Proceedings of 7th Transport Research Arena TRA 2018, April 16-19, 2018, Vienna, Austria

Using a consolidation centre to reduce deliveries and waste collections from an urban UK shopping centre

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Abstract

Today's shrinking product lifecycles and accelerated product-to-market launches are placing unprecedented pressures on the retail sector to deal with a surfeit of goods and end-of-life products. In response, the EU has enacted a considerable body of environmental legislation that place responsibility on retailers, producers and distributors for the collection, treatment and recovery of end-of-life materials. Due to the complexities of material-specific collections, many retailers outsource them to specialised waste contractors resulting in considerable variation in contractual, business and operational practices and complex waste logistics networks. This paper aims to identify the potential logistics and environmental impacts that could arise from the use of a traditional urban consolidation centre in Southampton UK as an inspection, treatment and consolidation platform for mixed, recycling and hazardous wastes produced by 92 retailers operating within the city's main urban shopping centre.

Keywords: waste logistics; urban consolidation centre; reverse logistics; green logistics; waste collections; waste management; retail sector; shopping centre.

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1. Introduction

Whilst today consumers enjoy greater inventory efficiencies and enhanced service performance, the retail sector faces unprecedented pressures to deal with a surfeit of products and a considerable amount and range of waste materials (Van Hoek, 1999). Accelerated product innovation and shrinking product lifecycles have increased the volume of returns and waste entering the reverse logistics channel (Giuntini and Andel, 1999). This phenomenon is currently more apparent in the electronics market in view of the continued launch of new communication, entertainment and computing devices. However, other sectors, such as the food industry, are also characterised by increased waste generation due to improper goods handling, inappropriate packaging, poor forecasting and inadequate transport and storage practices (Kantor et al, 1997). The fashion industry deals with a variety of packaging materials whose volume is inherently present in product flows that are closely correlated with the level of retail activity (de Koster et al., 2002; Triantafyllou and Cherrett, 2010a). Further, all retail businesses use a range of items containing hazardous elements as part of their day-to-day operations, including cleaning products, fluorescent lighting tubes, batteries and electrical and electronic equipment such as cashier machines and printers (Triantafyllou and Cherrett, 2010b). Irregular product flows and the diverse quality and random assortment of the wastes produced at the end of product lives add considerable pressures on retailers to design efficient collection networks for the overall perspective of compliance, performance and revenue. In this context, businesses need to treat the reverse portion of logistics with the same seriousness and deliberation as the forward (Beltran, 2002).

Though the examination of a dedicated shopping centre in Southampton UK, this paper aims to:

- Provide insights into the production of wastes as a result of typical commercial operations.
- Investigate the impact of legislation on waste treatment protocols and collection procedures.
- Describe how traditional urban consolidation centres (UCCs) can be used for the consolidation and treatment of wastes produced by retail businesses.
- Assess the transport and environmental impacts of various vehicle take-up combinations considering different fleet and load mixes.

To accurately quantify the transport and environmental effects of the use of Southampton's UCC as an inspection, treatment and consolidation platform for product returns and wastes, this paper also describes the development of a multi-stage analysis framework. That includes data collection, map routing and emissions assessment.

2. Literature Review

A two-fold review of the literature was carried out to identify appropriate sources for inclusion. This involved a search of online databases (i.e. Science Direct, Google Scholar) for peer-reviewed papers on retail waste management practices and urban freight consolidation, and a thorough review of the waste management legislation published in the National Archives (www.legislation.gov.uk) and the European Union Law Directory (Eur-Lex).

2.1. Complexity in Managing Commercial Waste

Different waste streams have different handling protocols, treatment possibilities and disposal alternatives (Batstone et al., 1989; Lagrega et al., 1994). Especially, in the case of hazardous wastes, the distinct characteristics and properties they possess (i.e. flammability, corrosivity, reactivity and toxicity) dictate their control and separation from the flow of mixed waste to ensure proper and safe collection, transport, treatment and disposal (Nema and Gupta, 1999; Wang et al., 2008). Waste collection is further complicated by uncertainties related to variations in production quantities, transportation costs and accident probabilities (Yong et al., 2007). In response, a considerable body of legislation, indispensable for safeguarding a high level of environmental and public health protection has been introduced around the world to regulate the diverse waste material-specific treatment and disposal criteria. In the UK, a plethora of rapidly evolving material-specific regulations and guidance documents aim to implement and enforce the provisions of the environmental acquis, including the 'Waste Framework [2008/98/EC]', the 'Landfill [1999/31/EC]', the 'Restriction of Hazardous Substances [2002/95/EC] and [2011/65/EC]' and the 'Waste Electrical and Electronic Waste [2002/96/EC]' European Commission directives. Under the wider 'Polluter Pays' principle, these laws aim to increase the environmental consciousness of customers and shift waste management to producers to increase the use of recycled materials and reduce the volume of waste generated. Further, a 'Duty of Care' is imposed upon commercial premises to make satisfactory waste treatment and collection arrangements including the establishment and operation of end-of-life product take-back schemes at stores and the operational and tactical optimisation of reverse logistics systems (Bettac et al., 1999).

