H2020 MSCA-RISE-2016

ProSFeT Project

Promoting **S**ustainable **F**r**e**ight **T**ransport in Urban Contexts:
Policy and Decision-Making Approaches

(Project ID: 734909)

Deliverable 4.2 – Work Package 4

ProSFeT Special Session at the ProLog Conference 2018:

An Introduction

According to the ProSFeT Dissemination Plan, outputs from this project will be delivered at international academic and professional conferences. In this sense, some results obtained during the development of the work packages (WP) will be presenting at the 4th Annual Project Logistics Conference (ProLog) which will be held at the University of Hull Logistics Institute from 28th to 29th June 2018 (http://www.prolog-conference.com)

After the reviewing process carried out by the ProLog Scientific Committee, five ProSFeT-related papers were accepted as contributions to be presented in a special session aimed at describing some of the WP results of this project. The main characteristics of those contributions are described as follows.

Genovese et al., in their paper titled "*An evaluation of current decision support systems for urban freight transport planning and their adaptability in multi-stakeholders' contexts*" provide a review of the extant literature on decision support systems (DSS) for urban freight transport. In particular, an overview of emerging themes within the current state-of-the-art is provided, such as: the adaptation of classical logistical decision-making problems to the urban context; the development of key performance indicators for evaluating logistical systems within multi-criteria decision-making frameworks; the promotion of integrated decision support tools for advancing the practical application of approaches developed in the academic literature to everyday scenarios. In addition, a review of currently commercially available DSSs for logistics planning is performed, in order to highlight gaps between theory and practice.

Jones et al., present the paper "*Hydrogen vehicles in urban logistics: A total cost of ownership analysis*", which progresses the discourse on alternative (hydrogen) vehicles as viable strategic options for addressing sustainability concerns in urban logistics. A critical component of sustainable logistics solutions is economic cost for concerned stakeholders, particularly for freight transport operators. Several studies have explored the cost competitiveness of battery electric vehicles (BEVs). However, there exist gaps related to the cost competitiveness of hydrogen fuel cell vehicles (HFCVs) in logistics despite their weight, space and emissions advantages over BEVs. The outcomes from this study not only support the economic competitiveness of HFCVs but also provide sensitivity impact from changes in the value of market condition factors on cost competitiveness.

"*A multi-stakeholder and multi-criteria decision-making approach for evaluating the performance of urban consolidation centres*" by Luo et al., proposes a multi-criteria decision-making (MCDM) approach for evaluating the performance of urban consolidation centres (UCC) systems. The approach combines and elaborates economic, environmental and social indicators arising from previous research and seeks to capture the perspective of the multiple stakeholders involved in UCC systems. The research identifies strengths and weaknesses of the different surveyed UCCs, establishing a benchmarking tool (also usable by decision- and policy-makers) that will contribute to a better understanding of UCCs functioning and to the identification of potential improvement areas.

Rubio et al., in their paper "*Reverse logistics and urban logistics: commonalities and opportunities for collaboration*", describe and analyse the existing relationships between Reverse Logistics and Urban Logistics in order to identify opportunities for collaboration between these two disciplines, taking advantage of the knowledge generated in each of them through its application to existing problems within our cities. Among the main challenges to be jointly addressed by the two disciplines are those relating to: 1) the proper treatment and management of urban waste; 2) the recovery and management of recoverable materials and products; and 3) the management of commercial refunds or returns.

Finally, the paper titled "*Transitioning Urban Consolidation Centres initiatives in successful operations: A collection of EU case experiences*", by Serena et al., investigates existing UCC initiatives within the EU, identifying some reasons for failures as well as critical success factors for transition from project to operations phase. The findings from this study offer knowledge insights that can help municipalities and their stakeholders design and implement sustainable UCC initiatives.

Selected contributions

Genovese, A., Luo, S., Rubio, S., Sgalambro, A., Tob-Ogu, A., Ballantyne, E. (2018). An evaluation of current decision support systems for urban freight transport planning and their adaptability in multi-stakeholders contexts.

Jones, J., Genovese, A., Tob-Ogu, A. (2018). Hydrogen vehicles in urban logistics: A total cost of ownership analysis.

Luo, S., Genovese, A., Sgalambro, A. (2018). A multi-stakeholder and multi-criteria decision-making approach for evaluating the performance of urban consolidation centres.

Rubio, S., García-Gallego, J.M., Valero-González, J.M., Chamorro-Mera, A., Miranda, F.J., Jiménez-Parra, B. (2018). Reverse logistics and urban logistics: commonalities and opportunities for collaboration.

Serena, A., Tob-Ogu, A., Genovese, A. (2018). Transitioning urban consolidation centres initiatives in successful operations: A collection of EU case experiences.

An evaluation of current decision support systems for urban freight transport planning and their adaptability in multi-stakeholders contexts

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Keywords: Decision Support Systems, Multi-Stakeholder Environments, Urban Freight transport, Urban Logistics

1. Introduction

With the growth of the population share living in urban areas, over recent decades, interest and awareness in urban logistics and transport activities has been steadily growing in both the research environment and wider policy context. Significantly, advances in urban logistics operations and improved local authority planning are seen as essential in order to alleviate the associated negative environmental and economic impacts occurring in cities (Lindholm and Behrends, 2012).

Several types of actors and stakeholders are therefore involved in such urban logistics management processes. Among them, freight carriers and shippers are interested in minimizing freight logistics costs in order to maximize their profits, while maintaining a competitive level of service to their customers. City administrators and residents are oriented towards a decrease in traffic congestion, social costs and environmental nuisances, even though they are often direct beneficiaries of high quality delivery services. This leads to a multitude of differing and possibly conflicting objectives that are involved in urban freight transport planning and decision making, yielding a high level of complexity and providing a strong motivation for the development of tools for helping decision-makers to reach higher grades of efficiency.

Decision support systems (DSS) can offer mechanisms and metrics that can provide useful basis for informed decision-making at an organisational level. They rely on an extensive use of operational research and data analytics techniques in order to predict and create scenario outcomes that can ease the decision-making process, provide comparisons of alternative courses of action and optimise a variety of objectives.

Although potentially positively impacting, the adoption, on a systematic basis, of Decision Support Systems in urban logistics practice has been limited, so far, by a variety of reasons. Indeed, despite an increasing number of advanced models and powerful algorithms presented in the literature for optimizing Urban Logistics, planning-oriented Decision Support Systems (DSSs) are seldom considered by private and public agents as tools to be adopted for practical purposes within real-world decision making processes. This is partly due to the fact that these models and methods rarely incorporate a multi-stakeholder perspective in their analysis, often resulting in centralised and hierarchical decision-making procedures that might be of little help in contexts where a more participatory approach is required.

However, advancements in the scientific and technological development of DSSs, designed and implemented in strict cooperation with potential beneficiaries such as local authorities, transport planners and private sector logistics operators, have the potential to increase the adoption of innovative model-driven DSS approaches in real-world urban logistics.

In this contribution, a review of the extant literature will be provided. In particular, an overview of emerging themes within the current state-of-the-art will be provided. Also, the review will be looking at the building blocks of DSSs, such as: the adaptation of classical logistical decision-making problems to the urban context; the development of key performance indicators for evaluating logistical systems within multi-criteria decision-making frameworks; the promotion of integrated decision support tools for advancing the practical application of approaches developed in the academic literature to everyday scenarios. At the same time, a review of currently commercially available DSSs for logistics planning will be performed, in order to highlight gaps between theory and practice.

2. Preliminary Findings

Alternative delivery modes, time-based strategies and urban consolidation centres are some of the main solutions being utilised by local authorities for addressing freight mobility challenges in urban spaces. Some of these solutions (such as UCCs) are becoming increasingly attractive options within Europe and one that is being embraced by local authorities across board (Battaia et al., 2014). However, a significant drawback to the implementation of such solutions is represented by the high set-up costs and the subsequent operations priority assignments once running (Leonardi et al., 2014). Additionally, the implementation of urban logistics solutions can create stakeholders conflicts as carriers' operations might be significantly disrupted (Van Duin et al., 2016).

Given the relatively low success rate of urban logistics initiatives (for instance, UCCs) especially in mainland Europe, contemporary and future initiatives have to be based on careful planning, and on the usage of appropriate DSSs for maximising success rates.

The successful case studies suggest that these elements of implementation are critical and the successful application of appropriate decision support systems is crucial to the implementation. Unfortunately, at the moment, approaches developed in the academic literature (mainly tested on numerical examples or on ad-hoc case studies) exhibit a low degree of transferability to real-world situations; at the same time, the lack of general-purpose systems aimed at decision-aiding in the field of urban logistics means that local authorities need, in most of the cases, invest significant resources in the creation of ad-hoc tools that might not be reutilised for future projects. Also, such investments might be problematic in an era of austerity, cuts to public expenditure and limited budgets. Findings highlight weaknesses in stakeholder modeling and excessively operational level focus that creates dichotomies between DSS models and their use by local authorities. The implications are instructive for future developments in the field and highlight the relevance of strategic level tools with capacity for complex scenario planning, optimal resource evaluation and stakeholder prioritization.

Based on initial conversations with public sector stakeholders, it emerges that a critical area for impact would be the possibility of turning *common operational tools* (designed, for instance, for the management of existing systems, such as UCCs) into strategic decision support systems (that could be utilised also by other stakeholders in the industry).

In particular, scenario planning functionalities would be very useful in the phase of strategic design of urban logistics solutions. As such, the development of core strategic tools that offer decision support beyond operational levels is critical to advancement in the field of sustainable urban logistics. Such strategy-based tools with capacity for scenario planning and optimal resource and stakeholder prioritisation can effectively move local authorities beyond the complexities of the many operations tools into single user friendly and optimal decision frameworks.

Acknowledgments

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Hydrogen Vehicles in Urban Logistics: A Total Cost of Ownership Analysis

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Abstract - Freight transport accounts for 8-15% of total traffic flow in urban areas within the European Union. Majority of these deliveries are undertaken by diesel powered vehicles with extremely disproportionate levels of CO_2, NO_x and particulate matter emissions. Accordingly, a variety of strategic option shave been advanced as key solutions for addressing fossil fuel demand and emissions in urban freight transport. This paper progresses the discourse on hydrogen vehicles as viable strategic options for addressing sustainability concerns in urban logistics, by undertaking a comprehensive total cost of ownership analysis. Outcomes from this study not only support the economic competitiveness of hydrogen vehicles, but also analyse implications of several future policy and market scenarios.

Keywords – Urban Logistics; Freight Transport; Alternative Vehicles; Total Cost of Ownership

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Keywords – Urban Logistics; Freight Transport; Alternative Vehicles; Total Cost of Ownership

1. Introduction

Logistics and freight activities in cities are at heightened levels due to increased trade volumes and purchase behavioural shifts towards e-commerce options intensifying last-mile delivery activities. Freight transport accounts for 8-15% of total traffic flow in urban areas within the European Union (EU) (MDS Transmodal Limited, 2012). The majority of these deliveries are undertaken by diesel powered vehicles with extremely disproportionate levels of CO_2, NO_x and particulate matter emissions (25%, 33%, and 50%) (Dablanc, 2007). Accordingly, a variety of strategic options (infrastructure; equipment; governance; modality) have been advanced as key solutions for addressing fossil fuel demand and emissions in urban freight transport (Asif and Muneer, 2007; Russo and Comi, 2011; Li et al., 2015).

This paper progresses the discourse on alternative (hydrogen) vehicles as viable strategic options for addressing sustainability concerns in urban logistics. A critical component of sustainable logistics solutions is economic cost for concerned stakeholders, particularly for freight transport operators. The importance of this component is widely recognised as evidenced by ubiquitous subsidies that support alternative vehicle and energy initiatives across the globe. Although studies have explored the cost competitiveness of battery electric vehicles (BEVs), there are gaps related to the cost competitiveness of hydrogen fuel cell vehicles (HFCVs) in logistics despite their weight, space and emissions advantages over BEVs (Ni et al., 2007; Silva Veras et al. 2017). The outcomes from this study not only support the economic competitiveness of HFCVs but also provide sensitivity impact from changes in the value of market condition factors on cost competitiveness.

The remainder of this paper is organised as follows: the next section provides a review of the literature, followed by an overview of the methodology. Section 4 is devoted to an examination of the findings; Section 5 presents some scenario analysis, while conclusions are summarised in section 6.

2. Literature Review

2.1 The role of equipment and technology

Electrification has been suggested as a way to reduce emissions (Sharma et al., 2012). Partial electrification, or hybrid vehicles, could reduce emissions by 38-41% compared to conventional vehicles (Samaras and Meisterling, 2008). Fully electric vehicles are emission free during use and so can reduce emissions by 100% if renewable sources are utilised for electricity generation (Schiffer and Walther 2017). Smith (2010) showed that electric vehicle technology allows for a reduction of 25-40% in CO_2 emissions in urban areas in Ireland. Longer term, Nicolaides et al. (2017) estimated that 88-93% reductions were possible by 2040. The US Department of Energy found that by powering on-board appliances in long-haul diesel trucks, diesel consumption could be reduce by up to 80% (Garbak, 2003).

HFCVs are also a suggested alternative to internal combustion engine (ICE) vehicles. HFCVs have been shown to reduce greenhouse gas emissions and lead to an improvement in air quality (Jacobson, 2005; Thomas, 2009). However, BEVs exhibit lower fuel costs per kilometre and so it follows that lower hydrogen costs and greater accessibility would increase the attractiveness of HFCVs.

Demirdoven (2004) found that HFCVs using fuel produced with non-renewable sourced electricity offered little to no advantage over hybrid electric vehicles for use in urban environments. However, it is possible to use renewable, or emission-free, sources of electricity to produce hydrogen fuel (Ni et al., 2007).

2.2 Cost studies

HFCV components are high-cost and less durable than ICE ones, meaning they must be replaced more often, driving up costs (Chalk and Miller, 2006); however, costs are falling and HFCVs are expected to be competitive with BEVs by 2020 (Pollet et al. 2012). To address this, da Silva Veras et al. (2017) recommended additional research on economic competitiveness. The provision of total cost of ownership (TCO) information has been found to increase consumers' preferences for hybrid and BEVs in small-medium size vehicle classes (Dumortier et al., 2015).

Al-Alawi and Bradley (2013) reviewed cost models for PHEVs and found that typically fewer cost components were considered than for ICE vehicles. Their principal finding was that under the correct conditions BEVs could be cheaper than hybrids and conventional vehicles.

In Offer et al. (2010) a TCO model considering HFCVs and BEVs was constructed and a 2030 scenario discussed. In the 2030 modelled scenario both BEVs and HFCVs exhibited higher capital costs than ICE vehicles, although technological developments did reduce the difference. However, once fuel costs over the lifetime of the vehicle were considered they found that both BEV and hybrid HFCVs appeared cheaper than ICE and pure HFCVs. They noted however that both the HFCV and the ICE case were highly sensitive to fuel costs and that accurate predictions of future fuel costs are not possible.

Contestabile et al. (2011) compared BEVs, HFCVs, and biofuel passenger vehicles in a TCO model and found there was no significant difference in predicted cost by 2030. They conclude that smaller BEVs offer cost advantages when operating on a low-energy driving cycle. They made clear that such models should not be considered predictive due to the difficulty in predicting technological developments. Davis and Figliozzi (2013) focussed exclusively on ICE and BEV delivery trucks operating in urban environments (the last-mile scenario). They noted that electric trucks are more expensive for almost all cases but the possibility of rising energy costs and development of battery technology could lead to a situation where electric trucks would be competitive in most cases. Wu et al. (2015) produced a probabilistic model to simulate the TCO of both BEVs and ICE vehicles. They concluded that BEVs have a "good probability" of becoming the most cost-efficient for smaller vehicles operating in urban contexts.

