de regio kan rendabel zijn voor transporteurs met één of meer van de volgende kenmerken: 1) lage consolidatiegraad, 2) lage dropdensiteit, 3) een voertuigvloot met (voornamelijk) truck trailers. Daarnaast kan uitbesteding van stadsbevoorrading voor transporteurs ook een baat opleveren in het transport voor en na de leveringen in het stedelijk gebied (bijv. vlootoptimalisatie). In hoeverre hetzelfde concept overdraagbaar is naar een andere stad hangt af van de omvang van het stedelijk gebied (potentieel kritische massa) in combinatie met de huidige problematiek (vertragingen en beperkingen).

Om het gebruik van een SDC te stimuleren hebben autoriteiten verschillende vormen van steun voorhanden (Lebeau et al., 2015b). Vooraleerst kan er financiële steun voor een SDC zijn. Dit kan verder onderverdeeld worden in de mate en het tijdstip van de steun: voor een haalbaarheidsstudie of het SDC ontwerp, enkel voor de opstartkosten of structurele financiële steun waarbij ook de operationele kosten worden gedekt totdat break-even omzet is behaald. Alternatieve vormen van financiële steun zijn onder andere toegang tot gunstige leningen, financieren van materiaal en het bieden van een depot. Voor dit laatste worden vaak publiek-private partnerschappen (PPP) gebruikt. Een tweede vorm van steun door autoriteiten is regelgevend. Hierbij dient er een onderscheid gemaakt te worden tussen directe en indirecte steun. De meest extreme vorm van directe steun is het gebruik van een SDC verplichten. Andere vormen zijn een licentiesysteem waarbij het gebruik van een SDC wordt gestimuleerd door toegang voor transporteurs op basis van bepaalde eisen te bemoeilijken (bijv. beladingsgraad) of het bieden van gunstige maatregelen exclusief voor een SDC (bijv. een verruiming van tijdsvensters). Deze vormen van steun zijn echter controversieel doordat het vaak leidt tot tegenstand van andere stakeholders, vooral omdat het tegen vrije marktwerking ingaat. Daarenboven kan handhaving tot (hoge) kosten voor autoriteiten leiden. Het geven van directe steun voor een SDC kan (deels) worden ondervangen door tijdens bijeenkomsten de dialoog aan te gaan met betrokken stakeholders waarbij samenwerking mogelijk wordt geïnstitutionaliseerd (bijv. Freight Quality Partnerships in het VK). Indirecte regelgevende maatregelen richten zich niet op het SDC maar kunnen het gebruik ervan wel stimuleren (venstertijden, gewichtsbeperkingen, beperkingen voor de omvang, EURO normen, leeftijd voertuig en tol / kilometerheffing). In hoeverre dit soort maatregelen een SDC ondersteunen is afhankelijk van de manier waarop deze zijn vormgegeven en welke maatregelen worden gecombineerd; wat het doel is (bijv. CO2 vrije stadslogistiek), de periode waarin dit behaald dient te worden (bijv. gefaseerd tot 2030), hoe effectief of strikt moet deze maatregel zijn (bijv. enkel het verbieden van de meest vervuilende voertuigen of alleen elektrische voertuigen toelaten?), specifieke stadskenmerken en de huidige problematiek. Naarmate de maatregelen strikter worden en de omvang van het gebied toeneemt, nemen de investeringen en de kosten voor handhaving toe. Ook voor indirecte maatregelen is het raadzaam dit in de mate van het mogelijke te doen in dialoog met de betrokken stakeholders. Dit kan bijvoorbeeld in het kader van beleidsplannen (bijv. Masterplan 2020) waarbij onder andere transporteurs worden geconsulteerd.

1 Introduction

Urban areas have different functions such as being a pleasant living, leisure, trade and employment environment. The provision of goods for cities – also called city logistics, city distribution or urban goods distribution – is indispensable but at the same time difficult to reconcile with these functions. The high density in cities and the type of vehicles that distribute the majority of the goods complicate city distribution further (Dablanc, 2007). Due to their size and the fact that most freight vehicles are diesel-powered, they contribute more to negative side effects of transport. Especially when it concerns heavy goods vehicles (HGV) (Browne et al., 2010). Effects include air pollution, noise pollution and a negative impact upon road safety (MDS Transmodal, 2012). The emission of pollutants because of transport related activities within cities can be up to 50% - depending on the pollutant considered (Dablanc, 2007). In addition, congestion is a severe problem. Although freight vehicles only represent 8 to 15% of the total traffic flow in urban areas, they often reduce the road capacity more than other types of vehicles when they park for loading and unloading operations (MDS Transmodal, 2012). Not only does this put a burden upon the society and the environment, city distribution is also complicated for the transport sector itself. Transport operators often do not have a clear insight in the exact costs that can be attributed to the last mile part in urban areas. Estimations on the costs as part of the total distance covered, vary considerably from 28% (Arvidsson, 2013) to 40% (PORTAL, 2003). In urban areas, other costs like fuel are higher because of the frequency of short trips and stops which increase even more in situations with congestion (Filippi et al., 2010; Zunder and Ibanez, 2004). Delays also lead to longer delivery trips and hence increased costs of drivers (Stathopoulos et al., 2012). At the same time local authorities increasingly impose restrictions which complicate delivery operations further. Restrictions include time windows, low emission zones (LEZ), and vehicle weight and size restrictions (Anderson et al., 2005; Muñuzuri et al., 2005). Complex and costly last mile delivery operations are, nevertheless, not only caused by city characteristics and local policies. A low load factor and empty rides of freight vehicles also generate high costs; in Europe more than 20% of the vehicles drive empty (Eurostat, 2011), whereas the average load factor is estimated to be 56% (Cruijssen, 2013).

The challenges mentioned also apply to a large extent to Antwerp. With a population of just over 500.000 in the city and almost 700.000 in the metropolitan region, it is the largest city in Flanders (UNdata, 2013). With regard to the number of goods distributed annually (number of load and unload operations), the number is two times the amount of the second largest Flemish city, Ghent (De Langhe et al., 2013). Consequently the same applies to the number of freight vehicle trips which ranges annually between 55 and 73 million in Antwerp, whereas the percentage of freight vehicles (i.e., vans, rigid trucks and articulated trucks) that enter Antwerp every day is 13% of the total number of vehicles (De Langhe et al., 2013). The traffic problems in Antwerp are considerable since it is one of the most congested cities in Europe. Of all European and North American cities it is ranked sixth in terms of average daily delays which amount 28.6% in Antwerp (INRIX, 2014). As part of the traffic, freight vehicles also face these delays which lead to costs in terms of personnel and fuel as well as less reliable deliveries. At the same time, other road users, including private cars, suffer from the presence of freight vehicles; especially when they park for loading and unloading operations. Since several years, the local authorities have introduced restrictive measures upon delivery operations in the city centre. These include time windows and weight restrictions (Maes et al., 2012). Despite these challenges, city distribution is indispensable for a liveable city (Mommens et al., 2014).

A multitude of initiatives has been introduced to make city distribution more economically, environmentally and socially sustainable (for an overview see Quak, 2008). This is described as the consideration of the triple bottom line: people, planet and profit (Vanclay, 2004). The majority of the (sustainable) city distribution concepts are initiated by the authorities and the private sector is often not extensively consulted (see Anderson et al., 2005; Lindholm, 2013; Muñuzuri et al., 2005). This is remarkable because although the authorities are responsible for governing urban areas, the private sector is responsible for the majority of the movement of goods (Ogden, 1992). Among initiatives to increase the sustainability of city distribution, an urban consolidation centre (UCC) is a broadly trialled concept. A UCC is mostly located on an easily accessible location on the city borders (Quak, 2008). Goods from outside the city destined for a specific delivery area are bundled in close proximity to the delivery area. It is generally accepted that this results in a higher load factor and fewer vehicle kilometres (vkm) (Huschebeck and Allen, 2005). For most UCC schemes there is not a lot of discussion regarding the social and environmental benefits. There is nevertheless a relatively low success rate of UCCs (Browne et al., 2005a). The main constraint is financial viability; stakeholders in city distribution (i.e. shippers, receivers and transport operators) are often not willing to pay for the additional cost of consolidation. Since it appears to be difficult to get a UCC autonomously running, many heavily rely upon subsidies. These are often provided by local authorities and UCCs tend to disappear as soon as these subsidies stop (Verlinde et al., 2012). Taking into account the current situation in Antwerp, an initiative making city distribution more sustainable with respect to the three aspects of sustainability, seems desirable. In the light of these problems, City Logistics as a business unit of bpost, started a UCC in Antwerp in June 2014. The public sector is not involved; neither with subsidies nor with supporting measures. The business model is based on offering transport operators a solution for the last mile for which they have to pay a fee to the UCC operator (City Logistics). A more thorough description of the UCC is given in the next section. In 2015 bpost acquired a majority in CityDepot. Hereafter City Logistics has been operating as CityDepot. In this study the name City Logistics is nevertheless used.

In order to evaluate the UCC a social cost-benefit analysis (SCBA) is applied. Social cost-benefit analyses quantify all the welfare effects of a project and have been applied extensively in the field of transport (e.g. Sælensminde, 2004), and specifically with regard to UCCs (Lewis et al., 2010; van Duin et al., 2008). Contrary to these studies, this SCBA reports on an operational UCC. It is therefore based on real volumes and data, and not on a theoretical model. The evaluation concerns one month during the start-up period. During this period four transport operators outsourced deliveries after which the UCC operator bundled their goods for subsequent last mile deliveries. The main purpose of the study is to compare the current situation with the operational UCC to the previous situation in which transport operators had to deliver goods throughout the designated urban area themselves. The SCBA takes all – direct, indirect and external – effects into account which leads to a benefit/cost-ratio. The core analysis is based on the first operational months with a relative small volume. Hereafter, additional calculations concern higher volumes to calculate the social and purely financial break-even turnovers. Based hereupon some implications for the transferability of this specific concept to other urban areas in Flanders are discussed. The ease of applicability of a UCC elsewhere depends on many factors including the size and density of the area, volume and types of goods and involvement of local authorities (SUGAR, 2011). This is discussed in section 6.2. The structure of the paper is as follows. The next section deals with the UCC concept, success factors and the evaluated UCC in this study. This is followed by an elaboration of the applied methodology. The section hereafter discusses the results of the analysis. Next, the extended analysis deals with the break-even turnovers in societal and purely financial terms. This serves as input for the discussion which also includes some recommendations for the role authorities can play. This is followed by the conclusion.

2 Urban consolidation centres

2.1 The UCC concept

Although there is not one standard for a UCC, most have several characteristics in common. The purpose of all consolidation centres is to bundle goods from outside the city by cross-docking them for subsequent deliveries throughout the city or a specific area within the city. In this way goods from different transport operators with delivery addresses in the same area can be bundled. A cross-dock point is preferably on a location that is easily accessible by main roads but at the same time in relative close proximity to the delivery area. Herewith the transport to the city is split in two: one with (larger) vehicles outside the city and one with (smaller) vehicles for last mile distribution within the city (Quak, 2008). Increased efficiency of deliveries should lead to a higher load factor and fewer vkm (Huschebeck & Allen, 2005). Consolidation can also take place at multimodal sites (Diziain et al., 2012). A UCC is not always necessarily located on a city border, but can also come in variations such as a micro-consolidation centre which is set-up much closer to the delivery area (Janjevic & Ndiaye, 2014). Micro-consolidation centres can have different forms like the mobile depot in Brussels, operated by TNT Express, from which electrically supported tricycles departed (Verlinde et al., 2014). In Paris, the Vert Chez Vous initiative concerns a mobile barge on the river Seine from where cyclocargos departed for inner-city deliveries (Janjevic & Ndiaye, 2014). The size of the serviced area can also vary considerably. Apart from the inner-city or another designated area, consolidation centres can also serve specific sites. Examples of site-specific consolidation centres are the Broadmead shopping centre in Bristol, Heathrow Airport and the construction site for the redevelopment of the Potsdamer Platz (Browne et al., 2005a). In line with this there are differences in the types of products that are handled (e.g. large bulk, small parcels). Consequently there are different supply chains and receivers involved. Another distinctive factor is the ownership which can be public, private or a partnership. In Yokohama, in Japan, a cooperative delivery system with a UCC has been implemented by an association of retailers (Browne et al., 2012). Finally, use of a UCC can be voluntary or mandatory (Browne et al., 2005a).

Potential changes in the urban area as a result of a UCC include: the number of vehicle trips, the number of vkm, number of vehicles used, travel time, goods per delivery point (consolidation factor), vehicle load factor, (un)loading time and frequency, fuel consumption, vehicle emissions and operating costs (Browne et al., 2005a). This is not only the result of purely consolidating, but also of other factors such as transhipping goods from large – often more polluting – vehicles into smaller and cleaner vehicles. A trial with electrically-driven tricycles in London for instance led to a considerable reduction in emissions (Leonardi et al., 2012). A reduction in emissions was also the result of the pilot with electrically-driven tricycles which departed from the mobile depot in Brussels (Verlinde et al., 2014). For the society as a whole, the benefits can therefore include a reduction in emissions as well as fewer vehicles with all potential positive side-effects such as a more pleasant shopping environment and an improved liveability of the city while the same amount of goods is still available. Based on a review of 67 UCC schemes Browne et al. (2005a) listed potential benefits and costs for more directly involved stakeholders (Table 1). Potential benefits include for transport operators the opportunity of night deliveries and greater efficiency, and for receivers improved delivery reliability and fewer deliveries. The main cost seems to be security and increased probability of damage.