Managing wastes in an efficient, cost-effective, environmental-friendly and legal manner can be a complex challenge especially for small-to-medium sized enterprises (Shih, 2001). Many businesses with limited resources and a small employee base outsource their waste management activities to fully specialised third-party providers (Yong et al., 2007). Although such waste collection systems are tailored towards specific financial and operational constraints (Maynard and Cherrett, 2010), collaborative work between neighboring businesses generating similar waste streams is not common (Sheu, 2005). Conflicting priorities, individual requirements including different collection time windows, incompatible waste types, as well as branding and privacy issues have impeded retailers from sharing the information needed to support integrated decision making and joint implementation of waste management operations. The apparent failure of the market to create integrated and coordinated system-wide reverse flows has resulted in the over-fragmentation of waste services (Pitt, 2005; Triantafyllou and Cherrett, 2010b). The multitude of waste contractors servicing small waste producers have led to unnecessary handling and an excess of sub-optimally loaded refuse vehicles moving too frequently through cities (Shakantu et al., 2002).

The considerable variation in contractual and operational practices in the sector combined with several overlapping administrative and policy layers have brought to the fore the importance of devising more sustainable solutions for waste collections (Browne and Allen, 2007). Logistics managers can reduce the level of urban transits by consolidating local waste collections into a central stream and balancing back-haul movements. Adding value to an often empty return journey can serve as incentive to increase vehicle load balance while alleviating traffic congestion and cutting down costs and pollutants (DfT, 2005). On this basis, retailers can either use their own distribution assets to remove waste from their premises or band with potentially rival businesses to share the burden and exploit any synergies that might arise from using an interlinked collection network, rather than a series of disparate operations (Ghisi et al., 2008). This concept is forming around the consensus that businesses may tackle their legislative obligations using their existing systems without investing in rather costly, made-to-measure reverse logistics systems when dealing with specialist contractors on a stand-alone basis (Triantafyllou, 2012). Wide scale participation in centrally coordinated material-specific collection schemes can help allied retailers generate critical mass and make use of premium specialised collection services at an affordable cost for their businesses (Shih, 2001). To this end, several projects and studies (i.e. Browne et al., 2005; Lewis et al., 2007; Triantafyllou et al., 2014) have highlighted the significant transport and environmental benefits that could be attained through the use of consolidation centres for managing product returns and waste materials.

2.2. Using Urban Consolidation Centres for Waste Management

While the concept of freight consolidation emerges as a means to offset rising freight costs, congestion and pollution in metropolitan areas, UCCs are increasingly promoted as spurs of regional growth and operational excellence. They serve as control elements in the supply chain as they are intermediate points where individual consignments and part-loads destined for the same locality are grouped together and shipped to their final destination (Lewis et al., 2007). UCCs are the last transit node of distribution networks; thus their optimal siting and the selection of the fleet servicing them are of strategic importance for the reduction of unnecessary transport movements, costs, emissions and administration. Their use provides logistics managers with the option to schedule, manage and monitor deliveries to and from the serviced areas under the most convenient, secure and timely conditions while it enables retailers to free up sales floor at shops and ensure better availability of stock (Triantafyllou et al., 2014). UCCs can offer benefits to all stages of retail processes and to this end many schemes offer a range of value-added services (i.e. pre-retailing activities, returns management, gate-keeping operations, packaging/waste collection and recycling, store transfers and staff training) besides standard stock-holding, cross-docking and replenishment activities (Browne et al., 2005; Campbell et al., 2010).

A UCC can make a major contribution to the environmental sustainability of the businesses it supports, especially when its operating structure is envisaged to incorporate waste management functions. A review of UK commercial consolidation schemes under operation (i.e. the Broadmead UCC in Bristol, the Heathrow airport UCC in London, and Bluewater UCC in Greenhithe, Kent) has indicated that it has almost been standard practice for urban consolidation facilities to contain basic waste management activities (Triantafyllou, 2012). UCCs role in handling return and recycling flows often extends beyond standard waste consolidation and transshipment services and includes storage, gate-keeping and processing activities. By aggregating similar waste streams at an early stage of the recovery process and screening return merchandise that contains hazardous elements, significant delays in the passage of products in the reverse logistics pipeline can be avoided and the probability of items with a recycling, recovery or re-use potential entering the waste stream can be reduced (Rogers and Tibben-Lembke, 1998). In this respect, UCCs do not serve merely as waste integration locations but also as waste control and separation points positioned early in the reverse supply chain. UCCs offer the opportunity to logistics managers to manage efficiently forward and reverse flows and thus minimise the last-mile for deliveries and the first-mile for collections.

