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Integrating Logistics Facilities in Inner Melbourne to Alleviate Impacts of Urban Freight Transport

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Abstract

Increasing movements of urban freight transport contribute to congestion, air pollution, noise, rising logistics costs and exacerbated road safety. The location of logistics facilities in urban areas significantly affects not only the activities of urban goods movements, but also the urban environment as these facilities represent major originators and receivers of freight movements. Urban planners need to develop a more proactive and dynamic logistics land use planning to not only focus on the locational requirement of logistics facilities, but also the spatial relationships between the major freight hubs and transport network to and from. This paper highlights the current structure, activities and challenges of last kilometre freight activities in Inner Melbourne. Inner Melbourne constitutes a major retail and freight destination while experiencing very limited availability of industrial lands for logistics facilities. The paper presents a framework for optimising the establishment of small-scale logistics facilities in Inner Melbourne. This will enhance the amenity of the central city and alleviate the negative impacts of last kilometre freight.

1. Introduction

Deliveries and pickup activities of goods and materials present a very important activity for the viability of the businesses and citizens. The last kilometre freight encompasses all activities related to delivering and picking up of products and materials from logistics facilities to the end-receiver in urban areas whether a retailer, business or consumer. It includes various activities including transportation, handling and storage of goods, management of inventory, waste and returns (Konstantinopoulou 2010). Nowadays, logistics appears to have contradicting issues, as it is required to operate efficiently and sustainably and adjust to the increasing movements of last kilometre freight activities inside the central city area. This has to be achieved with the majority of customers and retailers being located in inner urban areas while logistics facilities have been forced to relocate to the periphery of metropolitan areas (Labussière and Nappi-Choulet, 2014).

Inner urban areas still constitute a major retail and freight destination and attract/generate significant levels of freight movements with very limited supply of available and affordable commercial and industrial lands to establish and operate logistics facilities. The volume of freight movements in the central city area has significantly increased due to economical, operational and social factors. More freight vehicles are required to make very frequent and low-weight deliveries, which result in increasing the number of freight movements. This is accompanied by inefficient loading and parking infrastructure, which deteriorates the efficiency of last kilometre freight. This has contributed to increasing the number and distance travelled of intra-metropolitan freight movements, which increase the pressure on the transport network. Consequently, these freight movements lead to several negative social, environmental and economic impacts on society and businesses in the central city area.

This paper proposes a framework for optimising in a sustainable way the establishment of suitable small-scale logistics facilities in the central city area. The developed framework is composed of three stages: the 1st Stage develops and designs Central City Distribution Facility (CCDF); the 2nd Stage presents a Multi-Criteria Analysis Framework to select the most optimal configuration of CCDF based on the stakeholders' objective; the 3rd Stage selects the most optimal location of CCDF using a developed Suitability Index. The paper is structured as follow: section 2 presents a review of the literature on intra-metropolitan freight movements in Greater Melbourne. Section 3 evaluates the challenges and issues in last kilometre freight in Melbourne. Section 4 provides an overview and the results of the observational study conducted to evaluate the use of on-street loading zones in Melbourne CBD. Section 5 presents the proposed framework to establish Central City Distribution Facility in Inner Melbourne with description of the various stages involved in this framework. Section 6 provides a concluding summary and policy implications.

2. Literature Review

2.1 Challenges of Intra-Metropolitan Freight Movements in Melbourne:

About 19% of all vehicle movements on the Melbournian road network are commercial vehicles including 11.5% being Light Commercial Vehicles (LCV) and 7.5% being heavy trucks (ABS 2015a). LCV is a commercial vehicle used for transport of goods with a Gross Vehicle Mass (GVM) of less than 3.5 tonnes. Despite the large number of LCVs moving daily across Melbourne, only 25% of their total is involved in freight activities with the rest being involved in services activities (plumbers, electricians…etc) (Victorian Freight and Logistics Plan 2013). These services are not part of this research investigation as they are not classified as freight activities. LCVs involved in freight activities deliver only 10% of the total freight task in Melbourne compared to rigid and articulated trucks which deliver 41% and 40% of total metropolitan freight task (ABS 2015a, ABS 2015b).