As part of TCO analysis fiscal incentives that favour low emission activities must be considered. One example is congestion charging which discourages use of specific roads and thereby reduces both traffic and pollutant emissions. Börjesson et al. (2012) assessed the impact of congestion charges in Stockholm and found that as a measure for incentivising a switch to alternative fuel vehicles congestion charges are effective. Hidrue et al. (2011) and Lévay et al. (2017) analysed the demand for BEVs and buyers' attitudes in the USA and Norway and found that subsidies and tax relief were key to achieving BEV competitiveness.

None of the discussed models have dealt with hydrogen-powered light commercial vehicles (LCVs) and their role in last-mile or urban deliveries. As such, in this paper a TCO model is constructed that, unlike prior studies, includes HFC-LCVs operating in the UK and takes into consideration the indicators common to the models discussed previously as well as the impact of fiscal incentives.

3. Methodology and Results

A Total Cost of Ownership (TCO) approach models the costs of 'buying' a good or service from a particular supplier and includes the overall life costs associated with the ownership of a product. TCO models are traditionally implemented using aggregated forecast and historical data to establish costs (Heilala et al., 2006; Kimmel et al., 2013; Harrison and Theil, 2017).

For this study, we selected 13 vehicles to reflect BEVs, PHEVs and ICEs, all with similar functionality, size, interiors and EU classifications. To support comparison, annual mileage of 12921 miles was allocated per vehicle adopting industry assumptions[1] (DfT, 2017).

[1] 3.8 million licensed vans in the UK, driving a total of 49.1 billion miles. Per vehicle mileage average of 12,921.05 was chosen as our annual mileage variable

In line with our objective of modelling operating costs, the cost assumptions encompass critical operator costs for typical last mile fleet activities, deriving from the literature and the office of national statistics (ONS, 2015; Kohler et al., 2017).

Ownership costs reflect those that are commonly accrued through usage over the lifetime of the vehicle and these costs are dependent on period of ownership, annual mileage, or both. Capital costs include typical upfront purchase costs associated with each vehicle; in the case of subsidies these can be negative.

In this paper, the approach shown in Figure 1 was utilised in order to develop the employed calculation model, distinguishing between Capital Costs and Ownership Costs.

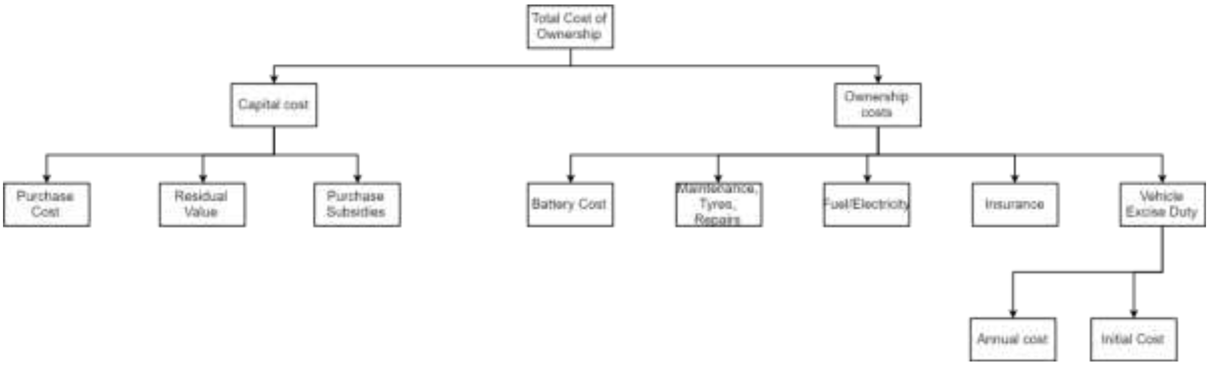

Figure 1 – Employed TCO approach

As a result, the following formula was used[2]:

$$TCO = (CE - RV - PS) + \sum_{x=1}^{5}\sum_{n=0}^{9}\left(C_{x_n} \times \frac{1}{(1+r)^n}\right)$$

The components of the formula are illustrated, in detail, in the following.

CE represents capital expenditure; this included initial asset or purchase costs exclusive of VAT per HMRC regulations (businesses can reclaim VAT on business vehicles as long as they are not for private use). These reflect the initial purchases cost of the vehicles as advertised by the manufacturers. One-off payment costs were adopted, as financing options would be impossible to account for with the range of variable interests accessible. Where applicable, the costs were converted from EUR to £ (e.g. the Renault Kangoo Z.E and Symbio HYKangoo).

[2] It is assumed that all costs rise in-line with inflation such that their present value remains the same, not including the discount rate. The exception to this assumption is the residual value, for which the depreciation rate considered is set in terms of present value

RV represents residual value, computed using average depreciation factors (Element Energy, 2016). Although the market for alternative vehicles remains largely underdeveloped, it was suggested that depreciation values for these vehicles converged overtime (Element Energy 2016). Residual values were computed as NPV of capital costs * residual % for period n, where n=10.[3]

PS represents purchase subsidy. The UK government offers grants for vehicles with ultra-low emissions, the amount of which depends on the amount of emissions the vehicle produces. Eight different vans are listed on OLEV's release, including the three BEVs and the fuel cell conversion vehicle under consideration in this study[4]. The grant allows for a 20% reduction in the purchase price of the vehicle, up to a maximum of £8,000. The value of the grant is deducted from the upfront cost of the car at the point of sale and includes VAT, thus a factor of 0.20 will be applied to the after tax purchase cost of the vehicle to determine the magnitude of grant available. In the event of this value exceeding £8,000 it is corrected to £8,000.

r represents the discount rate; in line with LCV operation periods average 10 years, the applied discount rate followed a 10-year gilt, supported by a three-month average from historical data (adjusted to 1.2) to three significant figures (HM Treasury, 2013; Clarke et al., 2014).

C_{x_n}represents running cost x, for year n; in particular, the following costs are considered.

C_{1_n} represents the cost of road tax (*Vehicle Excise Duty,* a compulsory duty on operational vehicles within the UK) for year *n*. Road taxes are pro-rated according to $C0_2$. Where applicable, data from the Department for Transport or calculated the applicable road tax by using the given emissions range of the vehicles and allocated charges. Discounted life time costs were calculated by discounting the given rates.

C_{2_n} represents fuel costs for year *n*. These were calculated for each vehicle in the form of pounds per mile (£/mi) using current diesel prices and MPG values from manufacturer

[3] For the purpose of this study, we have excluded capital gains tax as these are commercial vehicles used solely for business.

[4] It is assumed that the H350 will qualify for this grant as it meets all over criteria but is presumably not listed as it is not on general sale in the UK at the time of publication

specifications. Similarly, electricity price averages for 6 small businesses (Business Electricity, 2017) were adopted, accounting for the £ per kWh and premise standing charges. After averaging the costs for all 6 small businesses a £/mile figure was calculated which was then scaled up to an annual cost using the chosen annual mileage.In order to find the cost for the HFCVs, we assumed (per Hyundai H350 Concept) that fuel consumption guides in the technical specification were applicable as averages. First we reflected mileage consumption in kilograms (kg) and employed the listed vehicle capacities to determine consumption. Next we factored the cost of hydrogen (£10 per kg), therefore the costs for the HFCVs were computed as a product of annual mileage, miles per kilometre, and GBP per kilometre[5].

C_{3_n} represents maintenance, repair, and tyre (MRT) costs for year *n*. This reflects the costs that a user would incur in operating the vehicle due to both maintenance and repairs and also regular tyre replacements. MRT estimates for diesel vehicles were calculated by adding repair cost using pence per mile (5.2ppm) and tyre replacement costs (1.4ppm), i.e. 6.6ppm for diesel vehicles. Typical electric and hydrogen vehicles MRT costs have been pegged at 50% and 70% of ICEV types respectively, therefore we allocated this at 3.3ppm and 4.62ppm (Element Energy 2017). Annual MRT costs were set using the product of the relevant ppm value and annual mileage.

C_{4_n} represents insurance costs for year *n*; a variation of input data was used to inform insurance quotes for a typical UK based business van insurance in 2017. To support our data evaluation, we used a price comparison site (www.comparethemarket.com) to generate quotes. To account for difficulties of new models, we made some further adjustments to accommodate gaps in the returned quotes[6].

C_{5_n}represents battery costs for year *n*. As battery costs remain high, manufacturers offer a variety of purchase options to support customers; one such option is battery leasing whereby users pay a monthly fee which covers ownership and replacements. For example, the cost for

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[5] Kangoo, operates using both battery electric means and hydrogen fuel cell, we assumed a ratio of energy draw was the same as the ratio of the ranges, i.e. hydrogen range at 180 miles and battery mode at 106 miles (180:106 or 62.9% hydrogen and 37.1% battery).
[6] This assumption is valid as an estimate as the same stock vehicle is used in both cases, with the HyKangoo having an aftermarket fuel cell conversion. For the H350 vehicle the powertrain and vehicle allowed its estimation as a BEV and we used an average from the cost of the other BEVs to estimate the insurance cost for the H350. All prices were considered fixed for the 10-year period.

the *Renault Kangoo Z.E. 33* is determined by contract length and mileage, and it was this cost model which was used to estimate battery cost gaps for similar vehicles. Annual battery costs could then be deduced and subject to the discount rate at each year.

3.1 Sensitivity Analysis

Results were then subjected to 'what if' sensitivity analysis evaluating the impact of changing the determining characteristics on the cost outcomes for the different vehicles, using the preliminary results as baseline data.

Ultimately there are two situations that were analysed; a change in operating conditions at current market conditions, and a change in market conditions under current operating conditions. All analysis was performed using MS Excel Scenario Manager; results are reported below.

4. Results

The model shows that. typically, diesel vehicles offer lower TCO compared to the electric and fuel cell options. Our data shows insurance as the largest factor in this regard, constituting, on average, 64% of the total cost for BEVs and HFCVs. We project that this cost will reduce overtime as the market matures and insurers are better able to compute risks of coverage.

It is also clear that the effect of duties as a moderator is relatively limited.

HFCVs remain the most expensive options without the OLEV grant, however our findings suggest that the grant effectively supports the competitiveness of HFCVs. Additionally, results highlight greater overall capital expenditure costs for the hydrogen options as opposed to the electric and diesel vehicles. It is possible that the cost implications may be steeper as our model assumes a relatively competitive residual value component for the HFCVs and this assumption may not always hold true since the market is still growing. Full results are shown in Figure 2.

4.1 Sensitivity to Mileage

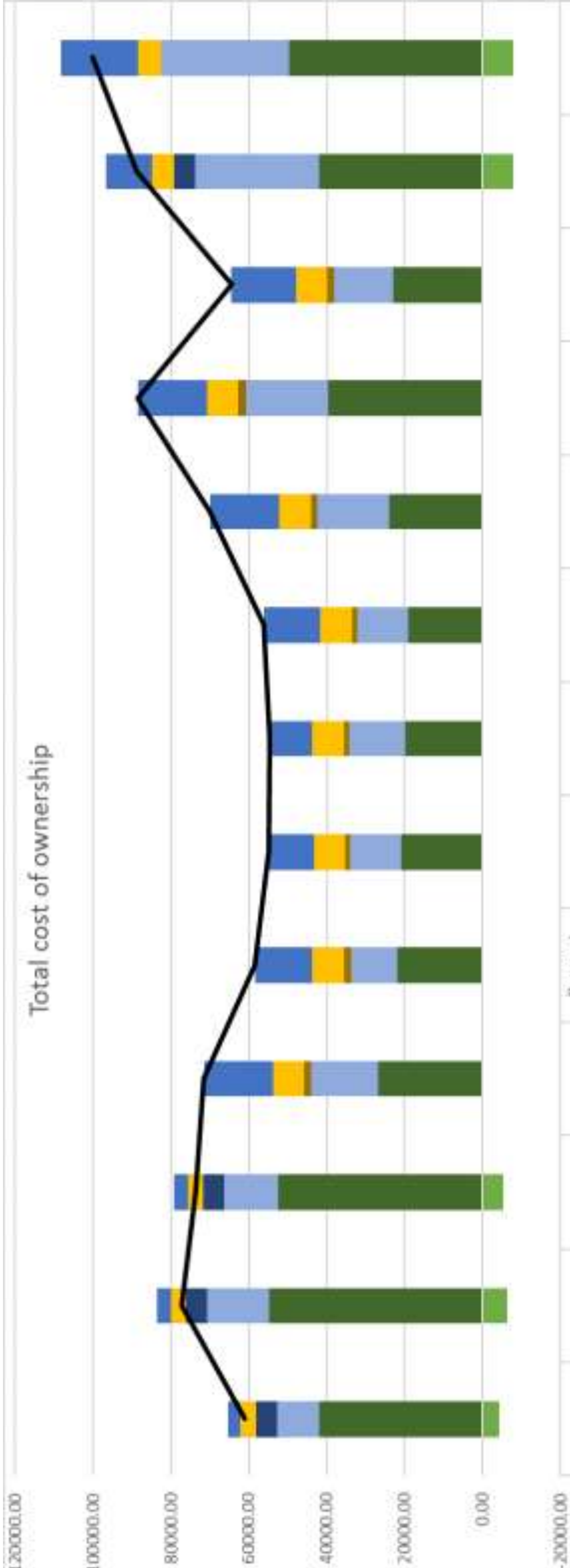
Electric vehicles typically exhibit lower running costs with higher capital expenditure; it follows that they become increasingly more competitive as the number of miles driven increases. All of the non-diesel vehicles exhibit higher pence per mile ownership costs than their diesel counterparts at lower end of the mileage scale. The exception to this is the Ford Transit Trend which remains disproportionately high, which can be explained by its high insurance cost; at £4157 per year it is far higher than any other diesel vehicle to insure (usually range within £1995 to £2804). Furthermore, we observe that the pence per mile cost for the

Renault Kangoo drops below all diesel vehicles at approximately 21,000 miles (Figure 3 and 4).

HFCVs do not fare as well as BEVs with adjusted mileage. Disregarding the Transit Trend as an outlier, the pence per mile cost of the Hyundai H350 never falls into the range of the diesel vehicle costs and never becomes competitive, although the HyKangoo falls into the range, this occurs at approximately 37,000 miles where the cost is comparable with the Renault Trafic and the Vauxhaul Vivaro (Figure 3). As mileage increases up to 100,000 miles, only the Peugeot Partner and the Citroen Berlingo offer lower pence per mile ownership costs than the HyKangoo. BEVs on the other hand become competitive with diesel alternatives at approximately 17,000 miles. Whilst it may be plausible for HFCVs to become competitive beyond the 100,000-mile range, our study did not account for periods beyond 100,000 p.a limits which we think is a boundary possibility for logistics vans. It is noteworthy that BEVs will tend to be the preferred option for operators looking to switch to low or ultra-low emission vehicles as they become competitive significantly sooner than the PHEVs. These results are shown in further detail in Annex A.

4.2 Sensitivity to Diesel Prices

Fuel cost can be broken down into three constituent components; VAT, fuel duty, and the fuel cost. Fuel duty is currently charged at 57.95 pence per litre (HM Revenue & Customs, 2016) which equates to 263.45 pence per gallon, and VAT is charged at 20% of the fuel cost plus the fuel duty, working out at 16.7% of the final price (Office for National Statistics, 2016). In this study the price per litre of diesel was set at £1.154/L or £5.246/gal (duty =£2.634, VAT = £0.876, Fuel cost = £1.735). Figure 4 shows the results of changes in fuel duty up to a maximum of £25 per gallon at which point all total costs for all diesel vehicles are greater than all other vehicles. This results in a diesel price that is perhaps unattainable but there are some valid findings from the adjustment. For example the table highlights the intersecting boundaries, dictating the price at which diesel vehicles are no longer competitive with BEVs and PHEVs. An increase of about £2 per gallon can make BEVs significantly more compelling compared to their diesel counterparts.