Table 1 : Potential benefits and costs of a UCC amongst involved parties (Source : Browne et al., 2005a)

	BENEFITS	COSTS
Supplier	• Less time spent making deliveries in cities, leading to reduced operating costs • Potential to use time savings to generate additional revenue	• Not a single "door-to-door" operation
Transport provider	• Routes involving UCCs allow more deliveries per day • Opportunity for night deliveries • Helps counter WTD driver shortage • Greater efficiency as no time spent slow running in town/parking problems etc. • Less slow running = improved fuel usage	• Security • Loss of control over timed deliveries/responsibility • Perceived increase in damage through extra handling • Additional handling/delivery charges – could be passed to supplier as "surcharge"
Receivers	• Improved delivery reliability • Fewer deliveries/less staff disruption • Ability to call-off orders in parts • Clients able to collect purchases from UCC • Less storage/more selling space • Off-site value-added activities • Improved retailing (street) environment • Continuous waste removal/recycling • Clients avoid travelling to store to collect orders – collect at UCC	• Additional stage when chasing missing/late deliveries
Local Authority	• Potential licensing revenue • Fewer delivery vehicles in zone, leading to cleaner air, less congestion, pedestrian benefits and improved traffic flow • Potential for alternative fuel vehicles	• Cost of policing freight movements
UCC operator	• Profit-making business	• Multitude of IT & paperwork systems to handle but not if UCC is considered final delivery point and operator has own system to cover the "last mile" • Timed deliveries – how to service • Responsibility for identifying losses/damages at intake stage
Developer (new retail sites only)	• A revenue stream, either if managed in-house or additional charge on rent • More rentable space as result of centralised receipt point and less "in-store" storage space • Single UCC makes whole site more attractive with fewer freight vehicle movements	• Cost of establishing UCC if condition of planning consent

Although a UCC seems to be a good solution, transhipping goods at the city border involves additional handling (see table) and hence additional costs. The main obstacle is that usually neither the transport operator, nor the receiver is willing to pay for the cost of consolidation. In order to overcome this, many UCCs heavily rely upon subsidies which are often provided by authorities. The UCC in Monaco, initiated by its government is for instance dependent upon subsidies since the start which eventually led to the governmental subsidy per delivery that exceeds the price customers pay per delivery. In addition to costs, other problems that arise can be the location, opposition against the UCC due to supporting measures it receives and a lack of volume. These are some of the reasons why the UCC in Leiden, in the Netherlands, failed (van Rooijen & Quak, 2010). Other comparable initiatives, such as the on in La Rochelle in France, albeit successful in their environmental and societal objectives, are dependent upon subsidies or other forms of external funding. And even if funding is present, a sustainable business model in order to secure long-term viability is lacking. As Browne et al. (2005a) conclude: ''*The general consensus is that in the medium / long term UCCs must be financially successful in their own right and that subsidies are not a viable solution.''*

Various operational UCCs have been evaluated in the past for which different methodologies have been used. In London, the local impact of a trialled UCC has been evaluated with a before-after assessment (Leonardi et al., 2012). Roca-Riu & Estrada (2012) focused more on the economic effects of a UCC in the metropolitan region of Barcelona. These two examples are ex-post evaluations. The number of ex-ante studies to evaluate the potential of a UCC in a specific region is even larger. An ex-ante study has been carried out to evaluate the feasibility of a UCC in The Hague (van Duin et al., 2010). Another study concentrated on the potential location of a UCC (Olsson & Woxenius, 2014). Correia et al. (2012) developed a methodology to analyse the economic as well as environmental impact of a UCC in the Brazilian city of Belo Horizonte, whereas the potential demand by receivers and transport operators is the core of a study in Italy (Marcucci & Danielis, 2007). In conclusion, although UCCs are often considered as a concept in city distribution as such, there are a lot of differences regarding the characteristics of the evaluated object as well as in the applied methodologies.

2.2 Success factors?

The question is then, are there any factors that have to be fulfilled to secure not only environmental and social sustainability but also economic? The latter concerns not only the initial investment but also a sustainable business model. As elaborated above, of the UCCs that are researched funding mostly came from public authorities. A business model that allows UCCs to become autonomously running is lacking. In their study, Browne et al. (2005a) conclude that in general there is potential for a UCC if one or more of in total five criteria are met:

- The availability of funding;
- Strong public sector involvement in encouraging the use through a regulatory framework;
- Significant problems in the area;
- Bottom-up pressure from local interests;
- The logistics problems that are solved should be associated with a site that has a single manager or landlord.

Regarding the business model, the four prerequisites to become economically viable are a critical mass of users and volumes, willingness by main stakeholders to use the UCC, additional services to gain extra revenues and no dependence upon subsidies (Browne et al., 2005a). In the conclusions these criteria are discussed in relation to the evaluated UCC and consequently its possible transferability.

2.3 City Logistics

In this paragraph the context of the evaluated object – the consolidation centre of City Logistics in Antwerp – is described. As described above, Antwerp is a large city in terms of population and number of deliveries. Additionally, there is considerable amount of goods because of the presence of a large port area where 191 million tons were cross-docked in 2013 (MOBILO, 2015). Congestion is in the wider area a substantial problem with average daily delays of 28%. Although exact numbers are unknown, there is also congestion in the port area; especially because of waiting times for loading and unloading during peak moments (Gubbi et al., 2014). In the city centre deliveries are complicated for transport operators because time windows and weight restrictions are in place. Time windows prohibit deliveries between 11am and 7pm (Maes et al., 2012). However, between 7am and 11am the number of freight vehicles in the city centre is considerable. Counts in the main shopping street (Meir) in 2012 show that around 60% of all the vehicles concern freight (De Langhe et al., 2013). The UCC itself is located between the city centre and the port area, near main roads (Figure 1). Due to its location near a waterway it has a bimodal character which allows deliveries by barge. In 2013 36% of all the goods arriving and departing in the port was done by barge (MOBILO, 2015).

Figure 1 : Location UCC City Logistics in Antwerp

In short, the UCC of City Logistics concerns a private initiative. Therefore the public authorities are not involved with any form of funding. Required start-up costs are provided by bpost of which City Logistics is a business unit. Contrary to for instance Binnenstadservice in the Netherlands, City Logistics does not focus on the receivers by asking them to change their delivery address (van Rooijen & Quak, 2010). It initially focuses on transport operators, who can deliver their goods to the UCC after which bundled last-mile deliveries are carried out. The business model is based on offering transport operators a solution for the last mile in a heavily congested delivery area. For this service, the transport operators pay a fee. Since the larger area of Antwerp is heavily congested with average delays of 28% and restrictions on inner-city delivery operations are in place, outsourcing deliveries to the UCC can be interesting for different transport operators. Liability issues are included in the contract between City Logistics and the transport operators. First of all, the ones who mostly use truck trailer combinations and have difficulties or are unable to enter the city centre. Second, also for the ones using smaller vehicles (e.g. rigid trucks, minivans), a UCC might be a solution. Especially when they have a low load factor, but also for those vehicles with a high load factor but who have to deliver to delivery addresses spread widely across the delivery area (low drop density). Furthermore, delivery rounds can become complicated because receivers might have special requests such as deliveries during specific hours. For the consolidation the transport operators thus pay a fee which comprises the main revenues of the UCC. These fees have to be substantial in order to recoup the investments and cover the operational costs. Figure 2 shows the business model of City Logistics.

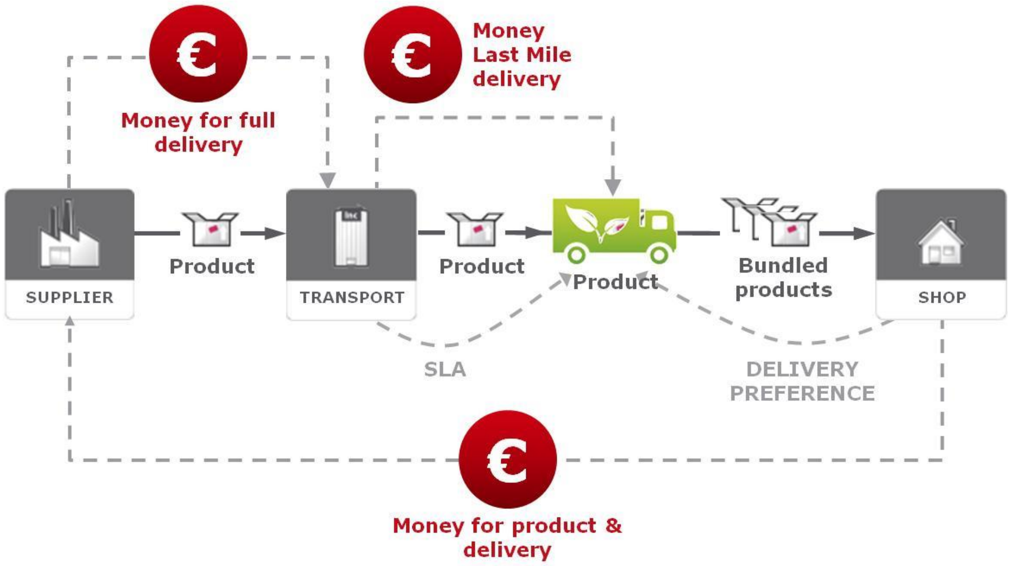

Figure 2 : City Logistics concept (Source: City Logistics)

In order to recoup investments and become financially viable, sufficient revenues have to be generated. In turn this all depends on gaining a critical mass. The UCC started in June 2014 with cross-docking and consolidating incoming goods – varying from pallets, parcels and roll cages to mixed types. Volumes currently with bpost – post, parcels (including e-commerce) and packing stations – are not consolidated by City Logistics. To guarantee a service, the first months are a pilot after which the volume is scaled, if transport operators are attracted. The investments in the UCC already take into account the possibility to cross-dock and consolidate relatively large volumes. Transport operators who have contracted City Logistics for last mile deliveries, send all the information regarding the deliveries digitally the night before. Based hereupon, the planning and routes of the vehicles are done by a planner of City Logistics with aid of planning software. The next morning, transport operators deliver their goods to the UCC after which the UCC vehicles depart just after peak-hours, around 9am. The UCC mostly uses rigid trucks to carry out the deliveries. In addition, a minivan is used for backorders. The first phase focuses on gaining the critical mass. Due to the location of the UCC near a waterway, additional volume can be delivered by barge. If successful, in later phases, value-added services are offered to both transport operators and receivers (i.e. storage at distance, retour logistics, pick-ups). This can generate additional revenues. Logically, as a private company, financial viability is key to the pre-existence of the UCC. Therefore notable beneficial effects for directly involved stakeholders, mainly transport operators, are vital. There are, however, also effects in the urban area for stakeholders who are not directly involved (e.g. change in vkm, emissions). The table below gives an overview of the role of the different stakeholders as well as their main interest in the UCC.

Table 2 : Stakeholders and their respective roles and interests in the UCC (Source : own setup based Mommens et al., 2014)

Stakeholder	Role	Interest
City Logistics	Operator of the UCC Takes care of last mile distribution Business unit bpost	Economically viable and efficient last mile distribution Acquire new revenue streams Provide as much service as possible at the lowest cost
Transport operators	Clients of City Logistics Deliver the goods to the UCC (outsource last mile)	Avoid time-consuming and costly last mile distribution If possible, attract additional volume
Shippers	Sender of goods Contracts transport operators	Want to keep receiving the same service at the same price
Receivers	Receivers of goods (retailers and other companies located in the centre, the port and surrounding areas) Possible clients later on	Want to keep receiving the same service at the same or a lower price More attractive shopping environment Use of possible other services to make their daily operations more convenient
Local authorities	Governing the city	Improve the liveability of the city in terms of pollution, safety and congestion
Citizens	People living, working and spending their free time in Antwerp	Want to be able to live their lives in a safe and healthy environment

In summary, in line with other UCCs as elaborated in section 2.1, the concept of City Logistics has several features. In essence it is a traditional UCC, located at a city border where goods are consolidated. Investments for the start-up are provided by a private company. It initially focuses on offering transport operators a service instead of receivers. Contrary to a micro-consolidation centre, it serves a wide area and subsequently it possible to consolidate large volumes. The consolidated goods include different kinds except for fresh products (i.e. food). Consequently this means that different sizes of goods are consolidated, varying from small parcels to pallets and construction materials. Accordingly different types of receivers are involved; small and large retailers, but also large companies in the port area. E-commerce deliveries to individual households are not included as elaborated above. Whereas the transport operators mostly deliver with truck trailer combinations – at least to the UCC – the UCC uses smaller, but conventional, rigid trucks. The trucks from the existing fleet of the parent company can be used. Thus contrary to several (micro-) consolidation centres, neither cleaner vehicle technologies nor alternative vehicles (e.g. cargobikes) are applied, at least in the beginning. Finally, the UCC has a bimodal character.

3 Evaluation framework

3.1 Methodologies

In the field of transport evaluation the most commonly used methods are the cost-benefit analysis (CBA), cost-effectiveness analysis (CEA), economic-effects analysis (EEA), social cost-benefit analysis (SCBA) and the multi-criteria analysis (MCA) (for an overview see Mommens et al., 2014). Additionally, the multi-actor multi-criteria analysis (MAMCA) is available to evaluate sustainable city distribution concepts. The different methods, or evaluation frameworks, can be used by different actors to measure the impact of policy measures, projects or technologies in the field of transport. The choice for a method depends on different factors. First, the object of evaluation matters; a measure to be implemented by authorities (e.g. Filippi et al., 2010), an infrastructural project (e.g. Sælensminde, 2004), decision-making whereby different stakeholders are involved (e.g. Vermote et al., 2014), or a city distribution concept such as a freight tram (e.g. Regué and Bristow, 2013). Second, it depends whether a project or measure is evaluated ex-ante or ex-post. Next, the number of alternatives is important. In case there are more alternatives these can be measured and ranked, and a MAMCA can be appropriate. Finally, the nature of the effects is crucial since these can be monetary, quantitative but non-monetary or qualitative (Munda et al., 1994). Some non-monetary effects can be monetised whereas this is difficult for other effects (van Malderen & Macharis, 2009). Consequently the choice for a specific evaluation method depends on different factors and the case to be evaluated. Different methods can also be used next to each other.

A CBA on a UCC has been carried out by van Duin et al. (2008) and it is not applied in this study because it is a pure economic analysis evaluating the financial costs and benefits of an investment. The impacts on the three aspects of sustainability are therefore neglected. Moreover, since the UCC is a private initiative it can be assumed that an ex-ante evaluation using a CBA has been carried out by bpost internally in order to calculate whether it is viable and in what period it can yield a net benefit. The CEA is also a more economic analysis whereby it is measured how effective a certain measure, project or technology is with respect to the total costs (investment + operational costs).