Major industrial users that generate and receive freight movements such as manufacturing, transport, postal and warehousing (TPW) and wholesale are located in suburban areas in Greater Melbourne which are far away from inner Melbourne, which encompasses Melbourne, Maribyrnong, Philip Port, Stonnington and Yarra Local Government Areas. Major industrial and commercial premises are located in the northern sub-region such as Somerton and Campbellfield, in the southeast sub-region such as Dandenong South, Moorabbin and Knoxfield, and in the western sub-region such Altona/Laverton and Sunshine/Deer Park (Department of Transport 2008). This has further increased the freight vehicles kilometres travelled (VKT) across Melbourne to deliver goods and materials to end-receivers in inner Melbourne as well as traffic and congestion on major freeways and roads. According to the Traffic Monitor report issued by VicRoads, the volume of freight VKT on the road network increased by 22% since 2002 (Traffic Monitor Report 2014). There is a significant volume of freight movements on the Western Ring Road, West Gate Fwy, Monash Fwy, CityLink Tollway and Princes Fwy (western part). Furthermore, in their submission to the Victorian Government in 2008, the Yarra Campaign for Action on Transport, which was an independent transport expert group led by Sir Rod Eddington, warned that freight movements across the major freight corridors would significantly increase in the 20 years with estimated growth exceeding 55% on the West Gate Bridge, CityLink and Monash Fwy (Investing in Transport 2008). Furthermore, the Traffic Monitor report by VicRoads alerted that over the last ten years, the average delay on the road network, which indicates the level of stoppage and congestion, has increased during both peak and off-peak periods (Traffic Monitor Report 2014). The congestion and delay on the road network exert negative impacts on intra-metropolitan freight movements with respect to the reliability of the travel time. Consequently, transport operators need to incorporate this increasing travel time in their assumed journey time, which in turn affect the reliability and efficiency of their delivery activities.

2.2 Very Limited Allocation of Industrial Lands in Inner Melbourne:

Majority of logistics facilities are located on industrial or commercial lands in Greater Melbourne. Out of the 25,712 hectares of industrially zoned lands across Greater Melbourne, 976 hectares of occupied industrial lands are located in Inner Melbourne with only 36 hectares being vacant according to the Urban Development Program (UDP) (2015), which is published by the Victorian Department of Transport, Planning and Local Infrastructure (DTPLI). This figure represents only 4% of all zoned industrial lands across Greater Melbourne. In the last 15 years, about 1,708 hectares of industrial lands across Greater Melbourne were rezoned for other uses with over 29% changed to residential use, 20% changed to commercial use and 21% changed to mixed-use according to the UDP report. About 22% of this industrial land rezoning occurred in inner Melbourne. According to report by Jones Lang LaSalle in 2010, which is a leading professional services and investment management company specializing in real estate, only 29 hectares of industrial land was developed between 1999-2009 in inner Melbourne due to the very limited land availability compared to 194 hectares in the Southeast sub-region, 185 hectares in the Western sub-region and 138 hectares in the Northern sub-region (Jones Lang LaSalle 2010). Furthermore, the Jones Lang LaSalle's report indicated that only 288,783 m^2 of industrial land/buildings have been developed in Inner Melbourne, which represented about 5% of the supply of industrial land/buildings in Greater Melbourne during 1999-2009. According to Melbourne's Census of Land Use & Employment (CLUE), storage and wholesale premises represents only 1% of all built space in Melbourne CBD (City of Melbourne 2015).

Moreover, scarcity of industrial lands in Inner Melbourne and competition with other land-uses such as residential and commercial developments further increased the land cost for logistics facilities to locate in inner Melbourne. For instance, the average cost of industrial lands in inner Melbourne is almost 2-3 times higher than other areas such as the Western or Northern sub-regions according to leading real estate services providers such as Savills, M3property and Jones Lang LaSalle (Briefing Melbourne Industrial 2015). Furthermore, the Jones Lang LaSalle report indicated that inner Melbourne has less than 1% of all future supply of industrial lands under the size of 1 hectare (10,000 m^2) hectare and 0% of industrial lands more than 1 hectare across Greater Melbourne. This further complicates the availability of land for logistics facilities as up to 32% of all transport, postal and warehouses (TPW) businesses in Melbourne operated on parcels averaging more than 0.5 hectares with the average size of TPW premise being 1.6 hectares (16,000 m^2) (Jones Lang LaSalle 2010; Spatial Economics 2010). Consequently, it can be argued that the shortage and high cost of industrial lands in inner Melbourne encouraged and promoted logistics facilities to look for and operate in other cheaper areas where large parcels of industrial lands are available and affordable.