	Renault Kangoo Z.E 33	Peugeot ePartner Ev Se L1	Nissan e-NV200 Acenta Auto	Renault Trafic SWB 1.6 dCi (120ps) SL29 Business Van	Peugeot Boxer 2.0 BlueHDi (110ps) 330 L1 H1 Professional Van	Citroen Berlingo 1.6 BlueHDi L1 Enterprise (75ps)	Peugeot Partner 1.6 BlueHDi (100bhp) L1 850 SE	Ford Transit Connect 200 L1 Diesel 1.5 Tdci 100Ps Econetic Van	Vauxhall Vivaro Swb Diesel 2700 1.6Cdti 120Ps Sportive H1 Van	Ford Transit 2.0 TDCi (130ps) 350 L3 H2 Trend Van RWD	Ford Transit Custom 270 Swb Diesel Fwd 2.0 Tdci 105Ps Low Roof Van	HyKangoo ZE with Fuel Cell Range Extender	Hyundai H350 concept
ULEV grant	-4272.00	-6264.00	-5432.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-8000.00	-8000.00
Fuel/electricity	3084.63	3442.21	3490.29	17700.84	14811.74	11630.16	10939.06	14610.22	17798.64	17798.64	16648.85	11887.17	19817.51
Maintenance, repair, tyres	4054.66	4054.66	4054.66	8109.32	8109.32	8109.32	8109.32	8109.32	8109.32	8109.32	8109.32	5676.53	5676.53
Vehicle Excise Duty	0.00	0.00	0.00	1691.28	1691.28	1351.28	1331.28	1351.28	1691.28	1991.28	1691.28	0.00	0.00
Battery costs	5363.17	5363.17	5363.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5363.17	0.00
Net capital expenditure	10822.40	15868.80	13761.06	17396.00	11836.00	12924.00	14314.00	13149.60	18446.40	21175.20	15257.81	31905.29	32923.10
Insurance	41930.85	54815.31	52546.51	26669.35	22012.76	20976.89	19906.49	18973.89	23999.39	39532.30	22850.93	41930.85	49764.23
Total cost	£60,983.72	£77,280.16	£73,783.70	£71,566.80	£58,461.11	£54,991.65	£54,600.16	£56,194.32	£70,045.04	£88,606.74	£64,558.21	£88,763.02	£100,181.36

Figure 2 – Total cost of Ownership results

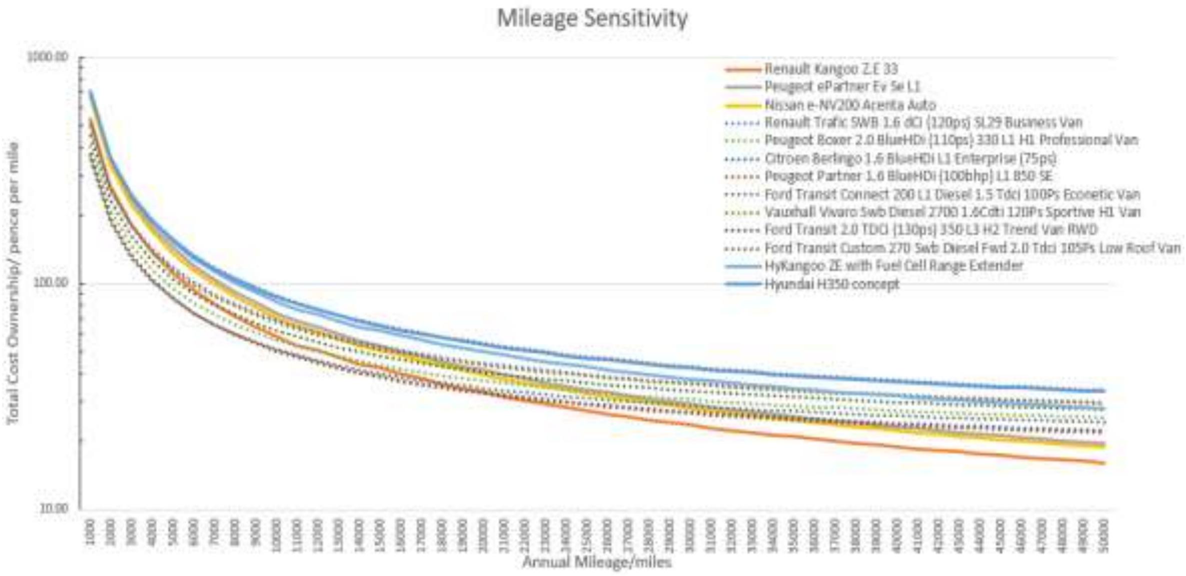


Figure 3 – Sensitivity to Annual Mileage

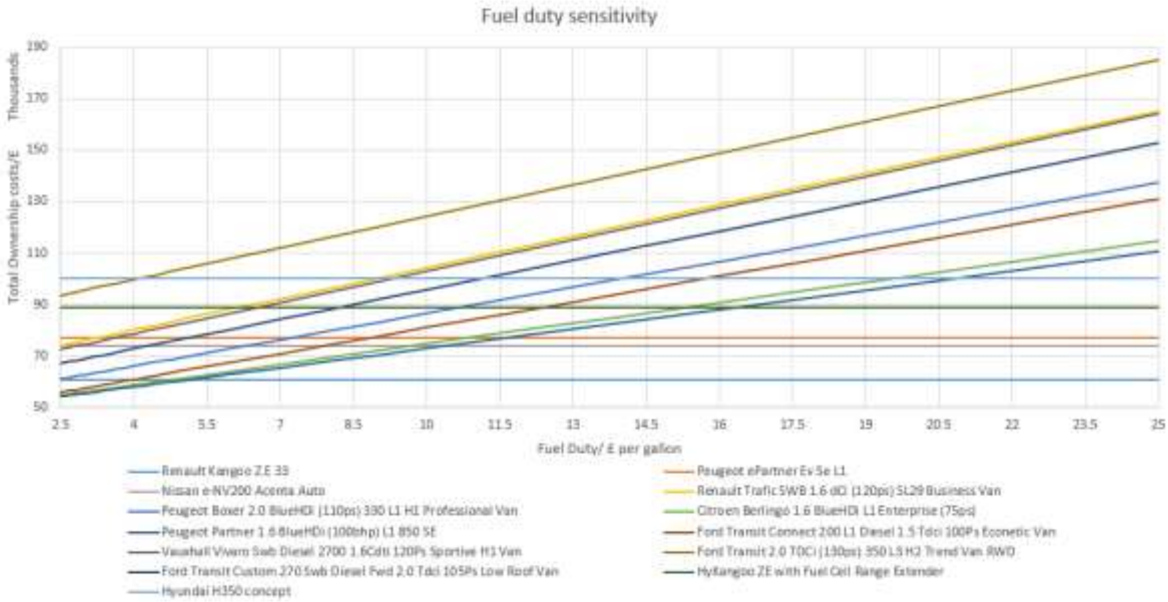


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Figure 4 - Sensitivity to fuel duty

4.3 Sensitivity to Hydrogen Prices

Figure 5 reveals our findings on HFCVs competitiveness dues to changes in price. A comparison with one BEV is shown. Of all three models, the H350 concept exhibits a steeper gradient as it is powered solely by hydrogen fuel, whereas the HyKangoo has a supplementing battery pack and therefore we observe that the total cost drops less as hydrogen fuel cost drops. By £7/kg both vehicles fall beneath the total cost of the Ford Transit Trend, but neither will reach the next most expensive diesel vehicle, or the BEV even with a complete removal of hydrogen cost. Each £1 per kilo cost decrease results in a 1.29% and a 2.18% decrease in total ownership costs of the HyKangoo and H350 respectively. Since generating hydrogen fuel requires electricity, perhaps an avenue to reducing the cost is to promote a reduction in electricity prices, although that would further increase the attractiveness of BEVs.

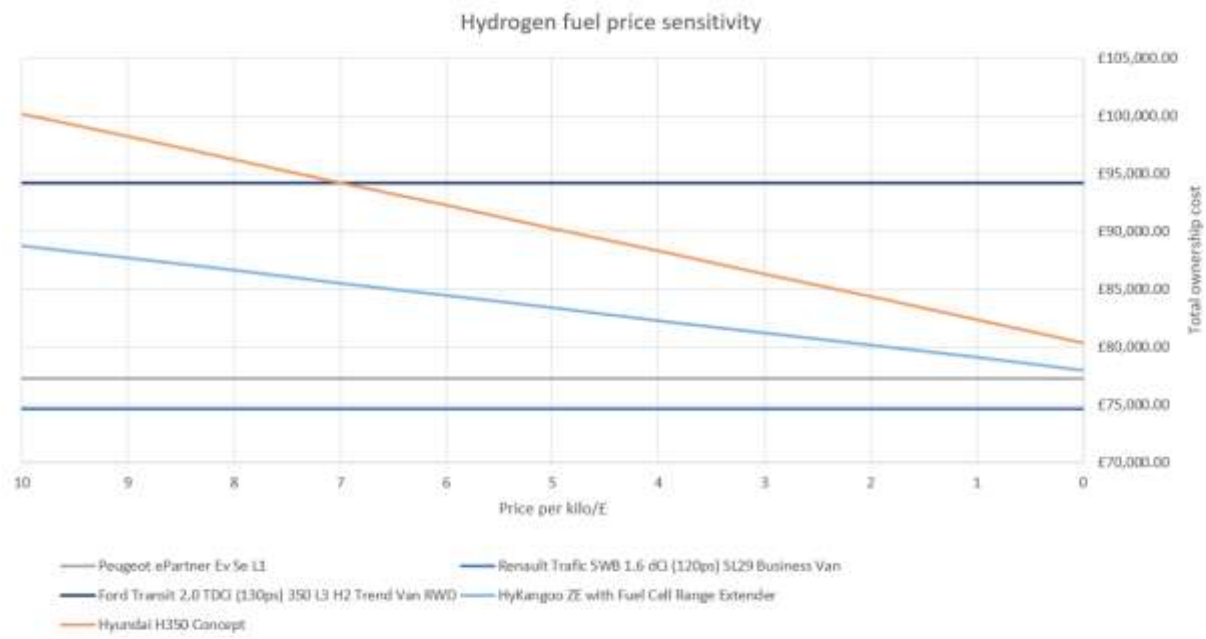


Figure 5 - Sensitivity to hydrogen fuel price

5. Scenario Analysis

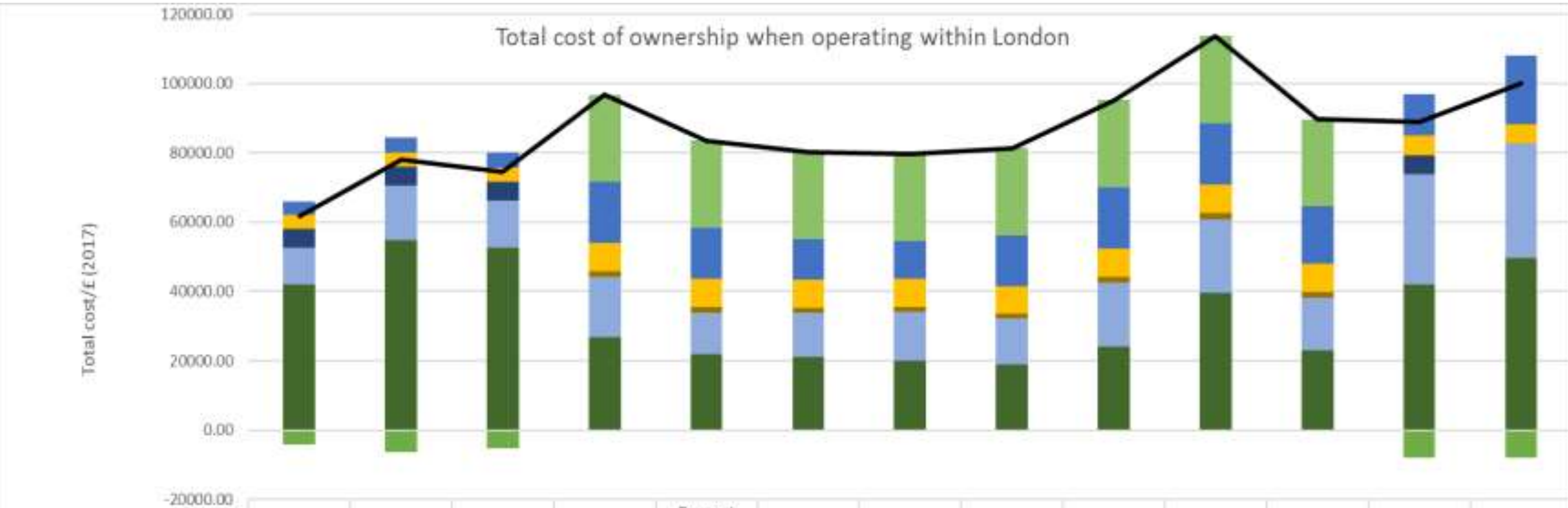
5.1 London Congestion Charge

The congestion charge is charged daily, excluding weekends and public holidays, and applies to most vehicles that are driven in a designated zone (Annex B) within London. BEVs are exempt, as are vehicles which emit less than 75g CO2/km and meet the Euro 5 emissions standards. For this study all diesel vehicles are liable for the congestion charge, whilst all BEVs and HFCVs are exempt. The fee is nominally £11.50 a day but can be reduced to £10.50 a day for business users or for individuals subscribing to the “autopay” system. It is assumed that there are 252 working days a year, as is the case in 2017. Inflation and discount rates are applied to future costs.

A further charge that must be considered for vehicles operating within London is the Low Emission Zone (LEZ). The LEZ boundaries are shown alongside the congestion charge zone in Annex B. LEZ restrictions apply for a greater period of time with charges valid every day of the year, including public holidays and weekends. The charge (£100 a day) applies to any diesel lorry, van, bus, or other larger vehicle that does not meet the Euro 3 emissions standards. While all diesel vehicles considered in this study are registered after this date, the charge will be considered here as it is possible that over time the threshold will drop until such a point that the considered vehicles are liable.

Finally, annual mileage figures are altered to reflect urban use only. Using the same report that was used to set the original mileage variable, Department for Transport, (2017), annual urban mileage was found to be 4342.11. The results for the London scenario are shown in Figure 6. The effect of the congestion charge is immediately apparent; all diesel vehicles now exhibit a higher TCO than all BEVs. Furthermore, both HFCVs are within diesel cost ranges, making them competitive for use within London. Their competitiveness with BEVs remains unchanged however as both are exempt.

Applying the LEZ to all diesel vehicles renders them obsolete with all vehicles exhibiting TCOs of different magnitudes to the BEV and HFCVs, the plotted results can be found in Annex C. These results have implications for other cities within the UK as the magnitude of a congestion charge necessary to raise low emission vehicles' competitiveness can be deduced. Utilising the Solver add-in for Excel the congestion charge value can be changed until such a point that all BEVs and HFCVs exhibit lower TCO than all diesel vehicles. Using this procedure, it was found that a congestion charge of £17.52 would be necessary to ensure competitiveness for all non-diesel vehicles. This represents an increase of 66.86% on the current congestion charge of £10.50. At its inception in 2003, the congestion charge was set at £5 and by 2005 it had raised to £8; a percentage increase of 60% (Transport for London, 2008). As such a 66.86% change in order to obtain total competitiveness for non-diesel vehicles is not beyond the realms of possibility, although it should be noted that although the percentage increase is comparable the absolute increase in terms of GBP is larger and therefore may have different effects on elasticity. This scenario is plotted in Annex C.