The major drawback regarding this method is that only one effect can be measured (D. Browne & Ryan, 2011; Mommens et al., 2014). Since the aim is to measure the wider impact of the UCC (i.e. economic, societal and environmental) and not just one effect, a CEA is deemed unsuitable for this study. The EEA mainly takes into account the impact of a project on the added value, employment and fiscal revenue and is specifically designed for the government perspective (Macharis, 2005). The main reason not to apply a MCA is because financial viability is the main constraint that impedes successful implementation of a UCC and monetary values are therefore taken into account (Mommens et al., 2014). As elaborated in Mommens et al. (2014) the MAMCA is an extension of the MCA and allows taking into account the interests of different stakeholders with regard to different (sustainable) alternatives in the field of city distribution. Eventually this provides insight to what extent each alternative contributes to the specific criteria of a separate stakeholder group as well as to the criteria of all stakeholder groups together. Similar to the MCA, the same reasoning is relevant not to apply the MAMCA. The project is initiated by one UCC operator. The application of the MAMCA would have been more applicable to be used before the start of the project (ex-ante), by for example formulating different business models as alternatives. In this way it would have been evaluated to what extent each alternative serves the criteria of the different involved stakeholders (i.e. City Logistics, transport operators, receivers, shippers, local authorities and citizens). Alternatively, it can also be applied to evaluate the previous situation, the current situation with the UCC and possible future extensions of it. This is currently not relevant because the project only started recently. The SCBA is applied because it concerns a city distribution concept which is privately initiated and the main goal of the analysis is to assess whether investments in the project yield a financial as well as societal/environmental benefit. Measuring the actual impact is especially relevant in the light of the objective of European cities to have CO_2-free city distribution in 2030 (European Commission, 2011). Because transport comprises a large part of these emissions, evaluating the actual impact of a potential sustainable city distribution concept is important (see section 1). With the aid of the SCBA the wider impact, in addition to emissions, is concretely demonstrated in monetary terms.

3.2 Social cost-benefit analysis

The SCBA is based on the Kaldor-Hicks compensation principle which considers welfare maximization. It assumes that 'winners' of a policy or project can compensate the 'losers'. Therefore all effects, including the negative externalities, are monetised to the extent possible. Herein a distinction is made between direct, indirect and external effects, which means that non-tradable goods such as noise and congestion are attributed a monetary value. By incorporating negative externalities, effects which are disadvantageous for a large part of the society but are only caused by a limited number of stakeholders, are taken into account. The outcome of a SCBA is the benefit/cost-ratio. A ratio of equal to or higher than one indicates that a project is beneficial for society. The higher the ratio the more beneficial the project is. A SCBA has two advantages compared to other methods. First, all impacts are to the extent possible, expressed in monetary terms. In this way all effects can be compared with each other. Second, the impacts of a project on a larger geographical level and with a longer time span can be analysed which provides a more realistic view of the total project impact on the society. The main disadvantage is the compensation criterion since the redistribution effects do not clearly emerge from the analysis (Mommens et al., 2014).

The application of the SCBA is based on the standard methodology for infrastructural projects as developed for the Flemish government (RebelGroup, 2013). In this study six steps are followed which are visualised in Figure 3. The eleven steps as mentioned by the RebelGroup (2013) are included herein. The first step involves the identification of the problem, description of the situation and the goals of the analysis. Regarding the latter, important aspects are the definition of the time horizon, and description of the current situation with the UCC as well as the previous situation. Step two includes the identification of the welfare effects; all effects that influence the welfare of the society's individuals. There will be elaborated upon the exact welfare effects of this study in the next section. The valuation of the welfare effects in the next step is the core of the SCBA. It holds that all effects of the project (e.g. investments, environmental impact) are quantified and valuated. To the extent possible all direct, indirect and external effects are expressed in monetary terms (for an overview of valuation methods, see van Lier et al., 2009). Even though it is the aim to monetise as many effects as possible, indirect ones are often vaguer and more difficult to quantify in monetary terms. In this case, these effects are included in the analysis in a qualitative way (van Lier et al., 2014). Based on this step, the costs and benefits of the UCC can be compared to the previous situation. The net present value (NPV), which is the present value of benefits minus the costs when a longer time period is taken, is taken into account for this (Sælensminde, 2004). Next, the trade-off of costs and benefits is presented as the benefit/cost-ratio. A ratio of equal or higher to one indicates that the project yields a net societal benefit. With for instance a ratio of 1,50, for every € invested, €1,50 is returned to society. On the results a sensitivity analysis is applied in order to perform a validity check for the data input and assumptions. The final, sixth, gives an overview of the results whereby the net overall effect as a result of the project becomes clear for the society as a whole (RebelGroup, 2013; van Lier et al., 2014).

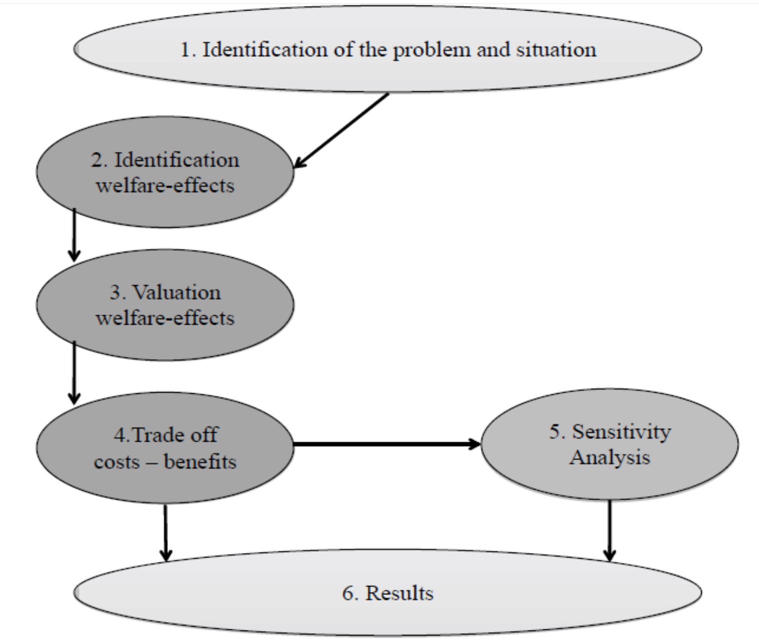

Figure 3 : Applied steps of the SCBA (Source : van Lier et al., 2014)

3.3 Application SCBA

In this section the first three steps as elaborated above are discussed. This provides input for the analysis. The remaining steps are elaborated in section 4 on the results.

3.3.1 Step 1: Identification of the problem and situation

The problem and the situation are identified and described above. In short, the problem can be summarised as complicated deliveries in the area of Antwerp as a result of congestion and restrictive measures (i.e. time windows and weight restrictions), whereas for some transport operators deliveries are possibly inefficient and therefore cause a disproportionate cost. In order to overcome this, City Logistics starts a UCC with the aim to acquire a new revenue stream by providing a solution to transport operators in the first place. Ultimately the UCC has to become financially viable. The main goal of the analysis is to calculate the benefit/cost-ratio of the consolidation centre as it is currently operational. Consequently the net societal effect compared to the previous situation becomes clear. The data of the current situation with the operational UCC are provided by the UCC operator. The planning software allows getting data on the vehicle trips after cross-docking and bundling. This is compared to the previous situation where the transport operators had to deliver the goods in the designated area themselves. In order to compare the two situations, the trips of the transport operators are simulated with the planning software. In other words, the delivery trips of the transport operators are planned as if they had to do the routes in the designated urban area with the pre-consolidated goods themselves. The reason for this is that all vehicles of the transport operators originate from different unknown destinations and their vehicles enter the urban area at different places. So in order to have an equal comparison, the vehicles of the transport operators in the simulation also depart from the location of the consolidation centre (see Table 7 : Assumptions simulation). It should be taken into account that this might lead to a small overestimation of the vkm of the transport operators. In both situations, the planning software calculates the most optimal routes in terms of kilometres and time. In this way a before-after assessment as applied by Leonardi et al. (2012) is done to calculate the difference between the two situations.

Data are collected for four weeks in November-December 2014. On some days the volume was lower due to (regional) strikes while on one day there was no volume at all. This month was still part of the pilot period in which four transport operators delivered to the UCC. Each transport operator delivered to the UCC with an articulated truck, whereas the UCC operator carried out consolidated deliveries with rigid trucks. The data collected are the number of delivered orders, number of stops, the weight, load meters, number and types of vehicles, total kilometres driven and the total time of the daily delivery trips. These data are subsequently calculated as the daily average. Other data like the investments are based on a five year period (228 operational days annually) and recalculated per day as well. All effects during this period are discounted to the base year (NPV) which allows comparing different monetary values. The main reason to focus on the current – relatively low – volume is that it concerns actual consolidated volumes. Calculating the higher volumes would no longer be based on actual data – which is one of the distinctive factors of this study. Higher volumes would therefore lead to less reliable results because different parameters change. Although the core is the SCBA of the currently consolidated volumes, hereafter the analysis is nevertheless extended because it is unlikely that the same low volume is maintained during five years. Additional goals of the analysis therefore include the calculation of the break-even turnovers in societal as well as in purely financial terms. These results of the extended analysis have to be interpreted with caution as is elaborated in section 5.

3.3.2 Step 2: Identification welfare effects

In this step all welfare effects of the implementation of a UCC are identified. A difference is made between direct, indirect and external effects. The direct effects are those directly related to the distribution of goods in the designated area. Indirect effects are those impacts upon the society which are the result of the direct effects. The external effects are non-price and ascribed to third parties such as citizens (RebelGroup, 2013). In this way negative externalities are taken into account. Welfare effects are identified after an examination of the situation and consultation with directly involved stakeholders in combination with a literature study. The consulted literature can be divided between applied (S)CBAs in the field of transport (Hyard, 2012; Sælensminde, 2004; van Lier et al., 2014) and studies (on the impact) of UCCs (Browne et al., 2005a, 2011; Correia et al., 2012; Huschebeck & Allen, 2005; Leonardi et al., 2012; Lewis et al., 2010; STRAIGHTSOL, 2014; van Duin et al., 2008, 2010; van Rooijen & Quak, 2010). The `Handbook on estimation of external costs in the transport sector` by Gibson et al. (2014) is consulted for the external effects.

The identified direct effects in this study are composed of three aspects. First, the different capital expenditures (capex) in the UCC: rent and renovation of the building, material (e.g. forklift), vehicles, energy costs, consultancy and ICT (software and licences). In the analysis all capex are deduced to the NPV per day from a five year period, based on 228 operational days per year. The operating expenditures (opex) change with a higher or lower volume. It mainly includes personnel and fuel costs. The third aspect is the revenues which are based on the average selling price per order. The first indirect effect is the service level. This is essentially the service which the shipper offers the receiver for which they are dependent on the transport operator. Outsourcing the deliveries to the UCC is the responsibility of the transport operator. The bottom line herein is reliability and punctuality of deliveries (Correia et al., 2012). Other indirect effects are security of goods, exposure space for retailers, employee satisfaction, supply chain visibility, green image, attractiveness of the shopping environment, quality of life and visual nuisance. With regard to the external effects, there is a vast literature. In this study Gibson et al. (2014) is consulted. The external effects are those caused by vehicle movements, or vkm, and differ per fuel type and vehicle category. The external effects calculated in this study are air pollution (PM, NOx and SO_2), climate change (CO_2), noise, accidents, congestion and infrastructure. The external effect of *air pollution* focuses on the impact of emissions on human health, damage to buildings, loss of crop and other costs for nature. *Climate change* is based on the kilograms of CO_2 emitted, whereas the different pollutants are calculated per gram. The main distinction with air pollution is, however, that climate change as an external effect is more complex because effects are more long-term, global and the risk patterns are more difficult to anticipate (van Lier et al., 2014). *Noise* nuisance, exposure or pollution increases as vehicles become heavier and is especially apparent in densely populated areas. Apart from the vehicle itself, loading and unloading operations further contribute to the nuisance caused by noise; especially since these operations systematically exceed the limit of 65 dBA (van Duin et al., 2008). The two main impacts as a result of noise are disturbance but also health impacts when people are exposed to noise on the long-term (Gibson et al., 2014). The external costs of *accidents* are those social costs of traffic accidents which are not covered by risk oriented insurance premiums (van Lier, 2014). It includes medical costs, production losses, material damages, administrative costs and the so-called risk value as a proxy to estimate pain, grief and suffering caused by accidents (Gibson et al., 2014). This is even more apparent for vulnerable road users such as pedestrians, cyclists and motorcyclists (European Commission, 2011). *Congestion* is often considered to be the most visible externality. The more cars and freight vehicles are delayed, the more expensive it becomes. It is even estimated that increased traffic in European towns and cities nearly costs 100 billion Euros every year. This corresponds to 1% of the GDP of the EU in 2006 (European Commission, 2007). A distinction in the costs as a result of congestion has to be made. There are internal or private costs which are the costs an additional vehicle is suffering itself by reducing the traffic flow. This is already taken into account in the travel time effects, which deal with the potential loss in time by spending it in congested traffic (van Lier et al., 2014). The complication with calculating the external cost of congestion lies in the fact that external costs like air pollution apply to the whole society (inter-sectoral), whereas congestion is mainly limited to the transport sector itself (intra-sectoral) (Verhoef, 2000). Additionally, the possible saved costs by less congestion can be off-set by the rebound effect; new traffic is attracted in the long run as the result of shorter travel times (Eliasson et al., 2013). The results regarding congestion therefore have to be interpreted with caution. Finally, the marginal *infrastructure* costs refer to the costs for maintenance and repair of roads (Gibson et al., 2014).

3.3.3 Step 3: Valuation welfare effects

Whereas the direct effects are already expressed in monetary terms, willingness to pay (WTP) is mostly used to determine the monetary value of external effects (Gamper et al., 2006; Gibson et al., 2014). And although all welfare effects are to the extent possible monetised, due to their secondary nature, indirect effects are often harder to quantify in monetary terms. If valuation is not possible, they are included in the analysis in a qualitative way.