3. Last Kilometre Freight in Inner Melbourne

3.1 Operational Activities and Challenges in Last Kilometre Freight in Melbourne CBD:

Furthermore, Melbourne CBD constitutes a major retail and freight destination with more than 10,000 freight vehicles making deliveries and more than 20,000 freight vehicles passing through the CBD as well as having more than thousands of retailers and businesses requiring frequent small deliveries (Casey et al. 2014; City of Melbourne 2015). LCVs represent about 81% (about 8,065 LCVs/day) of all the freight vehicles making deliveries in the CBD while heavy commercial vehicles make up the rest (about 1,825 heavy trucks) (Casey et al. 2014). The high number of LCVs movements, which are usually inefficient and unoptimised, delivers smaller volume of the freight into the CBD compared to freight tonnage transport on heavy vehicles. LCVs have very limited capacity compared to large freight vehicles. This further requires increasing the efficiency of these smaller vehicles and encourages enabling more heavy trucks to deliver freight into the CBD, which will reduce the number of LCVs on the roads. However, enabling larger freight vehicles into the CBD require more innovative and sustainable logistics buildings.

Moreover, the inefficient on-street loading zones as well as lack of off-street loading facilities in Melbourne CBD further complicate freight deliveries into the area (City of Melbourne 2015). Every day, thousands of freight vehicles compete for very limited number of on-street loading zones, which might force some vehicles to circulate around the city to find alternative space and consequently result in additional traffic and congestion. Traffic movement is considerably congested with a high mixed of passenger vehicles, cycling and pedestrians, which results in deteriorating travel time. This further complicates the reliability and efficiency of freight transport operators to comply with the time-sensitivity requirement of deliveries to receivers. Casey et al. (2014) interviewed carriers making deliveries in Melbourne CBD to evaluate whether the delivery was making a low or high impact based on the following factors: load factors, time of delivery, ability to find parking and fuel type. The analysis of the interviews' responses indicated that only 8% of the deliveries were classified as low-impact deliveries on Melbourne CBD. This reveals that many deliveries in Melbourne CBD experience problems with finding off-street parking, making deliveries in peak morning and afternoon hours and using primarily fossil-fuel vehicles.

3.2 Negative Impacts of Last Kilometre Freight in Inner Melbourne

The increasing movements of freight vehicles inside the central city area contribute to several negative economic, social and environmental impacts on the society, environment and businesses. The use of primarily fossil fuel-powered freight vehicles creates various atmospheric emissions. The significant VKT that freight vehicles travel between logistics facilities in suburban areas to receivers inside the city centre in addition to the often necessity to circulate around to find an available on-street loading zone result in an additional fuel consumption. Freight vehicles play a significant role in the constant deterioration of traffic conditions and travel time inside the congested city centre, which result in negative economic impacts on logistics companies and end-receivers. They negatively affect the quality of life for citizens in the central city areas as they expose pedestrians to accidents and safety hazards, noise and visual pollution. Moreover, as active transport mode (walking and cycling) is becoming more popular in the central city area, the increasing number of freight vehicles presents a safety hazard that should be eliminated or minimised to make streets more liveable and safe.

4. Use of On-Street Loading Zones by Freight Vehicles in Melbourne CBD:

4.1 Overview of Methodology:

It order to develop a better understanding of the utilisation, efficiency and challenges of parking and loading activities by freight vehicles in Melbourne CBD, a physical count of the on-street loading zones in Melbourne CBD and observational study (parking survey) of the use of these loading zones were conducted in September 2016. The physical count provided a complete inventory of the on-street parking supply in Melbourne CBD (major streets, one-way streets and laneways) for freight vehicles. Furthermore, seven on-street loading zones (along Collins St, Flinders Lane, Elizabeth St, Little Collins St, Little Bourke St, Queen Street and Exhibition St) were observed in person to record and identify the activities and utilisation of loading bays by freight vehicles. These selected OLZ serve various end-receivers such office buildings (Collins St, Queen St and Exhibition St), retail (Elizabeth St and Little Bourke St) and hospitality industry (Flinders Lane, Little Collins St). The selected locations are among the most heavily used OLZs in Melbourne CBD according to the Melbourne Freight Demand Generation Study (2014). Parking and loading activities at each location were observed and recorded on a different weekday between 07:30-10:30 AM. The data collected in the observational study included: vacancy of the loading bay, arrival and departure time, vehicle type and delivery address (on-street or off-street). Moreover, the researcher created a map illustrating the major locations of OLZs and various areas in Melbourne CBD with high commercial intensity (office buildings, high-rise residential towers, and retail & food outlets) as can be seen in figure 1. This provides an improved visualisation of the inefficient number and locations of OLZ compared with high number of freight movements and freight generators in Melbourne CBD. The physical count and observational study of OLZs provides actual and reliable representation of parking and loading activities by freight vehicles and illustrate the difficulties encountered which further raise the need to establish small-scale logistics facilities in the central city.