	Renault Kangoo Z.E 33	Peugeot ePartner Ev Se L1	Nissan e-NV200 Acenta Auto	Renault Trafic SWB 1.6 dCi (120ps) SL29 Business Van	Peugeot Boxer 2.0 BlueHDi (110ps) 330 L1 H1 Professional Van	Citroen Berlingo 1.6 BlueHDi L1 Enterprise (75ps)	Peugeot Partner 1.6 BlueHDi (100bhp) L1 850 SE	Ford Transit Connect 200 L1 Diesel 1.5 Tdci 100Ps Econetic Van	Vauxhall Vivaro Swb Diesel 2700 1.6Cdti 120Ps Sportive H1 Van	Ford Transit 2.0 TDCi (130ps) 350 L3 H2 Trend Van RWD	Ford Transit Custom 270 Swb Diesel Fwd 2.0 Tdci 105Ps Low Roof Van	HyKangoo ZE with Fuel Cell Range Extender	Hyundai H350 concept
Congestion charge	0.00	0.00	0.00	25161.28	25161.28	25161.28	25161.28	25161.28	25161.28	25161.28	25161.28	0.00	0.00
ULEV grant	-4272.00	-6264.00	-5432.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-8000.00	-8000.00
Fuel/electricity	3789.00	4237.82	4298.16	17700.84	14811.74	11630.16	10939.06	14610.22	17798.64	17798.64	16648.85	12169.39	19817.51
Maintenance, repair, tyres	4054.66	4054.66	4054.66	8109.32	8109.32	8109.32	8109.32	8109.32	8109.32	8109.32	8109.32	5676.53	5676.53
Vehicle Excise Duty	0.00	0.00	0.00	1691.28	1691.28	1351.28	1331.28	1351.28	1691.28	1991.28	1691.28	0.00	0.00
Battery costs	5363.17	5363.17	5363.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5363.17	0.00
Net capital expenditure	10822.40	15868.80	13761.06	17396.00	11836.00	12924.00	14314.00	13149.60	18446.40	21175.20	15257.81	31905.29	32923.10
Insurance	41930.85	54815.31	52546.51	26669.35	22012.76	20976.89	19906.49	18973.89	23999.39	39532.30	22850.93	41930.85	49764.23
Total cost	£61,688.08	£78,075.76	£74,591.58	£96,728.08	£83,622.39	£80,152.93	£79,761.44	£81,355.60	£95,206.31	£113,768.02	£89,719.48	£89,045.23	£100,181.36

Figure 6 - TCO in London

5.2 Green Energy

As was discussed in the previous sections, a vehicle with 0 kgCO2/km emissions can still have a carbon cost associated with it. If the electricity used to charge a BEV is sourced from a coal-fired power station for example, there may be a hidden carbon footprint that an operator is not aware of. Electricity from a provider generating their electricity from 100% renewable energy sources can be more expensive and a decision to opt for this provider can have impacts on the TCO.

Electricity prices were sourced using an electricity price aggregator, uswitch.com. Only providers utilising 100% renewable energy sources were selected for averaging. These values were then set as the respective variable values and the total cost results are shown in Annex D. As expected, the BEVs exhibit greater total costs than previously, there is also a slight increase in the HyKangoo total cost due to the supplementary battery pack. The Kangoo Z.E, ePartner, and e-NV200 exhibit percentage increases in total cost of 1.16%, 1.03%, and 1.09% respectively. The HyKangoo sees a 0.32% increase. These increases have a minimal effect on their overall competitiveness and as such, switching to an all renewable energy provider is a viable decision for most operators wishing to reduce lifetime emissions of their vehicles.

6. Conclusion

This study found that diesel vehicles remain the *most* competitive option for commercial use in the UK, even after consideration of tax relief and grants for low emission vehicles. However, both BEVs and HFCVs, with these considerations, do fall within the total lifetime cost range of a number of diesel vehicles and can therefore be considered competitive under current conditions. Competitiveness can be accelerated with an increase in ULEV grant which was found to be crucial, especially for HFCVs. BEVs would remain competitive with a reduced grant, however it would obviously slow uptake.

Analysis found that, due to lower running costs, the competitiveness of both BEVs and HFCVs was sensitive to mileage. On average, BEVs become more competitive than their diesel counterparts once annual mileage surpasses 17,000 miles. For HFCVs, competitiveness did increase although for the H350 an increase in mileage was not enough to result in overall competitiveness. It was found that congestion charges are incredibly effective in incentivising the use of low emission vehicles; also, the impact of low emission charges (which currently only applies to diesel vehicles failing to meet Euro 3 emission standards) was considered.

Furthermore, it was shown that opting for electricity sourced only from renewable sources does little to dampen the competitiveness of BEVs. It follows that current market conditions dictate that electricity sourced from renewable methods of generation is not drastically more expensive, and as such hydrogen fuel production from renewable electricity should be encouraged.

In terms of policy, this study should make the importance of the ULEV grant abundantly clear as it hugely increases the competitiveness of both battery electric and HFCVs; furthermore, it is clear that over the period of ownership the vehicle excise duty plays a relatively small role.

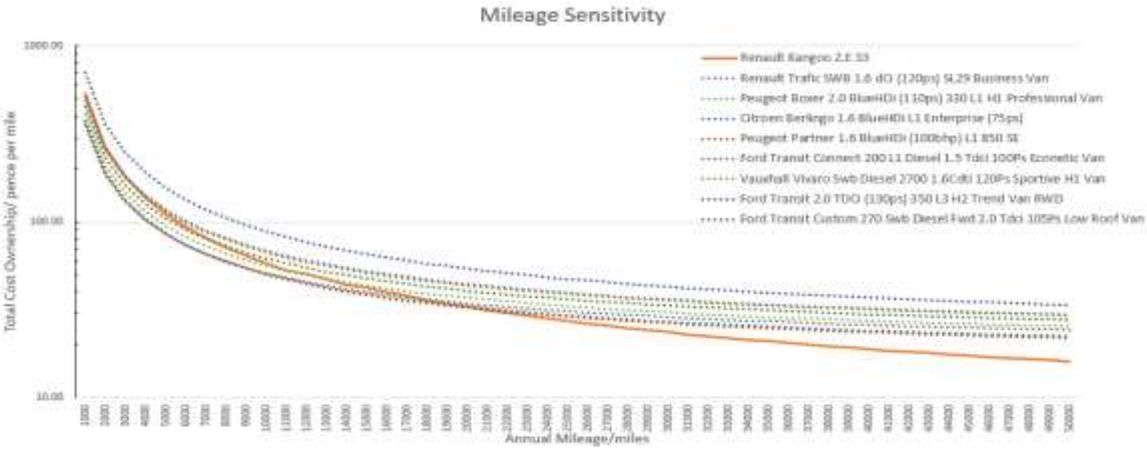
It was shown that a reduction in the fuel price of hydrogen to £7 per kilo would make both hybrid fuel cell and pure hydrogen vehicles competitive with diesel vehicles; also, of key concern is reducing capital expenditure necessary for fuel cell vehicles.

All the cases considered in the analysis section are univariate, which is to say the impact on competitiveness is found for each considered factor in turn. Finding an optimum change in all constituent costs could yield much more applicable results as diminishing returns may make it difficult to take any one cost to its most efficient. This could also consider simultaneously falling electricity/hydrogen costs and rising diesel prices.

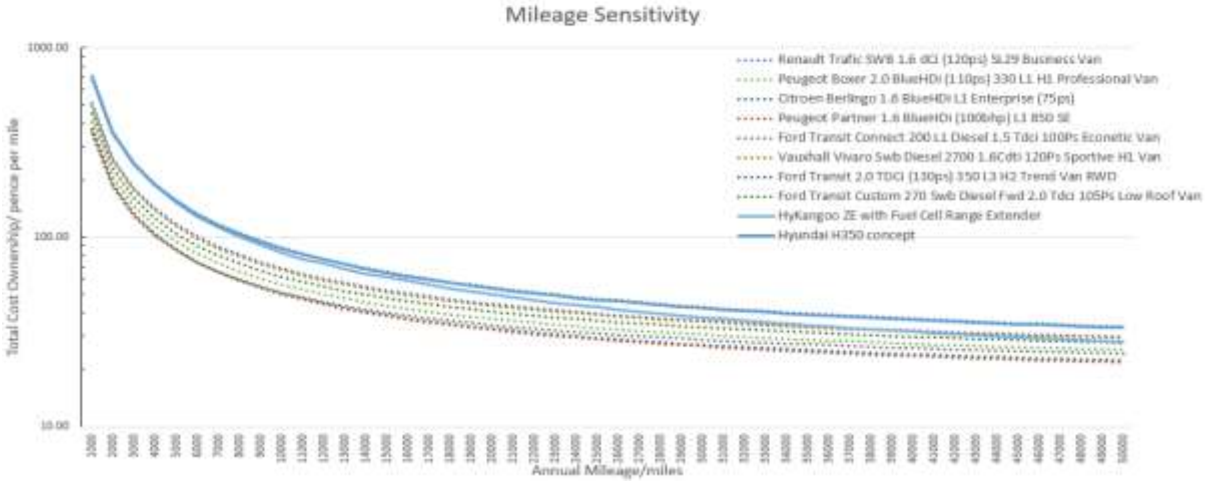
Acknowledgments

This research was partially supported by the project "*Promoting Sustainable Freight Transport in Urban Contexts: Policy and Decision-Making Approaches* (ProSFeT)", funded by the H2020-MSCA-RISE-2016 programme (Grant Number: 734909).

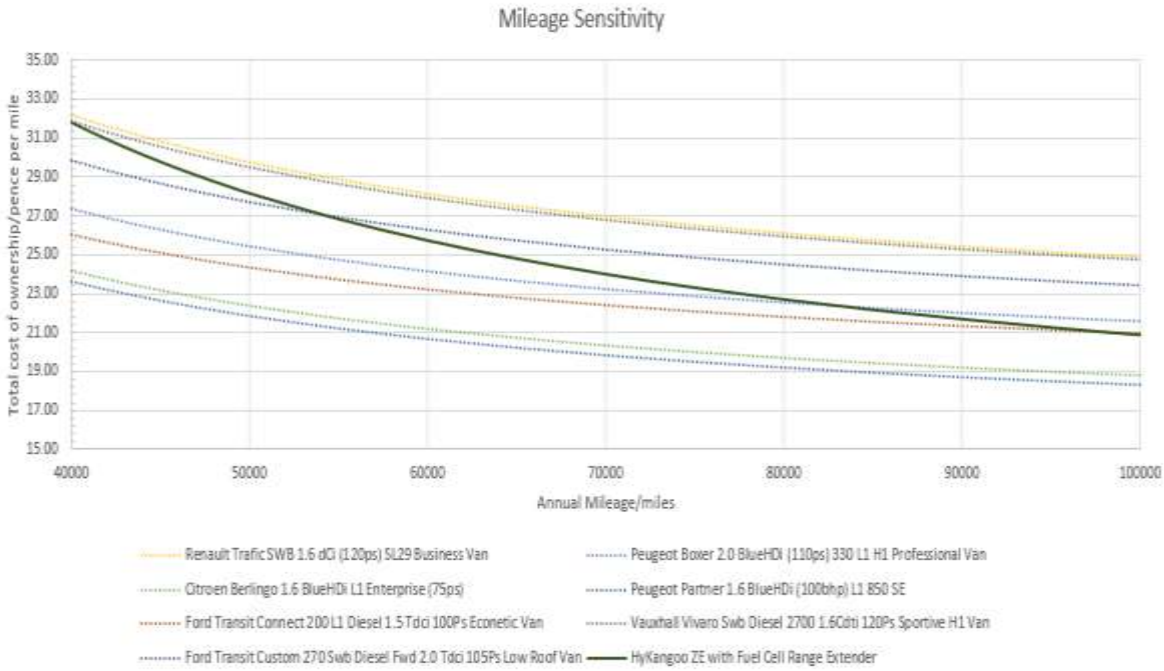
Annex A



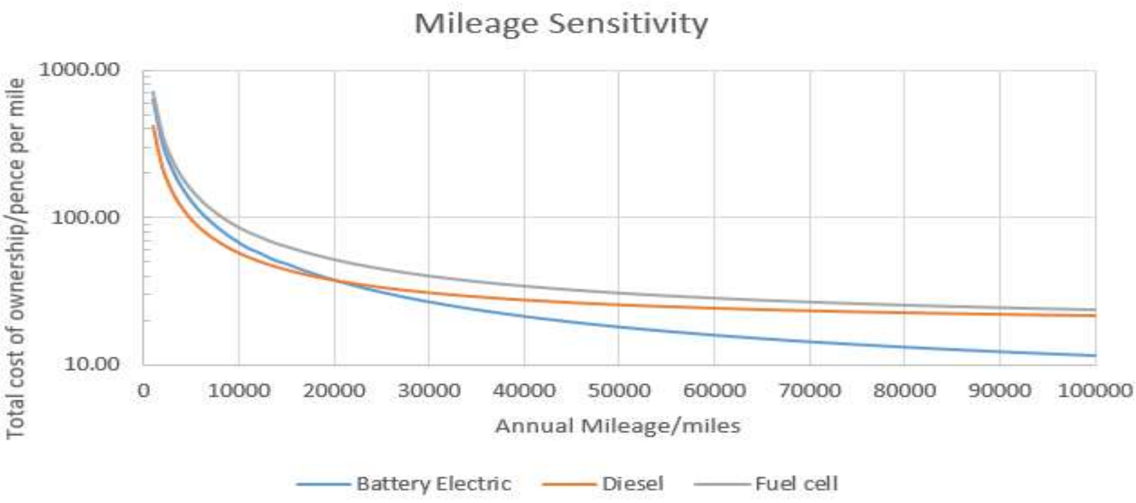
Sensitivity to annual mileage - Kangoo Z.E. and diesel vehicles