With regard to the direct effects, capex is already budgeted to cross-dock large volumes. In the previous situation capex are only the costs of the vehicles of transport operators. Opex consists of salaries and fuel costs. Salaries are calculated by multiplying the time of the delivery round (driver hours) with the national average salary per hour. In case of the UCC, there are additional personnel costs because there is also a planner and some employees loading and unloading vehicles at the depot. In order to calculate the fuel consumption per vkm, the type of vehicle (in terms of maximum payload and vehicle technology) and the actual average load factor in weight of that respective vehicle are used. This is calculated with the aid of STREAM data and the vehicle types that actually correspond to the report by den Boer et al. (2011). In this report each vehicle type (small van, rigid truck and articulated truck) has minimum and maximum fuel consumption in litres and emission of pollutants in grams or kilograms per vkm. The minimum value corresponds to an empty vehicle and the maximum to one that has a load capacity of 100%. The exact load factor per vehicle is obtained with the software as explained above and given for the moment the vehicle starts the urban delivery trip. The fuel consumption is calculated by multiplying this with the total vkm. The vehicle technology considered is for both the UCC and the transport operators a mix of EURO 3/4. The price per litre of diesel is based on the national average in Belgium during the study period. This price is maintained for the five year period because during the simulation period it was in-between the highest and lowest value in the past seven years. The fee is based on the average price transport operators pay for a pallet or a package with an average surcharge for special deliveries (e.g. requests regarding specific delivery times). To calculate the fee the transport operators received in the previous situation without the UCC, an average selling price transport operators receive for the last mile part is included.[1] Because the analysis only includes the effects of the deliveries within the urban area, potential costs for transport operators such as the fuel consumption of driving towards the urban area as well as deliveries outside Antwerp are excluded. Due to the fact that the data originate from companies, they are privacy-sensitive and therefore not all included. This does, however, not influence the analysis and its results.

None of the indirect effects are monetised in this study. These are rather included in a qualitative way. On the longer term, some can possibly monetised but this is currently not possible. In relation to a UCC, Correia et al. (2012) use for instance exposure space whereby more space becomes available for retailers in the inner-city to display products. In this regard the purpose is to store products in the UCC instead of in (expensive) storage space in the centre. This service is at the moment of evaluation not yet provided by the UCC operator. But even with this service in place, the exact calculation of the monetary value is complicated. Regarding the security of goods, the reason not to include is because it is hard to gather data regarding thefts or missing products. A more or less visible supply chain might lead to respectively lower or higher costs but it is complicated to extract the exact value. A green image is becoming increasingly advertised by companies. If a concept, such as a UCC, leads to environmental benefits this can possible be exploited. A way to do this for companies is to enter into programmes or certificates which indicate that their operations are environmentally friendly. An example is ‘Lean and Green Logistics’ which rewards companies when they deliver with a CO_2 reduction of 20% in five years’ time (Anten et al., 2014). The financial effects of a green image are nevertheless ambiguous. A more attractive shopping environment is relevant

[1] Due to the fact that the data come from companies they are privacy-sensitive and therefore not disclosed.

for retailers in the city centre, but attaching a monetary value to it is difficult. The same applies to the quality of life and visual nuisance.

Valuation of the external effects depends on different assumptions. In this study, the external effects as a result of deliveries in urban areas are taken into account. These effects are those that are caused by vehicle movements, and more specifically by the movements of specific vehicles with a certain load factor. As explained above, Gibson et al. (2014) is used. The assumptions per included external effect are the road type (e.g., urban road), period of the day (day or night), location (e.g. urban area) and the vehicle type (e.g., HGV 7.5-12t, 2 axles). Exact assumptions per effect are included in Table 8 in the Appendix. The external effects are mostly given in €/vkm and the sum is calculated by the number of kilometres driven with a specific vehicle. For diverse reasons there are differences in the costs per country, and where possible, local values for Belgium have been selected. Similar to the calculation of fuel consumption, the emissions of PM, NOx and SO_2 in grams per vkm (air pollution) and CO_2 in kilograms per vkm (climate change), are specified with the aid of STREAM data. The assumption on the congestion band (free flow, near capacity or overcapacity) has an enormous influence on the price. Congestion band is based on the volume-to-capacity (v/c) ratio whereby the v/c ratio in free flow is <0.75, for near capacity $0.75<v/c<1$ and for overcapacity a v/c ratio higher than 1 (Gibson et al., 2014). The costs mainly become apparent when traffic reaches a certain density (van Lier et al., 2014). Therefore the difference between free flow on the one hand and both near capacity and over capacity on the other hand is substantial (Gibson et al., 2014). For the calculation of the external costs of congestion, local congestion levels with 28% in near capacity and 72% in free flow (INRIX, 2014), are selected. A validity check is done in the sensitivity analysis.

4 Results

This section includes the trade-off of costs and benefits, sensitivity analysis and results (step 4-6). The table in the first section shows the results of the before-after assessment during the period of data collection. Based on the daily planning of the delivery routes, the number of vehicles, kilometres driven, delivery time, consolidation factor and load factor of the vehicles are clear. For the transport operators those data are obtained through simulation with the same software. The results are recalculated as the averages per day are. Based on these results, the SCBA is calculated (Table 4). This section concludes with sensitivity analyses on the results.

4.1 Results before-after assessment

The table below shows that despite the fact that the transport operators use larger vehicles, the difference in the average number of vehicles is rather small.[2] The average number of orders per day is 75. An order is a delivery with one barcode and can consist of one item, but also of multiple ones. The consolidation factor is the number of orders per delivery. As can be seen, the transport operators already consolidate to some extent. The utilisation of the vehicles, both in terms of weight and load meters increases with deliveries by the UCC. The higher fuel consumption in the previous situation is based on a higher number of vkm by more consuming, larger vehicles. Overall, it can be concluded that there is an improvement with the UCC in place in the sense that the emissions decrease, fuel consumption is lower, less time is needed for the deliveries and the consolidation factor increases.

[2] Per vehicle a maximum delivery time of 8 hours is considered as a parameter in the software because drivers are not allowed to work longer hours. Transport operators often delivered to the UCC with one articulated truck. Simulating the deliveries of the transport operators occasionally took more than 8 hours. Without the UCC transport operators would have been obliged to deploy more vehicles. Because it is unknown what kind of vehicles would have been deployed, the articulated ones are used in the planning when multiple routes are necessary for one transport operator.

Table 3 : Main results before-after assessment during simulation period (average per day)

Operational features	UCC	Transport operators
Number of vehicles	6,21 (0,53 small vans and 5,16 rigid trucks)	5,95 (articulated trucks)
Orders	75	
Kilometres driven	278,83	358,45
Time daily delivery	35h14m	38h02m
Consolidation factor (orders per stop)	1,17	1,12
Utilisation vehicles	31% (weight) 64% (load meters)	13% (weight) 32% (load meters)
Fuel consumption (litres diesel)	96	151
CO_2 emissions	251,79kg	396,19kg
PM emissions	56,18g	94,95g
SO_2 emissions	1,93g	3,02g
NOx emissions	2102,92g	3333,29g

4.2 Results SCBA

The results of the SCBA in effects per day are displayed in Table 4 below. The results are based on a trade-off of the data obtained in the before-after assessment in the previous section. In line with table 3, the results are given as daily averages. It is assumed that the same volume is transported during five years. This is rather unlikely but forecasts are not taken into account in the main analysis here because it is then no longer based on actual data. Since it concerns commercial information, not everything is disclosed.

Table 4 : Trade-off costs and benefits per day

Direct effects		
Direct costs	Capex	Negative
	Salaries	Negative
Direct benefits	Fuel	€75,66
	Revenues	Positive
Indirect effects	For the record	
External effects		
External benefits	Air pollution	€21,60
	Climate change	€13,00
	Noise	€8,34
	Accidents	€0,79
	Congestion	€250,94
	Infrastructure	€15,22
Benefit/cost-ratio		**0,42**

Overall, capex is negative for the UCC. The UCC involves costs that the transport operators do not have to consider. The start-up costs do not only take into account the possibility to cross-dock as such, but also to consolidate larger volumes than distributed during the study period. The salaries are at this volume also negative for the UCC. Although the time of the delivery round (i.e. driver costs) is less than in the previous situation, a planner and employees to load and unload at the depot have to be hired. The fuel costs are lower for the UCC because fewer kilometres are driven and lighter vehicles are used. The fact that the average load factor is higher does not lead to a higher consumption vis-à-vis the articulated trucks of the transport operators. The revenues show a positive net result. Indirect effects are included for the record since monetisation is not possible (see section 3.3.3). Lastly, the external effects – calculated with assumptions from Gibson et al. (2014) and further specified with STREAM data (den Boer et al., 2011) – all indicate that there is a net benefit with the UCC. Only taking into account these effects, leads to a positive effect for society because there is less air pollution and a lower impact upon climate change. Not only are less vkm driven, the vkm that are driven are done with smaller vehicles that emit less pollutants. The reduction in noise nuisance is only caused by the reduction in vkm since the vehicles in both situations are considered to be heavy goods vehicles (see table 7). The same reasoning applies to lower accident costs which is solely caused by the reduction in vkm and not by the vehicle type. The marginal infrastructural costs also show a benefit after the trade-off. This is caused by both a reduction in the number of vkm as well as the type of vehicles used. Whereas the rigid van is considered to be a HGV of 7.5-12 tonnes and 2 axles, the assumption for the articulated trucks is a HGV of 18-26 tonnes and 3 axles. The costs per vkm are respectively 0,015€ and 0,054€ (see table 7). The largest difference is made by congestion of which the costs decline considerably. Altogether, the trade-off of costs and benefits is negative for the UCC with a benefit/cost-ratio of 0,42. It could thus be said that the societal return for every € invested in the UCC, is only €0,42. Seen from the above elaboration, this is solely caused by the direct effects which are negative at the current consolidated volume. This is in line with many other evaluated UCCs that are successful regarding social and environmental effects but are not able to become financially viable in their own right.

4.3 Sensitivity analysis

Sensitivity analyses are performed in order to do a validity check on different data and assumptions. Differences in the congestion band, a high and low diesel price, different load factors and alternative vehicle types are taken into account (Lewis et al., 2010). Congestion is the external effect that causes the highest cost. In the analysis, the congestion band is based on local values; 72% of the vkm in free flow and 28% in near capacity. This congestion band is changed to lower and higher local values (INRIX, 2014). A lower value with 24% in near capacity and consequently 76% in free flow leads to a ratio of 0,38. A higher congestion band of 32% in near capacity leads to a ratio of 0,45. Overcapacity is not considered since even with busy traffic, most delivery operations take place outside peak hours. All in all, it can be said that congestion has a high impact on the final result. The diesel price that is applied in the calculation is the national price during the calculation period. Increasing or decreasing the fuel price by 15% barely affects the benefit/cost-ratio. A higher or lower load factor of vehicles influences the fuel consumption and the emissions of the pollutants. The latter are included in the external effects of air pollution and climate change. A large change in the load factor from 0% (empty) to 100% (full) in both situations influences both the fuel consumption and external effects but has a very limited effect on the benefit/cost-ratio. The vehicles of the UCC and the transport operators are all considered to have the Euro 4 standard for vehicle technology (den Boer et al., 2011; Gibson et al., 2014). Assuming that the UCC operator deploys cleaner vehicles (Euro 6) and the transport operators not, this has a limited impact on the external effects. The difference with regard to the external cost of air pollution and climate change widens somewhat, but vehicles still emit pollutants. Moreover, the main external effect that causes costs, is congestion. Replacing the fleet with cleaner vehicles does not decrease the presence of vehicles.

When the fleet of the UCC operator is, however, replaced with electric vehicles that do not emit anything there is a considerable change. Not taking into account well-to-tank processes (Messagie et al., 2014), it is assumed that there are no costs at all for climate change and air pollution. In that case the benefit cost ratio rises to 0,47. This gain for the society, nevertheless, has to be offset against the substantial investment. Moreover, electric vehicles are only competitive to conventional ones if they have a payload of less than 3.5 tonnes and ones with a payload of 8 tonnes are currently not commercially available (Lebeau et al., 2015a). Deploying cargocycles could involve benefits. When in a hypothetical case all consolidated deliveries are carried out by cargocycles instead of rigid trucks the ratio increases to 0,86. This is based on the assumption that there are no external costs at all. There could, however, be a minor contribution to congestion as current infrastructure is not always decent for bikes and therefore the road is used. This also applies to parking for loading and unloading. In addition there are no fuel costs involved at all. The exact calculation is, however, complicated and effects uncertain. Capex are considered to remain the same since the trucks are currently also not included. With regard to the personnel costs there could be an increase because more cyclists have to be hired than truck drivers to carry out the same number deliveries. Taking the same number of deliveries into account, most probably the purchase costs of a higher number of cargocycles is still considerably lower than that of fewer conventional vehicles. Another advantage are the lower running costs (e.g., tax, insurance and depreciation) (Lenz & Riehle, 2013). Replacing all conventional vehicles in this specific case with cargocyles is, however, not possible. First, there are deliveries which are either too heavy or too large. Next to the limited payload, the limited range is also a disadvantage. The current UCC is located in the port area and serves a relatively large area. As a result distances between the UCC and certain delivery areas (e.g., Southern area of Antwerp) can become relatively large. It is therefore argued that using cyclocargos for city distribution is especially interesting in combination with micro-consolidation centres or mobile depots (Conway et al., 2012; Leonardi et al., 2012; Transport for London, 2009; Verlinde et al., 2014). To conclude, cargocycles can have a major impact on sustainable city distribution. This is, however, dependent on different factors such the congestion level, type of products, size of the delivery area and the service types. In their paper, Schliwa et al. (2015) argue that authorities have a key role in creating conditions for a modal shift from motorised to cycle logistics. A third alternative clean vehicle technology type is the hydrogen vehicle which converts hydrogen into electricity in fuel cells. Hydrogen vehicles have a high efficiency, low maintenance requirements and zero-emission potential. The latter refers to the fact that currently the generation of hydrogen through electrolysis can produce emissions (Vergragt & Brown, 2007). Technologies for generation, distribution and storage of hydrogen has not reached maturity yet and it is therefore not included in the sensitivity analysis (Chen et al., 2011). Finally, gaspowered vehicles (CNG/LNG) are an option. Although CO_2 is emitted, its level is considerably lower than from diesel-powered vehicles (Browne et al., 2010). Compared to electric and hydrogen vehicles, gas provides greater flexibility in terms of vehicle range and size, and it is more widely available (MDS Transmodal, 2012). The impact on the ratio is rather small since it solely leads to a small decrease in the external effects of air pollution and climate change.