4.2 On-Street Loading Zones Count in Melbourne CBD

The researcher recorded (in person) the number of on-street loading zones (OLZ) and loading bays (OLB) in Melbourne CBD that displays the "Loading Zone" signage for delivery/pick up activities. According to VicRoads Loading Zones Guidelines, the on-street loading zone is provided for the use of commercial vehicles engaged in picking up or setting down goods or passengers on behalf of a company or business. Only freight vehicles and commercial passenger vehicles (e.g. busses) are allowed to use them. The OLZ varies in lengths and number of bays as well as the allowable time (15 mins or 30 mins). Table 1 highlights the number of existing OLZs in Melbourne CBD:

Location in CBD	**Major Streets e.g. Bourke St**	**One-way Street e.g. Little Bourke Street**	**Laneways e.g. Hardware Ln**
Number of On-Street Loading Zones	239	89	137
Number of On-Street Loading Bays	479	211	161
Number of OLZ in Melbourne CBD	465		
Number of OLB in Melbourne CBD	851		

4.2.1 Personal Observations from On-Street Loading Zones Count in Melbourne CBD

- Various areas with many high-rise residential buildings (such as corner of Little Bourke & Spencer St where about four 40-floors residential towers exist) have very limited number of OLZs. This further complicates the frequent delivery of express parcels to residents in these buildings. While all of these buildings have on-site loading docks, it was observed that most of couriers park on the street outside the building as the access to the on-site loading dock either is time-consuming or restricted.
- Inconsistency in allowable loading time with some OLZ allowing up to 15 mins and a nearby OLZ allowing 30 mins all in very close proximity.
- Signage of all other zones in Melbourne CBD (Bus Zone, Taxi Zone and Permit Zone) are marked in red colour with white background. This might be confusing to carriers who are not familiar with Melbourne CBD.
- While more than 10,000 freight vehicles conduct delivery and pickup activities daily into Melbourne CBD, there are only 851 on-street loading bays available in Melbourne CBD. This illustrates the challenges encountered by freight vehicles to find available OLZ during peak hours in the morning and late afternoon.

Figure 1 illustrates the high number of office buildings and high-rise residential towers located in Melbourne CBD, which require daily large volume of light parcel (less than 30 kg). It also displays the locations where high numbers of on-street loading zones (OLZ) are available in streets and laneways in Melbourne CBD. The figure displays areas with high concentration of retail and food outlets that generate and attract high volume of freight activities. Moreover, there is a cluster of high-rise residential towers (marked in green triangle) in west of Melbourne CBD (along Spencer St) with very limited number of OLZs. Furthermore, despite the high number of office buildings (marked in dark red diamond) along King St and William St, the number of OLZ is less only 12 loading bays.

Fig.1. Illustration of the Locations of On-Street Loading Zones and Major Generators of Freight Movement (Office Buildings, Residential Towers, Retail and Food Outlets) in Melbourne CBD.

4.3 Observational Study of Loading Activities at On-Street Loading Zones in Melbourne CBD (Parking & Loading Survey):

A total of 245 parking events were observed at the selected OLZs during the seven days observational study. Table 2 illustrates results of the observational study. Due to the illegal parking by cars, the availability of loading bays for freight vehicles was reduced by 11%. Furthermore, it was observed that a loading bay was available for the freight vehicle at the time of arrival on 63% of the parking events. The unavailability of loading bays forced freight vehicles to park illegally, wait and create traffic problem or circulate to look for available OLZ in a different location. Furthermore, the overall average of stay for all freight vehicles at the loading bay was around 16 minutes per freight vehicle during the observation period. It was observed that about 47% of deliveries were for receivers located within 40 metres from loading bay where the freight vehicle parked while 29% of deliveries were for receivers located more than 60 metres from the loading bay. The distribution of freight vehicles (89% light vehicles vs 11% heavy vehicles) during the observation period revealed different results compared with previous studies such as Casey et al. (2014). This could be attributed to difficulty of making deliveries using heavy freight trucks in on-street loading zones compared with other studies that included off-street loading facilities. Furthermore, it was observed that service vehicles such (plumpers, electricians… etc) used the OLZ on 16% of the parking evens even though they are not designated as legal users of the OLZ according to VicRoads guidelines.