Sensitivity to mileage - Hydrogen vehicles and diesel vehicles

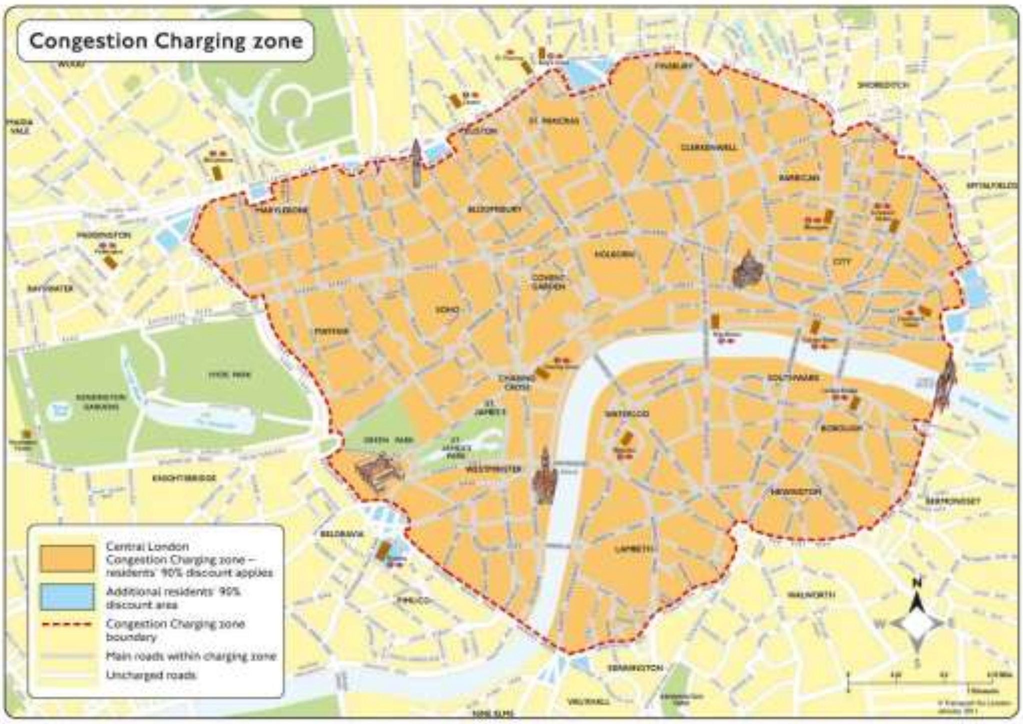


Sensitivity to mileage - HyKangoo and diesel vehicles

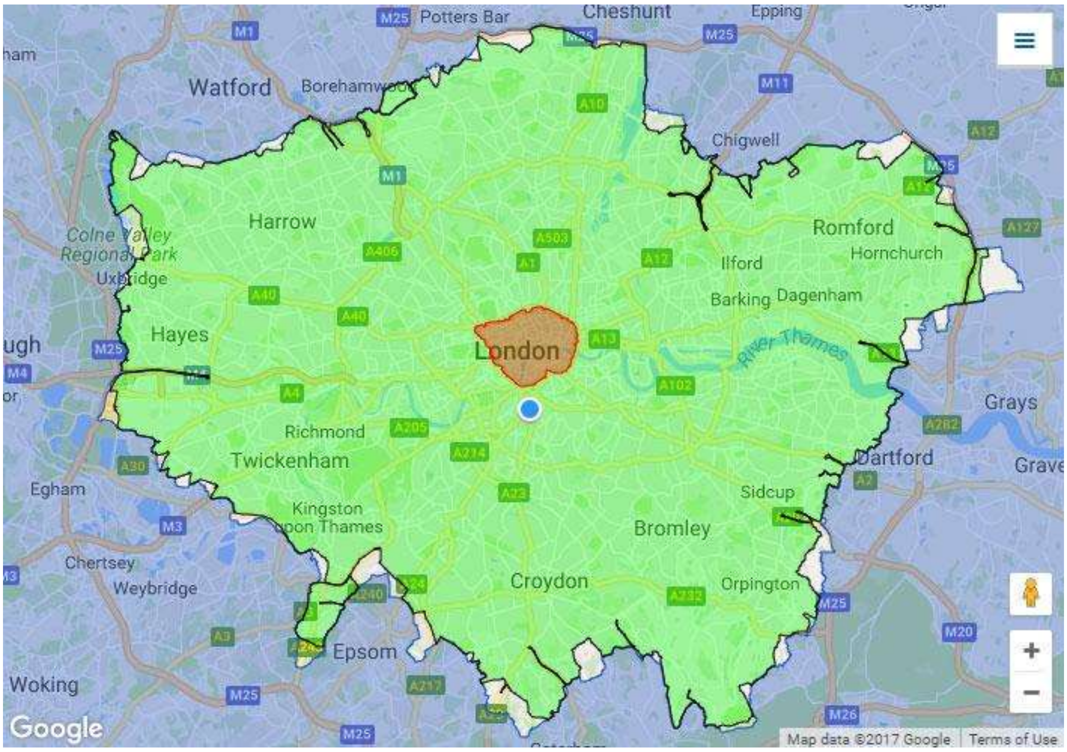


Average sensitivity to mileage by vehicle class

Annex B

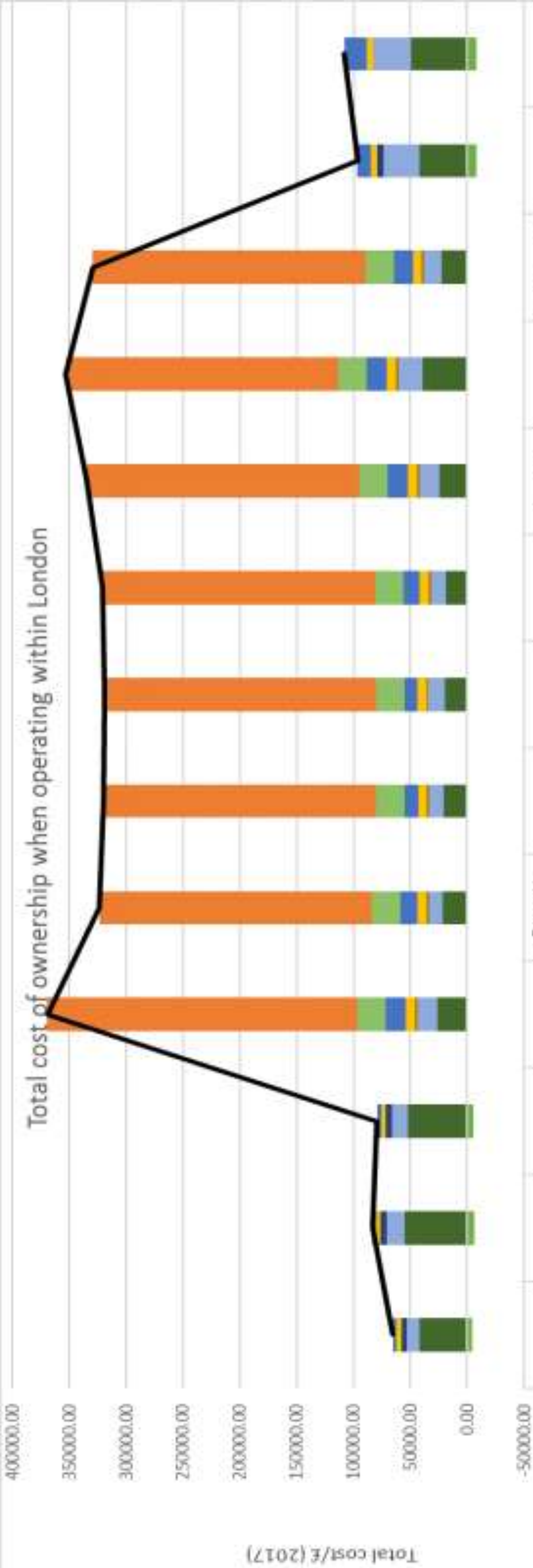


Congestion charge zone map (Transport for London, 2011)



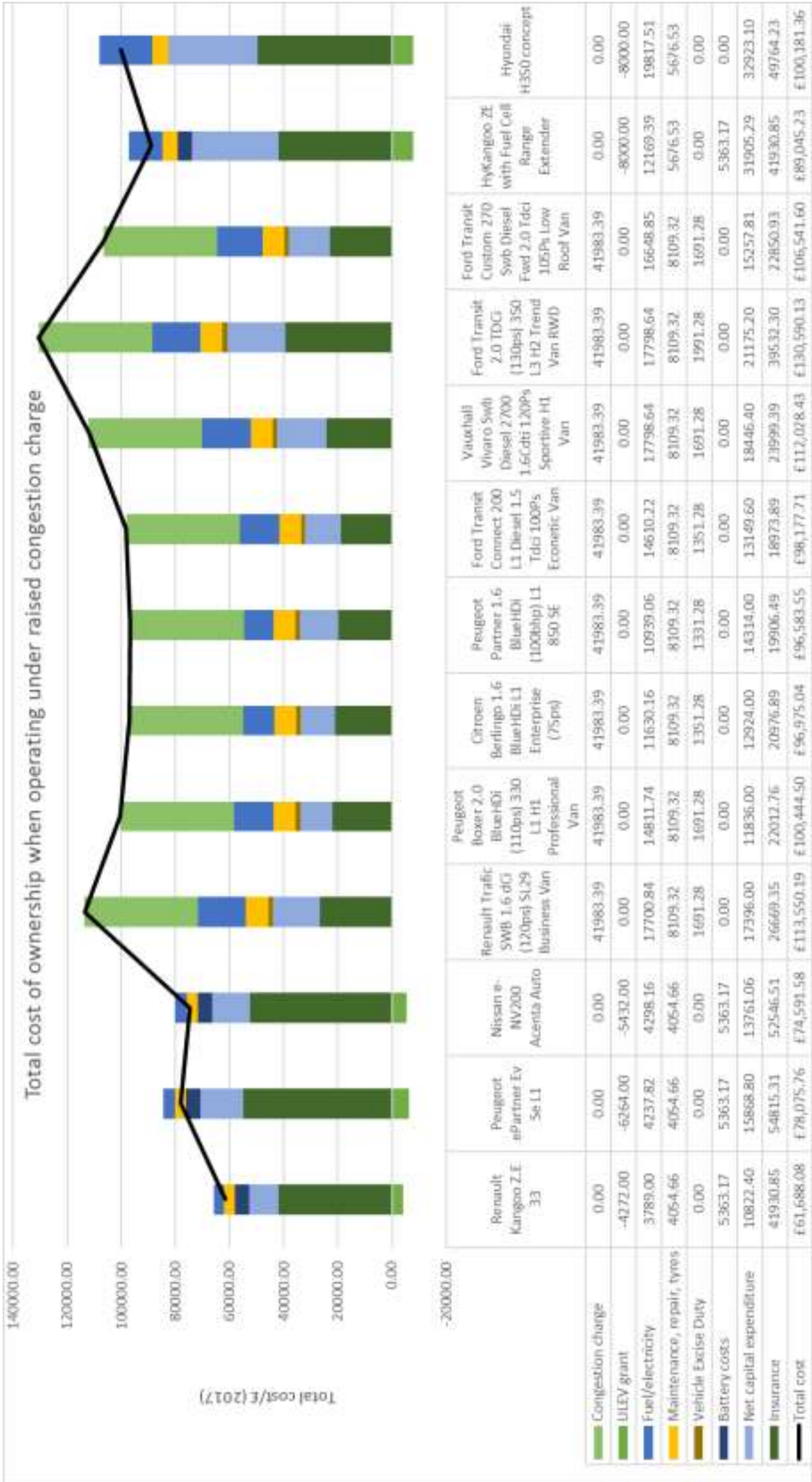
Low emission zone boundaries (green), congestion charge zone (red) (Ars Technica, 2017)

Annex C



	Renault Kangoo Z.E 33	Peugeot ePartner Ev Se L1	Nissan e-NV200 Acenta Auto	Renault Trafic SWB 1.6 dCi (120ps) SL29 Business Van	Peugeot Boxer 2.0 BlueHDi (110ps) 330 L1 H1 Professional Van	Citroen Berlingo 1.6 BlueHDi L1 Enterprise (75ps)	Peugeot Partner 1.6 BlueHDi (100bhp) L1 850 SE	Ford Transit Connect 200 L1 Diesel 1.5 Tdci 100Ps Econetic Van	Vauxhall Vivaro Swb Diesel 2700 1.6Cdti 120Ps Sportive H1 Van	Ford Transit 2.0 TDCi (130ps) 350 L3 H2 Trend Van RWD	Ford Transit Custom 270 Swb Diesel Fwd 2.0 Tdci 105Ps Low Roof Van	HyKangoo ZE with Fuel Cell Range Extender	Hyundai H350 concept
Low Emission Zone charge	0.00	0.00	0.00	272452.10	239631.22	239631.22	239631.22	239631.22	239631.22	239631.22	239631.22	0.00	0.00
Congestion charge	0.00	0.00	0.00	25161.28	25161.28	25161.28	25161.28	25161.28	25161.28	25161.28	25161.28	0.00	0.00
ULEV grant	-4272.00	-6264.00	-5432.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-8000.00	-8000.00
Fuel/electricity	3084.63	3442.21	3490.29	17700.84	14811.74	11630.16	10939.06	14610.22	17798.64	17798.64	16648.85	11887.17	19817.51
Maintenance, repair, tyres	4054.66	4054.66	4054.66	8109.32	8109.32	8109.32	8109.32	8109.32	8109.32	8109.32	8109.32	5676.53	5676.53
Vehicle Excise Duty	0.00	0.00	0.00	1691.28	1691.28	1351.28	1331.28	1351.28	1691.28	1991.28	1691.28	0.00	0.00
Battery costs	5363.17	5363.17	5363.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5363.17	0.00
Net capital expenditure	10822.40	15868.80	13761.06	17396.00	11836.00	12924.00	14314.00	13149.60	18446.40	21175.20	15257.81	31905.29	32923.10
Insurance	41930.85	54815.31	52546.51	26669.35	22012.76	20976.89	19906.49	18973.89	23999.39	39532.30	22850.93	41930.85	49764.23
Total cost	£65,255.72	£83,544.16	£79,215.70	£369,180.18	£323,253.61	£319,784.15	£319,392.66	£320,986.82	£334,837.54	£353,399.24	£329,350.71	£96,763.02	£108,181.36

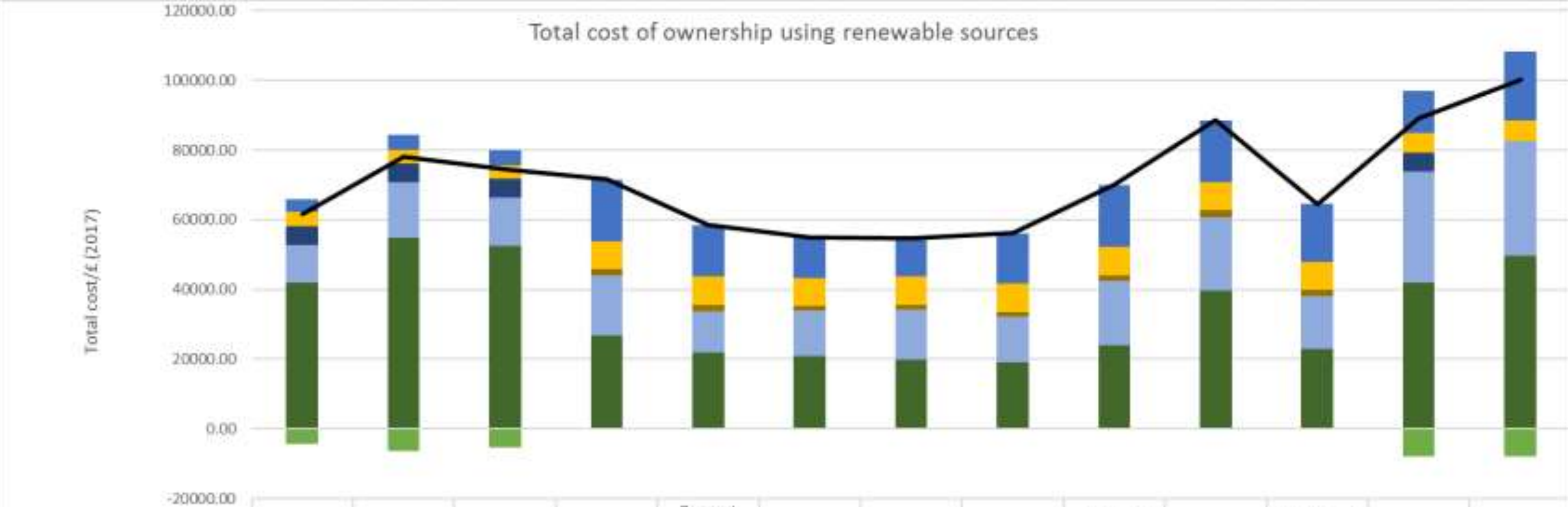
TCO in London with low emission zone charge applied