5 Extended analysis

5.1 Scaled volumes

The benefit/cost-ratio as calculated above is based on actual consolidated volumes during the start-up period. On the one hand, the calculations are based on real volumes and data and therefore reliable. On the other hand, however, it does not provide sufficient information regarding the long-term viability of the UCC. In order to say something about the impact when higher volumes are consolidated, as is expected in the future, the purpose of this section is to calculate the societal break even turn-over (benefit/cost-ratio of 1). Since the main problem of UCCs is to become autonomously running, the break-even turnover in purely financial terms (business volume) is calculated as well. The complication for these calculations is that the different parameters do not change linearly with the same factor as the volume does. When for instance the volume becomes twice as large, parameters like the number of vehicles and time cannot simply be multiplied by two. For instance, currently on average 3,7km are travelled per item in case of the UCC. Due to a higher drop density this is expected to change with a higher volume. Consequently the fuel consumption becomes higher in absolute terms, but lower relatively (fuel per item). Other parameters considered to change when the volumes increases are time and hence the salaries, consolidation factor and the external effects. In addition the daily vehicle costs change because even though more vehicles have to be deployed, an increase in the consolidation factor leads to more items per vehicle. This mainly applies to the UCC, because additional transport operators do not necessarily have a higher consolidation factor (currently 1,12). For the UCC, more employees to cross-dock the goods have to be hired as well. However, since the way these parameters change is unknown, all are multiplied with the same averages as during the simulation period (e.g. 3,7km per item). The results have to be interpreted with caution for three reasons. First, calculating the assumptions with the averages of the simulation period leads especially for the UCC to overestimation as described above. When more transport operators are contracted, the volume increases. As a result, the drop density most probably increases (more deliveries in the same area) as well as the consolidation factor (more items per delivery stop). Second, value-added services are offered as soon as the main service towards the transport operators is guaranteed. Consequently, additional income is generated and break-even turnover might be reached at a lower volume. Because the exact amount of revenues is unknown, it is not incorporated in the calculations. Finally, in the near future large volumes are expected to be delivered by barge. This complicates the comparison with the effects in the previous situation. Based upon the described above, it therefore has to be said that upscaling the volume shows the 'worst case situation' in the sense that there are different factors that most probably lead to lower volumes to reach break-even. At the same time too optimistic forecasts are prevented.

5.2 Societal break-even turnover

The benefit/cost-ratio in the current situation is 0,42 (section 0). This low ratio is mainly caused by the disproportionate capex. By increasing the ratio until 1, it is possible to calculate what the break-even turnover is by taking into account all the effects of the UCC. The current volume is 75 items per day. When this volume increases by 80% until it reaches 135 items per day a benefit/cost-ratio of 1 is reached. At this volume the UCC yields a net societal benefit. So for every € invested in the UCC, € is returned to society. When the same volume per transport operator is considered, three additional ones have to deliver to the UCC daily. The table below shows the trade-off between costs and benefits at a benefit/cost-ratio of 1. The assumptions for the external effects (Table 8 in the Appendix) are kept equal (e.g. congestion band). As can be seen in the table below the capex and salaries remain negative. With regard to the latter, this is again caused by the additional employees at the UCC. The capex is still too high to cover the revenues, which are positive. The UCC yields a benefit regarding the fuel and all the external effects. So again in line with many evaluated UCCs, even at a somewhat higher volume, the UCC is still not financially viable.

Table 5 : Trade-off costs and benefits at a benefit/cost-ratio of 1

Direct effects		
Direct costs	Capex	Negative
	Salaries	Negative
Direct benefits	Fuel	€126,67
	Revenues	Positive
Indirect effects	For the record	
External effects		
External benefits	Air pollution	€36,32
	Climate change	€21,67
	Noise	€13,79
	Accidents	€1,28
	Congestion	€438,49
	Infrastructure	€27,08
Benefit/cost-ratio		**1,00**

5.3 Financial break-even turnover

As becomes clear from the analyses above, at the current consolidated volume as well as at a slightly higher one, the UCC in Antwerp has environmental and societal benefits, but is not financially viable. In this section the business volume is calculated whereby only the direct effects are taken into account. In other words, at what volume do the revenues equalise the costs. For this calculation, the parameters are again based on averages from the simulation period. For instance, the vehicles of the UCC need 3,70km for each item and the transport operators 4,76km. In both situations a vehicle delivers on average 12 items. The load factors remain equal. Capex remains equal except for the vehicle costs which increase with an average cost per additional vehicle. With the limitations of this calculation taken into account, the current daily volumes have to increase by factor 4.47 to 335 items to make the UCC autonomously running. At this volume – ceteris paribus – the benefit/cost-ratio is 3,66. This seems to be substantial, but has to be mitigated. It means 13 additional transport operators with the average volume per transport operator have to deliver to the UCC. Considering that the problems transport operators in Antwerp face indeed lead to excessive costs for last mile deliveries, this is a small number; especially when the high number of vehicle trips in the area is taken into account. At the same time, the number of transport operators delivering by truck can also be lower because of future deliveries by barge.

6 Discussion

6.1 Scaled volume

The current volume has to increase by factor 4.47 to 335 items per day to reach the business volume which eventually secures the maintenance of the UCC on the long-term. As elaborated in the previous section this calculation is the most cautious because all parameters are kept equal. Despite the height of the business volume, ultimately the initiative depends on attracting more transport operators. Subsequently this depends whether or not transport operators are willing to pay a fee for outsourcing their deliveries. In other words, there has to be sufficient demand from the market for the service the UCC operator provides. Since it is unknown to what extent outsourcing deliveries yields a benefit or not, the willingness to make use of the UCC depends on the calculation each transport operator makes separately. Herein the trade-off between the fee and the saved costs of the last mile is decisive. Subsequently this depends per transport operator on the costs that deliveries in Antwerp cause vis-à-vis the fee that is received from shippers. As discussed, the problems in Antwerp are considerable. Congestion levels are high with average daily delays in traffic of more than 28%, whereas measures like time windows and weight restrictions restrict and hence complicate deliveries more. Altogether, it can be argued that these problems provide a motive to outsource deliveries to the UCC. It, nevertheless, depends on the specific transport operator. The transport operators who currently deliver to the UCC had 1) large vehicles; 2) a low load factor in weight and somewhat higher in load meters and 3) a relatively high number of deliveries spread across the wider urban area. Based hereupon it could be said that outsourcing deliveries to the UCC is interesting for transport operators who have one or more of the following characteristics:

- Only a few deliveries (low consolidation factor) which makes each delivery relatively expensive;
- Deliveries spread widely across the area (low drop density);
- A fleet with large vehicles (articulated trucks).

Apart from avoiding complicated and costly last mile deliveries, there might be another reason to use the UCC. An additional motive, which is often not taken into account, could be the changes in the pre- and post-haulage for transport operators, meaning that they can make possible adjustments in their operations. Adjustments that – depending on the transport operator considered – can lead to benefits, like for instance delivering to the UCC with one large vehicle instead of having to use multiple smaller ones that can access the delivery area. Thus benefitting from larger vehicles for the long haul outside the city without having the disadvantages within the city (Quak, 2008). In terms of investments, one large vehicle is cheaper than two or more rigid ones. Outsourcing can therefore be financially attractive because of lower long-term investments in vehicles (van Binsbergen & Visser, 2001). Additionally this can lead to fleet optimisation (van Duin et al., 2008). The interface between urban and long-distance transport (e.g. other cities) with the same vehicle can be better coordinated (Olsson & Woxenius, 2014). Planning of daily operations can thus change for transport operators. These changes have, however, not been widely studied but it is presumably relevant for larger transport operators who can optimise their fleet and whose core business is not only city distribution. For transport operators who do not meet these criteria, outsourcing deliveries is most probably not attractive. This is, for instance, because the core business is city distribution and hence the fleet is adapted to it. Also, for companies with only a small fleet it can be less interesting since fleet optimisation is complicated. In the paper by Kin et al. (2015) an overview of potential beneficial effects outside urban areas as a result of using a UCC in an urban area is given based.

6.2 Transferability

It is not the aim of this study to develop a transferability framework (e.g. Janjevic & Ndiaye, 2014; Macário & Marques, 2008) for this particular UCC. There are, however, several prerequisites for a UCC to be successful on the basis of which conclusions can be derived of the transferability to other urban areas. In section 2.2, five criteria that increase the potential of a UCC are mentioned. These are the availability of funding, strong public sector involvement, significant problems in the area, bottom-up pressure from local interests and a single manager or landlord that tries to solve the logistics problem. According to Browne et al. (2005a) the potential increases when one or more of these criteria are met. Although all are interrelated, eventually there should be a link to a sustainable business model which makes that a UCC becomes autonomously running. Only then can it be transferred to another area. Important factors for a sustainable business model are a critical mass of users and volume, willingness by main stakeholders to use the UCC, additional services to gain extra revenues and no dependence upon subsidies. The more transport operators are willing to pay the lower the critical mass becomes. Reaching it remains vital to the success. In this section these criteria are discussed in relation to the UCC in Antwerp, followed by a link to the transferability to other cities.

Despite being mentioned as a criterion, there is no government involvement. At least, the regulatory framework does not target the UCC directly. Time windows and weight restrictions are nevertheless in place in Antwerp. From 2016 on a low emission zone (LEZ) will be introduced in Antwerp within the ring. The LEZ is introduced in phases whereby the rules for entering the zone become tighter in

2020 and 2025 (Antwerpen, 2015; LNE, 2015). The exact effects and consequences for transport operators are nevertheless unknown. Inner-city deliveries, especially with articulated trucks are therefore considerably discouraged. Consequently transport operators who use such kind of vehicles might have a motive to use the UCC. Regarding the second criterion, significant problems in the area, there is not a lot of discussion. With Antwerp being one of the most congested cities in Europe, with average daily delays up to 28%, deliveries become increasingly costly compared to less congested cities. Moreover, poor accessibility impedes the smooth functioning of deliveries, whereas the physical characteristics (narrow streets in the historic centre) further enhance this (Janjevic & Ndiaye, 2014). Third, several transport operators already deliver to the UCC and this seems to indicate that there is demand from the sector (bottom-up pressure). Whether there is wide-scale demand from transport operators as well as from receivers (for other services) is currently uncertain and becomes clear after the pilot period. The issue of neutrality also becomes apparent here. In some initiatives it has been indicated that neutrality of a UCC operator – not being a competitor of transport operators operating in the area – is important (SUGAR, 2011). To what extent City Logistics – and thus bpost – can be considered a competitor, depends most probably on the type of transport operator. The transport operators that delivered to the UCC during the pilot are all larger transport companies also focusing on long-distance transport. Next, the UCC in Antwerp is managed by a single company and not based on a public-private partnership or a cooperative system of transport operators or retailers. Even though funding is available, it is an ambiguous one. Contrary to many initiatives that are funded with public money, this initiative does not depend upon subsidies. Considerable capital investments, which are normally not available for a new start-up – especially at this scale – are provided by bpost of which the UCC is a business unit.

With regard to the transferability of this UCC, the specifics of the concept in combination with the characteristics of the delivery area are crucial. Regarding the latter, the potential for critical mass and the gravity of the problems in the area are decisive. In a small area – even with considerable problems – the UCC is probably not going to be financially viable due to a lack of critical mass; especially when it concerns a UCC of this size and subsequent investments. Vice versa, a large area with only few delivery problems does not provide an incentive for a transport operator to outsource last mile deliveries, at least, not on a large scale. As discussed in the previous section, there could be other incentives for transport operators to use a UCC (changes in pre- and post-haulage), but this has not been studied and can thus not be taken into account. Regarding the concept, capital investments are ultimately necessary and volumes have to grow. Therefore, a comparable structure whereby a relatively large company, instead of a government, provides the necessary funds is an option to avoid dependence on subsidies. The business model itself, based on offering a solution to transport operators in the first place, seems to be a good approach. In this way a fee is paid if a certain transport operator experiences a concrete benefit. This is different from some other UCC schemes which ask receivers to pay a fee. In the end a receiver mainly cares whether its goods are delivered in a convenient, and above all cheap, way (Macharis et al., 2014). The possibility of extra services for receivers as well as for transport operators should be present as this can lead to additional revenues. In addition to transport operators, the location of the UCC allows for deliveries by barge. Assuming that a critical mass is reached in Antwerp, the extent to which another (Flemish) urban area has to resemble to Antwerp depends on several factors. First, it depends on the trade-off between the size of the area and the gravity of the problems. Second, volumes destined for the port area are also consolidated. The absence of a port or the presence of a smaller port elsewhere possibly leads to the consolidation of smaller volumes both in terms of size of goods as well as volume. To what extent the port is decisive for the critical mass is unfortunately unclear. At the same time, the capital investments in Antwerp incorporate the possibility to consolidate large volumes (e.g. large warehouse, trucks, barge). In another city with a lower volume, these costs can be scaled lower to a certain extent in order to recoup the investments at a lower volume.

6.3 Role local authorities

As argued in section 2, a lot of UCC's that have been implemented were financially supported with subsidies since it turned out to be difficult to get them autonomously running. The UCC of City Logistics evaluated in this study provided an exceptional case since it provided us with an opportunity to study the potential of an autonomously running concept. Although it is elaborated above that it is possible to reach a critical mass in Antwerp, it is important to discuss the potential role of local authorities to increase the success, also with regard to the implementation of a UCC in other Flemish cities. Even though the core of this study is a privately initiated concept without public support, government intervention seems to be justified because of different reasons; solving environmental externalities, address traffic congestion or other inefficiencies such as a lack of space for (un)loading (Panero et al., 2011; Verlinde, 2015). In some cases it is argued that transport companies are not willing to pay for a UCC unless there is a regulatory framework implemented by the local authorities that forces them (Browne et al., 2005a; Verlinde, 2015). The next section gives an overview of the different types of support that authorities can provide with regard to a UCC. This is followed by an elaboration of two measures – low emission zone and urban toll – in which external effects as analysed in this study can be internalised. This is concluded by some recommendations for Antwerp and other municipalities in Flanders, in which the results of this study are combined with the role that authorities can play.