Table 2: Summary of the Observational Study of Use of On-Street Loading Zones in Melbourne CBD

Vehicle Type	%		Freight Vehicle	%	Average Duration at Loading Zone (min)	Delivery Address (On- vs. Off-Street)
Freight Vehicle	71%		LCV	71%	14	On: 62% Off: 38%
Car (Illegal Parking)	13%		Light Truck	14%	17	On: 86% Off: 14%
Service & Maintenance	16%		Heavy Truck	11%	22	On: 72% Off: 28%
			Ute	4%	23	On: 20% Off: 80%

*Light Truck: Less than 4.5 Tonnes Gross Weight. Heavy Truck: Over 4.5 Tonnes Gross Weight.

5. Framework to Establish Central City Distribution Facility in Inner Melbourne

5.1 Description of Framework

The proposed framework utilises and builds on approaches and models from city logistics measures and multi-criteria decision-making. The developed framework enables establishing in a sustainable and optimal way Central City Logistics Facilities in the congested central city area while taking into consideration the various operational, social and environmental aspects and objectives of all the stakeholders in the decision-making process. The framework proposes and designs Central City Distribution Facilities (CCDF) that can be integrated in congested areas in the city centre and facilitate: a) reducing the number of freight vehicles in the central city, b) increasing the load utilisation of incoming freight vehicles, c) complete delivery and pickup activities to businesses and end-consumers on soft transportation modes, d) enhancing the utilisation and efficiency of loading zones and e) encouraging the delivery activities in central city to be changed to off-peak hours.

The developed framework presents a significant contribution as it sequentially and collectively involves stakeholder analysis and location selection of small-scale logistics facilities from a viability and sustainability perspective. This enables the ex-ante evaluation and assessment of the merits and potential of locating small-scale logistics facilities at a given position inside the congested central city area to minimise the negative impacts of last kilometre freight.

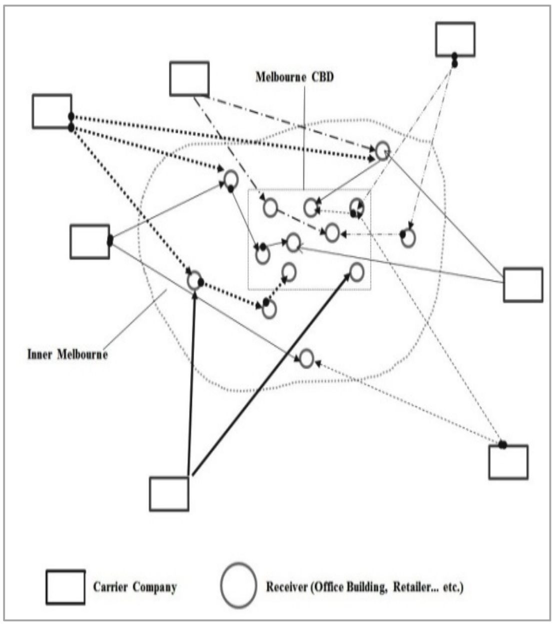
5.2 Stages of Proposed Framework

5.2.1. 1st Stage: Development of Central City Distribution Facility

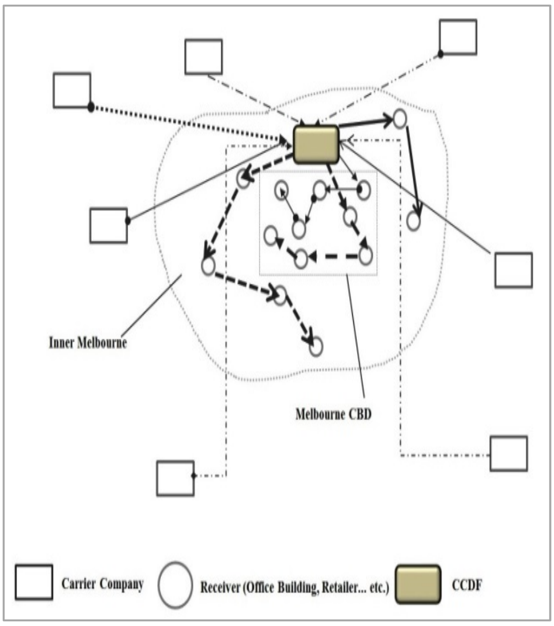
The establishment of CCDF is considered a network design problem that aims to optimally integrate the small-scale logistics facilities in the congested central city area and connect with existing supply chain networks of carriers and receivers. The CCDF will integrate with the outbound logistics network of the logistics service provider that will operate the facility. The following section describes the operational activities, potential users of the facility, freight transport modes used in the facility as well as supporting regulation and policies required for the establishment of CCDF.