The use of UCCs as a means to coordinate and integrate stand-alone waste management processes poses unique opportunities for businesses to streamline fragmented waste management operations, but also faces many challenges. Waste management is an area already fraught with much operational and legal complexity; hence many retailers are dissuaded from adding an extra layer of ramification to their existing processes. Whether they outsource waste management activities or not, they are always duty bound to follow a series of measures and actions and ensure that their waste will be managed appropriately until its ultimate disposal (from cradle to grave).

2.2.1. Legislative Challenges

According to the 'Waste (England and Wales) Regulations 2011 [S.I. 2011/988]' and the amended '[S.I. 2012/1889]' and '[S.I. 2014/656]' Regulations which ensure proper transposition of the 'Waste Directive [2008/98/EC]' into the UK national legislation, all commercial waste collection authorities have a 'Duty of Care' to:

- *Provide Single Stream Waste Collections*: Under the amended regulations, all waste collection authorities must make arrangements to collect waste paper, metal, plastic and glass separately to facilitate or improve recovery; where it is technically, environmentally and economically practicable.

According to the 'Producer Responsibility Obligations (Packaging Waste) Regulations [S.I. 2007/871]' and the amended '[S.I. 2016/000]' Regulations which harmonise the 'Packaging and Packaging Waste Directive [1994/62/EC]' in England, Scotland and Wales, all commercial packaging producers handling more than 50 tonnes of packaging materials and with a turnover of more than £2 million a year have a 'Duty of Care' to:

- *Set-up Take Back Schemes:* All sellers must take back customers packaging when returned in stores and incorporate that into the packaging waste streams produced in-store.
- *Use Re-Usable Containers*: All retailers must increase the level of re-usable tertiary containers.

The 'Waste Electrical and Electronic Equipment (WEEE) Regulations [S.I. 2007/3454]' and the amended '[S.I. 2013/3113]' and '[S.I. 2015/1968]' Regulations that transpose the main provisions of the 'WEEE [2002/96/EC] Directive', its amendment '[2012/19/EC]', the 'Restriction of Hazardous Substances (RoHS) [2002/95/ EC] Directive' and its amendment 'Restriction of Hazardous Substances Directive (RoHS 2) [2011/65/EC]' aim to minimise the impact of EEE on the environment by increasing re-use and recycling, reducing the amount of WEEE going to landfill, eliminating the use of 6 hazardous materials in the manufacture of EEE and running periodic re-valuations of the materials covered by the EEE. Retailers are duty bound to:

- *Segregate WEEE*: EEE sellers must store, collect, treat, recycle and dispose of WEEE separately unless different streams are mixed up to 15% by weight of material in a single consignment. Though display equipment containing cathode ray tubes and gas discharge tubes must remain separate from each other.
- *Operate Take-Back Schemes*: EEE sellers must offer in-store customer take-back systems or provide pre-paid mail order sacks or envelops.

According to the 'Hazardous Waste (England and Wales) Regulations [S.I. 2005/894]' and the Amended Regulations '[S.I. 2016/336]', all commercial hazardous waste producers have a 'Duty of Care' to:

- *Notify the Environment Agency*: The consignees of hazardous waste must complete a quarterly declaration to the Environment Agency that they have received the waste onto their site. In Wales producers of more than 500 kg of hazardous waste must notify their premises by registering them with the Natural Resources Wales. Business organisations with multiple premises must 'notify' each premises separately. Where there are several discrete units within a site (i.e. shopping centre) each unit must be 'notified' separately even if a central waste collection service is provided. The central collection point must be 'notified' too.
- *Aggregate and Store Waste Safely*: Commercial waste producers must store safely and securely end-of-life materials by properly containing and protecting hazardous wastes from weather and other damages and separating them from non-hazardous wastes and other types of hazardous wastes.
- *Produce Consignment Notes*: When hazardous waste is removed from a collection point, a 'consignment note' must be completed by the producers or site operators. This must include the 'premises code', details about the producer, a full description of the waste including its quantity and class under the UK List of Wastes and the European Waste Catalogue, the date of transit and details about the carrier and the next destination. In the case of central waste collections, a 'consignment note' is only required for the transfer of the waste from the central collection point to the recovery or disposal facilities.

- *Transfer Waste to an Authorised Person*: This 'person' or 'body' can be either a holder of a 'waste management license' under section 35 of the 'Environmental Protection Act (EPA) 1990' or a registered waste carrier under the 'Controlled Waste (Registration of Carriers and Seizure of Vehicles) Regulations [S.I. 1991/1624]' and their amendment '[S.I. 1998/605]'. Consignees must also ensure proper packaging of waste, inspect it to see if it matches producer's description and complete the documentation required.
- *Transfer Waste to an Authorised Facility*: The 'Landfill (England and Wales) Regulations [2002/1559] and their amendment '[S.I. 200/894]' ban the co-disposal of hazardous and non-hazardous wastes in landfills and set out the criteria for classifying waste management sites (hazardous, non-hazardous and inert: non-decomposable) according to the type of waste they are licensed to receive.