6.3.1 Support by authorities

Based on a review of 61 UCC's, Lebeau et al. (2015b) distinct between two types of public support which could increase the success of a UCC. The first is financial support of which there are different types. First of all there can be start-up support which basically holds that subsidies are granted to finance the start of a UCC (partially). The aim is to support the UCC until it reaches a critical mass of users. Examples are Binnenstadservice in the Netherlands and Cityporto in Padua. In those cases financial support was gradually decreased. In the cases of La Rochelle and Bristol the subsidies lasted longer than planned. A second form is structural support whereby authorities also cover (part of the) operational costs. The already mentioned case of Monaco is an example. Alternative forms of structural support include help to reduce the costs of the UCC, access to favourable loans and the provision of public infrastructure. The latter can be the use of depot. Herewith the UCC operator avoids real estate costs which are considerable as we have seen in this as well as in other studies. Public-Private Partnerships (PPPs) are increasingly used for this (De Schepper et al., 2014); this is especially the case in Italy (Panero et al., 2011). As Verlinde (2015) indicates, PPPs are used for UCCs but the structure and goals of PPPs differ between UCC schemes. Thirdly, there can be indirect financial support which means that parts of the equipment are subsidized; especially to test new technologies such as electric vehicles (e.g., for some examples in the CIVITAS initiative see van Rooijen and Quak, 2014). Finally, there can be no financial support as is the case in Antwerp. In some cases, however, the authorities provide financial support for the evaluation (Lebeau et al., 2015). According to Verlinde (2015) there are three timings for financial support by authorities: 1) to fund a feasibility study and/or UCC design; 2) fund/co-fund/subsidise the set-up and the procurement of related equipment (see above); and 3) the provision of operational subsidies until break-even is reached (see above). The second type of government support studied by Lebeau et al. (2015) is regulatory. The table below shows the distinction they make.

Table 6 : Different types of regulatory government support (own set-up based on Lebeau et al., 2015)

Direct	Indirect
One compulsory UCC	Time windows
License granted to transport operators	Weight restrictions
Favourable measures	Size restrictions
No direct support	EURO norms
	Age of vehicles
	Urban toll

The most extreme direct type of regulatory support is to make the use of a UCC obligatory, meaning that access is prohibited for transport operators. This is mostly used for specific sites such as a shopping mall or a construction site. Such a compulsory framework proves to be more difficult for a whole city. Alternatively, a license system based on favourable conditions given to the UCC operator can be implemented. Transport operators that do not meet the standards (e.g., certain (high) load rate) can drop their deliveries at a UCC that can meet the conditions. Such a system has been introduced in several cities in the Netherlands. Another favourable measure for the UCC can be an extension of time windows. In some cities UCC operators were allowed to use priority lanes destined for public transport (Lebeau et al., 2015; Panero et al., 2011). Direct regulatory support can, however, be controversial – especially because of opposition by different stakeholders. First, there can be opposition by local businesses (i.e., retailers) because it changes the current way of being delivered and a change herein leads to uncertainty. Therefore acceptance often only occurs after dialogues and meetings (van Rooijen & Quak, 2014). Opposition by local businesses was especially found in several UCC schemes in the Netherlands (i.e., Arnhem, Groningen, Leiden and Maastricht) (Browne et al., 2005a). Most opposition arises by transport operators. Transport operators are afraid to lose revenues as well as contact with their clients (Panero et al., 2011; van Rooijen & Quak, 2014). In a feasibility study of a UCC in The Hague, opposition arose because transport operators claimed that the municipality was creating a monopoly in the service of city distribution (van Duin et al., 2010). Exempting UCC vehicles from regulations can also lead to social opposition. In the case of Leiden, consolidated deliveries by a UCC were allowed outside time windows. The UCC, however, used slow electric vehicles which hindered other traffic (Quak, 2008). The most common criticism, principally by transport operators, is that support is unfair and it interferes with free market competition. As a result enforcement is necessary which leads to costs for the municipality (Panero et al., 2011; Quak, 2008). In 27 out of the 61 evaluated cases no direct support was involved (Lebeau et al., 2015b).

The other category of regulatory measures includes those that are not designed to support a present UCC. The measures may, however, support the UCC indirectly. The discussed measures primarily aim at limiting the access for freight vehicles in a city. Although time windows are in most cities mainly used to limit access to pedestrian areas, they can also be used in areas where authorities want to shift deliveries from congested hours. Time windows usually allow deliveries between 6am to 10-12 am. Another possibility is a time window in the evening as has been implemented in Freiburg between 19-22pm (Lebeau et al., 2015b). Time windows are a constraint for transport operators and provide an incentive to outsource deliveries to a UCC. Even more because time windows between cities are often not harmonized (Quak, 2008). The latter can lead to unnecessary vehicle movements as separate poorly loaded vehicles have to deliver in different cities at the same time instead of fewer vehicles with a higher load factor that can serve different cities during the day. In the observed cases with weight restrictions trucks with a weight over 7.5 tonnes are banned from city centres, whereas in some other cities only 3.5 tonnes is allowed. Weight restrictions have mainly been implemented in cities with historical cores characterized by narrow streets. Both measures can, however, also be counterproductive as indicated by Castro and Kuse (2005) in their study in Manila. After the introduction of weight restrictions and time windows in Manila, several transport operators deployed more vehicles to maintain the same service level in terms of number and volume (Castro & Kuse, 2005). Size restrictions are less common but in line with weight, mainly introduced in cities with a historical centre. To improve the air quality in cities, EURO norms can be used as a criterion to ban polluting vehicles. EURO norms become stricter every four to five years. Restricting access based on the age of the vehicle is less common, but in line with EURO norms. Both are regulations that can be included in a low emission zone (SUGAR, 2011). A LEZ intends to improve the air quality by banning or charging vehicles that do not comply to a certain vehicle technology before they enter a specific zone (Browne et al., 2005b) (e.g., LEZ in Utrecht since 2007; SUGAR, 2011). In the LEZ in London vehicles with technologies that emit a lot of pollutants are charged (Nakamura & Hayashi, 2013). The stricter the standards, the less attractive it becomes for transport operators to carry out deliveries themselves. Finally, an urban toll or congestion/road charging is considered to be more flexible since it can steer behavioural change based on how it is designed. These have, amongst others, been implemented in London in 2003 (see Anderson et al., 2005) and Stockholm in 2005 (see Eliasson et al., 2013). In the study by Verlinde et al. (2014) on the implementation of a mobile depot in Brussels which functions as a micro-consolidation centre, the implementation of a congestion charging scheme with a low and a high toll are included as scenarios. The results of the MAMCA indicate that the use of a mobile depot in combination with a congestion charge in general contributes to the criteria of the different stakeholders. For transport operators, more specifically, it could be an incentive to outsource deliveries. Although indirect regulatory support by the government is presented here as separate measures, it often comes down to the combination of different measures. In London congestion charging in combination with a LEZ is in place. Another illustration of combined measures is Switzerland where a fee for HGV is in place in cities. The fee is based on weight and the EURO vehicle technology (SUGAR, 2011). A combination of measures can nonetheless also be counterproductive, which is illustrated by the following fictive example: introducing a minimum load factor of vehicles could provide an incentive to use a UCC and push a transport operator to adapt its operations, but if simultaneously time windows are tight, neither a UCC nor a transport operator has sufficient time to carry out its deliveries. Consequently an exception has to be made for a UCC which may arouse opposition since it becomes direct regulatory support. Most indirect regulatory measures found in cities are not designed to support a UCC but are part of a larger city plan (Lebeau et al., 2015b). In total, authorities thus have a wide array of regulations at their disposal to support a UCC. A discussion on the use of these regulations in Flemish cities is included in section 6.3.3. The next section first deals with the internalisation of external effects.

6.3.2 Internalisation external effects

The intention of a carrying out a SCBA is to visualise the total effects of a measure or project. Although the total impact is studied, external effects are barely included in the actual project or measure in a monetary way. A SCBA as carried out in this study in the field of city logistics can provide input for a government to actually internalise external effects monetary. As demonstrated above, the previous situation in which transport operators deliver goods themselves (unconsolidated) causes considerable negative effects such as congestion and air pollution. Internalising (parts) of these effects in a monetary way in policy measures might increase the success of a UCC. As this study shows, a UCC in Antwerp provides environmental and societal benefits. These benefits are expected to increase if more critical mass is attracted (see sections 5, 6.1 and 6.2) and when cleaner vehicles are used by the UCC (see section 4.3). As indicated above, there are different measures that can actually internalise negative externalities; specifically the LEZ and/or an urban toll. Including external effects would lead to a change within the table whereby part of the external costs move to the direct costs. An extension of the SCBA with incorporation of measures that internalise negative externalities has, however, not been conducted for two reasons. The first refers to the availability of data and the second to the details of regulations which hinder the execution of reliable

SCBA with different scenarios. City Logistics currently uses conventional vehicles. In case of strict regulations, the vehicles of the UCC therefore either have to be exempted from the regulations or the vehicle fleet has to be replaced. With regard to the latter it holds that there are considerable capital investments which make it more difficult to recoup investments in the short term. However, at the same time additional volume is possibly attracted because it becomes more interesting for transport operators to use the UCC. Neither the exact (financial) data of potential investments, nor accurate data from transport operators are available which makes it impossible to calculate the eventual impact of the internalisation of external effects. Therefore a scenario would be based on too many assumptions. Second, the exact regulations of a pricing mechanism (i.e. urban toll) or a LEZ can be different and depend on too many assumptions as well. In other words, the exact details of the measure have to be clear (e.g., what types of vehicles are allowed to access a zone) to analyse a reliable scenario.

6.3.3 Recommendations

Based on the analysis in this study and the overview of regulatory support measures by authorities in section 6.3.1, some recommendations are given for the role authorities can play. The core of this study is to conduct research on the potential of an autonomously running concept without the involvement of subsidies. Financial support by authorities is therefore not included in this section. These recommendations have to be put in the context of supporting a private initiative to become financially viable or to make the barrier lower for a potential stakeholder to start a private UCC.

Authorities providing direct regulatory support (i.e., compulsory UCC, granting licences, favourable measures) are likely to encounter opposition from different stakeholders. On the one hand, because stakeholders are used to the current situation and they are afraid that they are worse of in a new situation. This can be overcome through structural meetings and dialogues. It is stressed by several authors that involvement of stakeholders in the field of urban freight is important but that consultation and structural collaboration is overall lacking (e.g., Bjerkan et al., 2014; Lindholm & Behrends, 2012; Macharis, 2005). Institutionalized collaboration can take place in a freight quality partnership (FQP) as is done in the United Kingdom. In these FQPs, policymakers, the private sector (i.e., transport operators, retailers), environmental groups, the local community and other interested stakeholders can work together to address specific freight transport topics. In essence a FQP serves to develop understanding and collaboration between different stakeholders (Ballantyne et al., 2013; Lindholm & Browne, 2013). Similarly, the region of Flanders enhanced in 2014-2015 the stakeholder dialogue in five Flemish cities and one municipality, thereby laying the basis for further local policy measures and collaboration. This also resulted in a guidance document supporting other municipalities that want to set up their own dialogue. (Vlaamse Overheid, 2015a ; Vlaamse Overheid, 2015b). Similar initiatives also exist in the Netherlands (Platform Stedeijke Distributie – PSD), France (Paris Freight Charter) and Sweden (Local Freight network) (Zunder et al., 2014). It can vary from exchanging information and experiences to initiating projects including lorry routing, loading and unloading provisions, UCCs and traffic information. Additionally, within these FQPs, local transport plans and other strategic plans can be developed (Allen et al., 2010). In this regard a link could be made to the plans that are (being) developed whereby urban freight transport is explicitly included based on input from the transport sector (e.g., Mobiliteitsplan Antwerpen, Masterplan 2020). On the other hand, and more difficult to overcome, opposition arises because support is considered to be unfair; especially when a concession is granted to a private operator. As elaborated above, opposition can also arise when there are favourable measures for a UCC or when there is a license system in place. Any recommendations regarding those two direct measures are difficult to give because it highly depends on how each measure is designed – or in other words, how strict it is. In this regard a possible measure is to only allow delivery vehicles with a minimum load factor (MDS Transmodal, 2012). In this case no distinction is made between a UCC operator and a transport company, but it forces the latter to look for a solution if the condition is not being met. Another example is to let the UCC use priority (bus) lanes (Lebeau et al., 2015b). Indirect regulatory support can also serve to support a UCC. Especially because transport operators feel more inclined to outsource their deliveries to a UCC in case of a voluntary scheme (Panero et al., 2011). The most discussed measures in relation to a UCC are time windows, a LEZ either based on EURO norms and/or age of vehicles, and the urban toll. For all these measures it depends on how they are defined; what is the goal (e.g., zero emission city logistics), the time frame (e.g., 2030) and how effective should they be (e.g., only prohibiting the most polluting vehicles or only allowing electric vehicles?)? In this regard a LEZ is often introduced in phases – as is done in Antwerp whereby access becomes more difficult in 2020 and again in 2025. A study by Browne et al. (2005b) showed that smaller companies are more concerned about a LEZ, especially if it means they would have to change their vehicle fleet. This depends on the time frame because the majority of the larger companies have replacement policies. If we look at the LEZ in Antwerp, the vehicles that are being use by transport operators in this study (i.e., HGV with diesel) are still allowed access until 2020 with EURO 3 technology when a particulate filter is installed. HGV with EURO 4 technology can access until 2025 whereby a fee has to be paid after 2020. EURO 5 vehicle technologies are allowed free access until at least 2025. The same regulations apply to a vehicle with a weight between 3.5 and 12 tonnes (Antwerpen, 2015). It can thus be argued that the LEZ in Antwerp is not very strict. Only looking at the LEZ regulation, transport operators are not obliged to outsource their deliveries to the UCC and this measure is not indirectly supporting it. On the one hand this LEZ allows transport operators to adapt their fleet over time because it cannot be expected that they change it overnight. On the other hand, however, if the goal is to move the majority of the deliveries to a UCC the LEZ has to be stricter. If the measure becomes tighter, the UCC has to adapt its fleet as well which in this case means that clean vehicles have to be deployed to avoid the accusation that direct support is given. Time windows can also become tighter or can be expanded geographically. If a UCC is, however, not exempted, its deliveries also become inefficient because more vehicles have to be deployed to carry out deliveries in a short time frame. Consequently it becomes more difficult to become financially viable. Exempting the UCC obviously can be labelled as direct support. An alternative is to combine different measures. A possibility in this regard is to only allow vehicles to a specific area (both transport operators and UCC) that can meet one or more requirements (certain EURO norm, load factor), and if they do, exceptional or easier access is allowed; either by extended time windows or in case of an urban toll by a lower or no charge. In this case inefficiently loaded and/or polluting vehicles are taken off the streets while it steers behavioural change in general (Stathopoulos et al., 2012); or at least pressures the transport sector to change the current way of delivering. An important issue to take into account for an authority is that the stricter measures are, the more important enforcement becomes (Quak, 2008). Apart from an urban toll most measures do not generate revenues; the costs of enforcement are therefore often not recouped. With regard to Antwerp the costs of the LEZ have to be taken into account vis-à-vis other measures that can support a UCC. van Rooijen & Quak (2010) for instance indicated that the costs of implementing a LEZ in the Netherlands in 2008 were on average €225,000. The larger the area, the more expensive the LEZ becomes due to monitoring and enforcement (Browne et al., 2005b).