5.2.1.1 Description of Central City Distribution Facility

The Central City Distribution facility (CCDF) can be set up inside an existing parking infrastructure (underground of above surface terminal) or a suitable building in high-density areas in the central city area. The facility works as a transshipment point and accommodates receiving deliveries from urban distribution centres as well as manufacturers and wholesalers via light and/or heavy trucks. Figure 2 illustrates the consolidated delivery scheme (Figure 2b) using the CCDF compared with existing direct delivery scheme by multiple transport carriers (Figure 2a).



a) Direct Delivery Scheme



b) Consolidated Delivery Scheme

Fig. 2. Illustration of the Proposed Consolidated Delivery Scheme Using CCDF Compared with Existing Direct Delivery Scheme by Multiple Transport Carriers.

This initiative aims to provide transport carriers with a common-user distribution facility that relieves them from the responsibility and challenges of last kilometre distribution activities within the congested central city area. As this last link is considered the most problematic and most expensive, these transport carriers will benefit from not having to deliver inside the central city area. The facility enables deconsolidation, transshipment and optimising the delivery and pickups of parcels from multiple transport carriers to receivers and neighbouring businesses in inner Melbourne using soft transportation modes or eco-friendly vans (LPG, Hybrid or electric) in case of delivery to surrounding suburbs. The out-bound distribution activities out of the facility will be carried out by a selected transport carrier. The parcels, which are usually up to 30 Kg, are unloaded from incoming vehicles from various carriers, sorted and then loaded onto soft transportation modes e.g. on foot, rolling carts and/or cargobikes with parcel carrying compartment. The selected facility should have enough height to enable the ingress and egress of the delivery truck without any restriction as well as conducting all the sorting and loading activities inside the facility. The logistics facility should be soundproofed and fireproofed. The CCDF can include space for vehicle and cargobikes overnight parking and quick repair as well as an office and a staff break room.

Besides offering above mentioned logistics activities, the CCDF will provide paid value-added retailing and recycling activities such as real-time tracking, product returns, unpacking and waste removal. The value-added activities will facilitate increasing revenues that will compensate the additional transshipment cost. In order to be economically viable, the CCDF needs to attract daily a large number of consignments from various transport carriers to be delivered from the facility to the central city area. The CCDF needs to be cost-efficient and enable maintaining the same level of service offered by the original transport carriers to receivers. The CCDF is proposed based on industry practices for delivery and pick up activities in congested central city areas.

Characteristics of CCDF

- Physical Infrastructure (Parking Facility vs Building).
- Leadership of Initiative (Private vs Public Private Partnership)
- Management: Attended or Unattended Delivery
- Vehicle: Does Facility's Height Limit Allow Light Trucks? Using LCV with trailer?
- Number of Cargobikes and clean vans.
- Capacity size of cargobikes.
- Operating Hours
- Geographical Coverage of Delivery Area Served from CCDF
- Extra Services: Temporary Storage
- Overnight Vehicles Parking: Yes/No
- Size of Facility

5.2.1.2 Supporting Regulations and Policies

Local authorities need to assess the social and environmental benefits of providing financial subsidies to establish the CCDF during the start-up stage. The subsidy scheme should be provided only to the facility's operator that offers the most innovative and optimized final distribution activities in central city at the lowest environmental and social impacts. The operator of the facility needs to efficiently integrate the facility to cohabit with surrounding residential and commercial uses. City planners should establish performance-zoning codes that set the land-use zone of CCDF based on performance standards that minimize the negative impacts on surroundings uses and enable conducting distribution activities in central city. Furthermore, local authorities need to set required regulations for the use of cargobikes on existing city's bicycle infrastructure as well as parking facilities.

5.2.1.3 Benefits of Central City Distribution Facility

The CCDF facilitates delivering consolidating deliveries on less polluting transport modes. The following benefits will be achieved:

- Relocating loading/unloading activities from on-street loading zones to the off-street facility.
- Increasing the load factor utilisation via consolidating deliveries.
- Reducing number of delivery vans making deliveries inside the congested central city area.
- Reducing health and safety hazards on citizens and businesses.
- Reducing congestion on roads inside the central city area.
- Improving the amenity of central city area.