2.2.2. Operational Challenges

Considering the above legislative requirements, the use of a UCC as a transhipment and treatment facility for wastes entails various operational complexities:

- Prior to the collection and shipment of waste from its producers to the UCC, waste has to be segregated on-site by specialised staff, hence it has to be double-handled.
- Waste producers must adjust their existing practices (i.e. business contracts, treatment processes, equipment) into standardised treatment protocols and share common resources such as tertiary re-usable packaging. This may cause a loss of control over their supply chains.
- The whole driver pool covering the last-mile of their journey (from UCC to WestQuay), and vice versa (first-mile), must be holders of a 'waste management licence' or be registered waste carriers. Also, the vehicles used must have the technical specifications to take-back material-specific and hazardous wastes.
- As deliveries are processed within a specified time interval due to access and parking restrictions or upper limits on total vehicle deployment time, back-haul operations must be well scheduled to avoid delays.
- All back-haul operations must be well organised considering any regulatory restrictions in mixing certain waste streams to avoid on-board load re-arrangements and ensure timely and safe delivery of services.
- The maximum waste quantities moved to the UCC must not exceed the allowable capacities of the respective waste management facilities and the fleet running between West Quay North and the UCC.
- If gate-keeping functions are taken on at the UCC, local skills (staff and equipment) are needed for the inspection and testing of returned products.

3. Case Study: Southampton's Urban Consolidation Centre

West Quay is a retail complex situated in the heart of Southampton in the south coast of England. It is owned and managed by Hammerson and comprises of the South development which opened in late 2016 and the North which opened in 2000. The South development includes a 10 screen cinema, a bowling alley and 21 restaurants. The North development boasts an exceptionally diverse commercial mix spread over three shopping levels, including two anchor stores, 20 restaurants and more than 70 fashion shops. Since 2000, West Quay has evolved into a dynamic retail cluster and has stimulated a series of regional retail, property and venture capital investments. The notable expansion of commercial activities in conjunction with the continuous growth of Southampton's port have challenged the capacity of the local transport network and instigated Southampton's City Council to carry out network improvements, including road widening works, rail gauge enhancements and construction of pedestrian links to improve accessibility in the city centre. Also, the City Council have examined a series of sustainable freight distribution measures both in the short-haul sector (i.e. replacement of consumer car trips with home deliveries) and the long-haul sector (i.e. establishment of a UCC) to reduce congestion, pollution and intra-modal conflicts. Funding was initially secured through the Government's Local Sustainable Transport Fund to support the UCC's operation and expansion over a 2-year period. The UCC opened in early 2014 at the outskirts of Southampton, with the City Council, two local universities, the city's general hospital and West Quay participating in the scheme. According to Southampton City Council, the new UCC is expected to reduce the number of vehicles entering the city by 75% (6,900 movements/year) and Southampton's carbon footprint by up to 75% (SDC, 2014).

Hammerson recognise West Quay's obligation to adhere to a range of waste management legislation and to this end they have a lead role in working with tenants to help them meet their legal obligations. They have developed a waste minimisation plan that includes a central collection system for mixed waste, paper, cardboard, polythene, plastic and glass to achieve economies of scale and simplify waste operations. For the purpose of licensing and regulatory controls, Hammerson hold certificates for general waste disposal which give them the right to collect, treat and dispose of waste through the provision of the necessary 'transfer notes' to tenants under an agreed annual service fee. Retailers can join the central waste collection system or make individual arrangements with their preferred contractors. At the time of the surveys, only three businesses were using private contractors due to contractual reasons, personnel preferences and reluctance to convert to a central supplier. The expansion of the existing central waste collection system to cover hazardous waste collections has been inhibited by on-site constraints (i.e. lack of on-site equipment, storage space, personnel and expertise) and regulatory restrictions (i.e. lack of waste storage, collection and disposal permits). As a result a variety of contractual, business and operational practices appear, turning reverse logistics complex and impeding joint working opportunities. Thus, the use of the newly opened UCC for the purpose of inspection, treatment and consolidation of mixed, recycling and hazardous wastes offers a unique opportunity for West Quay retailers to enjoy significant logistical and financial benefits.

4. Methodology

To assess the transport and environmental benefits that can arise from using Southampton's UCC as an inspection, treatment and consolidation platform for product returns and wastes, the following analysis steps were undertaken.

Stage 1: Data Collection

- *Step 1*: A structured questionnaire including closed and multiple-choice questions was used in face-to-face interviews with the managers of 92 retail and catering WestQuay businesses to collect data about product deliveries, stock and faulty returns, and mixed, recycling and hazardous waste collections.
- *Step 2*: Phone interviews with the main 10 logistics providers servicing the 92 businesses were made to gather data about the vehicle modes employed their fuel requirements and routing patterns.
- *Step 3*: Face-to-face interviews with WestQuay's sustainability manager were made to gather information about the centralised collections of general waste and recyclables. Further phone interviews were made with contractors collecting hazardous wastes such as WEEE, cooking oil and lighting tubes.