	Renault Kangoo Z.E 33	Peugeot ePartner Ev Se L1	Nissan e-NV200 Acenta Auto	Renault Trafic SWB 1.6 dCi (120ps) SL29 Business Van	Peugeot Boxer 2.0 BlueHDi (110ps) 330 L1 H1 Professional Van	Citroen Berlingo 1.6 BlueHDi L1 Enterprise (75ps)	Peugeot Partner 1.6 BlueHDi (100bhp) L1 850 SE	Ford Transit Connect 200 L1 Diesel 1.5 Tdci 100Ps Econetic Van	Vauxhall Vivaro Swb Diesel 2700 1.6Cdti 120Ps Sportive H1 Van	Ford Transit 2.0 TDCi (130ps) 350 L3 H2 Trend Van RWD	Ford Transit Custom 270 Swb Diesel Fwd 2.0 Tdci 105Ps Low Roof Van	HyKangoo ZE with Fuel Cell Range Extender	Hyundai H350 concept
Congestion charge	0.00	0.00	0.00	41983.39	41983.39	41983.39	41983.39	41983.39	41983.39	41983.39	41983.39	0.00	0.00
ULEV grant	-4272.00	-6264.00	-5432.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-8000.00	-8000.00
Fuel/electricity	3789.00	4237.82	4298.16	17700.84	14811.74	11630.16	10939.06	14610.22	17798.64	17798.64	16648.85	12169.39	19817.51
Maintenance, repair, tyres	4054.66	4054.66	4054.66	8109.32	8109.32	8109.32	8109.32	8109.32	8109.32	8109.32	8109.32	5676.53	5676.53
Vehicle Excise Duty	0.00	0.00	0.00	1691.28	1691.28	1351.28	1331.28	1351.28	1691.28	1991.28	1691.28	0.00	0.00
Battery costs	5363.17	5363.17	5363.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5363.17	0.00
Net capital expenditure	10822.40	15868.80	13761.06	17396.00	11836.00	12924.00	14314.00	13149.60	18446.40	21175.20	15257.81	31905.29	32923.10
Insurance	41930.85	54815.31	52546.51	26669.35	22012.76	20976.89	19906.49	18973.89	23999.39	39532.30	22850.93	41930.85	49764.23
Total cost	£61,688.08	£78,075.76	£74,591.58	£113,550.19	£100,444.50	£96,975.04	£96,583.55	£98,177.71	£112,028.43	£130,590.13	£106,541.60	£89,045.23	£100,181.36

TCO with raised congestion charge

Annex D



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ULEV grant	-4272.00	-6264.00	-5432.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-8000.00	-8000.00
Fuel/electricity	3789.00	4237.82	4298.16	17700.84	14811.74	11630.16	10939.06	14610.22	17798.64	17798.64	16648.85	12169.39	19817.51
Maintenance, repair, tyres	4054.66	4054.66	4054.66	8109.32	8109.32	8109.32	8109.32	8109.32	8109.32	8109.32	8109.32	5676.53	5676.53
Vehicle Excise Duty	0.00	0.00	0.00	1691.28	1691.28	1351.28	1331.28	1351.28	1691.28	1991.28	1691.28	0.00	0.00
Battery costs	5363.17	5363.17	5363.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5363.17	0.00
Net capital expenditure	10822.40	15868.80	13761.06	17396.00	11836.00	12924.00	14314.00	13149.60	18446.40	21175.20	15257.81	31905.29	32923.10
Insurance	41930.85	54815.31	52546.51	26669.35	22012.76	20976.89	19906.49	18973.89	23999.39	39532.30	22850.93	41930.85	49764.23
Total cost	£61,688.08	£78,075.76	£74,591.58	£71,566.80	£58,461.11	£54,991.65	£54,600.16	£56,194.32	£70,045.04	£88,606.74	£64,558.21	£89,045.23	£100,181.36

TCO using renewable electricity

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A Multi-Stakeholder and Multi-Criteria Decision-Making Approach for Evaluating the Performance of Urban Consolidation Centres

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Logistical activities contribute about 10% to 30% of the total volume of traffic in urban areas (Agrebi *et al*., 2015). Such activities generate approximately 25% of CO_2, 30% of NO_x, 40% of noise due to city traffic (Lebeau *et al*., 2017). Evidence from many urban areas shows that urban logistics generates about 40% of the total logistics cost in the supply chain and causes 50% of the road accidents in the city centre (Lebeau *et al*., 2017).

Within this context, *pooling solutions* proved to be an efficient way for alleviating environmental and congestion problems in urban areas. The significant feature of this method is to implement consolidation models within city areas. In this, different organisations (e.g. shippers, carriers, customers) collaborate in the common use of logistics resources regarding materials, equipment, and human resources (Jesus *et al*., 2014). As a pivotal type of facility within such models, Urban Consolidation Centres (UCCs) have received increasing interests from both the academic community and practitioners.

An UCC is *a facility involving the transhipment of goods directed to urban areas, aiming to consolidate deliveries, and thus provide greater efficiency (and effectiveness) in the distribution process by increasing the truckload factor and decreasing the number of trucks used, which help mitigate urban congestion and air pollution* (Tario *et al*., 2011). Normally, an UCC delivery network (Figure 1) is composed of different participants such as operators, shippers, carriers, UCC administrators. Furthermore, two more kinds of stakeholders: goods suppliers and consumers are involved in this delivery system (Wang *et al*., 2015).

Physically, goods from different origins should be gathered at the UCC before they move into urban areas. After this intermediate step, goods will be sorted depending on their destination and due date; finally, goods will be allocated for final deliveries in the city centre through the usage of smaller vehicles. The key objective of UCC facilities is to achieve a higher truck loading rate, along with a lower number of utilised trucks (Nguyen *et al*., 2015).

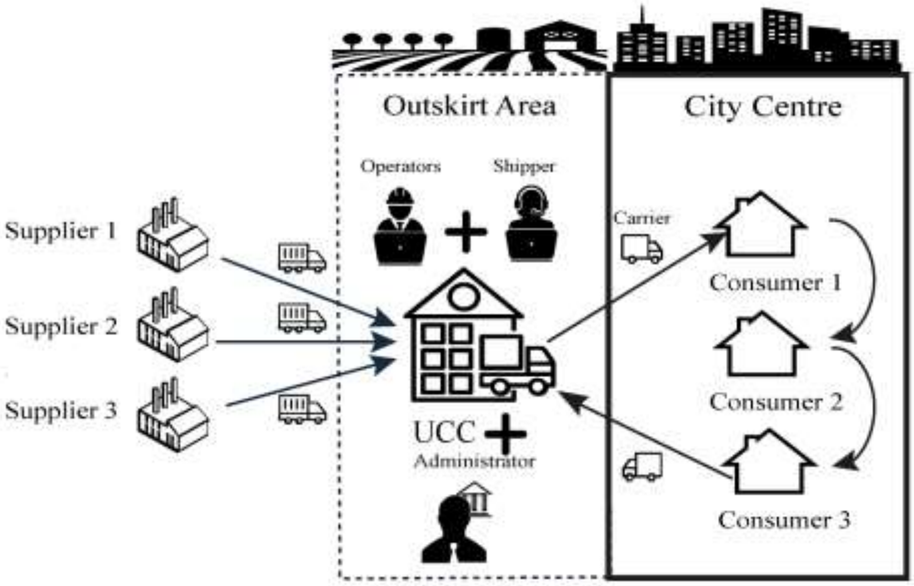

Figure 1 - A typical UCC delivery network

UCCs have become a popular research topic since the late 1990s; in particular several approaches have been developed in order to evaluate the performance of UCCs (Browne *et al*., 2005). Most of the papers produced within this research strand concentrate on the evaluation of the environmental performance of UCCs, investigating how operating models (Finnegan *et al*., 2005), locational decisions (Lindawati and De Souza, 2017) and technological choices (Allen *et al*., 2011) affect the performance of UCCs across several environmental indicators (such as fuel consumption, gas emission, pollution).

However, in the context of urban logistics, the performance evaluation of the UCCs should not ignore the economic and social perspectives. As highlighted by Lagorio *et al*. (2016) and Kin *et al*. (2017), to date UCCs effectiveness has been assessed mainly through multiple or single case studies analysing best practices and pilot projects. However, little is reported about the reasons for the high failure rate registered in projects adopting such facilities and the financial difficulties being often encountered.

The availability of adequate tools, capable of addressing, from a multi-stakeholder perspective, also strategic issues (for instance, related to the investment planning phase) rather than just operational ones (concerned with the day-to-day functioning of already established logistical platforms) could be of interest to stakeholders involved in the policy and decision-making processes that guide UCC initiatives.

In addition to this, the evaluation of the performances of UCCs according to a triple bottom line perspective remains a challenging taks, given the conflicting essence of involved criteria and the multi-stakeholder nature of the problem (Gonzalez-Feliu and Morana, 2014).

Within this context, this study will be aimed at developing a multi-criteria decision-making (MCDM) approach for evaluating the performance of UCC systems. The approach will combine and elaborate economic, environmental and social indicators arising from previous research (Patier and Browne, 2010, Allen *et al.*, 2011, Gonzalez-Feliu and Morana, 2014, Harrington *et al.*, 2016, Gogas and Nathanail, 2017) and seek to capture the perspective of the multiple stakeholders involved in UCC systems. Table 1 shows the indicators for the performance evaluation of UCC.

Dimension	Criterion	Indicator
Economic	Operating Cost	Annual Operating Cost(AOC)
	Profitability	Annual Revenues
	Pricing Policy	Typical Delivery Price
	Infrastructure Usage Efficiency	Infrastructure Surface Usage Rate
	Goods Handling Efficiency	Goods Handled per Full-Time Equivalent Employee
	Delivery Efficiency	Delivery Accuracy Rate
	Service Level	Lead Time of Delivery Goods from UCC to its Users
Environmental	Eco-Vehicle Equipment	Percentage of Alternative Vehicles
	Rational Vehicle Utilization	Truck Loading Rate
	Emission Generation	Travel Miles in Urban Areas
	Delivery Trips	Number of Delivery Trips per day
Social	Public Support	Public Financial investment
	Workers' salary	Average staff salary
	Fair Labour	Workers' overtime utilisation
	Approachability	Typical Workers' commute Time
	Traffic Volume Generation	Total Travel Time in City Centre
	Congestion Generation	Time for on-street Parking

Table 1- List of the Criteria and Indicators for the Evaluation of the UDC

Real-world UCC cases from UK, Sweden, Italy and China will be evaluated based on the above indicators. These four cases will reflect the diversity of UCCs performance across identified dimensions within different socio-economic contexts, including free-market economies with different degrees of state intervention (UK, Italy, Sweden) along with centrally-planned economies (China). For each case, a synthesis of UCC performances will be performed by aggregating indicators according to MCDM methodologies (such as Analytic Hierarchy Process and TOPSIS).

The research will allow the identification of strengths and weaknesses of the different surveyed UCCs, establishing a benchmarking tool (also usable by decision- and policy-makers) that will contribute to a better understanding of UCCs functioning and to the identification of potential improvement areas.

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Reverse Logistics and Urban Logistics: Commonalities and opportunities for collaboration

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Abstract: The aim of this paper is to provide a description of the processes related to urban logistics and reverse logistics and the relationships between them. Based on a review of the literature, some insights are provided regarding the challenges and opportunities for collaboration between reverse logistics and urban logistics, such as waste management and commercial returns. Additionally, some suggestions are made to improve the performance of these areas for academics and logistics professionals.

Keywords: reverse logistics; urban logistics; waste management; commercial returns.

1. Introduction

Reverse logistics has received a lot of attention in recent years, in both the academic field and the business world. This concept has evolved from a very basic approach related to the recycling of raw materials [1] to being considered such an important part of logistics activity, and the management of the supply chain in general, that this cannot be analysed without taking into account the return flows described in the field of reverse logistics [2]. The academic

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interest in reverse logistics can be seen from the upward trend in the number of papers, monographs and books published on this subject [3,4]. Moreover, from a business perspective it should be noted that increasing numbers of companies are incorporating reverse logistics practices into their regular activity [5]. In short, it can be argued that reverse logistics is one of the aspects that has contributed most to developing the study of logistics and the management of the supply chain in recent years [6].

Although a wide range of logistical problems and challenges have been addressed through the field of reverse logistics, to date urban logistics, as such, has not been one of them [7]. However, factors such as the growing population concentration in urban areas, traffic congestion, noise and atmospheric pollution and the growth of electronic commerce make it necessary to more efficiently and sustainably manage all the movements associated with the distribution of goods in our cities [8].

Despite the links between these two areas, as far as we know there is no detailed analysis in this regard. The main objective of this work is to describe the existing relationship between reverse logistics and urban logistics in order to identify opportunities for collaboration between them and take advantage of the knowledge generated in each discipline. The structure of this work is as follows: in the next section, the reverse logistics and urban logistics concepts are presented; next, the commonalities between these logistics areas are described; finally, the main conclusions are drawn, setting out a series of ideas on the main opportunities for collaboration between reverse logistics and urban logistics.

2. Reverse Logistics and Urban Logistics

2.1. Reverse Logistics

Making the most of the materials used and the presence of return flows in the production-distribution process, such as commercial returns, is nothing new. In this regard, various authors, [9–12], have highlighted the evolutionary process being experienced by this discipline: from the first contributions where an eminently technical approach dominated, to the most recent when a more strategic and holistic approach prevails [13]. Reverse logistics can be defined as "*the process of planning, implementing and controlling backward flows of raw materials, in process inventory, packaging and finished goods, from a manufacturing, distribution or use point, to a point of recovery or point of proper disposal*" [12].

However, this holistic and unifying approach finally won out in the 21st century and involves the explicit recognition of the joint existence of forward flows (producer-consumer) and reverse flows (consumer-producer). This is the source of the Closed-Loop Supply Chain concept that is defined as a supply chain where, in addition to the typical flows of materials from suppliers to customers, there are return flows of products (post-consumption or use) to the manufacturers [14].

In parallel to this growing academic interest in reverse logistics, business experiences have also been developed [3,4,15,16]. This interest in implementing reverse logistics systems can mainly be attributed to three factors: 1) obtaining competitive advantages, 2) environmental legislation and 3) stakeholders pressure [14,17,18].

Although Reverse logistics is a key factor in the development of the supply chain [6], there are significant challenges that still require special attention and further work [3,21]:

- Analysis of new opportunities relating to the return of products and the different options for their recovery: uncertainty associated with the recovery processes, consumer incentives to recover EOU products, cost structure of reverse flows, design of products to facilitate their recovery and the corresponding recovery networks [21–23].
- Development of marketing strategies for recovered products. Just as important as the issues regarding the recovery of EOU products are those relating to their proper marketing once they have been recovered [2,3,14,24].
- Development of specific legislation on the return of products in certain contexts: Extended Producer Responsibility principle, design for the environment, efficient mechanisms for recovery products, etc. [3,25,26,27].

2.2. Urban Logistics

According to [28], 54% of the world’s population lives in urban areas and it is estimated that this figure will reach 66% by 2050. In particular, on the European continent, where countries such as Belgium (98%), Iceland (94%) and the Netherlands (90%) already have a high population concentration in urban areas, it is estimated that the level of global urbanisation will increase to 82% by the year 2050.

Although urbanisation processes seem to be positively correlated with economic growth [29], the effects of these processes are not always symmetrical and there are externalities that will hinder them: overcrowding, traffic congestion, atmospheric, noise and light pollution, etc. All of this impacts on both the quality of life and health of the population and the efficiency of the logistic activities of companies [30]. Given this situation, it seems necessary to find a balance between urbanisation and sustainable development, placing special emphasis on suitable planning that promotes the economic and social development of cities whilst reducing the negative impact on the environment [31]. In this regard, both the public authorities and companies must be able to work together in order to improve the quality of life of the citizens through good mobility management and the suitable and efficient management of commercial activity [32]. Urban logistics can play a very important role in the search for that balance [33].

According to [33], urban logistics is "*the process for totally optimising the logistics and transport activities by private companies with support of advanced information systems in urban areas considering the traffic environment, the traffic congestion, the traffic safety and energy savings within the framework of a market economy*".

Whilst it is true that urban logistics involves both the transportation of passengers (in public and private vehicles) and the transportation of goods [34], the latter, along with the logistics activities that sustain it, has acquired special relevance due to the fact that it forms an essential part of a country's economic activity and has very important effects on all types of company. According to [8], urban freight transport is a very important component of traffic in cities (10%-15%) and significantly contributes to both noise and atmospheric pollution. For years, urban freight transport has been an issue of special interest both to researchers and to public authorities and companies [35–37]. This interest has also increased due to the development of new forms of consumption (e-commerce); to changes in consumer attitudes, tastes and preference, such as environmental awareness; and to the growing evolution of technology such as, for example, the use of drones or electronic vehicles [34].