In conclusion, whether authorities should be proactive or reactive depends on the current city characteristics and the regulations already in place (see section 6.2). In other words, does the current situation calls for a solution because last mile deliveries are no longer economically viable? The core of this study is a privately-initiated concept which started because of possible demand from the market due to complicated last mile deliveries. In this case the authorities can either do nothing and leave it to the private sector or steer deliveries to the UCC by making last mile deliveries more complicated with indirect measures. It is nevertheless important to make a trade-off between (softer) stimulating measures on the one hand and too strict measures that might endanger the provision of goods to a city on the other hand. The latter refers to the fact that the supply of goods is vital to the liveability of a city. Alternatively, if a UCC is not in place, authorities can implement measures in a proactive way to attract a UCC operator to the city. The question is then what kind of measures, and more importantly, what combination of measures? Direct support is not recommended because it seems that in Flanders an ‘urban consolidation market’ with different players is emerging. Because urban areas as well as the political contexts in cities differ (Panero et al., 2011), no recommendations on the perfect combination of measures can be given. Eventually it namely depends on different factors. First, what is the goal to be achieved? Second, how strict should a measure or a combination of measures be defined? Third, what is the time frame? Fourth, the size of the area within the city matters. Finally, the cost component has to be taken into account. Every measure causes investments which become higher as enforcement becomes more vital. There are thus several trade-offs an authority has to make.

7 Conclusion

In line with many other evaluated urban consolidation centres, the UCC in Antwerp has a positive impact on the society and the environment. Compared to the previous situation without the consolidated deliveries, it improves urban deliveries in the area of Antwerp with regard to pollutants emitted, congestion, noise, safety and infrastructure. The external cost of congestion has to be interpreted with caution because it emerges from the sensitivity analysis that a change in the congestion band influences the benefit/cost-ratio substantially. With regard to the total concept, however, the UCC does not yield a net societal benefit at is current scale as became clear with the benefit/cost-ratio of 0,42. This is the result of the direct costs, mainly caused by high initial investments, which have to be recouped. The current small scale (start-up period) in which four transport operators deliver to the UCC on a daily basis, is therefore not a long term option for this privately running concept. When the current volume increases by almost 80%, the UCC starts yielding a net societal benefit (benefit/cost-ratio of 1). Even though the UCC is beneficial for society, it also has to be financially sustainable in order to guarantee its existence on the long term. The business volume, not taking into account the external effects, lies considerably higher with almost 4.5 times the current volume. Although this is substantial, the financial break-even turnover is most likely lower for three reasons as mentioned in section 5.1; higher drop density and hence efficiency gains, income because of value-added services and additional volume by barge due to the intermodal character of the UCC. In conclusion, the size of the delivery area, current congestion levels of 28% and restrictions provide a high potential to reach a business volume in Antwerp which altogether leads to a positive effect on the three aspects of sustainability.

When it comes to transferability the specifics of this UCC as a sustainable urban distribution concept in combination with the characteristics of the urban area are decisive. The potential demand for a

UCC is based on a trade-off between the size of the area (availability critical mass) and the extent to which deliveries are complicated and hence become expensive (restrictions by authorities and problems like congestion). Despite the fact that the evaluated UCC operates with private money, authorities can play a role by supporting a UCC directly or indirectly with regulatory measures. As elaborated in section 6.3, in this way they can steer last mile deliveries to the UCC. The question remains whether the concept itself is sustainable. The required capital investments to start a UCC are considerable and often provided by authorities in the form of subsidies. To avoid the use of public money, a comparable structure whereby a large company provides start-up funds, is recommended. In order to recoup the investments and become autonomously running, revenues have to be generated. If not, the UCC is not granted a long life. Revenues all depend upon the business model and the one of this concept is based on providing transport operators a solution to avoid last mile deliveries. For the UCC a critical mass in combination with WTP by the transport operators is vital to a sustainable business model. A fee for this service is only being paid if it for a transport operator turns out that the cost of the last mile is too high compared to the fee it receives from the shipper. The higher the fee transport operators are willing to pay, the lower the critical mass becomes. The reasons for an excessive cost are diverse, including a low load factor (inefficiency within company), considerably delays (high congestion levels), a low drop density and inefficient fleet usage. Each transport operator assesses this specifically for its own company. From the perspective of the UCC, focusing on transport operators seems to be viable since a concrete solution is offered. The willingness of a transport operator to use the UCC possibly grows if it becomes clear that outsourcing last mile deliveries leads to beneficial changes outside the urban area during the pre- and post-haulage (e.g. fleet optimisation, pick-ups at more convenient times). Contrary, receivers often do not have a direct incentive to pay a fee for having their goods delivered by the UCC instead of by a regular transport operator. However, when the UCC is fully operational in a city, value-added services such as storage-at-distance and retour logistics can be beneficial for receivers and provide an additional source of income for the UCC operator. Future research into the exact costs of last mile deliveries as part of the total transport trip makes it more insightful whether a UCC is beneficial. The same applies to the possible operational adjustments in the pre- and post-haulage for certain transport operators.

Even though this study concerns a UCC which is not supported by authorities, some public support seems to be justifiable because a UCC can contribute positively to overall welfare. First of all, authorities can provide financial support whereby there are differences in the amount and the timing: for a feasibility study or UCC design, for the start-up costs, or before and during also including operational costs until break-even is reached. Alternative forms of support include access to favourable loans, providing infrastructure such as a depot or financing material (e.g. test electric vehicles). A second form of support, which is more relevant in this case, is stimulating a UCC through regulatory measures. Direct forms of regulatory measures are: making the use of a UCC compulsory, a license system whereby access to other transport operators is only granted if they meet certain conditions or favourable measures for the UCC operator. Direct regulatory support is likely to face opposition from other stakeholders because it impedes free market competition. Furthermore, implementing such measures and enforcing them can increase the authorities' costs. Giving direct support can (partly) be mitigated by enhancing the dialogue through meetings with the concerned stakeholders that institutionalize the collaboration (e.g. Freight quality partnerships in the UK).

Indirect regulatory measures do not directly target a UCC but might stimulate its use by making deliveries for transport operators more difficult. Often a combination of the following measures is mentioned in this regard: time windows, weight restrictions, size restrictions, EURO norms, age of the vehicle and a congestion charge. To what extent measures are supportive differs per context (i.e. current problems and measures, morphology city). Before implementing (additional) measures that either target city logistics in general or are supportive for a UCC different factors have to be taken into account: what is the goal (e.g. CO2 free city logistics), the time horizon (e.g. phased until 2030), how strict should they be implemented, what geographical area is targeted and most importantly what are the costs involved and how essential is strict enforcement. Also for indirect measures it is advisable to apply these as much as possible through a dialogue with the concerned stakeholders and create a link with the broader policy and plans.

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8 Bibliography

Allen, J., Browne, M., Piotrowska, M., & Woodburn, A. (2010). *Freight Quality Partnerships in the UK – an analysis of their work and achievements*. London.

Anderson, S., Allen, J., & Browne, M. (2005). Urban logistics—how can it meet policy makers' sustainability objectives? *Journal of Transport Geography*, *13*(1), 71–81.

Anten, N., Ploos van Amstel, W., & Verweij, K. (2014). Lean and green : creating a network community for sustainable logistics. In *Transport Research Arena 2014* (Vol. 31). Paris.

Antwerpen (2015). *Lage-emissiezone*. Available from: https://www.antwerpen.be/nl/kanalen/lage-emissiezone. [15 June, 2015].

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.

Ballantyne, E. E. F., Lindholm, M., & Whiteing, A. (2013). A comparative study of urban freight transport planning: addressing stakeholder needs. *Journal of Transport Geography*, *32*, 93–101.

Bjerkan, K. Y., Sund, A. B., & Nordtømme, M. E. (2014). Stakeholder responses to measures green and efficient urban freight. *Research in Transportation Business & Management*, *11*, 32–42.

BPF (2014). *Evolutie maximumprijzen*. Available from: http://www.petrolfed.be/nl/maximumprijzen/evolutie-maximumprijzen [13 November, 2014]

Browne, D., & Ryan, L. (2011). Comparative analysis of evaluation techniques for transport policies. *Environmental Impact Assessment Review*, *31*(3), 226–233.

Browne, M., Allen, J., & Anderson, S. (2005b). Low emission zones: the likely effects on the freight transport sector. In *International Journal of Logistics: Research and Applications*, 8(4), 269-281.

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.

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. *Procedia - Social and Behavioral Sciences*, *39*, 19–33.

Browne, M., Allen, J., Nemoto, T., & Visser, J. (2010). Light goods vehicles in urban areas. In *Procedia Social and Behavioral Sciences* (Vol. 2, pp. 5911–5919).

Browne, M., Sweet, M., Woodburn, A., & Allen, J. (2005a). *Urban Freight Consolidation Centres. Final Report* (p. 185).

Castro, J. T., & Kuse, H. (2005). Impacts of large truck restrictions in freight carrier operations in Metro Manila. *Journal of the Eastern Asia Society for Transportation Studies*, *6*, 2947–2962.

Chen, Y.-H., Chen, C.-Y., & Lee, S.-C. (2011). Technology forecasting and patent strategy of hydrogen energy and fuel cell technologies. *International Journal of Hydrogen Energy*, *36*(12), 6957–6969.

Conway, A., Fatisson, P.-E., Eickemeyer, P., Cheng, J., & Peters, D. (2012). Urban micro-consolidation and last mile goods delivery by freight-tricycle in Manhattan: opportunities and challenges. In *TRB Annual Meeting, 2011, Washington*.

Correia, V. D. A., Oliveira, L. K. De, & Guerra, A. L. (2012). Economical and Environmental Analysis of an Urban Consolidation Center for Belo Horizonte City (Brazil). *Procedia - Social and Behavioral Sciences*, *39*, 770–782.

Cruijssen, F. (2013). *CO^3 Postition paper: Framework for Collaboration* (p. 66).

Dablanc, L. (2007). Goods transport in large European cities: Difficult to organize, difficult to modernize. *Transportation Research Part A*, *41*(3), 280–285.

De Langhe, K., Gevaers, R., Sys, C., & Vanelslander, T. (2013). *Dataverzameling stedelijke distributie: stedelijke indicatoren en dataverzamelmethodes* (No. D/2013/11.528/1) (p. 49).

Den Boer, E., Otten, M., & van Essen, H. (2011). *STREAM International Freight 2011. Comparison of various transport modes on a EU scale with the STREAM database* (p. 103). Delft.

De Schepper, S., Dooms, M., & Haezendonck, E. (2014). Stakeholder dynamics and responsibilities in Public–Private Partnerships: A mixed experience. *International Journal of Project Management*, *32*(7), 1210–1222.

Diziain, D., Ripert, C., & Dablanc, L. (2012). How can we Bring Logistics Back into Cities? The Case of Paris Metropolitan Area. *Procedia - Social and Behavioral Sciences*, *39*, 267–281.

Eliasson, J., Börjesson, M., van Amelsfort, D., Brundell-Freij, K., & Engelson, L. (2013). Accuracy of congestion pricing forecasts. *Transportation Research Part A: Policy and Practice*, *52*, 34–46.

European Commission. (2007). *Green Paper: Towards a new culture for urban mobility*. Brussels.

European Commission. (2011). *White Paper Roadmap to a Single European Transport Area - Towards a competitive and resource efficient transport system* (p. 30). Brussels.

Eurostat (2011). A fall in average vehicle loads. Average loads, distances and empty running in road freight transport - 2010. *Eurostat. Statistics in focus, 63/2011*.

Filippi, F., Nuzzolo, A., Comi, A., & Delle Site, P. (2010). Ex-ante assessment of urban freight transport policies. *Procedia - Social and Behavioral Sciences*, *2*(3), 6332–6342.

Gamper, C. D., Thoni, M., & Weck-Hannemann, H. (2006). A conceptual approach to the use of Cost Benefit and Multi Criteria Analysis in natural hazard management. *Natural Hazards and Earth System Sciences*, *6*, 293–302.

Gibson, G., Korzhenevych, A., Dehnen, N., Bröcker, J., Holtkamp, M., Meier, H., … Cox, V. (2014). *Update of the Handbook on External Costs of Transport. Final Report* (p. 124).

Gubbi, C., Sys, C., Van de Voorde, E., & Vanelslander, T. (2014). *Vergelijking procedures tussen zeehavens: een analyse voor de havens Antwerpen en Rotterdam*. Antwerpen.

Huschebeck, M., & Allen, J. (2005). *D 1.1 BESTUFS Policy and Research Recommendations I. Urban Consolidation Centres, Last Mile Solutions* (p. 22).