Stage 2: Estimation of Transport Activity

- *Step 4*: Classification of vehicles servicing WestQuay into articulated trucks, rigid trucks, vans and other.
- *Step 5*: Estimation of the weekly number of deliveries and collections made at West Quay North.
- *Step 6*: Use of Microsoft MapPoint to model origin-destination data and estimate the distance travelled.
- *Step 7*: Calculation of the volume of all shipments and vehicle fill rates assuming that the maximum fill capacity of articulated trucks is 80 m³, rigid trucks 60 m³, vans 10 m³, and other vehicles 30 m³.
- *Step 8*: Estimation of weight equivalents assuming that the average recorded loads by volume corresponded to the UK average loads by weight and that their values were changing proportionally.

Stage 3: Greenhouse Gases (GHGs) Assessment

- *Step 9*: GHGs assessment using the method developed by the UK Departments for Transport (DfT), Energy & Climate Change, and Food & Rural Affairs (DEFRA, 2010). This method provides conversion factors that represent the rate at which different types of Heavy and Light Goods Vehicles (HGVs/LGVs) emit GHGs according to the distance travelled considering vehicle fuel efficiency, size and loading.

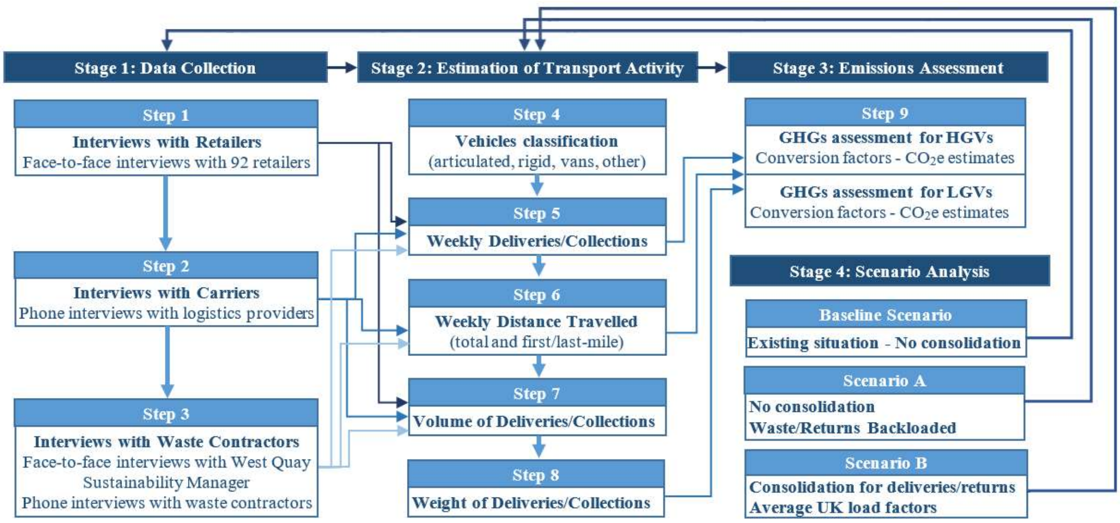

Fig. 1 Process flow diagram showing the data collection and analysis steps followed to assess the transport and environmental impacts under three operating scenarios for Southampton's UCC in the UK.

Stage 4: Scenario Analysis

- *Baseline Scenario*: It reflects existing goods distribution and waste collection arrangements and considers current efforts of WestQuay retailers to increase logistics efficiency and control emissions (Steps 1-9).
- *Scenario A*: It reflects existing goods distribution arrangements (no consolidation) and considers the backload of current returns and wastes to reduce empty-running (Steps 4-9; Table 2).
- *Scenario B*: It examines the consolidation of deliveries and the backload of returns and wastes considering that the weight laden factors for delivery vehicles are equal to the UK average loading rates (articulated trucks: 60%, rigid trucks: 52%, vans 43.2%, other: 58% and trailer: 60%) (Steps 4-9; Table 2).

For Scenarios A and B the following assumptions were made:

- *Recyclables*: In accordance with the requirements of the 'Waste Regulations', the different recycling streams were backloaded separately in the delivery vehicles calling in West Quay North daily.
- *Hazardous Wastes*: A trailer towed by the delivery vehicles was used to enable separate shipping of different hazardous streams and avoid any contamination of the products carried in the delivery trip. Under DfT guidance, the maximum size of trailers can be 7 m long and 2.55 m wide, while heavier vehicles can tow trailers up to 12 m long by 2.55m wide (DfT, 2016). In this study, a trailer 8.5 m long, 2.43 m wide and 3.81 m tall, with a maximum volumetric capacity of 78 m³ and weight capacity of 11 tons was towed by rigid delivery trucks one day per week.
- *Mixed Wastes*: These were backloaded to the UCC on a daily basis. It is assumed that their volume was spread equally across the total number of delivery rigid trucks calling in West Quay North.
- *Stock/Faulty Returns*: These were backloaded to the UCC on a daily basis. It is assumed that their volume was spread equally across the total number of delivery vans calling in West Quay North.