Whilst it is true that most of the measures and pilot programmes and projects implemented have helped to improve the management of urban logistics with a view to obtaining sustainable development [33], it is also true that there is still a long way to go in this regard [31], and different challenges can be highlighted [8,31,34, 38], such as: greater prominence for urban logistics in the long-term planning of cities; increased cooperation and collaboration between the different stakeholders. improved management of data and information; development in certain areas of research: energy efficiency, pollution, noise, customer satisfaction, or safety.

3. Areas of collaboration between Reverse Logistics and Urban Logistics

Despite the range of problems and challenges covered by the field of reverse logistics, until relatively recently urban logistics has not been one of them [7]. However, some very interesting connections can be observed between them. Specifically, it is worth highlighting the importance of reverse logistics in urban areas in terms of both urban waste management and the management of commercial returns [8,31].

3.1. Urban waste management

This is an aspect of particular complexity given that it includes not only domestic waste but also industrial and commercial waste, which require various forms of collection and treatment which differ from those usually applied to domestic waste [39]: special containers, modes of transport, safety measures, etc. Moreover, the collection and management of products and materials through their recycling, re-manufacturing or reuse is a complex task that requires careful planning in relation to their collection so that it is possible to recover most of the value that they still possess. For example, when recovering domestic use products for recycling, the choice of collection channel and the technology used depend, among other factors, on where that separation stage takes place; that is, in the consumer's own home or alternatively in specialised separation centres [40].

It should be noted that although aspects relating to the acquisition and collection of products entering the reverse logistics system have traditionally been analysed, this continues to be a completely unresolved issue [41], and the stage at which this return process (product collection) begins is considered an essential element to be carefully considered when designing these logistical networks [42,43]. This problem is intensified in the case of cities, since this is where much of the population is concentrated and they become critical areas for the collection of waste, materials and products.

In this context, the effectiveness of urban logistics and, therefore, the corresponding reverse logistics operations are conditioned by aspects relating to the type of city, its radial structure, the high concentration of commercial, leisure and restaurant areas, as well as by the different objectives and interests of the main stakeholders - companies, residents, consumers, local authorities, etc. [44]. The local authorities tend to be legally responsible for managing municipal waste and, consequently, planning its sustainable collection and transportation. However, there is a growing trend for these institutions to outsource waste management to private companies [45].

3.2. Management of commercial returns

Commercial returns normally occur because the product purchased by the consumer does not meet their needs, has not been delivered in the right conditions, or does not meet their expectations. Because of this, a product return process, from the consumer to the manufacturer, must be created. This type of process has become very important especially due to the appearance and development of 1) new business models (e-commerce), 2) new sales conditions (extension of product trial periods, elimination/reduction of shipping costs, free product returns, etc.) and 3) new payment methods (via mobile, PayPal, virtual wallet, etc.).

It is suggested in several studies that the trend for this type of return is increasing [46]. This logistics of returns, considered to be unwanted logistics [22] becomes a real problem for many companies [47], especially for those companies where the volume of returns is considerable, as is the case for the U.S. where approximately 8% to 10% of all products are returned, this figure increasing to 30% in the case of products purchased online [48].

However, it is necessary for companies to consider this type of process given that, in many cases, and especially for online purchases, it may determine the individual's purchasing decision [49]. This increase in commercial returns evidently involves a greater flow of products from the consumer to the manufacturer that need to be managed which represents an increase in the complexity of the system and a greater negative impact on traffic, urban mobility and the environment. Hence the importance of achieving the greater integration of these direct and reverse flows to increase the overall efficiency of logistics activity [8]. Many companies are already working on improving their product return service in order to be more efficient, making use of the new technologies [50], although there is still a long way to go in this regard [48].

4. Conclusions

In this work we have tried to identify and describe the main commonalities between reverse logistics and urban logistics. The main conclusions obtained from this work are as follows.

Firstly, regarding reverse logistics, despite the growing interest that this subject has aroused, there are still significant challenges requiring further work, such as: new opportunities related to product returns and recovery options; commercialization of remanufactured products; development of legislation on product returns.

Secondly, we have highlighted the importance of proper logistics management in urban areas and the existence of key aspects that must be addressed such as: logistics planning in cities;

collaboration between the different stakeholders; the development of new collaborative ways of exchanging data and information; and the development of research areas related to this topic.

Thirdly, we have identified the aspects where the two disciplines converge and that may represent opportunities for collaboration, such as: the proper treatment and management of urban waste; the proper recovery and management of recoverable materials and products (EOU and EOL); and the proper management of commercial returns.

Urban areas are a challenge for logistics. It is often difficult to provide effective solutions to logistics problems in cities, and not just for purely logistical reasons. Also having an influence are obsolete municipal regulations, the absence of effective mechanisms in the event of non-compliance, improperly planned policies, and user behaviour [51].

In any case, we believe that these two areas of logistics must be brought together as there are clear commonalities, not only for research but also for the business management of logistics.

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Transitioning Urban Consolidation Centres initiatives in successful operations:

A Collection of EU case experiences.

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Keywords – Urban Logistics; Freight Transport; Urban Consolidation Centres

Abstract - Freight transport accounts for 8-15% of total traffic flow in urban areas within the European Union. Majority of these deliveries are undertaken by diesel powered vehicles with extremely disproportionate levels of CO_2, NO_x and particulate matter emissions. Accordingly, previous studies have identified the use of consolidation centres (UCCs) within urban areas as a viable solution for reducing environmental and social impacts within cities.

This paper progresses the discourse on UCCs as a viable strategic options for addressing sustainability concerns in urban logistics, by undertaking a review of current cases in the field and highlighting critical success factor for the successful implementation of UCCs and for their long term sustainability.

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1. Introduction

Freight transport accounts for 8-15% of total traffic flow in urban areas within the European Union. Most of these activities are undertaken by diesel powered vehicles with extremely disproportionate levels of CO_2, NO_x and particulate matter emissions. Accordingly, a variety of strategic options have been advanced as key solutions for addressing fossil fuel demand and emissions in urban freight transport. Accordingly, previous studies have identified the use of consolidation centres (UCCs) within urban areas as a viable solution for reducing environmental and social impacts within cities (Browne et al., 2005; Allen et al., 2007). Within the EU, the uptake of UCC projects has been on the increase over the last decade with a variation of results for the implementing local authorities (Janjevic and Ndiaye, 2017). Although initiated as projects with definitive resources allocated for their setting up and initial running, the common objective for the majority of Local Authorities has been to see these UCC projects run as permanent operations within the different localities (Browne et al., 2005).

The failure or success of UCC initiatives is of interest to numerous stakeholder groups and offers an area of contemporary interest in the area of city logistics. However, we observe that the literature on UCC transition from project to operations phase is acutely lacking, with implications extending to replication of unsustainable UCC models and increasing pressure on city logistics stakeholders.

In this study, we investigate existing UCC initiatives within the EU, identifying some reasons for failures as well as critical success factors for transition from project to operations phase. The findings from our study offer knowledge insights that can help municipalities and their stakeholders design and implement sustainable UCC initiatives.

The rest of this paper is arranged as follows; section 2 sees a review of the existing literature; section 3 presents the research methodology and in section 4 our findings are presented and discussed. Finally in section 5, we offer some conclusion and directions for future research inquiry in this area.

2. Literature Review

Within urban logistics, a lot of emphasis has been placed, in recent years, on Urban Consolidation Centres (UCCs). The term UCCs identifies logistics facilities situated in relatively close proximity to the geographic area that they serve (be that a city centre, an entire town or a specific site such as a shopping centre), to which many logistics companies deliver goods destined for the area. From these facilities, consolidated deliveries are carried out within that area; often, a range of other value-added logistics and retail services can be provided (Allen et al., 2007; Gogas and Nathanail, 2017). UCCs (also referred to as Urban Distribution Centres, UDCs) serving to execute consolidated deliveries within the local municipality areas can certainly be valuable facilities, but they should not be seen as a quick *one-size fits all* solution for any sort of problem related to logistic in urban areas.

UCCs have become increasingly attractive options for a number of municipalities in the quest to address freight externalities, however, Browne et al., (2005) highlight the lack of comprehensive frameworks for evaluating the impacts of UCCs, suggesting an imbalance in terms of types of impacts measured. UCC initiatives are often driven by the need to reduce vehicular traffic in urban areas and offer local authorities useful control and opportunities for collaboration with freight stakeholders (Allen et al., 2012).

The EU (including the UK) has supported a significant number of UCC initiatives in the last decade with a variety of outcomes. UCC initiatives are often tied to specific objectives common to the municipality where the project is being trialled. As a result, the measures of successful implementation or trial may differ from one locality to the other. Common objectives include emissions reductions, reduction of congestion, service promotion, land appropriation, economic and territorial cohesion. Furthermore, the implementation of urban logistics initiatives can be significantly affected by political decisions; often, in the European context, local political situations might be uncertain and volatile, producing significant changes in the administrative landscape. This is not ideal for the stability and certainty requested for the success of most of the urban logistics initiatives

Allen et al., (2012) highlight that nearly two-thirds of UCCs initiatives in countries like the UK and France failed to go beyond feasibility studies, whilst countries like Germany, Italy and the Netherlands saw a vast majority achieving trial or operational scheme. This dichotomy in reported progress of UCC initiatives could be linked to the limited understanding of urban logistics on the part of the local councils (Ballantyne et al., 2013), limited or distorted objective focus on retail and similar establishments (Browne et al., 2005) as well as knowledge gaps relating to cost, risk and revenue sharing models that could lead to successful implementation and transition (van Duin et al., 2010; Janjevic and Ndiaye, 2017). Traditionally, other forms of flows (such as the ones related to construction materials, waste management, materials needed in the facilities management cycle, catering industry) that could also be integrated in UCC platforms (Lebeau et al., 2017) remained out of the picture with most UCC initiatives and as these now constitute a great part of the demand flows for urban logistics, many existing UCC models have been rendered unsuitable for purpose.

Since most UCC initiatives are driven by project funds, a common objective from the trial phase is the self-sustenance and financial viability of the facilities following the project phase (Allen et al., 2007; Janjevic and Ndiaye, 2017). However, the literature is fairly limited in this regard and none of the existing studies offer transitional metrics from real case examples. Recognising the complexity of interests in urban logistics initiatives, the literature suggests that the design and implementation of urban logistics solutions should be guided by a careful assessment of their estimated impacts; furthermore, an early involvement of stakeholders from both public and private sectors should be sought, in order to evaluate the long-term sustainability of potential solutions (Browne et al., 2005; van Duin et al., 2017; Gogas and Nathanial, 2017). This recognition of gaps in terms of adequate tools from addressing multi-stakeholder issues at strategic levels as opposed to just operational concerns is important to the policy and decision-making process of the planning and implementation of UCC initiatives (Kin et al., 2017).

As highlighted by Lagorio et al. (2016), so far UCCs effectiveness has been assessed mainly through multiple or single case studies analysing best practices and pilot projects. However, little is reported about the reasons for the failure of such facilities; being very difficult finding information on failed UCC projects and initiatives. The availability of adequate tools, capable of addressing, from a multi-stakeholder perspective, also strategic issues (for instance, related to the investment planning phase) rather than just operational ones (concerned with the day-to-day functioning of already established logistical platforms) could be of interest to stakeholders involved in the policy and decision-making processes that guide UCC initiatives. For example, questions concerning the traditional weaknesses of UCCs in attracting stable and viable revenues for meeting multiple stakeholder interests are yet to be explored. Accordingly, our study seeks to contribute by examining factors that underline successful transition of UCCs from trial projects into viable operations.

3. Research approach

A multiple case study approach was adopted in this study (Eisenhardt and Graebner, 2007). Incorporating interview and observation and documentary review techniques, data was collected from seven cases. These cases were identified following an extensive review of UCC projects, which was conducted by reviewing the literature and EU databases for information on commissioned UCC initiatives. Following the identification of specific projects, considerations for surveying specific projects was made with regards to geographic distribution, accessibility to facility and data availability. To date, over 30 in-depth interviews have been conducted, in addition to site visits and observations and extensive reviews of documentary evidence across 4 European countries; Italy, Sweden, Spain and the UK. We conducted a thematic analysis of the data, employing an iterative coding approach to support research validity and reliability. Data was arranged in case structures and analysed in 3 coding stages. Final themes were subject to independent assessment and cross-evaluation by members of the research team. The next section presents and overview of the cases, including some data extracts from both primary and secondary sources.

4. Cases

In this section of the report, we present summaries from several real-world case studies, highlighting some of the critical engagement issues as well as learning. Table 1 below presents a transition status of the cases investigated.

Location	UCC case initiative	Duration	Status
Parma, Italy	EcoCity / Agri-food and Logistics Centre	2008 - Date	Transferred
Huddinge, Sweden	Soderton 8	2014 – date	Transferred
Lucca, Italy	Lucca Port/ Metro s.r.l	2007	Not transferred
Sheffield, UK	Meadowhall/ Clipper Logistics	2006	Transferred
Vecenza, Italy	Veloce, Vicenza	2004	Not transffered
Padua, Italy	CityPorto	2004	Transferred
Barcelona, Spain	SuperBlock/ Catalonia	2016	Not transferred

Table. 1 - UCC cases with transition status

4.1 Parma (Italy) Case Study - EcoCity

Established in 2008, the “Agri-Food & Logistics Centre – CAL” was designed as an Urban Consolidation Centre platform in order to manage last mile deliveries of agri-food goods within Parma’s city centre. The project was first financed by the Emilia-Romagna region and the local municipality, which created “EcoCity”, a company owned by Parma’s city council that also managed all its operations (Morganti and Gonzalez-Feliu, 2015).

The project required a first investment of 2M€ and was soon praised as a best practice example (Fitconsulting, 2013). Specifically, the project consisted in the creation of an UCC, where agri-food products were daily brought by carriers and then delivered to customers via methane-fuelled vehicles, with an optimized load capacity and following optimal routes (Morganti and Gonzalez-Feliu, 2015).

An innovative characteristic of the project was digitalisation, offering the opportunity for local stores participating in the initiative, to order products directly through EcoCity website and getting them delivered in a few hours, straight into stores (Vaghi and Percoco, 2011). By 2015, the project involved, “*16 transport operators and carriers, 17 food manufacturers and suppliers (fresh and dry products), 7 corporate chain retailers and 10 produce wholesalers*” (Morganti and Gonzalez-Feliu, 2015) serving approximately 250 local food businesses, resulting in the management of roughly the 8% of all the food distributed in Parma. From an environmental point of view, the EcoCity project helped reducing PM and NOx emissions by 29% and 22% respectively (Morganti and Gonzalez-Feliu, 2015).

Although seemingly very good from an operational and environmental point of view, the EcoCity project encountered similar issues as many city logistics pilot projects faced before it. Financially, the project continuously increased its debt, without being able to repay investors. In 2013, the total amount of EcoCity’s debt was 14.5 M, leading to the distraint of several vehicles by creditors (ParmaQuotidiano, 2013a; La Repubblica, 2013).

Parma city council tried to sell EcoCity to private partners four times (ParmaQuotidiano, 2014). They failed on three occasions as no company showed interest in investing into it, until, 2014 when the Coop Taddei Group decided to acquire EcoCity, leaving the EUR14.5M debt to the local administration (ParmaQuotidiano, 2013b; ParmaQuotidiano, 2014).

Even though no data was found regarding the final transfer price, the city council had previously lowered the requested price from 332,000€ to 265,600€ (ParmaQuotidiano, 2013b). It is reasonable to assume that the price dropped further, underlining the serious issue of UCCs valuation and transition post implementation, particularly as financially sustainable ventures.

4.2 Lucca (Italy) Case Study - LuccaPort

Opened in 2007, LuccaPort is an Urban Consolidation Centre, located in Lucca (Tuscany - Italy), managed and owned by Lucca Holding and, therefore, by Lucca city council as it is Lucca Holding's only shareholder (Scintu, 2016). Lucca City Council invested a significant amount of money in the LuccaPort project – approximately 5 million euros; with the purpose of promoting sustainable freight transport in the urban context of Lucca (whose city centre is characterised by historic medieval structures), reducing the high level of pollution that was on the increase in the city centre area (Salotti, 2017a).