Hyard, A. (2012). Cost-benefit analysis according to Sen: An application in the evaluation of transport infrastructures in France. *Transportation Research Part A: Policy and Practice*, *46*(4), 707–719.

INRIX (2014). *INRIX Traffic Scorecard.* Available from: http://www.inrix.com/scorecard/ [26 January, 2015]

Janjevic, M., & Ndiaye, A. B. (2014). Development and Application of a Transferability Framework for Micro-consolidation Schemes in Urban Freight Transport. *Procedia - Social and Behavioral Sciences*, *125*, 284–296.

Kin, B., Macharis, C., & Verlinde, S. (2015). Beneficial effects outside urban areas for transport operators who outsource deliveries to an urban consolidation centre ? In *BIVEC/GIBET Transport Research Day 2015*. Eindhoven.

Lebeau, P., Macharis, C., Van Mierlo, J. & Lebeau, K. (2015a). Electrifying light commercial vehicles for urban freight transport? A total cost of ownership analysis. *European Journal of Transport and Infrastructure Research* (submitted).

Lebeau, P., Verlinde, S., & Macharis, C. (2015b). How Authorities can support Urban Consolidation Centres ? A Review of the Best Practices. In *NECTAR Cluster 3: City Logistics and Sustainable Freight Transport Workshop*. Algarve.

Leonardi, J., Browne, M., & Allen, J. (2012). Before-After Assessment of a Logistics Trial with Clean Urban Freight Vehicles: A Case Study in London. *Procedia - Social and Behavioral Sciences*, *39*, 146–157.

Lenz, B., & Riehle, E. (2013). Bikes for Urban Freight ? – Experience for the European Case. In *TRB 92th Annual Meeting 2013*.

Lewis, A., Fell, M., & Palmer, D. (2010). *Department for Transport Freight consolidation centre study - Main Report* (p. 107).

Lindholm, M. (2013). Urban freight transport from a local authority perspective – a literature review. *European Transport / Trasporti Europei*, *3*(54), 1–37.

Lindholm, M., & Behrends, S. (2012). Challenges in urban freight transport planning – a review in the Baltic Sea Region. *Journal of Transport Geography*, *22*, 129–136.

Lindholm, M., & Browne, M. (2013). Local Authority Cooperation with Urban Freight Stakeholders: A Comparison of Partnership Approaches. *European Journal of Transport and Infrastructure Research*, *13*(1), 20–38.

LNE (2015). *Lage-emisseizones (LEZ).* Available from: http://www.lne.be/themas/milieu-en-mobiliteit/lage-emissiezones. [15 June, 2015].

Macário, R., & Marques, C. F. (2008). Transferability of sustainable urban mobility measures. *Research in Transportation Economics*, *22*(1), 146–156.

Macharis, C. (2005). The importance of stakeholder analysis in freight transport. *European Transport / Trasporti Europei*, *25-26*, 114–126.

Macharis, C., Milan, L., & Verlinde, S. (2014). A stakeholder-based multicriteria evaluation framework for city distribution. *Research in Transportation Business & Management*, *11*, 75–84.

Maes, J., Sys, C., & Vanelslander, T. (2012). *Venstertijden in Vlaanderen*. Antwerpen.

Marcucci, E., & Danielis, R. (2007). The potential demand for a urban freight consolidation centre. *Transportation*, *35*(2), 269–284.

MDS Transmodal. (2012). *DG MOVE European Commission: Study on Urban Freight Transport* (p. 156).

Messagie, M., Boureima, F. S., Coosemans, T., Macharis, C., & Mierlo, J. van. (2014). A range-based vehicle life cycle assessment incorporating variability in the environmental assessment of different vehicle technologies and fuels. *Energies*, *7*, 1467–1482.

MOBILO. (2015). *Het indicatorenboek 2013-2014 - Duurzaam goederenvervoer in Vlaanderen*. Antwerpen.

Mommens, K., Kin, B., & Macharis, C. (2014). *Evaluatiekader voor duurzame stadsbevoorradingsconcepten* (p. 39). Antwerpen.

Munda, G., Nijkamp, P., & Rietveld, P. (1994). Qualitative multicriteria evaluation for environmental management. *Ecological Economics*, *10*(2), 97–112.

Muñuzuri, J., Larrañeta, J., Onieva, L., & Cortés, P. (2005). Solutions applicable by local administrations for urban logistics improvement. *Cities*, *22*(1), 15–28.

Nakamura, K., & Hayashi, Y. (2013). Strategies and instruments for low-carbon urban transport: An international review on trends and effects. *Transport Policy*, *29*, 264–274.

Ogden, K.W. (1992). *Urban Goods Movement: A Guide to Policy and Planning.* Ashgate, Aldershot, UK.

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.

Panero, M., Shin, H.-S., & Lopez, D. P. (2011). *Urban distribution centers: a means to reducing freight vehicle miles traveled*. New York.

PORTAL. (2003). *Inner Urban Freight Transport and city logistics* (p. 51). Retrieved from www.eu-portal.net

Quak, H. J. (2008). *Sustainability of Urban Freight Transport. Retail distribution and Local Regulations in Cities*. Erasmus University Rotterdam.

RebelGroup. (2013). *Standaardmethodiek voor MKBA van transportinfrastructuurprojecten - Algemene leidraad* (p. 108).

Regué, R., & Bristow, A. L. (2013). Appraising Freight Tram Schemes: A Case Study of Barcelona. *European Journal of Transport and Infrastructure Research*, *13*(1), 56–78.

Roca-Riu, M., & Estrada, M. (2012). An Evaluation of Urban Consolidation Centers Through Logistics Systems Analysis in Circumstances Where Companies have Equal Market Shares. *Procedia - Social and Behavioral Sciences*, *39*, 796–806.

Sælensminde, K. (2004). Cost–benefit analyses of walking and cycling track networks taking into account insecurity, health effects and external costs of motorized traffic. *Transportation Research Part A: Policy and Practice*, *38*(8), 593–606.

Schliwa, G., Armitage, R., Aziz, S., Evans, J., & Rhoades, J. (2015). Sustainable city logistics — Making cargo cycles viable for urban freight transport. *Research in Transportation Business & Management*, *15*, 50–57.

Stathopoulos, A., Valeri, E., & Marcucci, E. (2012). Stakeholder reactions to urban freight policy innovation. *Journal of Transport Geography*, *22*, 34–45.

STRAIGHTSOL. (2014). *Deliverable 5.3: Business models for innovative and sustainable urban-interurban transport* (p. 118).

SUGAR. (2011). *City logistics Best practices: a handbook for authorities* (p. 276). Bologna.

Transport for London. (2009). *Cycle freight in London : A scoping study*.

UNdata (2013). *City population by sex, city and city type (Belgium, Antwerpen, Urban agglomeration, 2011*. Available from: http://data.un.org/Data.aspx?d=POPandf=tableCode%3A240. [26 January, 2015].

van Binsbergen, A., & Visser, J. (2001). *Innovation steps towards efficient goods distribution systems for urban areas. Efficiency improvement of goods distribution in urban areas*. Technische Universiteit Delft.

van Duin, J. H. R., Quak, H. J., & Muñuzuri, J. (2008). Revival of Cost Benefit Analysis for Evaluating the City Distribution Center Concept. In E. Taniguchi & R. G. Thompson (Eds.), *Innovations in city logistics* (pp. 97–114). Nova Science Publishers, New York.

van Duin, J. H. R., Quak, H., & Muñuzuri, J. (2010). New challenges for urban consolidation centres: A case study in The Hague. *Procedia - Social and Behavioral Sciences*, *2*(3), 6177–6188.

van Lier, T. (2014). *The development of an external cost calculator framework for evaluating the sustainability of transport solutions*. Vrije Universiteit Brussel.

van Lier, T., De Witte, A., Mairesse, O., Hollevoet, J., Kavadias, D., & Macharis, C. (2014). Assessing the social relevance of school transport in Flanders (Belgium). *International Journal of Social Economics*, *41*(2), 162–179.

van Lier, T., van Malderen, F., & Macharis, C. (2009). *Indicatoren bij de beoordeling van verkeersveiligheidsmaatregelen (RA-MOW-2009-002)* (p. 72). Diepenbeek.

van Malderen, F., & Macharis, C. (2009). *Handleiding voor het evalueren van verkeersveiligheidsmaatregelen. Een eerste aanzet (RA-MOW-2009-003)* (p. 62). Diepenbeek.

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 Rooijen, T., & Quak, H. (2014). City Logistics in the European CIVITAS Initiative. *Procedia - Social and Behavioral Sciences*, *125*, 312–325.

Vanclay, F. (2004). The Triple Bottom Line and Impact Assessment: How do TBL, EIA, SIA , SEA and EMS relate to each other? *Journal of Environmental Assessment Policy and Management*, *6*(3), 265–288.

Vergragt, P. J., & Brown, H. S. (2007). Sustainable mobility: from technological innovation to societal learning. *Journal of Cleaner Production*, *15*(11-12), 1104–1115.

Verhoef, E. T. (2000). The implementation of marginal external cost pricing in road transport. Long run vs short run and first-best vs second-best. *Papers in Regional Science*, *79*, 307–332.

Verlinde, S. (2015). *Promising but challenging urban freight transport solutions : freight flow consolidation and off-hour deliveries*. Vrije Universiteit Brussel; Universiteit Gent.

Verlinde, S., Macharis, C., Milan, L., & Kin, B. (2014). Does a Mobile Depot Make Urban Deliveries Faster, More Sustainable and More Economically Viable: Results of a Pilot Test in Brussels. *Transportation Research Procedia*, *4*, 361–373.

Verlinde, S., Macharis, C., & Witlox, F. (2012). How to Consolidate Urban Flows of Goods Without Setting up an Urban Consolidation Centre? *Procedia - Social and Behavioral Sciences*, *39*, 687–701.

Vermote, L., Macharis, C., Hollevoet, J., & Putman, K. (2014). Participatory evaluation of regional light rail scenarios: A Flemish case on sustainable mobility and land-use. *Environmental Science & Policy*, *37*, 101–120.

Vlaamse Overheid, Departement Mobiliteit en Openbare Werken (2015a). PIEK 2, Dialoog stedelijke distributie, Eindrapport, 56p.

Vlaamse Overheid, Departement Mobiliteit en Openbare Werken (2015b). PIEK 2, Dialoog stedelijke distributie, Leidraad voor lokale overheden, 28p.

Zunder, T. H., Aditjandra, P. T., Schoemaker, J. T., Vaghi, C., Laparidou, K., & Österle, I. (2014). Engaging city stakeholders to achieve efficient and environmentally friendly urban freight movements. In *Transport Research Arena 2014*. Paris.

Zunder, T. H., & Ibanez, J. N. (2004). Urban freight logistics in the European Union. *European Transport / Trasporti Europei*, *28*, 77–84.

Appendix

Table 7 : Assumptions simulation

Assumption	UCC	Transport operators
Time period	NPV per day recalculated from 5 years with 228 operational days per year	
Simulation period	4 weeks with 19 operational days during November-December 2014.	
Volume	Average volume per day as based on simulation period	
Delivery trips	As planned with the software; departing and returning to the UCC	Simulated with software as if transport operators delivered from and returned to the UCC
Orders	Every delivery (order) has an own tag. There can be multiple orders destined for 1 stop. An order can hold multiple items or there can be separate goods with their own tags for 1 stop	
Time	- Start is at 8.30am for every vehicle, departure at the depot after 30min loading time at 9am. 20min returning time after the delivery trip is included per vehicle. - Minimal 14min delivery time which varies with the number of orders per stop, the weight and the load meters - Travel time is based on km and area (longer in city centre)	
Vehicles	Small van (payload 700kg) Rigid trucks (payload 8750kg)	Articulated trucks (payload 13.600kg)
Vehicle technology	Mix of EURO 3/4 (den Boer et al., 2011)	
Investment	Vehicles not taken into account as an investment since the UCC is part of a larger company which has multiple inactive rigid trucks during	Vehicles not taken into account as an investment because it is unclear what vehicles the transport operators would have used without the UCC (e.g. multiple rigid trucks

	daytime	instead of articulated trucks)
Fuel price	€1,372 per litre diesel on 13 November 2015 (Source: BPF, 2014)	
Salaries	€22,- per hour for drivers, planner (8h per day) and 2 employees at UCC (8h per day in total. This might seem a low salary, but consultancy and training are included in the direct costs).	€22,- per hour for drivers
Fuel consumption	Based on type of vehicle (in terms of maximum payload) and average load factor as taken from STREAM data (den Boer et al., 2011)	

Table 8 : Assumptions external effects (Source : den Boer et al., 2011; Gibson et al., 2014)

External effect	Region	Road type	Vehicle type	Other	Cost
Air pollution					
SO_2	Urban		Minivan Rigid truck Truck trailer	0,0022g/vkm 0,0072g/vkm 0,0084g/vkm	0,014€/g
PM2.5			Minivan Rigid truck Truck trailer	0,127g/vkm 0,206g/vkm 0,265g/vkm	0,208€/g
NOx			Minivan Rigid truck Truck trailer	1,0g/vkm 7,9g/vkm 9,3g/vkm	0,011€/g
Climate change (CO_2)	Urban		Minivan Rigid truck Truck trailer	0,22kg/vkm 0,937kg/vkm 1,105kg/vkm	0,09€/kg
Noise	Urban		LDV HGV (rigid, articulated)	Time: Day Traffic type: Dense	0,053€/vkm (LDV) 0,097€/vkm (HGV)
Accidents		Urban road	Car HGV (rigid, articulated)		0,004€/vkm 0,009€/vkm
Congestion	Metropolitan	Main roads	Car Rigid truck Articulated truck	Free flow Near capacity Free flow Near capacity Free flow Near capacity	0,011€/vkm 1,685€/vkm 0,021€/vkm 3,202€/vkm 0,032€/vkm 4,887€/vkm
Infrastructure		All roads	LDV <3,5t HGV 7.5-12t (2 axles) HGV 18-26t (3 axles)		0,007€/vkm 0,015€/vkm 0,054€/vkm

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