5. Results

Analysis of deliveries prior the use of the UCC (Baseline Scenario) suggested that 449 deliveries were made to the 92 West Quay North businesses during a typical week and 504 deliveries during a busy week (Table 1). 34.8% of delivery trips were made by vans, 35.3% by rigid vehicles, 25% by other/unknown vehicles and 4.9% by articulated trucks. These changes corresponded to a 14.2% increase in the total distance travelled (standard week: 98,067 km, busy week: 111,975 km). A much greater increase (434%) in the total volume of products transported was marked (standard week: 901.2 m^3, busy week: 3,917 m^3). These figures indicated a trend towards the increase of the size of consignments rather than the number of delivery visits during busy periods.

Table 1. Weekly activity of delivery and collection vehicles calling in West Quay North (Baseline Scenario).

Analysis Steps 5-9			Standard Week																			
			Step 5				Step 6				Step 7				Step 8				Step 9			
			Trips (n)				Distance (km)				Volume (m^3)				% Weight Fill Rate				GHGs (CO_2e)			
			A	R	V	O	A	R	V	O	A	R	V	O	A	R	V	O	A	R	V	O
Product Deliveries			22	159	156	112	132	954	936	672	154	452	118	178	60	51.8	40.1	58.0	156	886	281	121
Product Returns	Dedicated	Stock	0	1.6	0.3	5.0	0	10	2	30	0	4.0	0.0	5.4	0	45.6	0.0	39.4	0	9	3	5
		Faulty	0	0	5.0	0.1	0	0	30	1	0	0.2	0.2	0.2	0	0.0	2.1	73.0	0	0	41	0.1
	Take-Back	Stock	6.2	13.3	20.9	1.7	37	80	125	10	17.3	12.0	2.4	0.1	24.0	16.5	6.1	2.1	36	68	153	2
		Faulty	1.0	17.0	11.0	0.2	6	102	66	1	5.2	9.9	7.9	0.5	44.7	10.6	38.1	91.2	7	85	15	0.2
Waste Collections	Dedicated	Mixed	0	7	0	0	0	42	0	0	0	213	0	0	0	50.7	0	0	0	225	0	0
		Paper	0	1	0	0	0	6	0	0	0	31	0	0	0	51.7	0	0	0	33	0	0
		Cardboard	0	5	0	0	0	30	0	0	0	360	0	0	0	60.0	0	0	0	380	0	0
		Polythene	0	5	0	0	0	30	0	0	0	55	0	0	0	18.3	0	0	0	58	0	0
		WEEE	0	0	2.3	0	0	0	14	0	0	0	1.5	0	0	0	34.6	0.0	0	0	4	0
		Batteries	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0.0	0	0	0	0
		Used Oil	0	0	2.3	0	0	0	14	0	0	0	1.2	0	0	0	27.7	0.0	0	0	7	0
		Lamps	0	0	0.3	9.8	0	0	2	59	0	0	0.4	8	0	0	70.7	29.8	0	0	3	11
	Take-Back	Mixed & Recyclables	3	0	0	0	18	0	0	0	5	0	0	0	43	0	0	0	6.5	0	0	0
		WEEE	0	2.5	0	0	0	12	0	0	0	12.6	0	0	0	92.0	0	0	0	12	0	0
		Batteries	0	0.3	0	0	0	2	0	0	0	0.8	0	0	0	48.7	0	0	0	2	0	0
		Used Oil	0	2.3	1	0	0	14	6	0	0	1.2	0	0	0	9.5	26.5	0	0	12	3	0
		Lamps	0	0.2	1	0	0	1	6	0	0	0.8	1.8	0	0	73.0	95.4	0	0	1	13	0

A: Articulated trucks, R: Rigid trucks, V: Vans, O: Other

In Scenario A (Table 2), the weekly logistics and environmental impacts of freight trucks visiting West Quay were estimated for the urban leg of the trip (6 km) considering that the existing number of deliveries (449) and mix of vehicles were used to backload all returns and wastes to the UCC. It was assumed that all stock and faulty returns including those previously backloaded were backloaded on vans, mixed waste and recyclables on rigid trucks and hazardous wastes on a trailer towed by a rigid truck. All recycling streams and hazardous wastes were segregated and shipped separately to prevent cross-contamination and comply with legislation. Terminating all dedicated waste collections (mixed: 7, recyclables: 11, hazardous: 14.7) have led to a 5% reduction of all delivery and collection vehicle visits to West Quay. To assess the total GHGs produced, the return trip for each delivery vehicle was considered even when it was empty (0% load factor). Thus, the use of the backload capacity of delivery vehicles for returns and wastes has led to an approximate 43% reduction of overall GHGs levels.