5.2.2 2nd Stage: Assessment and Ranking of CCDFs based on Stakeholders' Objectives

There are various stakeholders or actors involved in last kilometre freight activities with different and sometimes conflicting objectives. Thus, it is very important to include the various objectives and interactions between the involved stakeholders before implementing a new concept to enhance last kilometre freight activities. Several authors warned that many previous distribution concepts have not succeeded due to lack of consideration for the stakeholders' various objectives early in the decision making of the concept as asserted by Suksri and Raicu (2012); Macharis et al. (2014) and Behrends (2016). As the concept of CCDF can implement various transportation modes and be located in different parts in the central city area, it is important to evaluate beforehand the various alternatives of these small-scale logistics facilities with respect to the objectives of all the involved stakeholders. Bjerkan et al. (2014) stressed that stakeholders will accept and cooperate with implemented measures and policies as long as they don't impose negative outcomes to their objectives and operations.

Therefore, this research will utilise and adapt the principles of the Multi-Actor Multi-Criteria Analysis (MAMCA) method, which was originally developed by Macharis (2007), to evaluate and rank the most appropriate configuration of CCDF with respect to the objectives of each stakeholders involved in last kilometre freight. MAMCA has been used extensively in early decision-making of freight transport projects in various European cities such as Flanders Region, Belgium (Macharis et al. 2010), Thessaloniki, Greece (Macharis et al. 2014), Brussels (Verlinde et al. 2014) and Amsterdam (Macharis et al. 2016). The following steps will be used to evaluate and rank the most suitable configuration of NDZ and CCDF:

1st Step: Problem Definition and Identifying the Alternatives for Evaluation:

The current operational activities and challenges of last kilometre freight in the congested central city area were described above in Section 3.1. Furthermore, various configurations of CCDF will be evaluated and compared with business-as-usual (BAU) scenario using the MAMCA method to rank the most suitable and optimal configuration based on the stakeholders' objectives.

2nd Step: Identify all the stakeholders involved in last kilometre freight activities and determine their key objectives.

3rd Step: Convert the stakeholders' objectives to criteria and assign a weight that indicates the criteria's importance based on the objective of the stakeholder.

Table 3 displays the objectives of all the stakeholders and the criteria of each stakeholder that will be used in MAMCA analysis. The objectives and criteria were adopted from Melbourne-based studies including Swanston Street Access Survey (2010), City of Melbourne Last Kilometre Freight Plan (2015) and international studies conducted in Europe and Asia.

Stakeholder	Objective	Criteria
Transport Carriers	Provide high service level to shippers and receivers	High Service Level
	Minimise total duration between picking up and delivering product	Delivery Timespan
	Integration with other transport modes	Multi-modality
	Reducing cost of collecting and delivering products	Profitable Operations
	Less number of vehicles and optimized vehicle usage	Load Utilisation
	Attractive and Safe working environment for employees	Employee Satisfaction

Stakeholder	Objective	Criteria
Receivers	Maintain receiving frequent deliveries on time.	Punctual Deliveries
	Low Cost Receiving Deliveries	Low Delivery Cost
	Real-Time information on deliveries	Supply Chain Visibility
	Receiving Small-weight deliveries during non-busy operating hours	Convenient Deliveries
	Shopping environment with minimum freight vehicles	Attractive Urban Environment
	Safety of delivered products	Security
Shippers	Maintain low cost of delivering product to receiver	Low-Cost Delivery
	Ensure the safe and on-time delivery of product to receiver	Receiver Satisfaction
Local Authorities	Livable city for citizens with limited nuisance (less congestion, noise, emissions and traffic accidents)	Attractive Urban environment
	Provide businesses with attractive requirement to carry out their commercial activities	Attractive Business Environment
	Implement low-cost measures to enhance the transport network and urban environment.	Low Cost Measures
Citizens	Minimise freight vehicles and reduce congestion near homes and shopping areas	Urban Accessibility
	Reduce nuisance (noise, emission, visual and accidents)	Quality of Life
	Continuous supply of required products and services	Product Availability
Logistics Real Estate Provider	Rent facility to LSP at a competitive price.	Profitability
	Minimise damage and deterioration to logistics facility	Low Maintenance
	Logistics Facility cohabit with other uses in building	Harmonious Integration

4th Step: Links each criterion to a measurable or qualitative indicator to determine a score and measurement scale.