LuccaPort is located in a highly strategic geographical area, well connected with the principal highways and is equipped with an electric fleet of vehicles as part of a city-centre congestion and pollution decrease initiative. This involved receiving goods from carriers and fulfilling their last mile deliveries via LuccaPort's alternative fuel fleet (Salotti, 2015).

Ambitious, the project has been running for several years without generating the expected results, resulting in the dismissal of the previous managing company (Metro s.r.l) with a view to transferring to a new management firm (Salotti, 2017b). However, this strategy has not been successful as no company has shown any interest in the project, the closest transfer opportunity resulted in a withdrawal by Manutencoop facility management in 2015 (Il Sole 24 Ore, 2017).

To solve the issues generated by LuccaPort, the current local administration has decided to explore different options. Firstly, LuccaPort will undergo a new phase of study where the focus will be put on the understanding of the criticalities encountered during its activity. Secondly, collaborating with an IT company the city council wants to understand how to integrate the study of big data with Lucca's urban structure, to gain specific data about congestion. Lastly, by trying to get funded by the Life Aspire project, a European initiative aimed at promoting sustainable urban logistics, the city council is raising funds to back this 'new' project (Salotti, 2017b).

4.3 Huddinge (Sweden) Case Study – Södertörn 8

The Södertörn UCC initiative is focused on consolidating supplies to public schools within the Stockholm sub-region. A total of 8 municipalities participated in the scheme, which transited into an operation in 2017, following 2 years of trial. The regional authority worked closely with a number of partners to review and plan the transition into an operational venture, following the successful trialling of the UCC. Some emergent indicators of its successful transition include early and pre-implementation consultation with a wide range of stakeholders, including the selection of a transition partner prior to the commencement of the project phase.

4.4 Sheffield (UK) Case Study – Meadowhall

Meadowhall represents one of the UK's largest shopping locations sprawling a large expanse of land and river and hosting over 20 million visitors annually. Although there are a number of alternative transport modes including train-tram, the principal access mode is road. With increasing number of shoppers and pressure on retailers, the resulting traffic congestions, land use and emissions raised concerns for the city and Meadowhall's management.

Clipper Logistics were appointed to trial and manage a consolidation facility for retailers in 2006 following some consultation and mini-tender process (Allen et al., 2014). Some key indicators for the project included carbon emissions reduction, efficient delivery and reverse logistics. The project remains operational with claimed savings in transport journeys, emissions and capacity utilisation.

Our recent observations have seen the opening of new shopping facilities in the area with some infrastructure investment in specialised retailing around the area. There are still gaps in terms of measurement metrics for reported emissions data, scope of indicators measured in terms of the UCC and its contribution as a freight solution as well as stakeholder engagement methodology employed in the tender process. However, a significant outcome is the successful experimentation and implementation of the UCC initiative.

4.5 Vicenza (Italy) Case Study - Veloce

Veloce Vicenza is a city logistics initiative that was established in Vicenza (Italy) by its local administration in 2004 (FerPress, 2017). It functions as an UCC which is located outside the city centre; where carriers can bring goods, which are then delivered within the city centre via sustainable vehicles such as electric or low-emission ones (Ville et al., 2010).

The initiative is most renowned for the legal feud between the local authority and international logistics companies such as DHL, TNT, UPS and FedEX (Ville et al., 2010). This was firstly originated by the regulations that the local authority imposed to all logistics companies operating within the city centre, forbidding them to enter all Vicenza LTZ areas – basically precluding them any sort of entrance to the city centre. Consequently, in 2008 DHL Express Ltd, TNT Global Express SpA, Federal Express Europe Inc. and United Parcel Service UPS

Italia SRL, instituted an association, the AICAI (Italian Association of International Air Express Carriers), requesting before the Veneto (Italian region in which Vicenza is located) regional administrative court – TAR – the cancellation of such ordinances. In the first place, the court's verdict was favourable to the AICAI, annulling the Vicenza city council's orders. However, the city council submitted an appeal to the Italian State Council, who overturned the previous results in 2009, justifying Vicenza local authority's regulations as "necessary for the protection of the cultural and environmental heritage" (Ville et al., 2010).

Although the verdict allowed Veloce Vicenza to be the only entity managing last mile deliveries in the city centre, carriers have tried to find alternative ways to overcome the restrictions. For example, in 2011, carriers begun using '*riscios*' (a type of bicycle), to complete their last mile deliveries, boycotting the Veloce Vecenza UCC facility (Negrin, 2011). As a result, the project has suffered financially and remains a burden on the local authorities who have had to invest further funds to make the project continue (Il Gazzettino, 2015). Although, the project has been represented as ongoing, its success status remains doubtful when the engagement failures and cost to the city authorities are taken into consideration. Perhaps its study may afford some lessons on limitations to the powers of city authorities to enforce sustainable urban logistics.

4.6 Padua (Italy) Case Study - CityPorto

Established in Padua (Italy) in 2004, CityPorto represents the urban logistics strategy put in place by the Padua city council in order to manage last mile deliveries within Padua city centre, utilising low-emission and electric vehicles. CityPorto's vehicles are kept in and managed by the city's local urban consolidation centre (Interporto Padova S.p.A.), which covers an area of 1.1M m^2 (Interporto Padova S.p.A., 2013). The project represents one of the few successful UCC projects within Europe.

The fundamental prerequisite that this project has been able to satisfy has been the establishment of a dialogue with different stakeholders (Gonzalez-Feliu and Morana, 2010). Indeed, contrary to what happened in the Vicenza case above, (where international carriers have been forbidden to enter the city centre without any sort of dialogue taking place before this decision) Padua city council opted to collaborate with logistics providers (DHL, Bartolini and GLS). These providers bring goods to the UCC and the last mile deliveries are managed by CityPorto fleet (Interporto Padova S.p.A., 2013).

The overall performance of the service has been constantly improving: deliveries increased 126% between 2005 and 2015; environmental indicators have reported significant decline in terms of PM pollution, CO_2, SO_x and NO_x emissions (Trasporti-Italia, 2015). Furthermore, Interporto is constantly investing in its capacity – which now is roughly 1M containers/year – and into CityPorto's fleet – new methane-fuelled vehicles joined the fleet in 2017 (Il Mattino di Padova, 2017).

Padua's model has been recognized as best practice also by other Italian cities, such as Aosta, Rovigo and Modena. These are collaborating with Padua to implement similar city logistics solutions within their cities (Il Mattino di Padova, 2017). Critical factors identified included strong partner relationships such as that between Interporto S.p.a. and logistics companies and inclusive stakeholder collaboration. This project denotes that, contrary to the Vicenza example, efficiency can be reached through an enhanced dialogue between city councils managing UCCs and logistics providers, fostering collaboration instead of competition.

4.7 Barcelona (Spain) Case Study - SuperBlock

In the recent years, Barcelona, the largest city and capital of Catalonia (an autonomous community of Spain) has been facing serious issues linked to pollution. In fact, the Catalan city has been constantly exceeding the recommended thresholds set by the World Health Organization with regard to nitrogen dioxide and particles (Brass, 2017). This, has then been linked to an average of more than 3500 premature deaths caused by pollution per year (Garfield, 2016). With urban freight is expected to increase by 40% by 2050, there are serious concerns of its impact on the society (Hu, 2016; Michell, 2017). In this regard, in 2013, the local administration initiated the "Urban Mobility Plan" (Navarro, 2016). Its objectives involved reducing traffic by 13% and air pollution levels by 21% by 2018 through a 'Superblock' initiative (Hu, 2016). These Superblocks exploits the unique layout of Barcelona which is based on a distinctive grid system (Figures 1), refocusing planning on traffic reduction, liveability and creating a better environment for residents (Stewart, 2017).

Figure 1 - Barcelona grid system (Source: Google Maps)

In 2016, the first Superblock pilot project was implemented in Poblenou – a neighbourhood in Barcelona – and five further pilot projects were originally scheduled for implementation in 2017 (Hu, 2016). Although results have been positive with regard to air pollution, traffic congestion and freight delivery, the first pilot project in Poblenou, which cost approximately €55000, received mixed reactions from citizens (Hu, 2016; Garfield, 2016).

In this regard, Vincente Guallart, founder of the Institute for Advanced Architecture of Catalonia commented the implementation of the Superblock in Poblenou as follows: "*The big mistake done with the test was to build without a budget and without discourse with the citizens*" (Brass, 2017).

This case study illustrates the impact of inadequate stakeholder engagement and structured planning phases which can lead to a long-term unfeasibility of UCC projects. Nevertheless, the Superblock project is still going on, even though it will probably need more time to be implemented than what was scheduled. It is, however, noteworthy to highlight the importance of stakeholders' engagement in planning phases in order for such projects to be accepted by communities and attain long term sustainability vis-à-vis transferability.

5. Findings

Based on the short cases reported above and analysis of the data, we extracted success themes. These crucial success factors for UCC facilities can be classified as: *Engagement*, *Interoperability, Contractual Duration, Impact Modelling*. These are discussed below in addition to a listing of some emergent stakeholder categories highlighted in our data.

5.1 Engagement

Our findings reemphasize the importance of stakeholder engagement as crucial to the success of sustainable urban logistics initiatives. In many of the failure cases, we found low stakeholder engagement. For example, in the Lucca case, where the local authority exclusively held control and *later* attempted to transfer. This position corresponds with the literature on UCC and stakeholder engagement (Ballantyne et al., 2013; van Duin et al., 2017). Perhaps the importance of this finding relates more to the gaps in UCC initiative design and the scarcity of learning in terms of stakeholder engagement for UCC initiatives. The Vicenza case, which has become well documented, offers learning on limitations to the powers of city authorities in terms of failure to effectively engage stakeholders in the design and implementation of urban freight solutions. Although a few engagement techniques for modelling multi-stakeholder perspectives in urban logistics have been developed, their application in real UCC cases remains lacking (Bjerkan et al., 2014; Macharis et al., 2014; Duin et al, 2017). Additionally, we found that many local authorities still lack the required expertise for employing multi criteria decision making (MCDM) systems to obtain optimised stakeholder preference overlap in the mapping, consultation and decision process for urban freight solutions (Kin et al., 2017).

5.2 Interoperability

Closely linked to the integration of multi-criteria decision systems, our findings also identified interoperability of UCC information and communications technology (ICT) infrastructure as a cause of failure. ICT interoperability relates to the ease of connectivity of dedicated computer infrastructure for the exchange and analysis of information. According to the CEO of a leading UCC handler in Sweden, interoperability in terms flexibility and speed of ICT legacy systems were some defining issues that needed to be addressed in the transfer process, posing a significant challenge for their on-going UCC operations. He suggested that "*most UCC ICT models are built with specific configurations and this often creates difficulties at the point of transition because of the extra investment required to improve the ease of connectivity*. *This is* *a common challenge when we have to integrate new suppliers into existing legacy frameworks every time there is a tender process"* (MD, Widrikssons).

5.3 Contractual duration

Additionally, contract durations for operations is another important factor that impacts UCC transition. In many of the successful transfer or transition cases, the duration of management contracts averaged five years or more. Examples include CityPorto and Padua, which has now been in operation for over ten years, Widrikssons and the Soderton initiative, which is presently operational, and Clippers Logistics and Meadowhall that has been operational for over five years. Some of the interviewees indicated that key financial considerations in the uptake of UCC management operations, stemmed from the justifiable returns that can only truly be achieved in the long term. Not only did this improve the financial returns but it also indicated the willingness to create sustainable relations on the part of the parties involved.

5.4 Impact modelling

Finally, our findings indicated that UCC design and implementation should be guided by a careful assessment of their estimated impacts. Data from the Padua and Barcelona cases suggest that inadequate impact modelling and assessment frameworks can undermine the transition process. In the Padua case, respondents revealed extensive assessment frameworks that preluded the initiative. This framework remains flexible and has been updated regularly with the incorporation of bio-fuel vehicles as a good example. However, we observed that the scarcity of robust impact modelling tools that can support strategic planning in this area remains a challenge (Janjevic and Ndiaye, 2017). For this reason, the availability of adequate tools, capable of addressing strategic issues (for instance, related to the investment planning phase) rather than just operational ones (concerned with the day-to-day functioning of already established logistical platforms) could be of interest to stakeholders involved in the policy- and decision-making process.

5.5 Emerging Stakeholders' categories

The complexity of impact assessment is exacerbated by the fact that a wide range of stakeholders is involved in UCC systems. Table 2 highlights emerging stakeholder categories which were observed in the mentioned case studies; for each of the stakeholder categories, impact focus categories are reported. It can be noticed that impact focus categories vary greatly across stakeholders' groups; as such, this might lead to several stakeholders' tensions that have been observed in some of the mentioned cases.

This highlights the fact that stakeholder engagement is very crucial to the success of UCC initiatives; although the literature is advancing, the access to and application instances of existing stakeholder engagement techniques in urban logistics planning remains relatively rare. Local Authorities and planning bodies require expert solutions that use decision support systems in order to obtain optimised stakeholder preference overlap in the mapping, consultation and decision process for urban freight solutions.

Stakeholder Group	**Impact Focus Categories**	**Data Source (Country)**
Local Authorities	Nuisance, Safety, Time, Viability, Transferability, ROI,	Sweden, Italy, Spain
Commuters (Public Transport)	Time, Safety, Nuisance	UK, Sweden, Italy, Spain
Pedestrians	Safety. Nuisance	UK, Sweden, Italy, Spain
UCC project managers	Viability, Interoperability, Transferability, Duration	UK, Sweden, Italy, Spain
Academic partners	Learning, Transferability	UK, Sweden, Italy
EU Commission	Viability, Efficiency, Effectiveness, Duties	N/A
Financing partners	Viability. ROI	Italy, Sweden
UCC employees	Viability, Long-term, Working Conditions	Sweden, Italy
International logistics companies	Accessibility, ROI, Time and Customer retention	Italy
Alternative vehicle OEMS	Viability, Scalability, ROI	Italy, Sweden
Land and property owners	Property rights, viability, ROI	Spain, Italy, Sweden,

Education providers	Learning	Sweden
IT providers	ROI, Viability and Efficiency	Sweden
Insurance	ROI, Risk management	Italy, Sweden, Spain
Suppliers	Time, Effectiveness, Efficiency, Scope	UK, Italy, Spain, Sweden
Service users	Quality, Efficiency, Effectiveness	UK, Italy, Spain, Sweden
Trade Unions	Membership rights, Job Security, Working Conditions	Italy
Commuters (Private)	Safety, Time, Emissions, Nuisance	UK, Italy, Sweden, Spain

Table 2 - Identified UCC Stakeholder categories (atypical)

6. Conclusion

Our study sought to examine transferability in the use of UCCs to promote sustainable urban logistics. Although adopting a local authority perspective, the focus ascertained the importance of multi-stakeholder perspectives in the design and implementation of UCCs. From the case studies analysed, many of the UCCs are designed to effect last mile deliveries that require more significant collaboration in order to produce lasting results. Our findings underline the importance of stakeholder engagement as a critical component for UCC initiatives, in addition to interoperability, impact modelling and contract durations. In affirming the findings from previous studies (Browne, 2005; van Duin et al., 2010; Ballantyne et al., 2013), our study also extends the literature in this area by highlighting the importance of multi criteria decision-making systems that can support local authorities in modelling and managing stakeholders at strategic levels very early on in the project life cycle.

Interoperability is of contemporary interest as it underpins the future of logistics. In particular, UCC initiatives have to incorporate flexible ICT legacy systems that ease integration for management companies. This perhaps reflects an area of future research in terms of exploring ICT technologies that promote interoperability in the ICT infrastructure of UCCs.

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