In Scenario B (Table 2), the overall utilisation of the fill capacity of delivery/collection vehicles were further improved by increasing the load factor towards to UK's average rates while reducing the total number of the vehicles running. All wastes and returns were backloaded on delivery vehicles following the same allocation of the various streams across the four vehicle modes. Hazardous wastes were loaded on a trailer bowed by a rigid truck in 4 trips, to carry separately the 4 different hazardous waste streams. This operational scenario has led to an approximate 90% reduction of the total vehicle visits and a 90% reduction of overall GHGs levels.

Table 2. Scenario analysis of the weekly activity of delivery and collection vehicles calling in West Quay North.

Scenarios		% Vehicle Mix					Deliveries					Stock/Faulty Returns					Mixed Waste/ Recyclables					Hazardous Waste				
		A	R	V	O	T	A	R	V	O	T	A	R	V	O	T	A	R	V	O	T	A	R	V	O	T
Baseline	Trips (n)	4.9	35.3	34.8	4.8	0	22	159	156	112	0	0	1.6	5.3	5.1	0	0	18	0	0	0	0	0	4.9	9.8	0
	Volume (m^3)						154	452	118	178	0	0	4.2	0.2	5.6	0	0	659	0	0	0	0	0	3.1	8.0	0
	GHGs (CO_2e)						156	886	281	121	0	0	9.0	44.0	5.1	0	0	696	0	0	0	0	0	14.0	11.0	0
	Fill Rate (%)						8.8	4.7	7.6	5.3	0	0	1.3	0.4	3.7	0	0	61	0	0	0	0	0	6.3	2.7	0
A	Trips (n)	4.9	35.3	34.8	4.8	0	22	159	156	112	4	0	0	156	0	0	0	159	0	0	0	0	0	0	0	4
	Volume (m^3)						154	452	118	178	0	0	0	65.3	0	0	0	664	0	0	0	0	0	0	0	28.3
	GHGs (CO_2e)						156	886	281	121	0	0	0	281	0	0	0	702	0	0	0	0	0	0	0	28
	Fill Rate (%)						8.8	4.7	7.6	5.3	0	0	0	4.2	0	0	0	7.0	0	0	0	0	0	0	0	14.2
B	Trips (n)	0	55.5	44.5	0	8.9	0	25	20	0	4	0	0	20	0	0	0	25	0	0	0	0	0	0	0	4
	Volume (m^3)						0	796	106	0	0	0	0	65.3	0	0	0	664	0	0	0	0	0	0	0	28.3
	GHGs (CO_2e)						0	178	38	0	0	0	0	36	0	0	0	177	0	0	0	0	0	0	0	29.5
	Fill Rate (%)						0	53.1	53.1	0	0	0	0	32.7	0	0	0	44.2	0	0	0	0	0	0	0	60

A: Articulated trucks, R: Rigid trucks, V: Vans, O: Other, T: Trailer

In Tables 1 and 2, GHGs emissions were estimated for one-way trips. In Figure 2b, the GHGs generated by delivery vehicles returning empty to the UCC and trucks arriving empty in West Quay to collect wastes were also considered. The following figures demonstrate the significant logistics and environmental savings that can be achieved through a higher level of integration and consolidation.

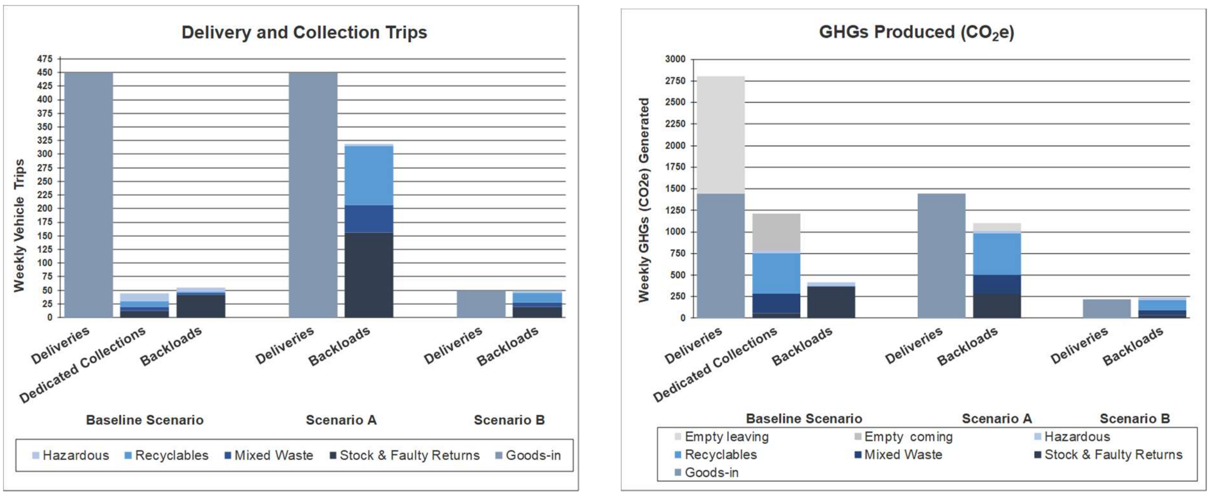

Fig. 2 (a) Number of weekly delivery/collection trips and (b) GHGs generated by vehicles servicing West Quay and Southampton's UCC.