5th Step: Evaluate the extent to which a specific alternative separately scores on a specific criterion, which is then aggregated into an evaluation table containing all the criterion scores of an alternative into one single synthetic final score or ranking.

6th Step: Once the evaluation table is completed, a Multi-Criteria Decision (MCD) method will be used to determine the overall score of the all alternatives on the objectives of each stakeholder group.

7th Step: The MAMCA analysis provides a ranking of the various alternatives as well as highlighting the strengths and weaknesses of the alternatives which aids the decision maker select the most suitable alternative based on stakeholders' objective for implementation.

5.2.3 3rd Stage: Area Suitability Index for Setting CCDF in the Central City Area

Various parts in the central city area may experience different levels of congestions and issues due to last kilometre freight. Thus, CCDF might be more suitable and successful in parts where congestion is high and areas for loading and parking are very limited or not enough. Micro-analysis of the potential parts in the central city area should be thoroughly evaluation to select the part that is most suited and feasible based on relevant attributes and indicators. As no such an index exists that achieves the above mentioned evaluation while taking into consideration the relationship between land-use and last kilometre freight, impact on surrounding uses, and freight demand requirements, it was necessary to develop a suitability index for this analysis. The developed Area Suitability Index enables thorough evaluation and assessment of the suitability and feasibility of the potential area where the CCDF is best suited. The following attributes and indicators should be included in the analysis to select the area is the best suited to establish the CCDF in Central Melbourne.

5.2.3.1 Logistics Land-Use Attributes

- Existing Logistics Facilities
- Land-Use Zones of Existing Logistics Facilities
- Existing Transport Service Operators Located in Area (Employment Size and Revenue).
- Loading/Unloading and Parking Infrastructure
- Freight Vehicle Access Restrictions

5.2.3.2 Characteristics of Freight Demand

- Numbers of Private/Public Receivers Requiring Freight Deliveries in selected ANZSIC classifications
- Size of Total Area and Employment of Major Receivers Requiring Freight Deliveries
- Estimated Volume of Freight Attraction/Production
- Demographic and Employment Attributes (Population Density, Median Age, Income, Employment Size)

5.2.3.3 Suitability Indicators

- Streetscape
- Road Network Accessibility
- Road Network Connectivity (distance to different types of routes) and Proximity to Major Locations of Industrial Lands
- Interface between Local and Intra-Metropolitan Freight Movements
- Number of Commercial Vehicles Moving on Major Roads within Area
- Proximity to Retail, Commercial, Health, Education and/or Employment Precincts/Clusters.
- Pedestrian Areas
- Impacts on nearby Residents

5.2.3.4 Feasibility Indicators

- Involvement of Local Authorities in Freight Transport
- Implemented Measures to Improve Last Kilometre Freight
- Real Estate Cost

- Availability of Affordable Commercial Parking Facility or Warehouse with High Ceiling to Accommodate Freight Trucks
- Cycling Infrastructure

6. Conclusion and Policy Recommendations:

Central Melbourne is undergoing higher density residential development with more than 30 high-rise towers being built in the coming years. The number of retail and hospitality premises is significantly increasing on a yearly basis as more people live, visit and work in Central Melbourne. This will further increase the volume of delivery and pick up services into Melbourne CBD. Furthermore, local governments are contemplating converting parts in Melbourne CBD to pedestrian areas such as south-end of Elizabeth St and Market Street. This will further complicate the access of freight vehicles and delivery activities to receivers located in these areas. While deliveries to office buildings and shopping outlets in the central city area are sometimes performed using off-street loading docks, many historical parts and streets with large number of retailers, businesses and residents still depend on on-street loading zones to receive deliveries and send out products. The observational study supported claims by transport carriers about the inefficient and not enough on-street loading zones. As the exclusive use of on-street loading zones to only freight vehicles could not be systematically enforced, local authorities need to consider setting regulations that enable establishing small-scale logistics facilities in the central city area. As most off-site parking facilities in Central Melbourne are owned and operated by private companies in addition to the limited availability of vacant industrial lands, this signals the need for local authorities to provide financial subsidies to sustainable and innovative transport carriers that will be willing to provide consolidated and optimized distribution activities into Melbourne CBD out of the new distribution facility. The public financial subsidies need be compared with the social and environmental costs and negative impacts associated with increasing number of freight movements within Central Melbourne. The proposed framework provides a practical decision-support tool for local authorities and transport carriers for setting up small-scale logistics facilities in the congested central city area.

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