6. Conclusions and Discussion

This paper investigated the potential logistics and environmental impacts that can arise from the use of a traditional UCC as an inspection, treatment and consolidation platform for mixed, recycling and hazardous wastes produced by commercial businesses. In examining 92 retailers operating in West Quay shopping centre in Southampton UK, it was found that the retail sector today has to deal with a surfeit of products and a considerable amount and range of wastes with different handling protocols, treatment possibilities and disposal alternatives. Their management is further complicated by a considerable body of environmental legislation which aims to regulate the diverse waste material-specific treatment and disposal practices. As a result, managing wastes in an efficient, cost-effective, environmental-friendly and legal manner has turned into a complex operational challenge for many retailers.

The considerable variation in contractual and operational practices along with several overlapping administrative and policy layers have highlighted the importance of devising more sustainable solutions for the management of commercial wastes. Considering a range of regulatory compliance and operational issues inherent in the mixing and shipping of different waste streams, the study developed a data collection and analysis framework which can be used to estimate the transport and environmental benefits that can arise from the creation of a shared waste collection network using a UCC in order to facilitate the formation of critical waste quantities, rationalise asset utilisation and lower collection costs. The proposed framework can be used in other freight consolidation studies aiming to evaluate the transport and environmental impacts that could be generated from the use of a consolidation centre as a platform where retailers can backload and pool their wastes together.

The study suggested that by merging material-specific arisings and receiving more frequent collections, retailers can reduce the waste stored in stores and free valuable storage and shop floor. At the same time, congestion, noise and carbon emissions can be reduced through the minimisation of unnecessary vehicle movements and the improved utilisation of the backload capacity of delivery vehicles moving too frequently through cities. Fewer and more productive vehicle trips and faster turnaround times can mean cost savings for suppliers, carriers, retailers and waste contractors. Although these savings can help offset the significant costs related to capital expenditures (i.e. real estate, fleet and equipment), the review of UK consolidation centres (i.e. Meadowhall's, Broadmead's and Norwich UCCs) has revealed that most of the schemes require public funding during their initial operational stages to acquire essential infrastructures, facilities and human and technical resources. To generate new revenue streams that will ensure the economic continuity of the scheme and slowly diminish external funding dependence over the longer term, many UCCs have started providing value-added services such as gate-keeping and waste management operations (Triantafyllou et al., 2014). Thus, the same analysis framework could be adopted to collect and analyse financial data and estimate the potential cost savings that could be achieved from the centralisation of waste management activities and the provision of waste management services to existing and new UCC customers.

Cross-organisational collaboration in the context of waste management can lead undoubtedly to improved service quality and costs reduction for retailers, but it may also create significant challenges to those involved in the process. Retailers will have to continue the operation of waste take-back schemes at stores, join central waste management systems, invest in new standardised equipment, share assets, data, transport and expertise with rival businesses, and treat wastes following material-specific protocols set by the central waste management controllers. The latter will have to invest in on-site infrastructure and ensure compliance with current legislation. Also, they will have to integrate waste flows and coordinate the shipping of wastes to the UCC. In addition, they will have to identify available funding sources, run consultations with local stakeholders on service fees to encourage participation, and offer retailers the opportunity to sample and experience the benefits of the scheme without incurring a charge. Logistics providers will have to hold the required licenses and conduct the necessary inspections to ensure the safe, timely and efficient transport of wastes to the UCC. The UCC will have to provide the necessary reception facilities, train its staff and drivers, maintain a full visibility of the system-wide operations using cutting-edge technology and ensure the proper treatment of wastes from downstream waste contractors.

Although the UK Government efforts have focused on diverting waste away from landfill through regulation, taxation and public awareness, there is an apparent failure of the market to create integrated and coordinated system-wide reverse flows. This study demonstrated the opportunities that the use of the UCCs can offer in reducing the existing variation in contractual, business and operational waste management practices, while improving the total logistical and environmental performance. To support this, the UK Government must produce planning guidelines, develop a reporting framework for users and operators and create an appropriate legal framework to support UCC operations and synergies among retailers.

Acknowledgements

The authors are grateful to the management team of Waste Quay shopping centre for their support and to all the store managers and personnel, carriers, waste contractors and recyclers who contributed to the interview surveys.

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